Performance of circular shafts and ground behaviour during construction

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There are few well-documented case studies of circular shafts which makes it difficult to accurately predict their performance or estimate the magnitude and extent of surrounding ground movement. The aim of this thesis was to gather and interpret field observations of circular shaft construction and conduct well-controlled centrifuge model tests.

Field observations of circular shaft construction were assembled from three major tunnelling projects in London. The shafts had a range of geometries and two categories of shaft construction were identified. For the first category, the shaft was supported by pre-installed walls which were either diaphragm walls, secant bored piles or sheet piles. Excavation was carried out after the pre-installed walls were built. For the second category, the shaft was progressively constructed using a concurrent sequence. It was excavated in sections to expose the ground, typically 1 m height, followed by the erection of either pre-cast segments or a sprayed concrete lining. When a complete ring was formed the sequence was repeated for the underlining ring until the desired shaft depth was reached. In some cases, a combination of both techniques was adopted. The field observations were collated to form a database of shaft performance and adjacent ground movements, the first of its kind.

Centrifuge tests were undertaken for circular shaft excavation in dry sand and overconsolidated clay. Centrifuge tests on an elliptical shaft were also carried out. The aluminium model shaft was placed in the soil before the centrifuge tests were conducted and was analogous to a pre-installed shaft. New apparatus and new centrifuge testing procedures were developed to extract small quantities of dry sand or clay from the centre of the shaft in-flight. The centrifuge model was well-instrumented with miniature transducers to measure strains in the shaft lining and displacement of the ground around the shaft. Visual aids were also installed to observe operation of the new apparatus during the centrifuge tests.

Detailed analysis of the centrifuge test results helped to elucidate the field observations and provided a comprehensive view of the behaviour of circular shafts and the surrounding ground. Ground movements are more significant for concurrent shaft construction than for pre-installed walls; in the latter case the ground movements in clay become substantial as failure by basal heave is approached. Hoop stresses induced in circular shafts are considerably greater than bending stresses.