Bir Vaka Analizi: Heyelan Riski Olan Alanda Tünel İnşaatı

A Case Study: Tunnel Construction at an Area with Landslide Risk

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ÖZET Sarayköy Tünelleri Karadeniz Sahil Yolu projesi kapsamında Karayolları Genel Müdürlüğü tarafından inşa ettirilmiştir. Çift tüp olarak tasarlanan tüneller çok ayrışmış ve zayıf Eosen yaşlı volkanik kayaçlar içinde açılmıştır.

Batı portali (Trabzon portali) çakıl-silt ve killi formasyonlardan oluşan 20–25 m lik bir örtü altında açılmıştır. Tünel hattı üzerinde bir köy ve tarımsal amaçla kullanılan alanlar mevcuttur.

Çok olumsuz jeolojik koşullar, topografik problemler, su problemleri ve kötü kaya kalitesi nedeniyle tüneller C2-C3 NATM sınıfına göre projelendirilmiş olup iyileştirme amacı ile jet-grout kolon uygulaması ve betonarme kazık çalışmaları yapılmıştır. Buna rağmen portal yapısının sağ tarafında yer alan ankrajlı kazıklı duvarda, yüzey hareketiyle ilişkili yatay hareketlenmeler meydana gelmiştir. Gerilme artışlarına bağlı olarak tünellerde deformasyon artışları gözlenmiştir.

Bu çalışma Sarayköy Tüneli Trabzon portalindeki ölçümler ve imalat aşamaları ile ilgili değerlendirmeleri kapsamaktadır.

ABSTRACT Sarayköy Tunnels were constructed under Black Sea Highway Project by General Directorate of Turkish Highways. Twin tube tunnels were excavated through highly altered Eocene aged weak volcanic rocks.

The western portal (Trabzon portal) was constructed under 20-25 m of overburden through gravel-silt and clay formations. There is a village settlement above the tunnel and area is widely used for agricultural purposes.

Due to very loose geological conditions, topographical problems, water income and adverse rock quality the tunnels were designed according to C2-C3 NATM class with jet-grout columns and concrete pile applications which were performed to improve the ground. However, lateral displacements at right anchored pile wall associated with ground movement occured. Deformations in tunnels due to increasing stresses were recorded.

This study covers the evaluation of measurements and construction phases of Sarayköy Tunnel's Trabzon portal.

1 INTRODUCTION

Sarayköy tunnels are located on the main transportation artery of Black Sea Coast Road, İyidere - Çayeli section (Km: 111+700-113+300), (Fig. 1). They are twin tube highway tunnels under-crossing a village and agricultural area. The tunnels are 10.25 m in width, 6.85 m in height and the horizontal distance between the tubes is 11 m and the overburden on the tunnel varies between 20-25 m at Trabzon (western) portal.

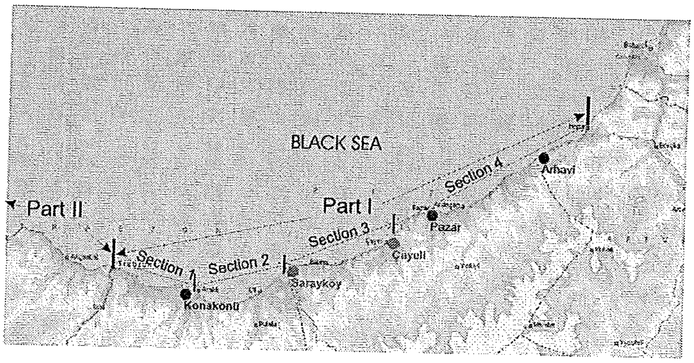

Figure 1. Main route of the Eastern Black Sea coastal express road

There exist landslide risks and weathering in gravelly, silty and clayey formations, tuffs-basaltic tuffs and agglomerate due to highly rainy climate and steep morphology of Black Sea region (Vardar M., Koçak B., Karaoğlan V., 2005)

According to the site investigations the western portal geologically consisted of Eocene aged weak volcanic rocks comprising of agglomerate, basaltic tuff, and monzo-gabbro and dolerite while the overburden was mainly formed of silt and clay. The groundwater table changed between 5-20 m in depth. Survey results indicated that there existed a landslide and creep over the western portal section, (Fig. 2). Due to very loose geological conditions, topographical problems, water income and adverse rock conditions the construction phases in the portal area were designed successively as; sequential excavation comprising of top heading, bench and invert excavations. Support system includes 25-30 cm shotcrete, double layer wire mesh, I-160 steel ribs, rock bolts, grouted forepoling, jet-grout and concrete piles if required.

