Rikoti tunnel operational problems and seismic stability

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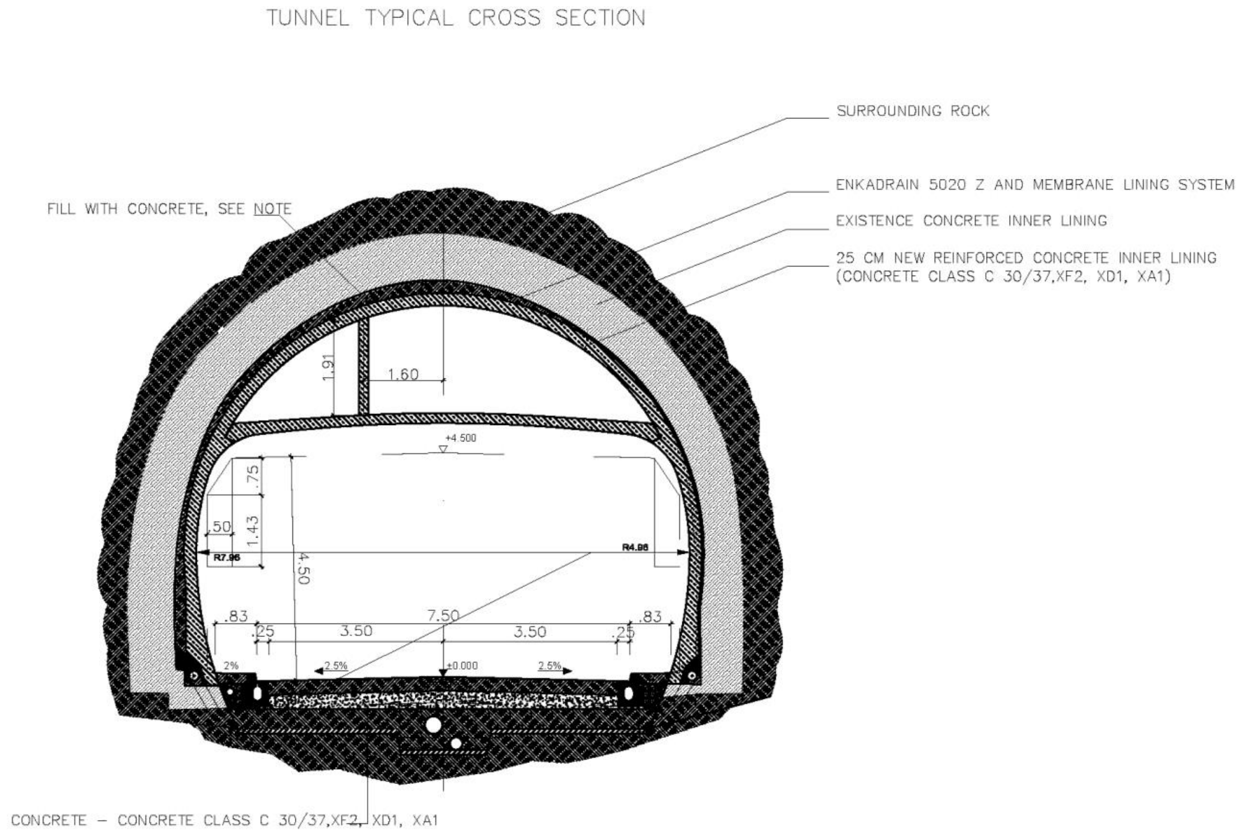
Rehabilitation solution of tunnel by strengthening lining



Calculation model

Calculations were carried out with the use of a two-dimensional quasi-static finite-element model (FEM), where the following assumptions were taken .

Seismic waves:

are elastic, harmonious and propagate in a flat front;

are represented by superposition of flat waves spread in various directions.

;

;

Calculation Model

The combination of two problems was considered: a) compression-stretching waves and b) long seismic shear waves.

