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Pipe-Jacked Tunnelling: Jacking Loads and Ground Movements

Summary

The reported work constituted the third phase of a programme of research into the performance of concrete pipes during installation by the pipe-jacked tunnelling technique. This third stage was a continuation of the on-site monitoring of full-scale pipe jacks during construction. Four schemes were monitored in different ground conditions: London clay, dense fine sand below the water table, stiff glacial till and soft alluvial clay. Pipe sizes ranged from 1000mm to 1800mm internal diameter and excavation methods included hand tools, slurry machines and an open face tunnel boring machine.

The main objective was to collect information on jacking loads and stresses at the pipe-soil interface to provide a better basis for future designs. This was achieved by building twelve stress cells -capable of measuring total normal stresses, shear stresses and pore pressures - into the wall of a standard concrete jacking pipe that could be inserted anywhere in the pipe string. Jacking loads and forward movement of the pipe spring were simultaneously recorded and the results were correlated against site activities, including lubrication operations, and tunnel alignment surveys.

Another objective was to monitor the ground response by measuring displacements around the tunnel and ground pressures above the perpendicular tot he intended line. Ground movements were measured using conventional surveying techniques for surface settlements, and inclinometer access tubes for sub-surface deformation. On one scheme, electro-levels were employed in a near-horizontal tube to measure centre line settlement as the tunnel bore advanced. Push-in spade cells and pneumatic piezometers were installed on two schemes to measure the change in horizontal pressures with the passage of the shield.

Because of the myriad data collected, it has only been possible to present a summary of the results obtained. Jacking force records from all the monitored schemes - including the previous fieldwork stage - are presented. The pattern of jacking load build up and the magnitude of frictional resistance can differ significantly according to the type of ground and use of lubricants. Stress measurements at the pipe-soil interface show that the interaction between jacking loads, pipeline misalignment, stoppages, lubrication, excavation technique etc, is highly complex.

Ground movement measurements compared to well established empirical predictive methods show that short-term displacements are related to ground losses caused by closure of the overbreak void between shield and pipe.