

Tunneling Squeezing and Swelling Rocks



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Tunnelling in both Swelling and Squeezing Rock

Deformation Mechanisms are different in Squeezing and Swelling in tunnels:

Squeezing

1. Squeezing rocks contain large amounts of clay. The harmless members of the kaolinite group and derivatives of the montmorillonites dominate the clay part of the rocks.
2. The squeezing is a large, time-dependent convergence along the tunnel excavation.
3. Squeezing depends on time and friction. Squeezing is happened in long time and without a sign.

Tunnelling in both Swelling and Squeezing Rock

Swelling

1. Rocks containing clay minerals (especially clays in smectite group) swell when they interact with water; these rocks are called swelling rocks.
2. Time-dependent convergence amount in under- ground structure put forward the effect of swelling.
3. This convergence amount is related to water.
4. Swelling in tunnels generally happens at invert. High pressures derived from swelling cause occurring cracks at invert.

Non-Deformable Support System for Highly Deformable Rocks

1. If a **support design** can bear the high pressures derived from high deformation, it will be possible to excavate a tunnel without any damage.
2. The pressures derived from **high deformation** cause some deformations on support system.
3. However, the important thing for the **designed support system** is permitting to excavate tunnel safely by behaving in limits of calculated deformations.

Non-Deformable Support System for Highly Deformable Rocks

1. The deformable behavior of these rocks can be limited by cutting the interaction of the excavated area with air and non-deformable support application with certain excavation toleration.
2. The important thing here is making **support immediately after excavation.**
3. **If this time span is shorter, rock mass are exposed atmospheric conditions at minimum level.** This situation decreases the swelling or squeezing capacity of the rock. However, time-dependent swelling and squeezing properties of the rock must be considered in support analysis.

Parameters used to Design Support System

The most important parameters concerning rock engineers to design support systems in highly deformable rocks are:

1. Swelling and squeezing index of rock,
2. Liquid limit,
3. Plastic limit,
4. Plasticity index,
5. Cohesion,
6. Friction angle,
7. Elasticity modulus without drainage,
8. and porosity.

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Parameters used to Design Support System

Soft Soil Creep Model was used as material model. In other words, this model's (also known as Modified Cam Clay Model) failure criterions were same as Mohr–Coulomb Model's (cohesion, friction Angle and dilatancy angle).

The basic stiffness parameters are Modified Swelling Index (κ^*), Modified Compression Index (λ^*) and Modified Creep Index (μ^*):

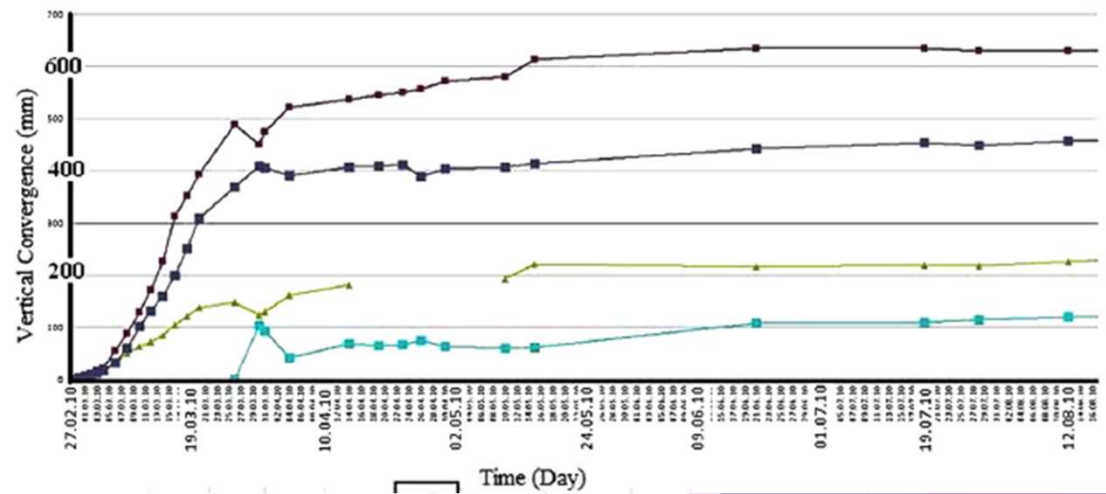
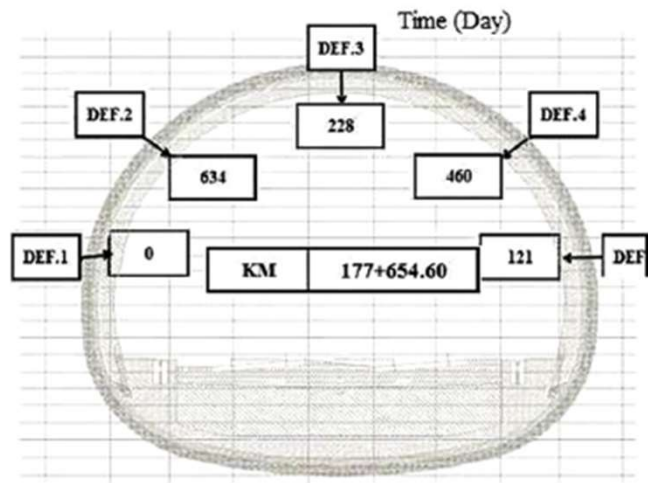
$$\lambda^* = \frac{C_c}{2.3(1+e)}$$

