Geosynthetics, J. Kuwano & J. Koseki (eds)
 ISBN 90 5966 044 7

Research of geosynthetics and highway application in Ningxia loess area

Jin, J., Zhang, Z., Sui, Y. & Tao, L.
Beijing University of Technology, No. 100 Pingleyuan, 100022, Beijing, China

Keywords: geosynthetics, highway application, loess, road diseases

ABSTRACT: This paper expounds the characters of geosynthetics and analyzes the principles of reinforcing embankment, preventing reflecting cracks and protecting slopes of embankment by usage of geosynthetics. In addition, some geosynthetics are applied to treat highway diseases such as embankment sinking, uneven sinking between new and old embankment and reflecting cracks of semi-rigid asphalt pavement in Ningxia loess area. As a result, geosynthetics material is a kind of novel and effective material to prevent road diseases in Ningxia loess area.

1 INTRODUCTION

Geosynthetics is made from polymer such as polypropylene (PP), polyester (PET), polyethylene (PE), polyvinyl chloride (PVC), polyamide (PA), and etc. As a kind of novel engineering material, it can be put into rock and soil engineering to strengthen the structures. Recently it is widely used in water conservancy, water electricity generation and highway and railroad engineering.

In recent years, there are more than 400 manufacture factories in China with abundant production. According to Technical Specification for Application of Geosynthetics in Highway, geosynthetics can be sorted into geotextile, geo membrane, special geosynthetics and complex geosynthetics. Special geosynthetics includes geogrid, fabriform, geonet, geomat and geocell, and complex geosynthetics is the mixture of all the materials mentioned above.

The function of geosynthetics in highway engineering is extensive including strengthening, filtrating, draining, preventing infiltration and protecting. In order to apply geosynthetics effectively, some rules should be conformed accord to the variety of characters.

2 APPLICATION OF GEOSYNTHETICS TO REINFORCE EMBANKMENT

2.1 *Reinforcement of embankment*

The intensity and rigidity of soil can be improved by mixing or paving geosynthetics into the structure. Research on reinforced soil is one of the focuses in soil and rock engineering. Although technique of reinforcing soil has been widely used in engineering, the principle of reinforced soil has not been found out clearly. The main study fields in soil reinforcement are as following: characters of reinforcing materials(Gurung N, Iwao), model and prototype tests of reinforced structure, structure analysis by limit equilibrium method or finite element method (Rowe R K, Ling H I), dynamic response analysis of reinforced structure.

Reinforced embankment is a structure in which some geosynthetics of high tensile strength are located into proper positions and then friction will rise between geosynthetics and soil, which prevents soil from distortion, enhances strength and stability of embankment and reduces the total displacement.

Geosynthetics that act as reinforcement material need be satisfied with the following characters: enough tensile strength, low stretch rate, less creepage, high puncturable strength and CBR value, adequate friction with soil.

In consideration of the characters of geosynthetics, geotextile, geogrid, geonet, geocell and geomembrane could be applied to reinforce embankment. Geotextile and geonet are not the best type owing to their low tensile strength and high stretch rate. Geogrid should be chosen to reinforce embankment due to its high tensile strength, low stretch rate and high occlusive strength with soil. Although geocell reduce the vertical displacement effectively because of its high tensile strength and rigidity, it is mainly used to protect slope. Geomembrane is not more appropriate than geogrid because of its large stretch rate and low occlusive strength. As a result, both plastic geogrid and fiberglas geogrid are fit to enhance embankment. The comparison is given in Table 1, which may be useful to choose right material for a given engineering.

Table 1. Comparison of main parameters between plastic geogrid and fiberglass geogrid.

	Plastic Geogrid	Fibreglass Geogrid
Tensile Strength (KN/m)	Single Directional: 25~110 Bidirectional: 15~45	Longitudinal: 30~100 Transverse: 30~50
Elongate Rate of Fracture(%)	9~16	3~4
Joint Strength	High	Common
Character of Resisting Head	Common	Good
Creepage	Big	Little

2.2 *Geosynthetics application for reinforcing embankment in Ningxia loess area*

It is common that embankment and slope tend to be destroyed by rain corroding in loess area for loess is porous, osmotic and prone to sink once meeting water. According to the research of Ningxia Institute of Highway Survey and Design, diseases in loess area mainly include slope destroying, embankment sinking, pavement cracking, road surface reflecting cracks and drainage demolishing. Aiming at these diseases, this research put forward the method of using geosynthetics.