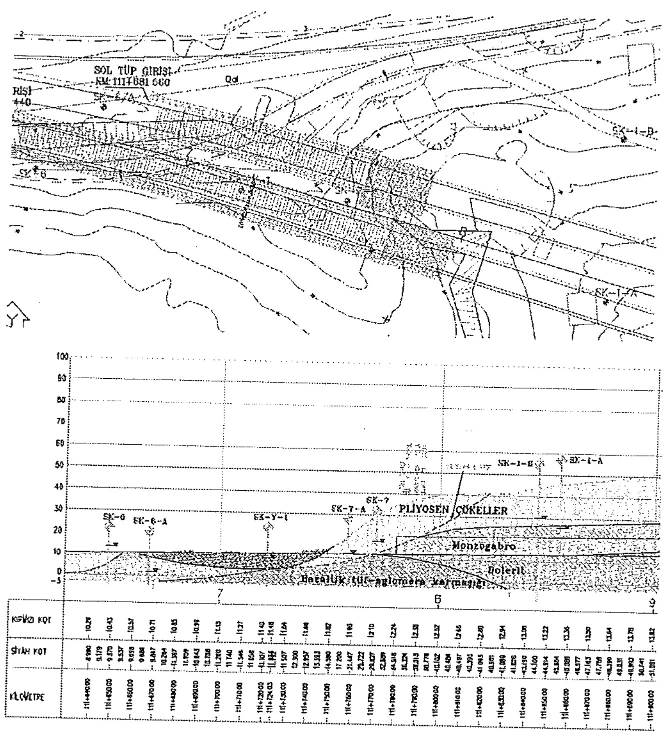

Figure 2. Plan view and geological cross-section of the western portal

The anchored pile wall was designed for the open section of portal area. Jet-grout columns were applied at the beginning of tunnel excavation area and a monitoring program was performed at the surface (Fig. 3) and inside the tunnel.

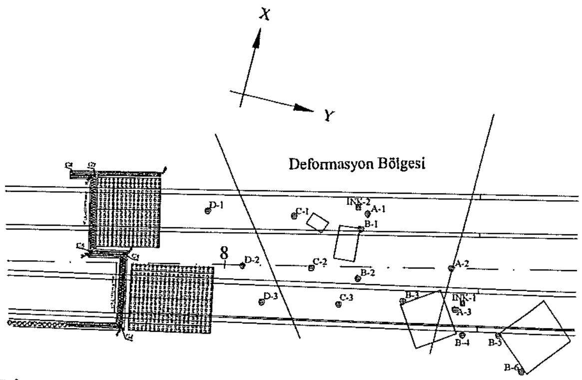

Figure 3. Deformation measurement points and inclonometer station location.

After 148 m and 91 m advance in top heading and bench respectively at T1 tube and 130 m and 88 m in top heading and bench respectively at T3 tube, cracks on the walls of houses and displacements on the village roads were observed. The maximum total displacement observed was 25 cm on the pile wall. Approximately 15 cm displacement was recorded inside the tunnel tubes.

2 GEOTECHNICAL EVALUATION

The descriptions related to the formations encountered during the construction were given above.

Before the tunnel excavation, anchored pile wall was constructed at right side of the portal as a measure to prevent potential landslide risk.

The rock mass conditions encountered during the tunnel construction are shown in two representative face maps from Km: 111+840 at T1 tube (Fig. 4) and Km: 111+890 at T3 tube (Fig. 5).

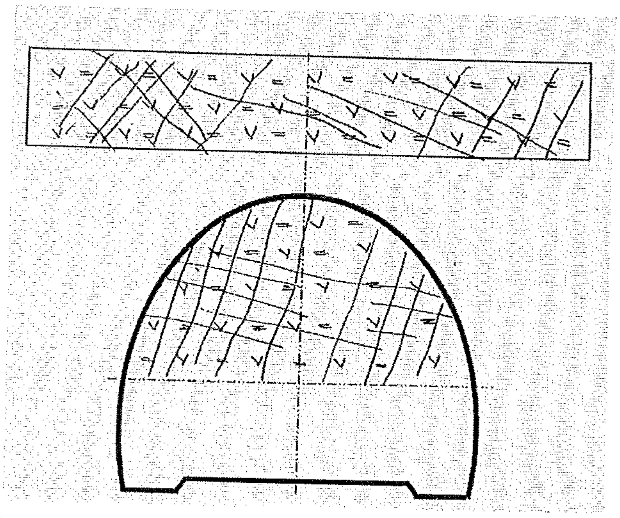

Figure 4. Km:111+840 tunnel face map-very weak rock (T1 tube)