$$\kappa^* \approx \frac{2.3C_r}{2.3(1+e)}$$

$$\mu^* = \frac{C_\alpha}{2.3(1+e)}$$

Parameters used to Design Support System

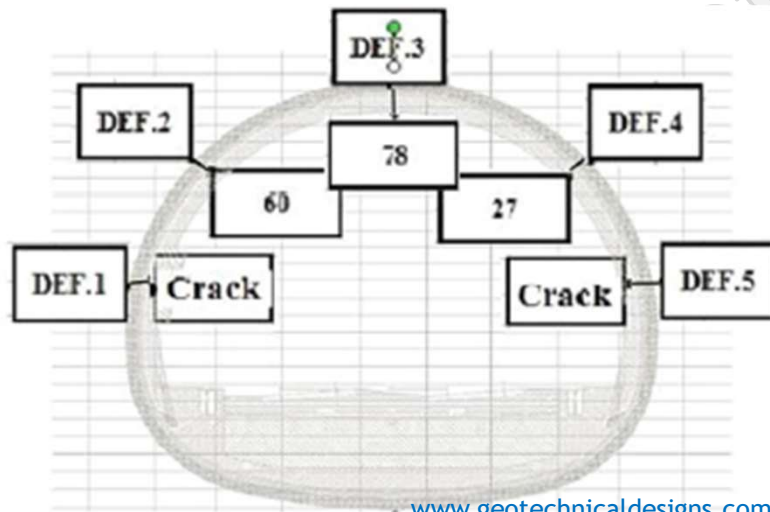
The deformation measurements, which were taken before non-deformable support system which illustrates an important deformation (about 500 mm), within first 20-day period and is on going process of deformations



Parameters used to Design Support System

Newly applied non-deformable support, deformations were monitored over time. Analyzing the deformations approximately **78 mm deformations** were seen. Since this value is within a predetermined convergence tolerance for the excavation, it does not constitute a problem.

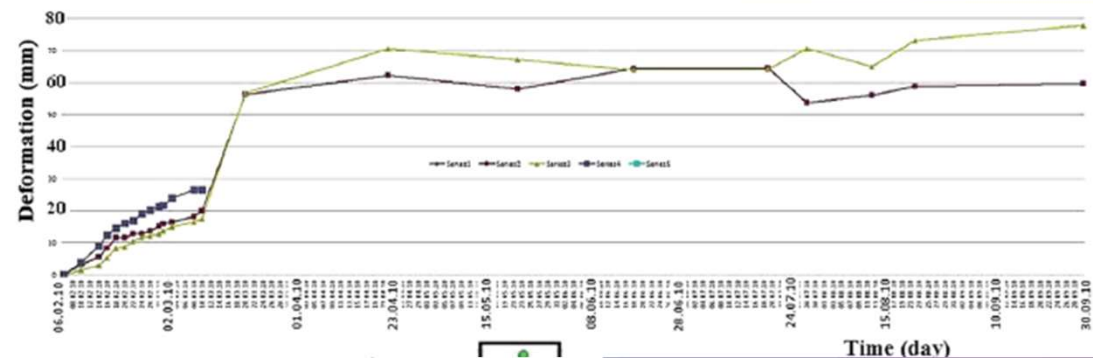
Non-deformable support system provided to limit the deformations



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Non-Deformable support system and element properties.

Support element	Properties
Steel support	I 200 Profile (1 m)
Shotcrete	40 cm
Bolt	IBO (l=8 m and 1 × 1 m)
Pipe	6 m (2 in., overlap= 3 m)
Top heading temporary invert	40 cm
Face bolts	10 unit (12 m, overlap= 3 m)
Face shotcrete	10 cm
Invert concrete	3,15 m



Thank You

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