Expanded clay in deep mechanised tunnel boring

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1 ABSTRACT

Mechanised tunnel boring technique is generally employed to realise deep tunnels within rock mass having good geo-mechanical characteristics. Nevertheless, tunnels often cross rock portions where the rock mass presents poor mechanical parameters and consequently develops large convergences. The high stress concentration due to large convergence is generally non compatible with tunnel liners' resistance and designers have to take particular care of these areas. Designers can face the problem mainly by adjusting two parameters: liners mechanical resistance and machine overcut dimension. These parameters cannot be changed as desired as their range of variation is very limited. Furthermore, overcut area has to be quickly backfilled to ensure ring's segments stability.

The paper describes a novel application of expanded clay in deep mechanised bored tunnels with segmented precast liner rings. The paper investigates the use of expanded clay as backfill grouting behind the lining. Due to its mechanical properties, expanded clay acts as support during the first segment erection stages and as dissipater when the rock mass develops long term convergence.

The paper describes the numerical and experimental studies performed by the writers to characterise material mechanical behaviour and the overall combined behaviour expected on site.

Expanded clay of different sizes and mixed with other materials have been tested to isolate the material having the best mechanical characteristics as backfiller. The testing equipment designed to reproduce at best the full scale conditions expected on site and the results obtained are described.

Furthermore, two kinds of numerical simulations have been performed. A first series of analyses was aimed at assessing segment stability after placing. The simulation was performed with Strand7, a finite element software particularly suited for structural analysis. At this stage rock mass was treated as a fix restraint while a major attention was paid to geometrical and mechanical discretisation of the concrete ring and of the expanded clay filler. Nonlinear mechanical behaviour and details of segments joint were carefully modelled.

A second series of numerical analysis was aimed at assessing the long term effects and stresses in the liners. In particular, the analysis verified the suitability of expanded clay as backfiller for "Gran San Bernardo" security tunnel on the Alps at the border between Italy and Switzerland. In a carbonifer portion of the tunnel, large long term convergence are expected and a dissipative backfiller layer has been foreseen to reduce the thickness of the liners. The simulation was performed with Phase2 a structural/geotechnical finite element software which enabled a reliable simulation of the evolution of rock mass convergence with time. Tunnel and liners geometry, rock mass and expanded clay characteristics were

carefully modelled to simulate the overall behaviour and interactions to obtain the long term actions in the liners.

The numerical models and the results obtained are carefully described in the paper. Some brief technological remarks conclude the paper.