DIFFERENCES BETWEEN PLANNED AND ACTUAL EXCAVATION CLASSES IN ANTALYA-ALANYA ROAD TUNNELS

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SUMMARY

This study involves comparison of excavation and support classes planned in design stage with actual ones observed in Antalya-Alanya road tunnel construction. Five tunnels with a total length of 2116 m have been constructed since 1999. During design stage, limited drillings, surface geology and examination of cuts of existing road near the project area, which is covered by vegetation, were used. As geological structure there are different types of schists, graphite, pèlitic and calkschist, gravelstone, limestone and excavation classes were described as stable to friable rocks in design. There are differences between planned and actual cases related to rock conditions in tunnel construction. During construction, rock conditions varying from very friable to squeezing were observed, excess deformations were encountered due to weakness of geological formations and carstic structure, large voids, affecting tunnel construction. All those factors have been effecting construction time ,expenses/cost and economy of tunnel

1-INTRODUCTION

There are variance between tunnel data at design stage and actual one in some cases because they are underground structures. These variances result from lack of sufficient drillings and detailed surface geology study due to morphological structure of the site, plant covered area and time limitation. Such problems are encountered during the construction of five tunnels, two lane single tube, with a length of 2116 m on Antalya-Alanya State Road. Tunnel site is located on an area where three naps, Alanya, Antalya, Hadim, overlaps within tectonic contacts. Geological formations, through which tunnels were excavated, are limestone, pelitic schist, grafitic schist, cloritschist, calkschist and gravelstone. According to signs of tectonism, geological units are cut each other by discontinuties. Carstic spaces were formed with water effect in contact surfaces of units. Position and variance of these units with different physical and engineering properties along tunnel axis could not be observed from ground surface and investigated with vertical drillings sufficiently.

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Difference between rock classes during excavation and design stage and unfair rock conditions bring change in excavation and support classes and consequently delay in construction plans and exceeding bidding amount. In this paper data from tunnel excavation is compared with that at tunnel design.

2-DESIGN DATA

Alanya region comprises a part of Taurus belt which carry deep signs of various and complicated movements of Africa and Euro-Asia continents in Triassic age. Geological studies carried out on this belt are complex to correlate to each other. Hence tectonical modelling of Alanya Region is somehow difficult.

Geological units (Asmaca formation) of tunnels are pelitic schist, grafitic schist, calkschist, limestone and gravelstone. As evaluated from site investigations and boreholes these units are observed in vertical and horizontal transitions.

Characteristic properties of the geological units in tunnel area is summarized below.

Pelitikschist is yellow,light green in color. There is highly developed very thin (2-6 cm)-thin (6-20 cm) foliation. Strenght of the unit is controlled by foliation and weathering. It has low strength in highly foliated areas.

Grafiticschist is dark gray, grayish black in color. Discontinuities are controlled by well developed foliation. Foliation surfaces are filled with secondary calsit and clay. It is sensitive to water. It is the most problematic unit in project area and has low strength.

Calcschist is ligth-dark gray in color. Discontinuty surfaces are controlled bybedding. It has fair strength and there are signs of carstic formations.

Limestone is ligth gray, white in color. There are transitions between limestone and calcschist. Site investigation showed that there are highly developed carstic structures. It has medium to high strength.

Gravelstone is yellow, pink in color. It is formed by angular sediments of gravel size that were originated from limestone. Gravel stone has medium strength and in areas of sudden carstic development it an be broken easily.

For evaluation of excavation classes, engineering and behavioral properties of rocks as a mass , ÖNORM Classification system has been controlled by excavation data and deformation measurements in conjunction with other classification systems. Rock masses were classified mainly as B (friable) type, excavation/support design were made accordingly.

