

## **ROCK BOLTS AND SHOTCRETE EFFECTIVENESS AGAINST GEOLOGICAL FAILURES. APPLICATION ON EGNATIA HIGHWAY IN N. GREECE**

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### **ABSTRACT**

This paper investigates the support techniques and measures as far as geological failures are concerned, and also the applicability of the most common used support measures, rock bolts and shotcrete, against the above geological failures. The investigation was based on in-situ observation of the support techniques and measures effectiveness during the construction of Thessaloniki – Kavala section of the Egnatia highway in N. Greece.

Comparing different support measures, shotcrete up to 8cm thick could support with efficacy the unstable wedges better than rock bolts, as rock bolts could not support the cracked wedges using them alone. Rock bolts from 1m to 3m and one hundred per cent grouted were also effective. When rock bolts were longer than 3m, they could not increase the safety. Also, the safety of a semi-grouted bolt was equal to the safety of non-grouted one. Examining the effectiveness of different types of anchors, on suddenly changed rock mass quality, we concluded that the mechanical anchors could support more wedges than the swellex could do.

The support ability of shotcrete was related mainly to the grain size of aggregates than to the pumping characteristics. The most effective grout mix contained only sand without gravel, diameter of grains smaller than 10mm and proportion of cement to sand about 50 kg cements to 0,1m<sup>3</sup>. The most uniform the grain size distribution of the mixing was, the better applicable could be. Also, mineral composition affected shotcrete application. The presence of calcite and dolomite facilitated the application ability of shotcrete, while the presence of quartz made the use of shotcrete more difficult.

**KEYWORDS:** Tunnels, Support Measures, Shotcrete, Rock Bolts, Grouting

### **INTRODUCTION**

The present paper refers to the support methods used in tunnels, including rock bolts and shotcrete, as it tries to divide the different support functions for determining their application properties. The theoretical investigation is applied on tunnels support at the 100km part of Egnatia Highway, which connects Thessaloniki and Kavala cities, in Northern Greece (Figure 1): Vrasna tunnel, Asprovalta tunnels and Symvolo tunnel. During the excavation works, tectonic data were collected and rock mass quality classification systems, RMR (Bieniawski, 1989), and GSI (Hoek, 1994) were used in order to study the quality and estimate the stability along the tunnels. In stability analysis, test Markland (Markland, 1972) was used.

The main support measures on tunneling construction are steel ribs, rock bolts, wire mesh and shotcrete. The choice of the appropriate support measure is due to rock mass quality. Although steel ribs are usually used on poor quality rock masses and rock bolts are efficient on good quality rock masses, shotcrete is highly used on poor and also on good quality rock masses. It supports the soil, creating a stable shell around the excavation, it penetrates among the joints of a cracked rockmass, increasing the cohesion strength and creates a protection shell which prevent rock pieces to fall down (Oraee-Mirzamni et al, 2011).