Abstract

The tunnelling industry traditionally carries out impact assessments on existing infrastructure by assuming that surface structures deform to the same extent as the greenfield tunnelling movement profile. This is sometimes highly conservative and can lead to grossly disproportionate internal structural forces.

Three soil-structure interaction numerical models were developed under this study based on foundations on an isotropic elastic half-space and a superstructure consisting of elastic beam elements. The models were used to study the response of an arch bridge as a result of tunnelling induced movements. Field observations from the construction of the Tideway Tunnel in London and the movement monitoring carried out on Grosvenor Bridge were used to validate the numerical models. Settlement monitoring conducted within three utility tunnels prior to the crossing of the bridge provided an early indication of the performance of the TBM and the resulting volume loss.

Back analyses from the deformed shapes of the utility tunnels indicate that the volume loss during the Tideway Tunnel construction at the Battersea area was in the order of 0.64~1.2%. The ratio between the settlement above the cutterhead and the final settlement is found to be 0.1~0.3. Based on best pre-construction estimates of geotechnical and tunnelling parameters, the transient settlement and three-dimensional deflection of the bridge piers in response to the approaching TBM were obtained. Compared to an uncoupled analysis based on the direct imposition of greenfield displacements to the foundations, structural displacements and internal forces are reduced by 20% using the proposed coupled numerical analysis. Comparison with field monitoring data at the bridge indicates that the response of the bridge is consistent with numerical results at 1% volume loss and a ratio of 0.25 between the immediate settlement above the cutterhead and the final immediate settlement.

A parametric study was conducted to investigate the effects of different combinations of tunnel configuration, bridge structural details and key geotechnical parameters on the bridge response. In particular, results demonstrate that there are different combinations of tunnel alignment and depth which would give rise to the greatest settlement or horizontal displacement in the bridge

structure. Depending on whether vertical or horizontal movements are more critical for the serviceability of the bridge or associated utilities, the critical tunnel location giving rise to the largest unfavourable loading on the bridge would be different. The effect of different connection details in the bridge between major structural members was also studied. It is found that numerical results are sensitive to the modelling of connection details and of fixities within the superstructure.

It is demonstrated in this study that the elastic continuum method adopted is able to return reasonable solutions which are consistent with field observations.