In the first problem compressing stresses are defined by formulae:

$$\sigma_x(\infty) = -p$$
$$\sigma_y(\infty) = \xi p \qquad (2.1)$$

In the second problem long shear stresses are defined by formula:

$$\tau_{xy}^{\infty} = -Q \qquad (2.2)$$

$$p = \frac{1}{2\pi} A \cdot K_1 \cdot \rho_0 \cdot c_1 \cdot T_0$$

$$Q = \frac{1}{2\pi} A \cdot K_1 \cdot \rho_0 \cdot c_2 \cdot T_0 \qquad \xi = \frac{\nu_0}{1-\nu_0}$$

A - a coefficient, the value of which depends on seismicity; K1- a coefficient, which takes into consideration local faults of structure;   - strength of ground; C1 and C2 – velocities of longitudinal and shear seismic waves propagation, respectively; T_0 – the primary period of ground vibration.

Four calculation alternatives were considered, which took into account the simultaneous combination of compression-stretching and shear waves:

$$\begin{cases} \sigma_1 = \sigma_c + \sigma_{sh} \\ \sigma_2 = \sigma_c - \sigma_{sh} \\ \sigma_3 = -\sigma_t - \sigma_{sh} \\ \sigma_4 = -\sigma_t + \sigma_{sh} \end{cases}$$

where, σ_1, σ_2 represent the combination of stresses at the simultaneous propagation of compression and shear, and σ_3, σ_4 - stretching and shear waves.

The assessment of stability of contact „lining-massif“ and rock massif

$$\sigma < [\sigma] \qquad (a)$$

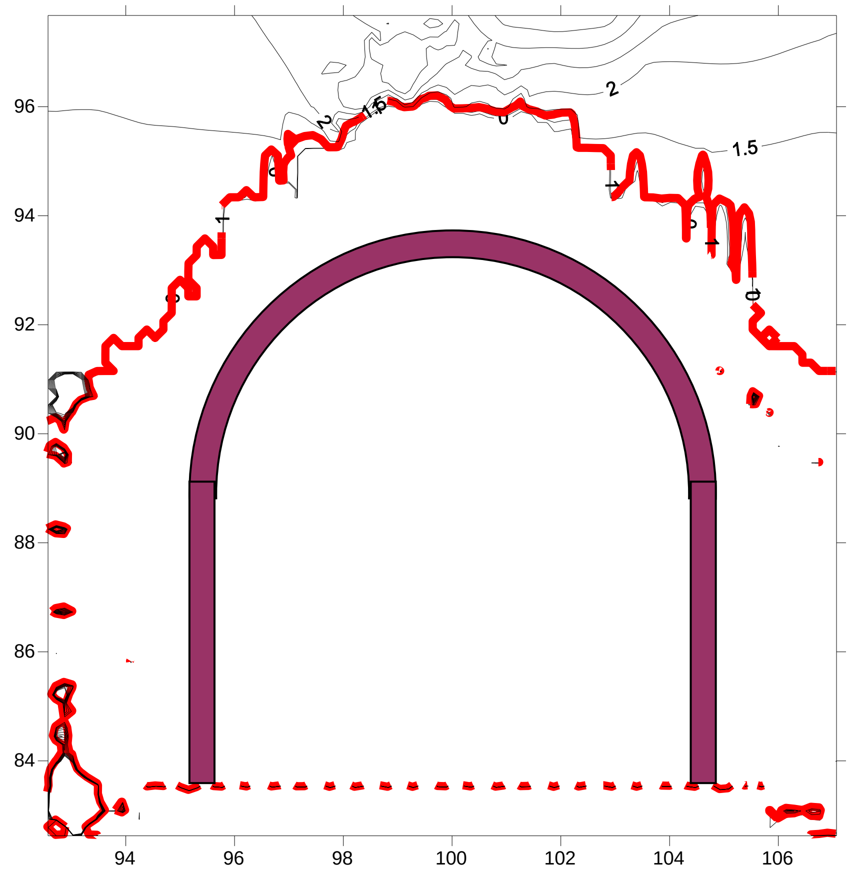
$$\eta = \frac{\tau_{\alpha\,0}}{\tau_0} > 1 \qquad (b)$$

where, σ, $[\sigma]$ - calculating and permissible tensile stresses; η - margins of shear stresses; τ_{α} - is a shear stress on a risk sliding surface; $\tau_{\alpha 0}$ - an estimated resistance of rock material on shear defined by the dependence: $\tau_{\alpha 0} = \sigma \cdot tg\varphi + c$