The testing road is an assistant roadway of Yinchuan to Guyaozi freeway, which is 8.5 meter wide of embankment and 7.0 meter wide of pavement. The roadway gets across the Huanghe River from west to east. The physiognomy in west is 0.9~2.5 meter thick low liquid limit clay on the surface layer and thick sand in the under layer. The physiognomy in east is 0.2~0.8 meter thick loess on the surface layer, 0.2~4.0 meter thick scree or sand in the middle layer and mudstone or sandstone in the under layer. The loess on surface contains gravel in somewhere and distributes discontinuously. Other characters of loess in Ningxia are even, porous and prone to sink with water.

Figure 1 shows the application of geosynthetics to prevent embankment from sinking. The gradient of slope is 1:1.5, and 4.5 meter wide geogrid with 0.5 metre space from bottom up to 2.0 metre of embankment has been paved, which spaced each outside of slope about 5~10 centimeters. In order to be reinforced effectively, the geogrid has been paved all through the transect and 0.5 metre high lime stabilized soil was above the base. While constructed,

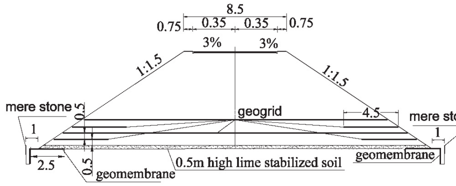

Figure 1. Design of embankment reinforcement.

0.2~0.3 meter width needed to be broadened and 0.3~0.5 metre length need to be spliced for necessary compacted density. Consequently, it was necessary to be covered with soil for fear of vehicle and sunshine.

According to the principle of choice, bidirectional geogrid was applied, which was made of polypropylene and the main parameters were as following: mass per square meter was 550 g, intensity of tension was 45 KN/m, lognitudinal elongate rate of fracture was 13%, transverse elongate rate of fracture was 16%, and the force was 25 KN/m at 5% lognitudinal elongate rate and 22 KN/m at 5% transverse elongate rate. Furthermore, polyester geomembrane of 500 g/m^2 was paved on the bottom for preventing water from filtering into the embankment.

Comparing the distortion of the sections with geogrid and without geogrid (reported by Headquarters of Ningxia Gu-Wang Highway and Yanxin Highway), it was concluded that geogrid improved rigidity and capability of embankment and pavement effectively.

3 APPLICATION OF GEOSYNTHETICS TO REINFORCE PAVEMENT

3.1 *Reinforcement of pavement*

Using geosynthetics to reinforce pavement is the technique by which they are paved on the top of some layers such as base or surface of old asphalt pavement and old cement pavement. With the application in some engineering, it is concluded that the method could stay or prevent reflecting cracks by reducing the additive stress of surface brought by base, decreasing the tensile stress of surface and confining crack of surface.

It is obvious that geosynthetics for preventing reflecting cracks need high tensile strength, better resisting heat, low elongate rate, good conglutination with base and surface. Moreover, acid and alkali resistance are also needed with geosynthetics. Shown in Table 2, both fibreglass geogrid and geotextile meet the above requirements. Comparing geotextile to fibreglass geogrid, the latter's tensile strength is higher and its heat resistance is stronger. However, geotextile could produce a damp course after dipped asphalt, which could prevent water filtering into structure. Another strongpoint of geotextile is that it

Table 2. Technical requirement for fibreglass geogrid and geotextile.

Fibreglass geogrid (Temperature 20 ± 2)		Geotextile (Temperature 20 ± 2)	
Parameter	Requirement	Parameter	Requirement
Tensile Strength (kn/m)	≥50	Tensile Strength (kn/m)	≥50
The Biggest Elongate Rate (%)	≤3	Mass (g/m^2)	≤200
Net Size (mm × mm)	12 × 12~20 × 20		
Net shape	Rectangle		

could decrease temperature stress owing to its low heat exchange rate. To sum up, both materials have respective characteristics and should be chosen carefully.

3.2 *Application of geosynthetics to reinforce pavement in Ningxia loess area*

Adding geosynthetics to pavement is effective to improve capabilities of resisting crack in low temperature, resisting track, prolonging working life and restraining reflecting crack.