Table 1: Summary of Excavation and Support Systems for Tunnels on Antalya-Alanya State Road

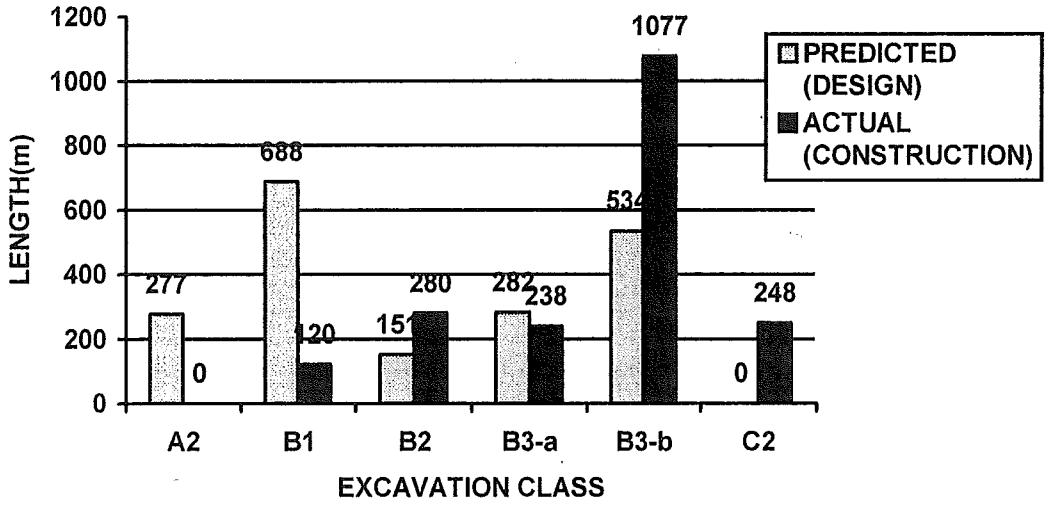
Rock Class	Excavation Stages	Excavation Method	Round length (m)	Support System		Dt (cm)
				Top Heading	Bench	
A2	Top h,bench	Smb	th 2.5-3.5m b 4.0m	s-5 cm, sb	s- 5cm	0
B1	Top h,bench	Smb	th 2.0-3.0 m b 4.0 m	s(mr) 5-10 cm b	s(mr)5 cm b	2-3
B2	Top h,bench	Smb	th 2.0-2.5 m b 4.0 m	s(mr) 10-15cm b	s(mr)5-10cm b	3-5
B3-a	Top h, bench	Smb, mex if required	th 1.5-2.0 m b 3.0 m	s(mr) 15 cm b,sr, fp	s(mr)10-15cm b,sr	5-10
B3-b	Top h,bench Invert	Smb, mex if required	th 1.5-2.0m b 3.0 m	s(mr) 15 cm b, sr, fp	s(mr) 15 cm b, sr, fp	5-10

th: top heading, b: bench, smb: smooth blasting, mex: mechanical excavation s:shotcrete, mr: mesh reinforced, b: bolting, sr: steel rib, fp: forepoling dt: deformation tolerance

3-CONSTRUCTION DATA

Due to physical properties of geological units through tunnel, which carries deep signs of tectonism, behavior of rock varies in elastic-plastic region. Limited site investigation, insufficient surface geology study brought deviation from tunnel design. Excavation classes observed during tunnel construction are different from those determined during tunnel design. Lower excavation classes were encountered during excavation. Additional supports were applied to stabilize locally weak parts during tunnel construction. Revision in tunnel design was required. Excavation and support design for C2 type rock mass was developed. The comparison of excavation classes during tunnel design and construction in Alanya-Antalya Road Tunnels is given in Figure1. Excavation classes observed in tunnel construction varied in short distances. For Ulaş tunnel, in which deviation from predicted values are much.

Figure 1: Comparison of predicted and actual excavation classes in tunnels on Antalya-Alanya State Road



Observed deformations in tunnel construction varies between 5-10 cm. In some parts of the tunnel observed deformations were higher than the deformation tolerances predicted for excavation classes. Especially support systems in B1, B2 were modified by adding bolts, steel ribs and shortening round length. Another reason of the excess deformation in these classes was asymetrical loading from slope. Deformations were formed generally as settlements. C2 type support and excavation system was applied generally in grafiticschist and pelitic schist. Sensitivity to water of these rocks created critical conditions with time. Deformation tolerances and measured deformations are given in Table 2 according to excavation classes.

