

## Ultimate Limit State analysis of a segmented tunnel lining

Because of lack of space and low hindrance of existing infrastructure during construction, in populated areas, shield driven tunnels are becoming more and more popular. Since 1997 these segmented tunnel linings are also constructed in the Netherlands, but they are difficult to accomplish in soft soils. Because of unexpected damages observed during the construction of the first tunnels a full scale test set up was implemented at the Delft University of Technology to gain knowledge on the lining behaviour. The tests that were directed towards the construction stage and the SLS, made clear that the joints in between the segments play an important role in the global lining behaviour.

In order to assess the safety level of a concrete lining, tests have also been performed in the ULS. The load capacity of an ovalizing lining strongly depends on the extent of cooperation of the successive rings in the lining. With poor cooperation the segment joint capacity is decisive, whereas with good cooperation the bending moment strength of the segments defines the ultimate load. From the collected test data a detailed description of the failure mechanisms is obtained. The influence of the segment joints and ring joints on the global lining behaviour is analysed especially at extreme loading conditions. Based on the measured segment joint rotations and lining deformations, interaction forces between adjoining rings are analysed.

With the obtained knowledge on lining behaviour a FE model is developed in Diana for predicting internal forces and external deformations for loadings in the ULS. With the aid of this model different loading combinations can be analysed and eventually the influence of soil can be incorporated. Because the load capacity of the lining and its failure mechanisms is known, a probabilistic analysis may be performed for assessing the safety level of a tunnel lining.