New Horizons in Earth Reinforcement – Otani, Miyata & Mukunoki (eds)

Geotechnical problems on reinforcement soil ground in Kazakhstan

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ABSTRACT: The priority task of the development of modern construction is improvement the reliability and longevity of building materials along with economical effectiveness which satisfy mass high volume growth in the term of progressive intensification of constructions. Geosynthetic reliability and durability criterion under the interest of engineers, and reinforced soil model is one of the progressive solution of engineering.

1 INTRODUCTION

Reinforcement means to use special elements in soft soil constructions which allow increase the mechanical property of soil. Dealing with soil the reinforced elements redistribute load among construction parts, providing the transmission of stress from the overloading zone to the adjacent underloading zone. Nowadays there are a lot of different reinforcing materials in a world practice. The most part of them consists of geosynthetic – materials on base of synthetic polymer fiber which are made of polypropylene (PP) or polyester (PET). The geosynthetics subdivide into geogrid (PET material) and geotextile (PP material). Geotextile – material is produced from fabric by the method of needle punching and might be woven or not woven and geogrid for soil reinforcement might be as volumetrically or flat (biaxial or uniaxial too) according to their assignments. Although there are many cases when composite materials by combining geogrid with geotextile methods have been used. Geosynthetic material provides its high chemical inertness against acid and alkaline, stability against termooxidizely process. The material is fast against ultra-violet rays and it is although green product. Physical and mechanical properties of geosynthetics are shown in Table 1.

Under the highest possible loading, geosynthetic has till 45 percent elongation. It depends on the applicable thickness of material. In this way local damages do not lead to the destruction of materials. Due to the high index of elastic modules, the material can bear considerable load, implementing function of reinforcement at not great deformation (F. Tatsuoka etc.).

Choice of reinforced material does not depend on its characteristics of strength. The polymer which is produced from reinforced material has substantial degree. By way of illustration geosynthetic made from polypropylene is used in dynamic loading as polypropylene has high index of creep, that is it has ability to long the term extension under the dead load. Therefore the material is used in road building in pavement capacity. Geosynthetic, produced from polyester, with very low index of creep, usually is used in case of static load or exists probability uneven development of settlement in the result of heterogeneousness soil. As example, we can give retaining wall, strengthening of embankment, reinforcment the heterogeneousness soils which have very low index of bearing capacity.

Table 1. Physical and mechanical properties of geosynthetics.

Characteristics	Geotextile (PET)	Geotextile (PP)	Composite
Surface density, g/м^2	250	250	250
Tensile strength, κN/м^2	4,2	2,8	8,4
Thickness at the load 2 MPa, мм	3,2	3,2	3,2

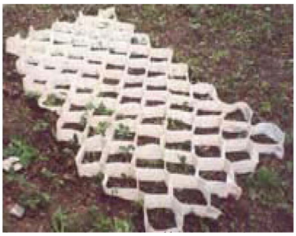
2 REINFORCEMENT MODEL

2.1 *Construction of retaining wall within the reinforcement model*

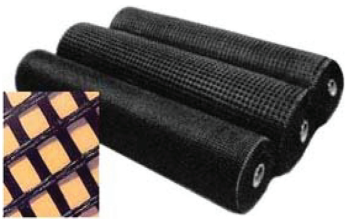
Construction of retaining wall within the reinforcement model is usually used to strengthen slope covers of railways and highways in bridge abutments, foundations of different constructions (Figure 2)

As tests have shown the destructing load for these types of constructions exceeds the design load. This is explained as that geotextile possesses high index of tensile strength and follows for deformation of soil of the construction creating general state of

a) woven geo textile



b) volumetrically biaxial geogrid



c) flat biaxial geogrid

d) flat uniaxial geogrid

e) combined (woven geotextile with flat biaxial geogrid)

Figure 1. Types of geosynthetic reinforced materials.

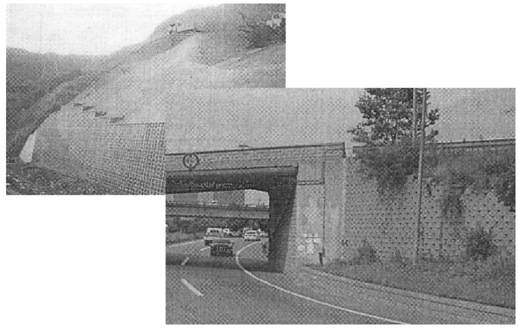
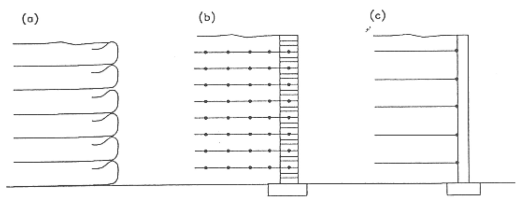


Figure 2. Construction of retaining wall within the reinforcement model.