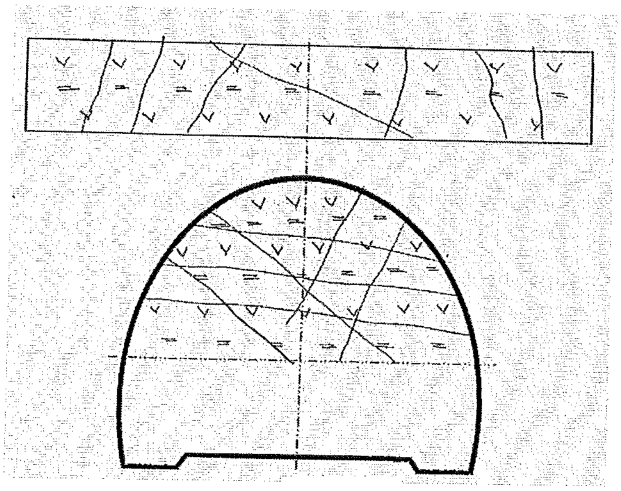

Figure 5. Km:111+890 tunnel face map-very weak rock (T3 tube)

Tunnel excavation started on 02.06.2005 for T1 tube and 26.06.2006 for T3 tube. Due to very loose geological conditions and presence of an old landslide at the tunnel area and its surroundings comprising of the village, maximum importance was given to the geotechnical monitoring works. The monitoring program consisted of measurements carried out both on the ground surface and inside the tunnel. 3D data at five points in the tunnel cross-section were recorded in the tunnel. Stations were established on the anchored pile wall and on the ground surface above the tunnel tubes. Inclinometers were established at three different locations in the ground above the tunnels. (Fig. 3) Construction continued until October 2005 without any problem.

At the beginning of October 2005 the distance between the faces of T1 and T3 tubes was reduced to 17 m.

After a heavy rain, monitoring records showed a movement on the ground above the tunnel. Cracks were observed on the walls of houses, village roads and retaining walls in association with an increase on the deformation records obtained from the tunnel. The horizontal deformation on the anchored pile wall was 25 cm, the cracks on the walls of houses reached up to 2.5 cm and inclinometer records showed 4.5 cm lateral displacement.In tunnel tubes 13-16 cm displacements were recorded for T1 and T3 tubes respectively. After intensive site survey and evaluation of monitored data, it was concluded that with the excavation of the tunnels the ground stresses increased and heavy rain accelerated the movement.

The deformations in the tunnel tubes did not exceed the tolerances for the support class. Therefore the tunnel support system was not changed but new construction sequences were utilized. The target was to stabilized the landslide by quick closure of the ring therefore by strengthening the toe of the landslide.

3 REMEDIAL MEASURES

Construction stages were organized as:

- inner lining should be constructed at a distance 10 m from the invert concrete up to 20 m behind the face at T1 tube,
- if the deformations increase between Km: 0+174 – 0+216, temporary invert should be constructed at top heading,

- after the completion of these works in T1 tube, similar construction methodology would be applied up to 20 m behind existing face at T3 tube,
- top heading excavation should not be started until the completion of the works mentioned above,
- in case of increasing surface deformations, evacuation of the houses above the tunnel should be considered,
- the excavation in T1 tube should be started. The excavation in T3 tube should be started when the distance between the faces of the tubes arrived 70 m,
- If the tunnel section became smaller due to deformations the thickness of inner lining should be decreased while concrete class was increased,
- Construction segment length should be at most 30 m for the inner lining. Joints should be established in every 30 meter for inner lining.

The construction stages were followed and the cracks on house walls were observed, they didn't increase during the remedial construction works. There was no need for vacation of the houses.

Stabilization was achived both at the surface and tunnel deformation measurements after the remedial measures. There was no need for landslide remedial works. The constructions of the tunnels were completed successfully.

4 CONCLUSION

Tunnel construction under a landslide area requires special care. It is very important to make well informed predictions depending on carefully performed monitoring works associated with construction methodology.

Especially for twin tube tunnel construction in a landslide area, the distance between the tube faces gain very high importance. Construction of invert concrete and inner lining earlier than usual for quick closure of the ring can be used as a contribution to the solution for the problems encountered in such conditions.

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