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Effect of rock creep behaviour on tunnel long-term performance at CERN

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1 INTRODUCTION

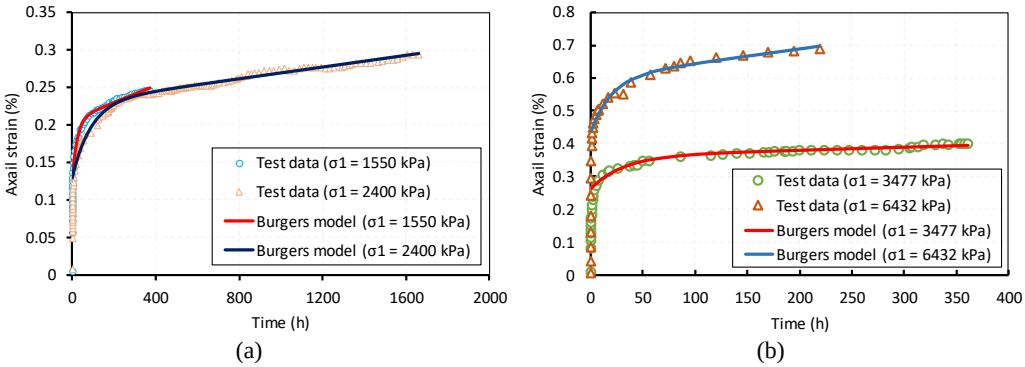
Creep behaviour of rock acts as a crucial role in the long-term deformation of tunnel underground structures. After tunnel excavation, the surrounding rock of a tunnel usually tends to continuously deform as the rock pressure around varies with time. This is mainly since natural rocks contain pre-existing discontinuities and cracks which may be generated or exacerbated by the effect of ground excavations at the construction stage [1, 2]. The creep behaviour of rocks has an important impact on the long-term rock-structure interaction [3-5], and in turn leads to the long-term deformation of underground structures [6-8].

At CERN tunnel, field observation and measurements clearly show that substantial visible cracks, water infiltration and structural deformation have been developing with time after tunnel excavation over more than four decades. In this paper, we attempted to investigate the long-term deformation of the ageing CERN tunnel subject to the rock creep behaviour. A numerical model was developed to describe the creep behaviour of rocks based on the experimental data, and then to evaluate the long-term deformation of tunnel lining of a CERN tunnel situated in the molasse rock. The purpose of our research is to reveal the effect of creep behavior on the tunnel long-term deformation and to provide insights into the design and maintenance of underground structures.

2 METHODOLOGY

The rock creep test data from CERN tunnel investigation report was analysed to characterise the creep behaviour, such as the creep curve depicted in Figure 1. The Burgers model was employed to capture the time-dependent creep behaviour of rock of Marl and then calibrated against rock laboratory tests as shown in Figure 1.

A series of 2D finite element numerical analyses were performed to investigate the impact of rock creep behaviour on a representative CERN tunnel section embedded in marl and sandstone rock. (see Figure 2).



(a) (b)

Figure 1: Comparison between Burgers modela and triaxial creep data of marl under confining stress : (a) 700 kPa and (b) 2000 kPa. (Data from [9])

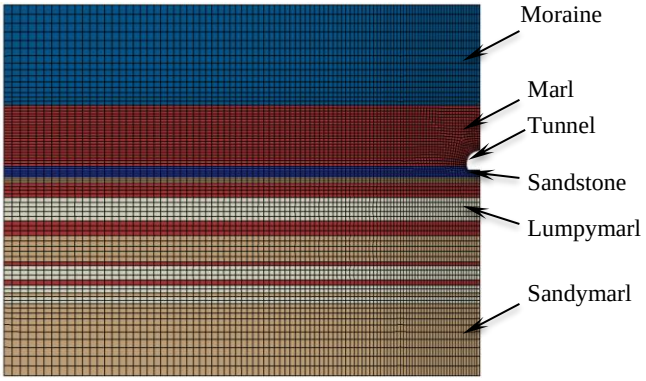


Figure 2: Numerical model

3 RESULTS & DISCUSSIONS

Figure 3 compares the computed tunnel deformation with and without the impact of rock creep behaviour. When the rock creep is ignored, the horizontal diameter of the tunnel increase during the pore pressure dissipation while the vertical diameter decreases, resulting in horizontal elongation deformation of the tunnel.

On the contrary, if the rock creep is taken into account, the tunnel lining tends to continuously converge inwardly. This results in a tunnel deformation mode that differs from the one when the creep behaviour is not considered. However, some assumptions were made for simplicity, more specific study is required to better understand the impact of creep in greater details.

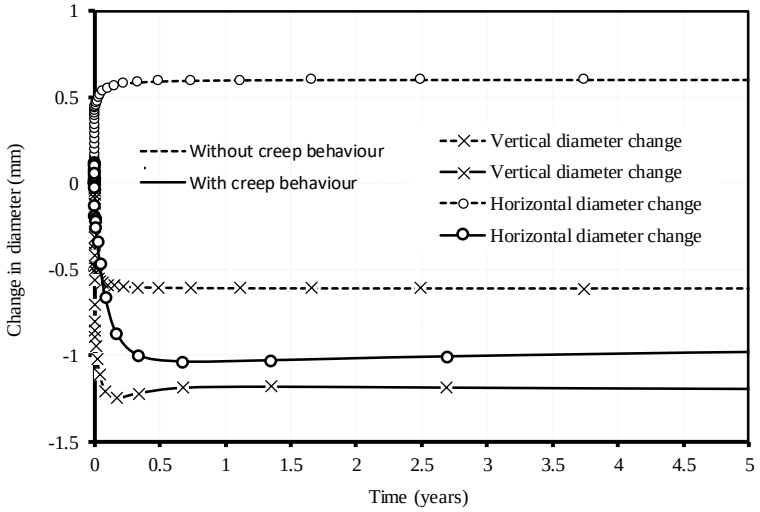


Figure 3: Comparisons of the tunnel deformation with and without considering the creep behaviour

4 CONCLUSIONS

A series of finite element analyses were conducted, aiming to evaluate the effect of creep behaviour of rocks on the long-term CERN tunnel deformation in layered ground. The constitutive model was calibrated by the experimental data, and the computed tunnel deformation shows that the creep of rocks results in inward tunnel deformation. Results provide new insights into the long-term performance of ageing non-circular tunnel embedded in layered rock mass.

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