

**Title:** Design of frozen soil bodies for the construction of cross-passages between two shield driven tunnels in the Amsterdam North/South metro line

**Speaker:** A.J.T. Luttikholt

**Firm:** Witteveen+Bos, The Netherlands

Between the two bored tunnels of the North/South metro line, cross-passages are situated. These cross-passages allow for a safe escape route to the parallel tunnel tube in case of an emergency. In areas where the two tunnels are located at separate depth levels a vertical shaft is situated in between. Access to this escape shaft is provided by a horizontal tunnel between the tunnel tube and the vertical shaft.

The cross-passages are constructed by means of the New Austrian Tunnelling Method. Due to the soft soil conditions in Amsterdam these passages cannot be excavated without temporary support of the soil. By freezing the soil surrounding the passage the stiffness and strength of the soil is increased significantly and the passage is sequentially excavated. After removal of a soil slice a shotcrete lining is applied. After excavation and completion of the temporary shotcrete a final insitu lining is constructed. When hardened the frozen soil thaws and the cross-passage is finished.

The sequential excavation of the soil is most often modelled with a 2D plane strain model. To account for the force distribution in the out of plane direction a stress relief factor is applied at the excavation. Now, with a more sophisticated 3D model the sequential excavation and shotcreting is modelled without the necessity to make use of an uncertain stress relief factor. By extensive post-processing of the principal stresses and comparing these with the Mohr-Coulomb failure surface, derived from experimental test results, the safety level is determined.

For two different horizontal passages in the North/South metro line the safety level along the length of the cross-passage and in every construction phase is analysed. Based on this more insight giving calculation the safety of the frozen soil bodies during construction is validated.

**Figure 1: Sliced view of the 3D FEM-model with the vertical shaft, partially excavated cross-passage and tunnel tube (left) and frozen soil body surrounding the cross-passage (right)**

