Abstract

Soil conditioning for pipe-jacking and tunnelling

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In pipe jacking, reduction of jacking forces may be achieved by injecting bentonite, polymer solutions, or other additives into a thin overcut annulus excavated around the pipes. Physicochemical interactions, including clay swelling inhibition and filter-cake formation at or near the cavity boundary, are believed to alter the process of cavity contraction. This may help reduce radial effective stresses on the pipe and, in turn, the jacking forces. However, the interplay between the contracting cavity, the overcut size, the lubricant chemistry and its injection pressure are not understood with sufficient confidence to allow informed decisions to be made when selecting lubrication schemes. A physical model replicating the pipe jacking process at laboratory-scale has been devised to identify the key interactions and measure the effects of the lubricant chemistry on the radial effective stresses between the pipe and the clay. A cylindrical cavity was excavated in an overconsolidated kaolin clay model using a low-disturbance drilling system. During excavation, lubricant fluids were injected at controlled pressures in an annulus around the pipe. Tests performed using different chemical compositions but under otherwise identical conditions have demonstrated that the lubricant composition significantly affects the rate of build-up of effective stresses on the model pipe, as well as their final magnitude. In comparison to water, polymer achieved a 65% reduction of radial effective stress on the pipe.

In earth pressure balance (*EPB)* tunnelling machines, the provision of a supporting pressure to the tunnel face often demands that the properties of the excavated ground be altered by means of soil conditioning. Foam and polymer are almost invariably injected into the excavation chamber to help remould the excavated ground into a mixture that may be discharged by the screw conveyor in a controllable manner. Again, little guidance is available to recommend appropriate types and quantities of soil conditioners in different ground conditions, and serious difficulties have sometimes arisen from the common sense and experience approach usually adopted in industry. The effects of soil conditioning on the operational parameters of the *EPB* machines used on the Channel Tunnel Rail Link project have been back-analysed. It has been shown that the 8.15 m diameter machines could be driven efficiently in a wide variety of ground conditions and that appropriate soil conditioning allowed the machines to be operated in closed-mode in the very stiff clays of the Lambeth Group as well as in the London Clay. Remarkably well-controlled face pressures have been achieved in London Clay. Polymer injection ratios of about 15% reduced the undrained shear strengths of the London Clay to about 25 kPa. Little or no foam was injected when the EPB machines were in the London Clay, suggesting that foam only has limited benefits in stiff clays. Volume losses of below 1% were achieved throughout the tunnel drives, with only a few instances of larger volume loss.