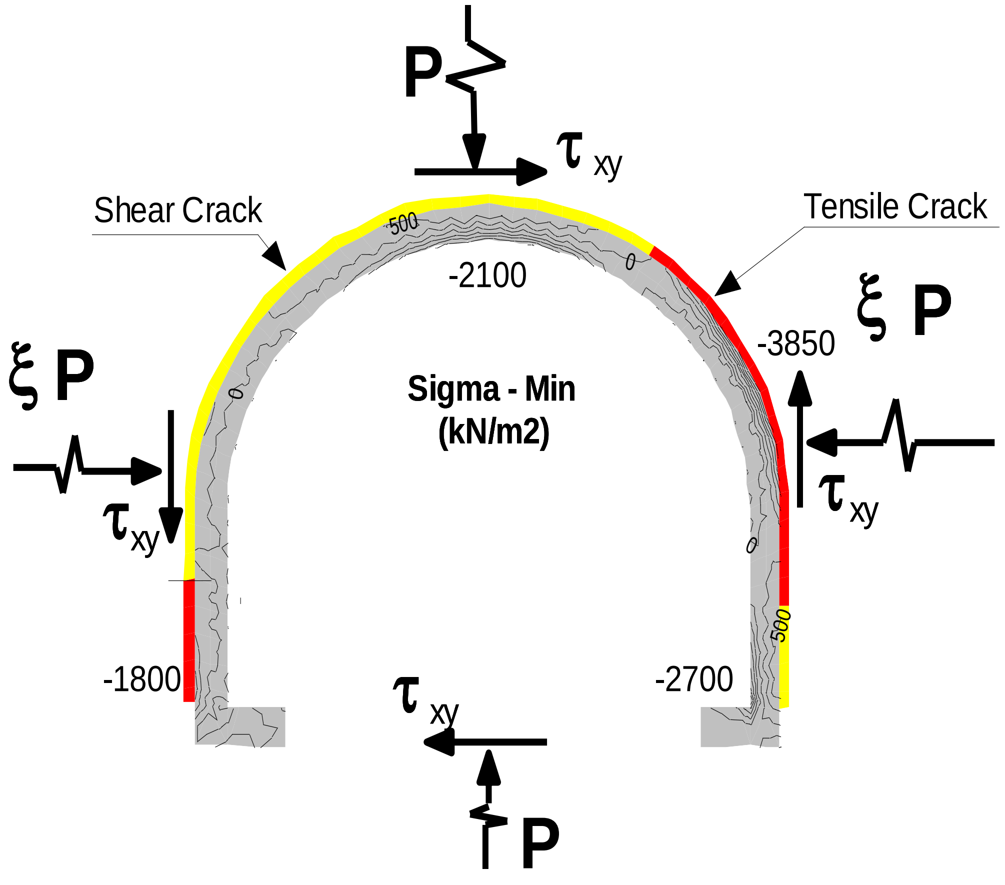
(φ; c - are sliding parameters).

when, $\eta \leq 1$ a fracture occurs, and when $\eta > 1$ strength on sliding secured.

