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Use of Geosynthetics in Road Construction

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ABSTRACT

Road and railway stabilization is the use of geosynthetic reinforcing elements to strengthen the ground in order to work on very soft and weak ground in the construction of asphalted or unpaved vehicle roads and rail systems. The geosynthetics increase the performance and design life of highways and railway construction structures in applications such as geogrids, roads, railways, airports and other earthworks with poor ground strength. Geosynthetics offer a much higher value than traditional road construction products and the fast, simple installation process greatly reduces the construction process. On highways, geosynthetics are placed on the weak base floor before the geosynthetic granular substrate is placed. Geosynthetics protect the structural integrity of the slab and prevent the granular sub-base material from slipping into the weak substrate. The use of geosynthetics extends the maintenance requirement of the flooring that is built on a weak floor.

Anahtar Kelimeler:
Asfalt,
Geosentetik,
Yol İnşaatı,
Demiryolu Stabilizasyonu.

ÖZ

Karayolu ve demiryolu stabilizasyonu, asfaltlı veya asfaltsız araç yollarının ve raylı sistemlerin yapımında çok yumuşak, zayıf zeminde çalışmak ve zemini güçlendirmek için geosentetik takviye elemanlarının kullanılmasıdır. Geosentetikler, geogridler, yollar, demiryolları, havaalanları ve zemin dayanımı zayıf olan diğer toprak işleri gibi uygulamalarda otoyolların ve demiryolu inşaat yapılarının performansını ve tasarım ömrünü artırır. Geosentetikler, geleneksel yol yapım ürünlerinden çok daha yüksek bir değer sunar ve hızlı, basit kurulum süreci ile inşaat sürecini büyük ölçüde azaltır. Karayollarında, geosentetik granüler alt tabaka yerleştirilmeden önce zayıf taban zemine geosentetikler yerleştirilir. Geosentetikler, levhanın yapısal bütünlüğünü korur ve granüler alt taban malzemesinin zayıf alt tabakaya kaymasını önler. Geosentetik kullanımı, zayıf bir zemin üzerine inşa edilen döşemenin bakım ihtiyacını artırır.

1. Introduction

Geosynthetic materials are widely used in many civil engineering fields, especially geotechnical engineering. Synthetic fiber, which is the raw material of geotextile, was produced from PVC (polyvinyl chloride) in the beginning of 1900s and since the mid-1960s, non-woven fabrics were manufactured as fabrication. The first known geosynthetic material application was synthetic woven fabrics (geotextiles) used in Florida USA for the control of coastal erosion in 1958 and it is seen that this geotextile material application still continues its duty [1].

In the following years, the usage of geosynthetics has increased rapidly in other fields of civil engineering such as geotechnics with the expansion of the usage area of geotextile products with different functions and the creation of geomembrane, geogrid and geocomposite products [2].

The ability of these polymer-based products to be produced by adapting them according to their needs, their lightweight structures with ease of transportation and being easy-to-use materials compared to other building materials play an important role in the expansion of their usage areas [3].

According to the definition of ASTM, Geosynthetics are polymeric planar products that are used in conjunction with a soil, rock, soil or other Geotechnical engineering material as part of a construction project, structure or system. Although the first known application of geosynthetic materials in the field of civil engineering has been seen in the field of geotechnical engineering with the application of soil improvement with geotextile material, its usage has become widespread due to different manufacturing types and application possibilities and it is used in almost all fields of civil engineering today [4].

According to production types; geosynthetics, including geotextiles, geogrids, geomembranes, geonets, geocomposites, and geosynthetic clay coatings and some other products are included with conventional materials known in applications [5].

2. Geosynthetics

Geosynthetic materials are used in civil engineering projects for many purposes including separation, drainage, strengthening and filtering. In order to replace these materials with alternative materials, gaining advantages in terms of material quality control, manufacturing quality control, cost advantages, technical superiority, shortening of construction time, material development, material availability and environmental sensitivity play an important role [6,7].

Table 1. Functions of geosynthetic materials (Hayden and friends, 1999)

Function	Geotextile	Geogrid	Geomembrane	Geocomposite
Filtering	√			√
Drainage	√			√
Separation	√			
Strengthening	√	√		
Insulation	√		√	

ASTM defines a geotextile as a permeable textile product used as a part of a construction project, structure or system in combination with soil, rock, soil or other Geotechnical engineering material [8].

