Parametric Study of Factors Affecting Face Stability in Shield Tunneling

The Institute for Structural Engineering of the Ruhr-Universität Bochum is offering a three-month internship through the RISE program of the DAAD. The trainee will support a research assistant at our institution in his scientific work concerning mechanized soft ground tunnelling.

Scientific focus:
Tunnel face support is of particular importance for soft ground tunnelling. If applied face pressures are too high, then a blow out or ground heaving at the surface can occur; conversely, if face pressures are too low, the soil mass can cause serious damage to the machine and lead to excessive ground settlement or even a sink hole. The necessary face pressure is typically calculated by using analytical models to calculate an upper or lower bound for the pressure, and then by multiplying the obtained result by a given safety factor taken from design codes. A more reliable safety assessment can be obtained through Finite Element Analysis, using the so-called Strength Reduction Technique, in which the soil strength parameters are successively reduced until the numerical model cannot reach equilibrium and produces a numerical failure. This method more accurately predicts the real operability range of a tunnel-boring machine, yet it fails to consider all soil parameters in the calculation of the safety factor. This leads to a misrepresentation of the physical phenomena that cause face collapse. In order to identify the true nature of face failure and the interactions between the different parameters, a large-scale parametric study is needed, in which not only on the safety factor, but also on the failure mechanism of the soil is investigated.

Tasks and Requirement Profile
The work of this project will be performed using the open source Finite Element (FE) code Kratos Multiphysics. The Student will perform a parametric study analyzing the factors that affect face failure in the mechanized tunneling process in which the soil parameters (cohesion, friction angle, dilatancy angle), and the operational parameters (depth, diameter, face support) will be varied. The results of these tests must then be analyzed in order to draw a conclusion concerning the relationship between these parameters and the stability of the tunnel face.

Surroundings
Bochum lies in the center of the Ruhr-Area, which, with over 5 million inhabitants, is the most populous region in Germany. Although the Ruhr-Area is a former coal-mining region, many old industrial facilities have been reimagined as exhibition spaces and tourist attractions. A diversified cultural program and a broad offer of recreational activities led to the Ruhr-region being named the European Capital of Culture 2010. Furthermore, with 15 colleges and universities, the region boasts the highest density of research institutions in Europe. The Institute for Structural Analysis at the Ruhr-University Bochum is largely focused on the development and improvement of existing Finite Element Technologies. Furthermore, the head of the institute, Prof. Dr. Günther Meschke is also the speaker for a German Research Foundation funded Collaborative Research Center 837 “Interaction Methods for mechanized Tunneling,” and, as such, the institute, as well as the University, is at the center of Tunneling research in Germany.

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