The pavement structure (in Fig. 2) of Guyaozi to Wangquanliang freeway in Ningxia is 4 cm thick middle gravel asphalt concrete, 8 cm thick great gravel asphalt concrete, 23 cm thick cement stabilized compound, 20 cm thick grading sand and low liquid limit clay whose elasticity module is 48 MPa. Difference of temperature of day and night is great and sunshine is ample in Ningxia area. So the structure is tend to crack under this environment. Applying geosynthetics to resist crack is an effective method. So fibreglass geogrid has been paved 75 centimeters in length with about 20 metre distance and extended total breadth.

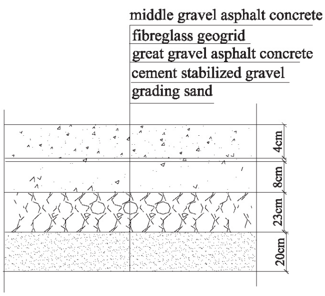

Figure 2. Pavement structure.

The main physical parameters of fibreglass geogrid in this project were as following: mass 370 g/m^2, net distance 12.5 mm, tensile strength 100 KN/m at two directions, stretch rate 4% and melting point 1000°C. The road paved in July 2001 and has few reflecting crack up to the present, but the sections without geogrid appear cracks obviously. In conclusion, geogrid is effective to prevent reflecting crack.

4 APPLICATION OF GEOSYNTHETICS TO PROTECT SLOPE

4.1 *Protection of slope*

Slope protecting is very important and usage of geosynthetics such as geonet, geomat and geocell to protect road slope is a new technique in recent years. The strength of geonet and geomat has almost no difference. Geonet is not proper in rainy and sandy area owing to its two dimension structure and big nets. Geomat steadies soil more effectively than geonet for its three dimension structure and small nets. Geocell can also steady soil very well for its three dimension structure. As a whole, geocell working with geonet is a good structure to stabilize slope on the condition of heavy water scouring.

4.2 *Application of geosynthetics to protect slope in Ningxia loess area*

Stone structure is one of the conventional methods of slope protecting, but it is not effective in loess area because it is captious for slope, easy to coast, laborious and harmful to nature. Swarding is not suited in loess area because of severe soil erosion. Combining geocell with geonet to stabilize slope in loess area can bring about better effect.

Geosynthetics was adopted to protect slope in freeway from Yingchuan to Guyaozi which located in loess area. The gradient of slope was 1:1 and the height is 6~8 meters. Because of heavy sand blown by wind and rain scouring, it was difficult to stabilize slope. In this research, firstly geocell was embedded into soil, and then three dimension geonet was paved on it, at last clover seeds were sowed in the cultivable interspaces. Having been observed for several years, the clover is growing very well and the slopes maintain steady. This method is not only easy to perform but also economical.

The geocell in the road was made of PE with 100 mm height and 1.0~1.3 mm thickness. The geonet's parameter was as following: mass 260 g/m^2, height 12 mm and tensile strength more than 1.6KN/m.

5 CONCLUSION

This paper researched the principle of choosing geosynthetics for road disease treatment and applied appropriate materials in road construction in Ningxia loess area. It is proved that geosynthetics can reinforce embankment, strengthen pavement and protect slope successfully in Ningxia loess area.

REFERENCES

Gurung, N. and Iwao Y. Pull-Out Test Analysis for Geo-Reinforcement [J]. Geotextiles and Geomembrances 1999, 17(3): 157-170.

Headquarters of Ningxia Gu-Wang Highway and Yanxin Highway, Beijing University of Technology. Research on Using Geosynthetics in Highway Projects of Loess Region in Ningxia. Beijng: Beijing University of Technology, 2005.

Ling, H.I., Cardany, C.P., Sun, L.X. and Hashimoto, H. Finite Element Study of a Geosynthetic-Reinforced Soil Retaining Wall with Concrete Block Facing [J]. Geosynthetics International, 2000. 7(2): 137-162.

Ningxia Institute of Highway Survey and Design. Research on Construction Technology and Road Disease Prevention at Loess Region in Ningxia [R]. Ningxia: Ningxia Institute of Highway Survey and Design, 2001.

Rowe, R.K. and Skinner, G.D. Numerical Analysis of Geosynthetic Reinforced Retaining Wall Constructed on a Layered Soil Foundation [J]. Geotextiles and Geomembrances, 2001, 19(7): 387-412.