Geotextile materials are mainly made of polyester (PES), polypropylene (PP) or polyethylene (PE-HD). It is found in the form of felt mats, either as geocafes or as combined materials. Felt materials are obtained by mechanical, thermal or chemical stabilization of superficially superimposed fibers or endless fibers.

• Mechanically reinforced matting mats are obtained by needling method. In this method, the eared needles are immersed in the fiber mat to be compressed and withdrawn again, thereby ensuring that the fiber systems are wound together. The mechanically reinforced felt-like material becomes soft, easy to shape and is bulky [9,10].

• The thermally stabilized felt material is usually bonded by heating under pressure. The fibers have a low melting sheath and a fusion occurs at the overlapping points.

• Chemically stiffening felt material is obtained by wetting with a bonding material which hardens by heat treatment. A solid bond occurs where the fibers come into contact with each other. Therefore, the chemically hardened material becomes very hard.

This felt-like material (geotextile) is water permeable and generally has the ability to stretch. The tissue consists of fibers arranged perpendicular to each other. They are separated from each other by the type and type of fibers [11].

Medium, bad and especially very bad infrastructures can be improved with Geotextile application. Geotextiles are permeable geosynthetics containing synthetic polypropylene or polyester fibers with a thickness of 0.4-3 mm and a weight of 70-350 gr. Geosynthetics are studied in two different classes according to their structure; [12,13]

• Woven Geotextile, perpendicular to the fiber layer

• Nonwoven geotextile materials with isotropic behavior where fibers are randomly distributed. These flexible geosynthetic materials with high deformation properties,

• Separating the layers of granular material,

• Strengthening the ground by increasing the contact surface on the ground with insufficient mechanical strength,

• Filter with small cavity structure,

• Water permeable structure is used to provide drainage [14].

3. Functions of Geosynthetics

Geotextiles are widely used in many fields of the construction sector with their hollow, partially durable structure and easy to use functionalities [15].

When designing the geotextiles in construction structures, six functions of geotextiles are taken into consideration. Geosynthetics with raw cavity structure; They are used with separation, filtering, drainage, protection and strengthening functions, and they are also used with insulation function by saturating the hollow structure.

Separation function: When the geotextile is placed on the interface of fine-grained ground and coarse ground, it acts as a separation. Thus, it prevents the mixture of materials to be formed due to dynamic or static load coming from the superstructure. As a result of their continuity, flexibility, deformability, permeability and high tensile strength, geotextiles distinguish between two floors with different geotechnical properties without interfering with the natural circulation of water [16,17].

In addition to these functions, when geotextile materials are used for separation purposes; [18]

• Increases the service life and carrying capacity of the roads as it prevents the movement of fine-grained soils under dynamic loads and allows the drainage of excess water,

• Ensures continuity even in weather conditions where construction can stop, as it prevents mixing of quality material and fine-grained ground,

• Using less aggregate in the filling and infrastructure works of road and railway constructions and providing better compaction,

It provides many functions by itself by performing its functions [19].

Filtration function: The geotextile acts as a filter, allowing water to pass through, but still holds the smallest grain diameter floor and does not allow it to drift. Geotextile is placed against water flow. It is desirable that the geotextile to be used in filtration work should have suitable maximum pore opening, sufficient water permeability, less impact from compression and high porosity [20].

After the placement of the geotextile, some fine-grained soil is carried along with the water in the soil. This material carried in the first stage must pass through Geotextile material. Thus, a layer is formed against the geotextile without fine-grained material. This naturally acts as a screened filter layer to prevent the movement of small particles towards the Geotextile. If these fine grains are retained within the Geotextile, a less permeable layer is formed and the flow of water is prevented. In order not to interfere with the flow of water and to prevent the formation of pore pressure, the permeability of the geotextile should be at least the permeability of the ground. Considering the risk of clogging and the compression of the geotextile into an impermeable structure, the safety factor is taken as 10 or 100 in the construction of important dam structures [21].

Drainage function: The geotextile transports liquid or gas along its plane to the desired outlet. During this transmission, the liquid or gas is collected in the Geotextile and transferred in its own plane. Geotextiles are more permeable than ground. Especially when they are porous and sufficient slope is achieved, water flow can be provided in their planes. Therefore, it is useful to use in constructions such as tunnels, vertical drains, reservoir pavements and foundation walls where water must be drained [22].

