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# Use of geosynthetic to increase compaction level of embankment fills over soft ground

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**ABSTRACT:** Alat-Astara Motorways Project consists of the construction of a completely new road, which will form a part of the important road connecting Azerbaijan and Iran. The 32.2 km stretch of the Alat-Astara Motorway between Masalli and Jalilabad is built on young alluvial deposits with an extremely flat topography and the ground water level is generally very close to the ground surface. According to site investigations, the main soil type encountered along the alignment of the road is clay of low to high plasticity. Although there are parts of the road where foundation soil is weak with CBR of less than 3, there are no bearing capacity, consolidation or slope stability problems due to the low embankment height (generally  $H_{emb} < 3$  m) and gentle slope. On the other hand, embankment fills made over this foundation were not able to meet the design requirements regarding the compaction, whatever the compaction effort. The use of geocomposite, made of high tensile strength PET woven geogrid and nonwoven geotextile, was proposed at the base to increase compaction degree. To quantify the contribution of the geocomposite, a trial construction, on the right-hand side of the embankment spanning 100 m, was constructed with geocomposite; the left-hand side of the same embankment was constructed unreinforced. It was observed that the use of geogrid at the base significantly increased compaction degree, especially for the first two lifts of the fill and enabled the engineers to achieve the necessary compaction levels.

## 1 INTRODUCTION

There are widespread uses of geosynthetics in road and pavement construction. For instance, geotextile, geogrid or geotextile-geogrid composite are most commonly used in embankment fills over soft ground for basal reinforcement and subgrade stabilisation. The geogrid provides tensile reinforcement, while nonwoven geotextile functions as a separator between base course and subgrade soils to prevent intermixing and subgrade intrusion. Another application of geogrids over soft ground is to use them as a compaction aid. The interlock between geogrid and base course material restrains the lateral deformation of the base material during compaction, thus base course on weak subgrade can be compacted to a higher compaction levels with an equivalent compaction effort. This paper will evaluate how the inclusion of a geocomposite affects the compaction levels of base course material for a chainage of Alat-Astara Motorways Project over weak subgrade.

## 2 PROJECT DESCRIPTION

The Alat-Astara Motorways Project consists of the construction of a completely new road between Masalli rayon and Astara rayon of Azerbaijan. The project will form part of the important road connecting Azerbaijan and Iran. The site location map is provided in Figure 1.

### 2.1 *Subsurface Conditions*

Comprehensive field investigations and laboratory testing program were conducted to characterise subsurface conditions along the road alignment. According to site investigation results, the foundation soil consists of young alluvial deposits with an extremely flat topography and ground water level that is generally very close to the ground surface. The predominant units encountered on the site are classified as clay and silty clay.



Figure 1. Site location map

## 2.2 Statement of Problem

Although there are parts of the road where the foundation soil is weak, there are no bearing capacity, consolidation settlement or slope stability problems due to the low embankment height (generally  $H_{emb} < 3m$ ) and gentle slope. On the other hand, embankment fills made over this foundation were not able to meet the design requirements regarding the compaction, whatever the compaction effort.

According to the specifications, the upper 500 mm of embankment shall be compacted to 95 % of MDD (AASHTO T180). The remaining embankment fill requires a compaction of at least 93 % of MDD (AASHTO T180). The fill material can be classified as **A1a** and **A1b** material according to AASHTO Soil Classification System (AASHTO M 145) and it consists of very fine material with low plasticity. Although the fill material is excellent material for the construction of an embankment, it was not possible to achieve the aforementioned compaction level requirements whatever, especially at lower lifts. Since compaction of the base course is critical to ensure long term performance of the highway, it warrants a special measure to deal with the problem.

Since compaction requirements could not be reached, measures like soil replacement, lime stabilisation and geocomposite were evaluated to solve the problem. Replacement of the top 1 to 3 meters of thick soft soil with rock or boulders was considered, however appropriate fill materials were not available in the proximity of the area and it the resulting costs were beyond the budget to source materials from the closest location. Lime stabilisation was another measure that was considered, but this method had never been used in Azerbaijan before and the necessary

technical skills and equipment were not available. Consequently, the use of geogrid was selected as the most feasible solution for this project. Because the ground water table is close to the ground level and it rises during winter periods, geogrid is combined with a nonwoven geotextile for separation and filtration purposes.