(a) with wrap-around geotextile facing,
(b) with segmented precast concrete or timber panels
(c) with full-height precast panels

Figure 3. Reinforced retaining wall system using geotextile.

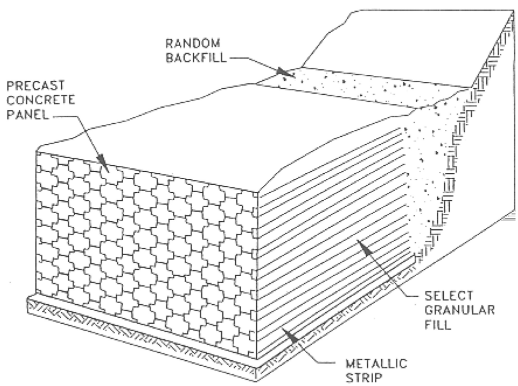


Figure 4. Component parts of a reinforced earth wall.

stress and increasing construction stability (E.C. Shin etc.).Model of geotextile retaining walls and consisting reinforced elements are given in Figures 3 & 4.

A number of approaches to geotextile and geogrid reinforced retaining wall design have been proposed, and these are summarized by Christopher and Holtz (1985), Mitchell and Villet (1987), Christopher, et al. (1989), and Claybourn and Wu (1993). The most commonly used method is classical Rankin earth pressure theory combined with tensile-resistat tie-backs, in which the reinforcement extends beyond an assumed Rankin failure plane. Figure 5 shows an system and the model typically analyzed. Because this design approach was first proposed by Steward, Williamson, and Mohney (1977) of the U.S. Forest Service, it is

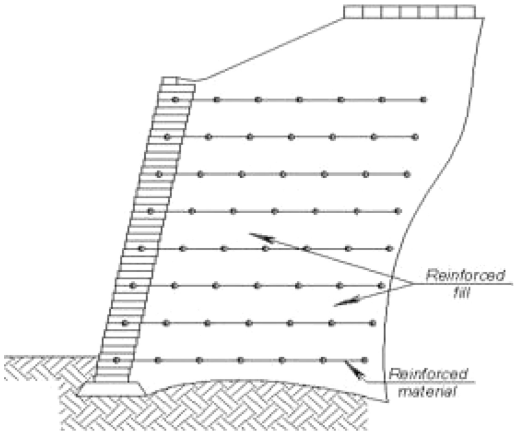


Figure 5. Actual geosynthetic reinforced soil wall in contrast to the design model.

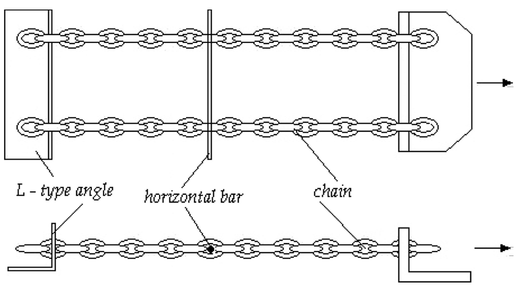


Figure 6. Type of chain reinforcement.

often referred to as the Forest Service or tie-back wedge method (E.C. Shin etc.).

Except geosynthetic material to other materials can be used make reinforcement. So during the pullout test chains from non-rusting steel have considerable figures of resistance (Figure 6, Table 2).

The Pullout resistance by chain reinforcement can be defined by the following equation:

$$F_{tc} = F_1 + F_2 + F_3 \qquad (1)$$

where F_1 = the frictional force between chain and soil skeleton; F_2 = the shearing resistance with including the soil inside the chain; F_3 = the passive resistance in cross sectional area of chain.

The earth pressure resistance of horizontal bar is defined as $F_{ri} \cdot F_{bi}$ is the pullout force with a L type angle.