Geotextile materials to be used for drainage should have high permeability, high resistance against pressure and good filter properties in their plane.

Strengthening function: It is the spreading of point loads over a wide area evenly and strengthening the floor mass by resisting the tensile forces formed.

Unlike floors, Geotextile materials have tensile strength. By joining the soil structure, they increase the tensile strength and deformation ability before breaking and provide strengthening of the soil. Thanks to reinforcement, significant material savings can be achieved by reducing or eliminating the need for aggregate material to be used for reinforcement in road constructions on soft floors [23].

Protection function: Geotextile materials protect the desired material by spreading it over a larger area by reducing the deformation and stress by placing it around the ground layer or the structural element or contact surface where it is required. For example; The geotextile material placed between the asphalt pavement and the old road pavement or between the geomembrane and the concrete surface for which waterproofing is required, protects the materials between which it is placed against deformation such as puncture and tearing.

Insulation function: The geotextile material is saturated with bitumen or plastic insulating materials to form an impermeable layer to provide a structure that will act as a kind of geomembrane. Geotextile materials are used with insulation function, especially by laying on the old road pavement on the roads to be renewed. The geotextile to be used with the insulation function must be capable of retaining a sufficient amount of bitumen in order to achieve an impermeable structure [24].

4. Usage areas of Geosynthetics

Geotextile materials have a wide range of applications. However, if the main titles are to be examined, geotextile materials are used on the basis of separation, filtering, drainage, strengthening, protection and insulation functions [25].

The main task of geotextile materials is to help reduce stresses and deformations, and to increase the bearing capacity and prolong the life of the added layers. Geo synthetic material is used between the existing floor and platform or frost protection layer. It is placed on the compacted platform and covered with a protective material. Geotextile material is used to prevent irregular settlements by regularly distributing both static and dynamic effects to the ground in highways and railways. In this case, geotextile materials are under the influence of both hydraulic and mechanical formations and should also prevent the pumping of fine materials into coarser top sheets [26].

Geotextile materials are thermally bonded or pinned felt mats or cages made of non-decaying synthetic material fibers. The lower the bearing capacity of the floor, the more heavy the felt must be used. The thermally stabilized geotextiles have a weight of about 100-200 g/m^2 and the needled ones weigh about twice that. The application of geotextile materials can be done mechanically during platform correction. In this way, since no additional work is required for the application of geotextile material, initial construction costs are very low, after the application will reduce the maintenance and renewal costs in the region and frost damage is seen as an economic advantage [27].

5. Geosynthetics in road construction

Geosynthetics have an assortment of employments from disintegration control to bank fortification to improved subsurface seepage. One of the most widely recognized uses, in any case, is in road construction, especially impermanent roads, for example, construction roads, get to roads and woods ways. These are the advantages of utilizing geosynthetics for these applications. Geotextile to the road infrastructure in Figure 1 thanks to the separation function when applied the layers are prevented from mixing with each other [28].

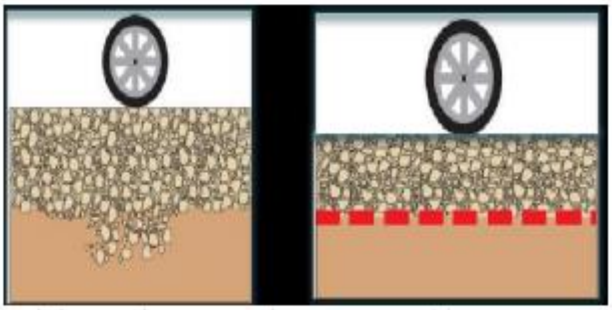

Figure 1. Geosynthetics in road construction

Bearing limit:

For building the two roads and parking garages, it's significant subgrade is steady with adequate bearing limit. By utilizing geogrids between the subsoil and base course, bearing limit is expanded. The interlocking of the spread soil with the geogrid gives level power move, which serves to expand bearing limit and, by and large, take into consideration base course thickness to be decreased. This strategy additionally makes costly soil trade superfluous [29].

Rutting:

One of the essential concerns when building unpaved roads on delicate subsoil is rutting and between blending of spread material into the subsoil. By improving burden circulation, geogrids serve to limit both rutting and soil intermixing. A particular task's necessities will direct the determinations of the geogrid required [30].