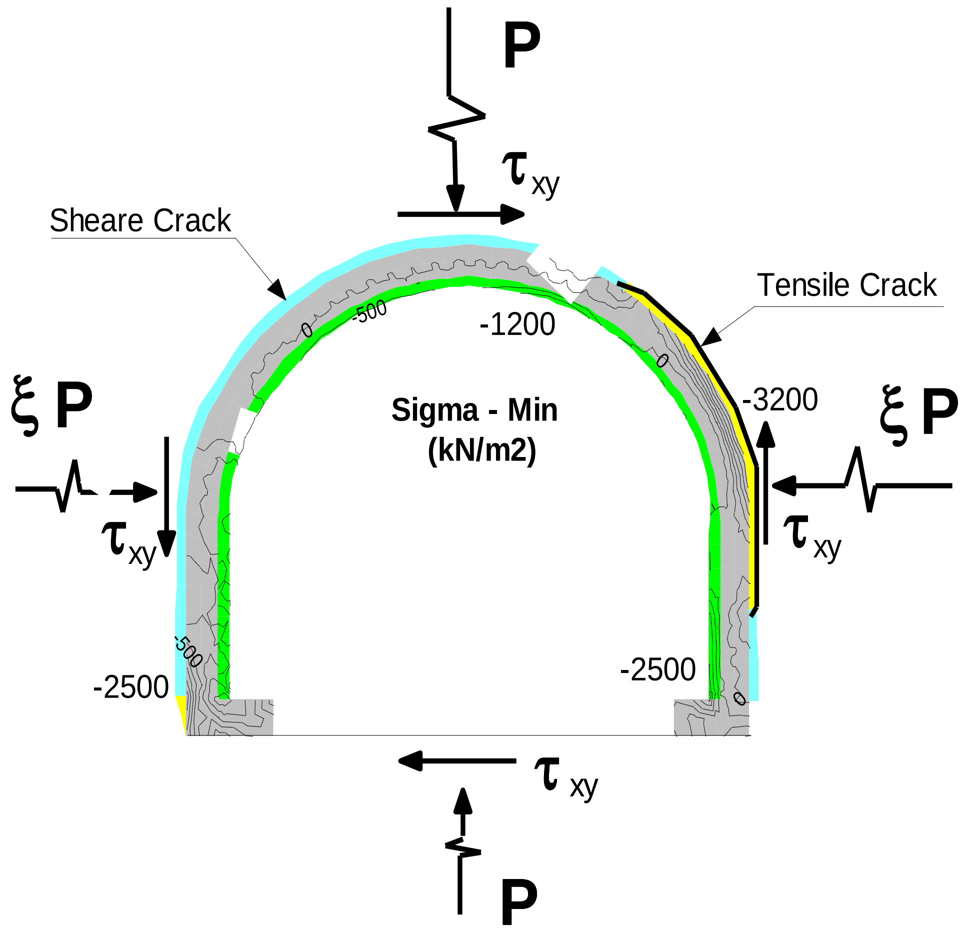
Fracture zones around the existing lining with filled gaps



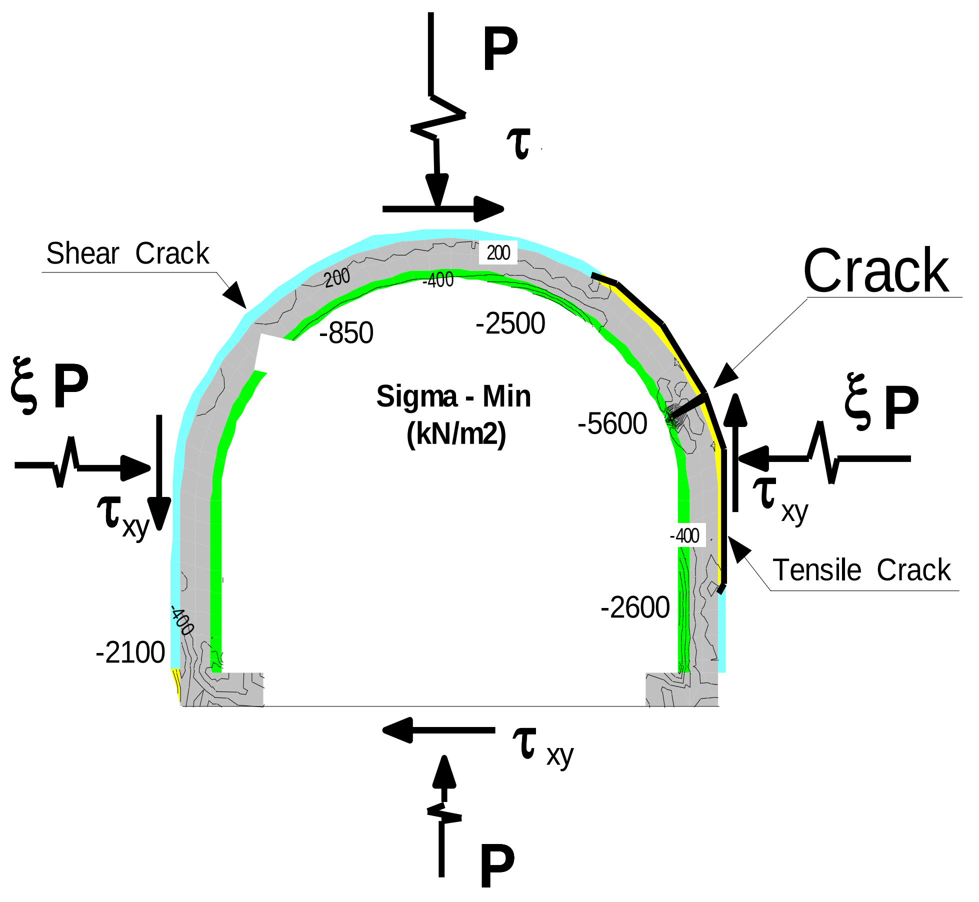
Minimal main stresses in the existing lining construction after filling the gaps.