2.2 *Reinforcement of road building*

In road building reinforcement fulfills the function of layer separation. This permits to increase the index of bearing capacity largely due to of its stress redistribution. By way of illustration – The model of reinforcement installation of "The new western road" project (city of Atyrau, Kazakhstan, 2003). In the result of the research, which was held on road building "The new western road" project we want to say that is very difficult to compact natural soil to required coefficient of compaction because the natural soil (loamy soil) has very low index of bearing capacity. To increase of durability and deformation property of road basement the model of reinforcement with the following steps were decided to choose (A. Zhusupbekov etc.).

1. The natural loamy soil is compacted by road-roller to ultimate level according to required standards. Evening of surface (Filling the pits, pot-holes and another local damage where the water may stay for a long period)
2. Installation of reinforced material (Figure 7)
3. Filling of the soil (Figure 7), with height no more that 200 mm, and its compaction to required coefficient of compaction standard.

The benefit of reinforcement was determined by examine of surface during three years service. The economical efficiency diagram which has been determined by comparing appearance of pits, pot-holes represent on Figure 8.

Initially the reinforced pavement cost more but after a certain period of time the reinforced pavement is a lower total cost.

The next research represents that the effective work of reinforced materials depends on its shape of geosinthetic (Figure 9) besides its type (PET, PP).

Efficiency of geogrid application serviceability with comparing geotextile is represented in Figure 10. For the initial data the appearance of serviceability pits and pot-holes were considered.

A cost comparison for reinforced versus other types of retaining walls is present in Figure 11.

Geosynthetic is recommended for use in soft soil subgrade because is the less expensive. Application of reinforcement materials allow to decrease thickness (ellipse in Figure 12) of stone base simultaneously require to demands of reliability and durability.

However there exists several variations (Figure 13) of choosing reinforced materials for soft soil condition, the final selection is based on technical and economical comparing.

Consequently one of the traditional types of road construction – asphalt pavement has the best characteristics of serviceability but not perfect. Working in various temperature and considerable dynamic load influence lead to the appearance of cracks because of low index of asphalt tensile strength. Even the low level of tensile load leads to appearance of crack and decreases serviceability properties and durability of asphalt pavement. Therefore the most

Table 2. The results of pullout test with different chain lengths.

Length of chain	Vertical pressure (kgf/cm^2)	Pullout force (kgf)						Sum (kgf)	
		F_1	F_2	F_3	F_{tc}	F_{ri}	F_{bi}	$F_{tc} + F_{ri}$	$F_{tc} + F_{bi}$
2.0 m	0.4	90.93	68.20	81.15	200.27	108.69	360	308.96	560.27
	0.8	101.85	136.39	162.30	400.53	184.45	720	584.98	1120.53
	1.2	152.78	204.58	243.44	600.80	260.21	1080	861.01	1680.80
2.5 m	0.4	63.49	85.02	101.17	249.68	108.69	360	358.37	609.68
	0.8	126.98	170.04	202.34	499.37	184.45	720	683.82	1219.37
	1.2	190.47	255.06	303.51	749.05	260.61	1080	1009.26	1829.05
3.0 m	0.4	76.06	101.85	121.19	299.10	108.69	360	407.79	659.10
	0.8	152.12	203.70	242.39	598.20	184.45	720	782.65	1318.20
	1.2	228.17	305.55	363.58	897.30	260.61	1080	1157.51	1977.30

Figure 7. Installation of reinforced soil of "The new western road" object (Atyrau city, Kazakhstan, 2003).

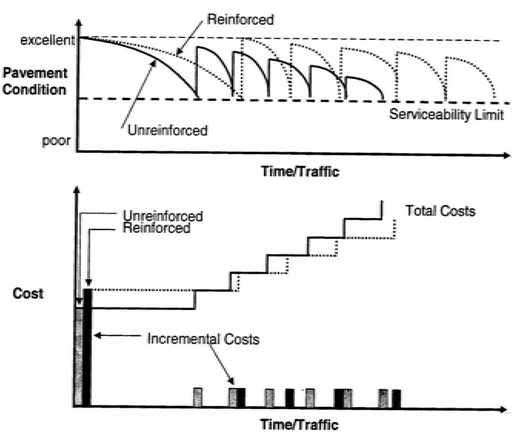


Figure 8. Economical efficiency of reinforcement model.

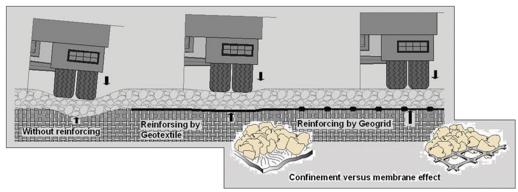


Figure 9. The work of reinforcement model.