## 2.3 Trial Embankment Section

To evaluate the effectiveness of geocomposite against the problem, a 100 m long trial section was constructed. The right-hand side (RHS) of the embankment was constructed on geocomposite material (Fig. 2) while no geocomposite had been used on the left-hand side (LHS) of the trial section.



Figure 2. Right hand side of trial embankment, installation of geocomposite (Fortex 35/35+ geotextile)

Both sides of the trial section were constructed using the same fill material with the same moisture content and using the same compaction equipment with the same passing of rolling; thus, using equivalent compaction effort. The foundation material underlying the trial embankment is classified as clayey soil with a high water content and plasticity index ranging between 6 to 32 %. Table 1 shows results of laboratory tests performed on samples retrieved from weak top layer of the subgrade along the trial section.

Table 1. Laboratory test results of subgrade materials along the trial embankment

Boring	Boring 1 (Km:138+330)		Boring 2 (Km:137+990)		
	1.0	3.0	1.0	3.0	5.0
Depth (m)	1.0	3.0	1.0	3.0	5.0
$w_n$ (%)	27	29	-	34	27
$\gamma_d$ (kN/m <sup>3</sup> )	15.5	15.1	-	13.6	14.6
LL	49	58	36	50	28
PL	21	26	21	26	22
LI	28	32	15	24	6
USCS	CL	CH	CL	CH	ML

During the construction of the trial embankment, significant differences between RHS (constructed on ge-

ocomposite) and LHS (constructed without geocomposite) materials were observed. Table 2 shows the results of the proof rolling and field compaction tests conducted for both sides of the embankment. To evaluate the effectiveness of the geocomposite, proof rolling tests and field compaction tests were conducted for four lifts of the embankment. In proof rolling tests, it was measured how much the top of the compacted fills deflect while a loaded scraper or truck with a minimum axle load of 8 tonnes moves across. A substantial improvement in terms of proof rolling and field compaction level has been noticed on the section where the geocomposite material was placed. The improvement is especially significant for the first two lifts of the fill, where geocomposite enabled fill materials to be compacted to the minimum design requirement of 92 % MDD. For instance, fills that had only reached approximately 88 % MDD without a geocomposite layer was compacted to 99 % MDD over a geocomposite layer.

Table 2. Results of proof rolling and field compaction tests at the trial section

		Embankment Fill			
		Layer No: 1	Layer No: 2	Layer No: 3	Layer No: 4
(LHS)	Deflection cm	3.2	4.6	0.8	0.0
w/o GC*	Rut Depth cm	7.3	1.0	1.6	0.3
(RHS)	Deflection cm	0.8	1.2	0.2	0.2
with GC**	Rut depth cm	1.7	0.9	0.5	0.3
LHS*	RC %	88.2	91.1	96.1	94.4
RHS**	RC %	99.0	96.6	97.6	98.5

\* LHS Left Hand Side without geocomposite

\*\* RHS Right Hand Side with geocomposite

In addition to the increase in compaction level of embankment materials, there are also significant improvements on average rut depth between the right- and left-hand side. According to Foster (1999) large rut depths developed during placement of the first aggregate lift, reveals the need for reinforcement. Geocomposite reduced the rut depth tremendously which shows its reinforcement function in addition to its compaction aid function.

### 3 CONCLUSION

The embankment foundation and each lift of the embankment should satisfy the specified compaction criteria for the road's construction. For sections where weak foundation conditions were unable to satisfy the project specifications related to compaction, geosynthetics can be used as a compaction aid. The trial embankment section that was constructed and tested on

the actual site, showed that geocomposite reinforced base course material achieved a higher density level compared to unreinforced material. The addition of a geogrid decreased the lateral spreading during compaction effort, thus increasing the vertical compaction capacity of the fill materials. Geocomposite that was tested under the trial section was applied for other sections of the low volume embankment that was affected by weak foundation problems, and compaction level requirements were successfully achieved for other sections.

### 4 REFERENCES

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