Power extension:

Low extension qualities of a geogrid are required for a fruitful fortification application. In numerous tasks, power assimilation at stretching requires an item with between 2-percent and 5-percent limit. For all the more requesting applications, items with up to 8-percent extension at break are accessible [31].

Establishment power:

At long last, it's essential to consider a geogrid's protection from establishment loads. High unique anxieties can negatively affect support while introducing and compacting spread soils and base course materials. To withstand this pressure, a geogrid ought to have thick, solid support bars [32].

Utilizing geosynthetics gives a more financially perceptive and productive technique than numerous options in an assortment of utilizations. To find out additional, or to discover the geosynthetics required for your next undertaking, come see us at Maxwell Supply of Tulsa.

6. Conclusion

Geosynthetic materials, which started to be used in the field of geotechnical engineering with the fabrication of geotextile materials in the 1960s, are now widely used in many fields of civil engineering, including road structures. In road engineering, geosynthetic materials are involved in forming drainage structures, separating different layers, preventing irregular settlements, providing waterproofing, protection of products providing waterproofing and strengthening of road infrastructure and superstructure layers.

As in the world, the use of geotextile and geomembrane materials in road engineering is widely seen in our country and different applications are frequently encountered according to the functions of these materials. However, as it can be seen in the researches, although it has been seen that there are many applications around the world to improve the road line stabilization by using geogrid material and to decrease the ballast and sub-ballast layer thicknesses, there is no known application in this regard in our country yet.

Competing Interest / Conflict of Interest

The author declare that they have no conflict of interests.

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7. References

[1] Wilmers, W. (2002). The revised German regulations for the use of geosynthetics in road construction. In Geosynthetics: State of The Art-Recent Developments. Proceedings of The Seventh International Conference on Geosynthetics, 7(4), 22-27

[2] Van Santvoort, G. P. (1994). Geotextiles and geomembranes in civil engineering. CRC Press.

[3] Webster, S. L., & Santoni, R. L. (1997). Contingency airfield and road construction using geosynthetic fiber stabilization of sands (Vol. 97, No. 4). US Army Engineer Waterways Experiment Station.

[4] Bloise, N., & Ucciardo, S. (2000). On site test of reinforced freeway with high-strength geosynthetics. In EUROGEO 2000: Proceedings of The 2nd European Geosynthetics Conference. Volume 1: Mercer Lecture, Keynote Lectures, Geotechnical Applications.

[5] Han, J., & Thakur, J. K. (2015). Sustainable roadway construction using recycled aggregates with geosynthetics. Sustainable Cities and Society, 14, 342-350.

[6] Collin, J. G., Watson, C. H., & Han, J. (2005). Column-supported embankment solves time constraint for new road construction. In Contemporary issues in foundation engineering (pp. 1-10).

[7] Hayden, S. A., Humphrey, D. N., Christopher, B. R., Henry, K. S., & Fetten, C. (1999). Effectiveness of geosynthetics for roadway construction in cold regions: results of a multi-use test section (No. Volume 2).

[8] Powell, W., Keller, G. R., & Brunette, B. (1999). Applications for geosynthetics on forest service low-volume roads. Transportation Research Record, 1652(1), 113-120.

[9] Kinney, T. C., & Connor, B. (1987). Geosynthetics supporting embankments over voids. Journal of cold regions engineering, 1(4), 158-170.

[10] Adams, C. A., Apraku, E., & Opoku-Boahen, R. (2015). Effect of triaxial geogrid reinforcement on CBR strength of natural gravel soil for road pavements. J. Civ. Eng. Res, 5(2), 45-51.

[11] Anniello, P. J., Zhao, A., & Capra, G. (2003). U.S. Patent No. 6,505,996. Washington, DC: U.S. Patent and Trademark Office.

[12] Vinod, P., & Minu, M. (2010). Use of coir geotextiles in unpaved road construction. Geosynthetics International, 17(4), 220-227.

[13] Laurinavičius, A., Oginskas, R., & Žilionienė, D. (2006). Research and evaluation of Lithuanian asphalt concrete road pavements reinforced by geosynthetics. The Baltic Journal of Road and Bridge Engineering, 1(1), 21-28.

