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Assessment of the dynamic stability of the portals of the Dorukhan tunnel (Turkey) by finite different method

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Numeric modeling technique is one of the leading design methods widely used in the civil and mining engineering. Some instability problems may arise during the construction and operation of tunnels depending on the quality of the rock mass. In particular, determining instability problems at the portals of a tunnel is of utmost importance during excavation and operation of the tunnel. Slope instability and rock falls are the most frequent instability problems that may be encountered at tunnel portals. Such instability problems can be triggered by dynamic effects such as earthquakes, blasting etc. This study investigates the stability of the portals of the Dorukhan Tunnel connecting the provinces of Zonguldak and Bolu in the close vicinity of the North Anatolian Fault Zone (NAFZ). The effect of an earthquake that may occur in the NAFZ on the extent of failure has also been studied by numerical analyses. In the dynamic analyses, FLAC3D, a three-dimensional stress analysis computer program that is based on the finite difference method, has been used. In numerical analysis, it is very important to determine the properties of rock mass and in-situ stress state correctly. As a first step, classification systems such as RMR, Q, RMi and GSI were used in establishing the properties of the rock mass at the portals. In earthquake engineering, the maximum ground acceleration is an important input parameter. In dynamic loadings which this study is based on, the variation of the ground acceleration in the form of a fixed-amplitude sinus function was applied to base of the model created.

Following the dynamic modeling studies on the Mengen and Devrek portals of the Dorukhan Tunnel close to the NAFZ, it was established that earthquake loads may bring about varying failures depending on the magnitude. When a 0.3g earthquake wave acts on the Mengen portal in perpendicular to the tunnel axis, the failure zone occurring in a 20 m distance of the tunnel entrance is half the width of the opening. In the case of a 0.6g dynamic loading, the failure zone forming around the tunnel reaches the ground surface, causing serious instability problems. In conclusion, when a 0.3g dynamic loading is applied, a failure zone is formed which may cause a complete failure within 19 m distance from the tunnel entrance. In the case of a dynamic loading of 0.6g, this may affect the area within 45 m distance from the tunnel entrance. The failure zone along tunnel axis is given Figure 1. When a 0.3g earthquake acts on the Devrek portal in perpendicular to the tunnel axis, the failure zone forming within 10 m distance from the tunnel entrance reaches surface. When the dynamic loading is 0.6g, failure occurring around the tunnel portals increases a large extend and reaches to surface. In view of the direction the dynamic wave propagation in relation to the tunnel axis, on a horizontal plane, wave propagation in perpendicular to the tunnel axis gives rise to more failure zone around the opening and in the slopes as compared to that in parallel to the tunnel axis. In the case of a dynamic wave of sufficient magnitude propagating in perpendicular to the tunnel axis, the failure in the crown and bottom areas tends to expand as compared to that occurring in the side walls of the opening when the propagation is in parallel to the tunnel axis. In the tunnels driven in parallel to the slopes of mountain with a steep gradient, the propagation of a dynamic wave in parallel to the tunnel axis may cause instability problems all along the tunnel route besides the tunnel portals as a result of failure of the rock mass between the tunnel and slope.