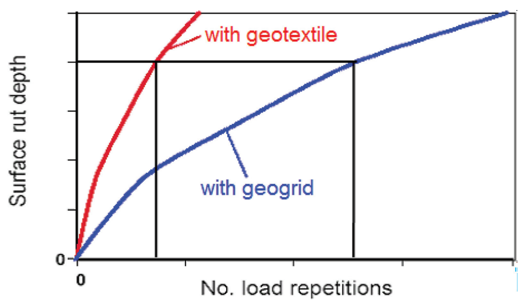


Figure 10. Efficiency of geogrid application serviceability.

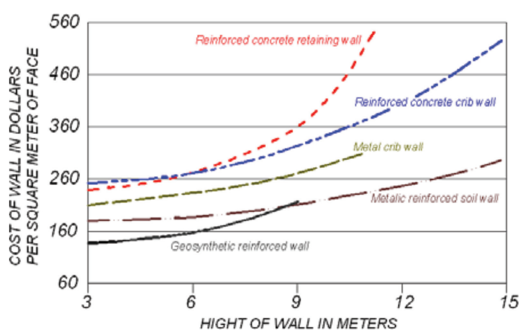


Figure 11. Cost comparison of reinforced system.

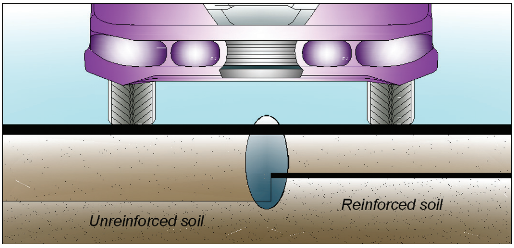
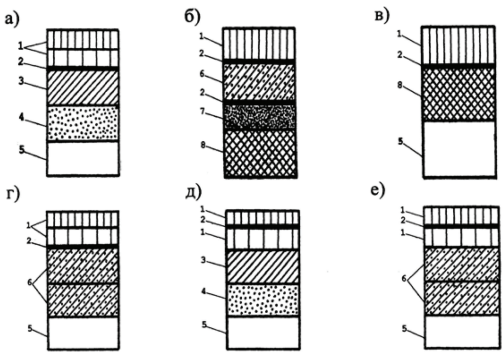


Figure 12. The difference in required thickness of stone base is then compared with the cost.



1 – asphalt, 2 – reinforced materials, 3 – gravel or crashed stone, 4 – sand, 5 – earth, 6 – gravel processed by bitumen, 7 – leveling coat (sand), 8 – existing road.

Figure 13. Type of road reinforcement.

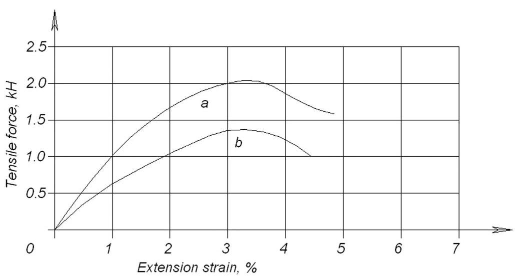


Figure 14. Dependence extension strain different asphalt pavement from tensile force.

progressive solution, based on durability and reliability of construction which excepts such problems, is reinforcement. Influence of reinforced geogrid of asphalt pavement samples are given in Figure 14 (A. Zhusupbekov etc.).

Usually in contrast in non-reinforced asphalt pavement samples where we can see big cracks appear than small distributed cracks will appear in reinforced sample.

3 CONCLUSIONS

Retaining walls with use geosynthetic are generally less expensive than conventional earth retaining system. Using geogrids or geotextiles as reinforcement has been found to be 30 to 50% less expensive than other reinforced soil construction with concrete facing panels. Due to their greater flexibility, this model offer significant technical and cost advantage over conventional gravity or reinforced concrete cantilever walls at site with poor foundations and slope conditions.

As the results of research work show that the application of reinforced construction will be proved from the economical point in case if that height of retained construction are higher than three meters. The cost of one meter reinforced wall with reinforcement is cheaper for 2 or 3 times than the price for one meter reinforced concrete.

From the point of economical and technical expediency the reinforcement application is conformed by its wide usage in developed countries of the world and the base of its successful application that will provide to increase its serviceability road period for 2 times.

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