[14] Brandon, T. L., Al-Qadi, I. L., Lacina, B. A., & Bhutta, S. A. (1996). Construction and instrumentation of geosynthetically stabilized secondary road test sections. Transportation research record, 1534(1), 50-57.

[15] Vieira, C. S., & Pereira, P. M. (2016). Interface shear properties of geosynthetics and construction and demolition waste from large-scale direct shear tests. Geosynthetics International, 23(1), 62-70.

[16] Tutumluer, E., & Kwon, J. (2006). Evaluation of geosynthetics use for pavement subgrade restraint and working platform construction. In Geotechnical Applications for Transportation Infrastructure: Featuring the Marquette Interchange Project in Milwaukee, Wisconsin (pp. 96-107).

[17] Tingle, J. S., & Jersey, S. R. (2007). Empirical design methods for geosynthetic-reinforced low-volume roads. Transportation research record, 1989(1), 91-101.

[18] Kinney, T. C. (1996). Use of geosynthetics in road and airfield construction in cold regions. Roads and Airfields in Cold Regions: A State of The Practice Report. ASCE, 271-288.

[19] Ai-Qadi, I. L., & Appea, A. K. (2003). Eight-year field performance of secondary road incorporating geosynthetics at subgrade-base interface. Transportation research record, 1849(1), 212-220.

[20] Tingle, J. S., & Jersey, S. R. (2005). Cyclic plate load testing of geosynthetic-reinforced unbound aggregate roads. Transportation research record, 1936(1), 60-69.

[21] Douglas, R. A., & Valsangkar, A. J. (1992). Unpaved geosynthetic-built resource access roads: stiffness rather than rut depth as the key design criterion. Geotextiles and Geomembranes, 11(1), 45-59.

[22] Vaitkus, A., Laurinavičius, A., & Čygas, D. (2006). Site Damage Tests of Geotextiles Used For Layer Separation ın Road Construction. Baltic Journal of Road & Bridge Engineering (Baltic Journal of Road & Bridge Engineering), 1(1), 29-37.

[23] Vaitkus, A., Šiukščius, A., & Ramūnas, V. (2014). Regulations for use of geosynthetics for road embankments and subgrades. The Baltic Journal of Road and Bridge Engineering, 9(2), 88-93.

[24] Yan, L., Yang, J., Gao, Y., & Liu, B. (2006). Numerical analysis of geosynthetics treatment in old road widening. Yanshilixue Yu Gongcheng Xuebao/Chinese Journal of Rock Mechanics and Engineering, 25(8), 1670-1675.

[25] Anderson, R. P., Molina, F. G., Salazar, R. Z., Diaz, A. L., Sánchez, N., & Jorge, A. (2003). Geosynthetics facilitate road construction and mitigate environmental impact in Amazon Basin rainforest–10 years of performance.

[26] Vaitkus, A., Čygas, D., & Laurinavičius, A. (2010). Use of geosynthetics for the strengthening of road pave ment structure in Lithuania. In Geosynthetics for a challenging world: 9th International Conference on Geosynthetics (Vol. 3, pp. 1575-1580).

[27] Santoni, R. L., Tingle, J. S., & Webster, S. L. (2001). Engineering properties of sand-fiber mixtures for road construction. Journal of geotechnical and geoenvironmental engineering, 127(3), 258-268.

[28] Frischknecht, R., Stucki, M., Büsser, S., & Itten, R. (2012). Comparative life cycle assessment of geosynthetics versus conventional construction materials. Ground Engineering.

[29] Stucki, M., Büsser, S., Itten, R., Frischknecht, R., & Wallbaum, H. (2011). Comparative life cycle assessment of geosynthetics versus conventional construction materials. ESU-services Ltd. Uster, ETH Zürich, Switzerland, Commissioned by the European Association for Geosynthetic Manufacturers (EAGM).

[30] Han, J., & Collin, J. G. (2005). Geosynthetic support systems over pile foundations. In Geosynthetics Research and Development in Progress (pp. 1-5).

[31] De Groot, M. B., Den Hoedt, G., & TerMaat, R. J. (Eds.). (1996). Geosynthetics: Applications, Design and Construction. AA Balkema.

[32] Kinney, T., & Connor, B. (1990). Geosynthetic reinforcement of paved road embankments on polygonal ground. Journal of Cold Regions Engineering, 4(2), 102-112.