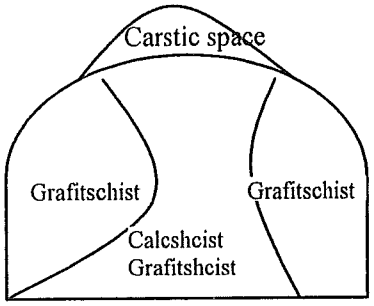
Table 2: Deformation tolerances and measured deformations for Tunnels

Excavation Classes	Deformation Tolerance (cm)	Measured Deformation (cm)
B1	2-3 cm	6,3-7,2
B2	3-5 cm	5,6-7,2
B3-a	5-10 cm	5,4-8,9
B3-b	5-10 cm	5,3-9,5
C2	10-15 cm	9,9-10,3

4- RECORDS AT ULAŞ TUNNEL CONSTRUCTION

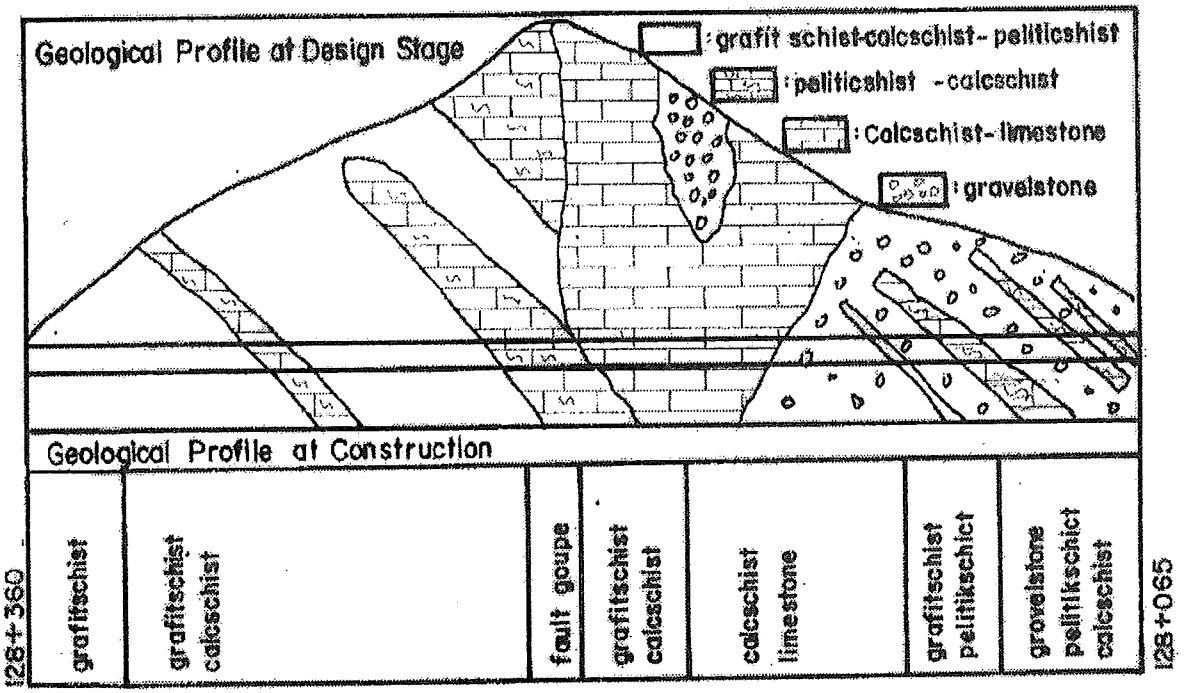
As in other tunnels, during Ulaş Tunnel excavation records were taken according to tunnel construction specification. At each round geological mapping were taken at face and walls, rock mass classifications were determined. As geological mapping showed there were complicated geological conditions. At one face three different units, grafiticschist-peliticschist-calkschist, and carstic spaces were observed (Figure 2).