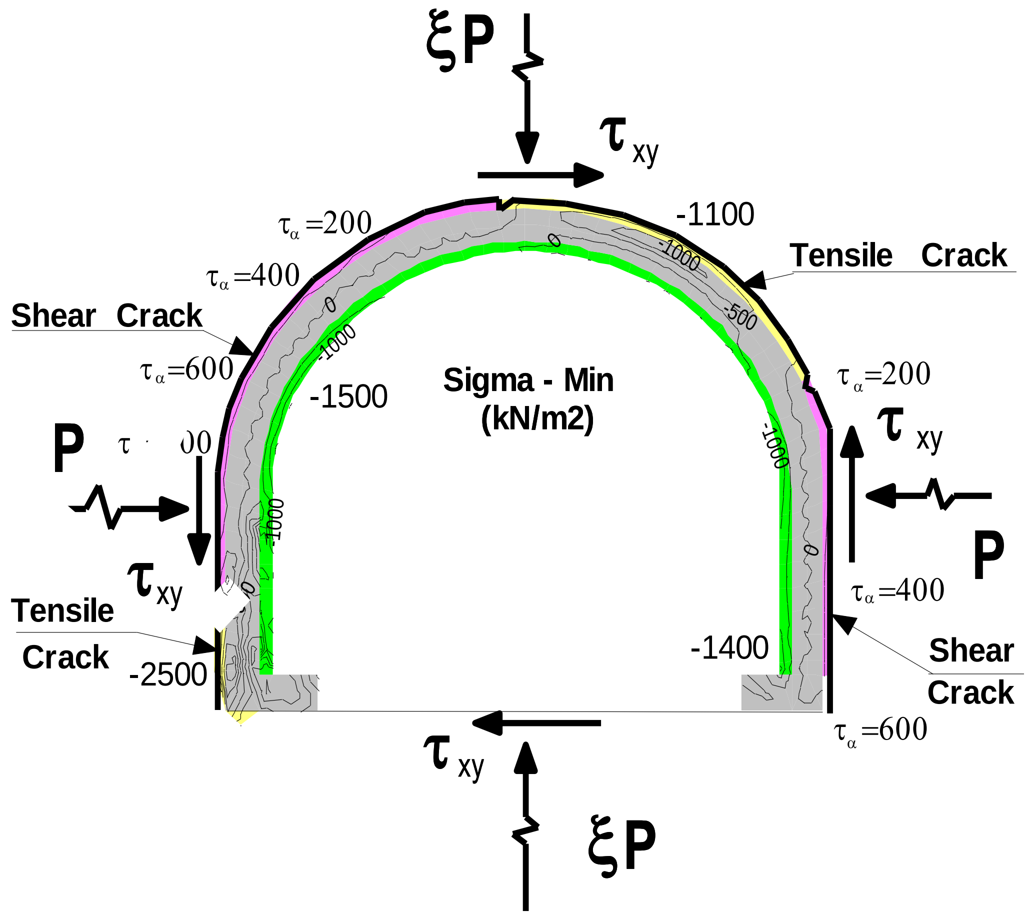
The strengthening lining with filled gaps and internal reinforced belt at the passage of vertical compressing seismic waves (Linear solution)



