

# Long-term Behaviour of Cast-iron Tunnel Cross Passage in London Clay

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## ABSTRACT

London has one of the most extensive network and oldest sections of subway tunnels in the world. In particular, the engineering conditions of old cross passages between adjacent cast-iron tunnels are found to be critical by recent assessment. This thesis investigates long-term behaviour of old cross passage tunnels through three dimensional structural & geotechnical finite-element analyses, which provides an understanding of cast-iron tunnel behaviour as well as the effect of cross passage on ground response.

The behaviour of cast-iron tunnel segments is investigated using the 3-D finite element (FE) method. Results show the details of segmental joint, especially the bolt behaviour, significantly influence its overall joint behaviour. Since such detailed modelling of bolts increases the computational time, it is proposed to replace the bolt model to a set of bolt-spring models.

Based upon the bolt-spring model, a series of numerical simulations on a cast-iron segmental ring are conducted. It is found that the construction process, which occurs before soil loading is applied, influences the ring deformation as well as stress built up after soil loading is applied.

Further to a full tunnel ring, the behaviour of a critical cast-iron cross passage in London Underground is investigated. Results indicate that a lintel across an opening effectively transfers the hoop thrust applied on the opened section to adjacent rings, and hence lintel distortion behaviour can be critical.

Finally, to examine the long-term tunnel behaviour in stiff clay, a series of 3D soil-fluid coupled finite element analyses is conducted. Results show that surface ground settlement is similar along the tunnel rail direction regardless of a cross passage. A semi-coupled soil-structure model is proposed to consider both the complex soil behaviour and the structural features in precise manner, which in turn simulates the tunnel behaviour more realistically and predicts a more critical tunnel structural condition against previous efforts.