Figure 2: Geological Mapping at Rounds 340-343 between km: 128+744-128+741

<table>
<tr><td colspan="3">Tunnel : Ulaş</td><td colspan="2">Road: Antalya-Alanya</td></tr>
<tr><td colspan="2">Round: 340-343</td><td colspan="3">Km: 128+744-128+741</td></tr>
<tr><td colspan="3"> 
</td><td colspan="2">General notes:
- gray highly weathered grafitschist with thin layers
-weak calcschist-grafit schist
-overbreak due to water</td></tr>
<tr><td>Rock Mass Type</td><td colspan="4">Grafitschist-calcschist-pelitikschict</td></tr>
<tr><td rowspan="2">Discontinuties</td><td>No:1</td><td>type: fault</td><td>dip/strike:295/80</td><td>type of fill: clay filled</td></tr>
<tr><td>No:2</td><td>type: foliation</td><td>dip/strike:220/45</td><td>type of fill: clay filled</td></tr>
<tr><td rowspan="2">Rock Mass Discontinuties</td><td colspan="2">space : 60-200 mm</td><td colspan="2" rowspan="2">Condition of discontinuty:
mostly open</td></tr>
<tr><td colspan="2">aperture: 1-5 mm</td></tr>
<tr><td>Weathering due to water</td><td colspan="2">Water income as leakage, wet</td><td colspan="2">Weathering and overbreaks due to water</td></tr>
<tr><td>Behavior of rock mass</td><td colspan="4">B3-b</td></tr>
</table>

Geological Profile obtained from geological mappings during Ulaş Tunnel excavation is different from that predicted at design stage (Figure 3).

Figure 3: Geological Profile of Ulaş Tunnel at Design Stage and Construction Stage

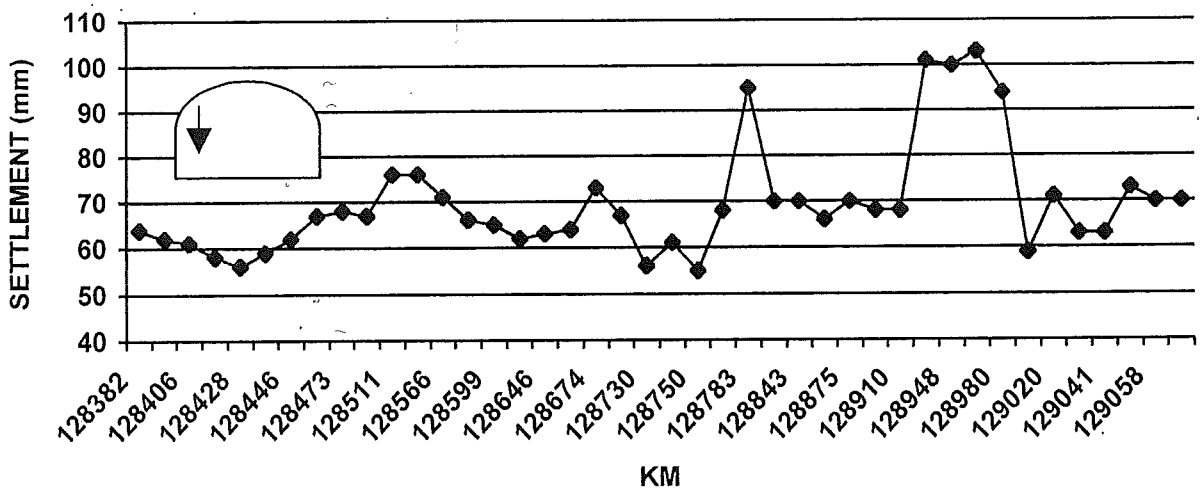


Variance of predicted and actual excavation classes in Ulaş Tunnel is given in Figure 4. In order to control the adequacy of supports, displacement measurements were taken at five points on tunnel cross section. Measurement Stations were located a distance of app. 20m. Displacements are generally in the form of settlement. Because tunnels are located on steep slope especially at tunnel portals displacements at left side of tunnel cross section is more than that at right side. The graph which gives displacement measurements at Ulaş Tunnel is given at Figure 5.

Figure 4: Variance of predicted and actual excavation classes in Ulaş Tunnels

KM	128+370	128+410	128+650	128+710	128+810	129+005	129+034
DESIGN	B3-b	B3-a	B1	A2	B1	B2	
ACTUAL	B3-b			B2	B1-B2-B3b-C2	B2	
KM				128+790	128+820	129+065	

Figure 5: Max. Displacements in Ulaş Tunnels



3-CONCLUSION

For a proper tunnel design detailed site investigations consisting of sufficient boreholes, detailed geological and geotechnical study are essential. Other requirements are experience of design engineers. Especially for tunnels located in complicated and varying geological conditions, importance of site investigations for tunnel design increases. Variance betwen design data and actual construction data bring problems in tunnel construction such as delays and increasing expenses. Deviation of construction data from design considerations in tunnels on Antalya-Alanya State Road brings 31.6% increase in construction cost. and 8 month delay considering planned completion date.

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