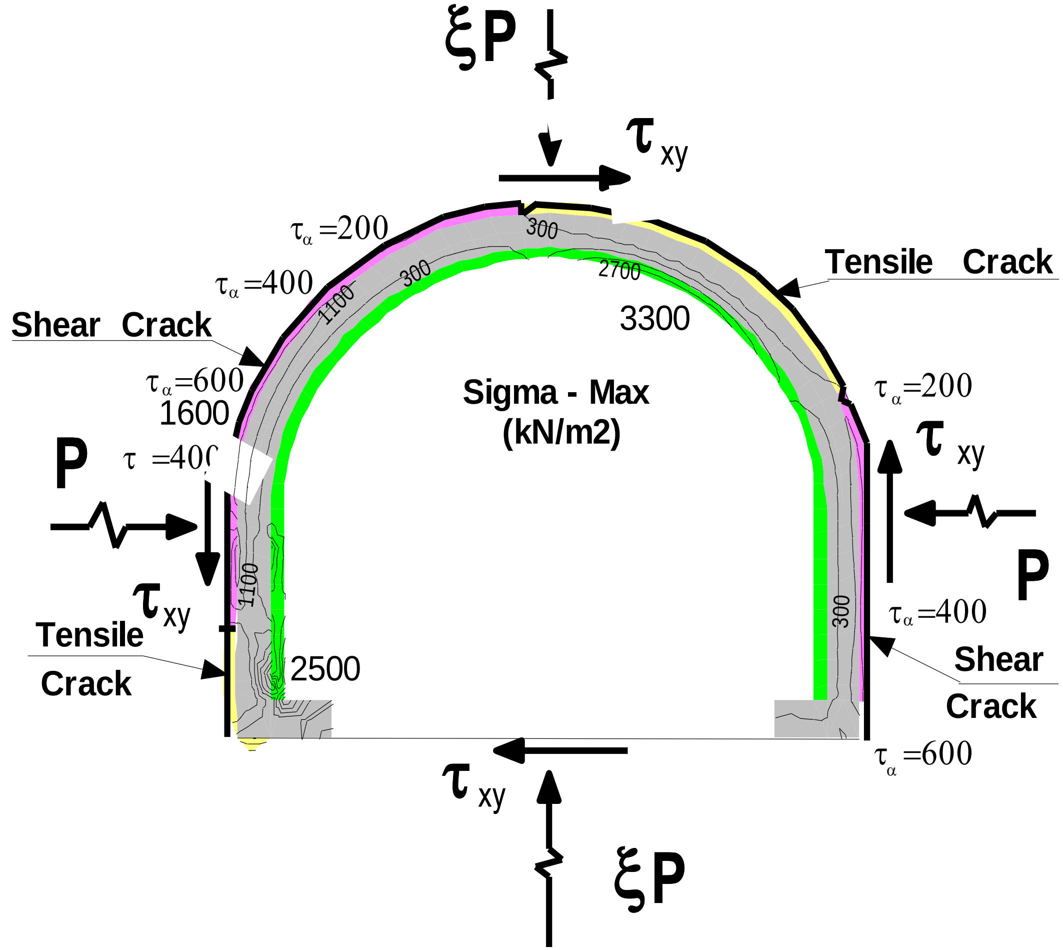
The strengthening lining with filled gaps and internal reinforced belt at the passage of vertical compressing seismic waves (Nonlinear solution)



Minimal main stresses in the strengthened lining construction at the passage of horizontal compressing seismic waves (Linear Solution)



Minimal main stresses in the strengthened lining construction at the passage of horizontal compressing seismic waves (Nonlinear solution)



Thank You For Attention