XIV International Mineral Processing
and Recycling Conference
Belgrade, Serbia, 12-14 May 2021

HYBRID GEOMATERIALS

Milenko Jovanović[#], Miomir Mikić, Radmilo Rajković, Daniel Kržanović, Emina Požega
Mining and Metallurgy Institute Bor, Bor, Serbia

ABSTRACT – Waste is a big (global) problem, which has been accumulating more and more over the years, so it needs to be stored somewhere permanently. However, it should be disposed of in the prescribed manner - it's not the same where and how we dispose of waste. Various variations of geosynthetics have been playing this most important role lately. Geosynthetics play a major role in soil protection whether it is a landfill or some other surface pollution. Geosynthetics has been developing in the last four decades and all products in this field can still be considered relatively new, which certainly does not mean that they have not proven themselves on many demanding projects (applications) in various occasions and requirements, especially in mining and construction.

Keywords: Geosynthetic, Geogrids, Hybridgeomaterials, Slope, Landfill.

INTRODUCTION

In accordance with the technical documentation of the Law on Mining, the obligation to recultivate the land is determined, according to the valid Project. The amendment of the Law and its harmonization with international standards (EN ISO 10318-1: 2015 CEN / TC 189) and articles (ISO 10318-1: 2015 ISO / TC 221) related to ecology and safety of works envisages the introduction of "new" security and protection measures. Mining facilities and surroundings. One of them is the application (installation) of geosynthetics (various types), as (in the future) a mandatory measure for securing mining and construction facilities (landfills, securing slopes, embankments, canals, etc.). [1,2]

A special part of this area refers to geogrids and geotextiles made of organic material (from nature), which, along with some variations in the use of building materials, is the main topic of this paper. Organic geogrids have unique characteristics, consisting of biologically and chemically degradable natural fibers. They are designed to keep the land in place until natural vegetation is established. On the other hand, geogrids and geotextiles made of synthetic materials have much greater strength, elasticity and durability. [1,3,4]

By combining these types (materials) of geogrids and geotextiles in the form of a certain hybrid technology of making these products, we obtain usable parameters suitable in the field of environmental protection and the necessary mechanical and temporal usability (long-lasting).

Seemingly contradictory requirements, by applying these hybrid geomaterials, can be effectively fulfilled.

[#] corresponding author: milenko.jovanovic@irmbor.co.rs

EXPERIMENTAL

Geogrids - materials, differences and types

Geogrids (Fig. 1) are made of polymeric materials such as polyethylene, polyester and polypropylene and are characterized by high tensile strength. The original geogrids were made by drilling holes in the sheet of material. Today, such geogrids are made by the so-called extrusion process. We now have geogrids made of polyester fibers coated with polyethylene. A multitude of continuous fibers are joined into a thread, which is then woven in the longitudinal and transverse direction with a certain distance between the ribs, and the folds are additionally strengthened, and then the fibers are coated. Geogrids are most often used to strengthen and stabilize poorly bearing soil. Apart from stabilizing and strengthening poorly bearing soil, geogrids are also used to strengthen asphalt by installing a geogrid between the layers of asphalt. The geogrid takes over the action of forces and prevents the formation of cracks on the newly installed layer of asphalt. The third important purpose of geogrids is to protect against soil erosion. For this purpose, there are two-dimensional geogrids that have small eye openings and three-dimensional geogrids. Depending on the manufacturer, geogrids may differ, but their primary function and mode of operation are the same: [1,3,5]

- absorb the kinetic energy of erosive elements (rain, wind) and stabilize the soil surface, creating numerous micro-dams over it,
- keeps seeds and hydrosowing materials in place, even on a steep slope of the soil, which leads to successful seed germination,
- helps water penetrate through the soil and retain moisture, leading to better seed germination and good grass growth.

The use of anti-erosion geotextiles can increase and support the effect of erosion control in areas with particularly steep slopes or in substrates susceptible to erosion. [1,3,5,6,7]

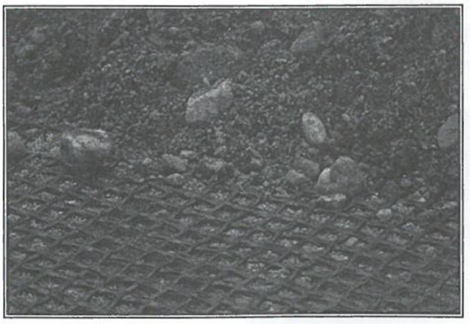

Figure 1 Setting up a geogrid

Organic geogrids

The greatest role of vegetation in the protection of slopes from erosion and its stabilization is provided when its surface enables the establishment of a given vegetation and allows water to flow at a certain speed and intensity on the surface and thus prevents the degradation of vegetative cover. Organic geogrids have unique characteristics, consisting of biologically and chemically photo degradable natural fibers. They are designed to keep the land in place until vegetation is established. The organic geogrid has the following roles:

- To absorb the kinetic energy of erosive elements (rain, wind).
- To facilitate the penetration of rain into the ground.
- To retain moisture from rain: In addition to being eco-friendly, they can absorb water about five times the dry weight.
- Allows to avoid loss or dispersion of seeds necessary for revegetation.
- Provides radical establishment of plant species.
- Allows control of soil temperature by mitigating its natural oscillations: so that they can mitigate extreme temperatures and create a pleasant micro-climate for vegetation growth.
- Allows to reduce the loss of soil moisture.

Organic geogrids are more flexible than most types of synthetic geogrids. This allows them to easily follow the contour of the soil surface. The ability to make direct contact between the fibers and the soil and enable the development of a connection between them, enables the reduction of soil loss by 90% or more. In addition to the above, organic geogrids act as "mulch" and thus improve the establishment of vegetation. After degradation, they do not leave any toxic material. [4,8,9]

Geo-network of Jute – Jute is an annual plant that requires a very warm climate and a lot of moisture. Utah geogrid (Fig. 2) is used to cover slopes and protect against erosion. Jute yarns are thick with pronounced 3D characteristics and provide a number of barriers, thus reducing the rate of water runoff. The openings of the jute net retain the displacement of the clearings of the soil. The jute net has an excellent ability to shape and follow the contours of the land on which it is placed. It absorbs water up to almost 4-5 times its dry weight, storing water from the rain and preventing the soil from separating. In humid conditions, its flexibility increases due to water absorption. The jute mesh provides surface stability on steep slopes and slopes with an angle of about 45 degrees. When vegetation begins to grow it takes on the role of a jute net. It takes about 2 years for the biodegradation of the jute network. [4,6,9]

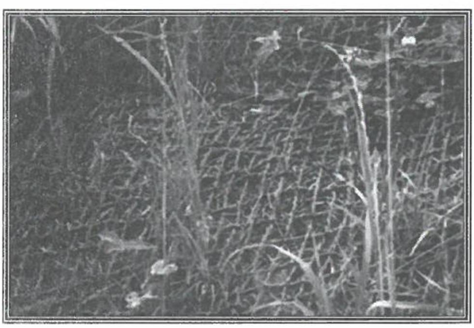

Figure 2 Jute geogrid

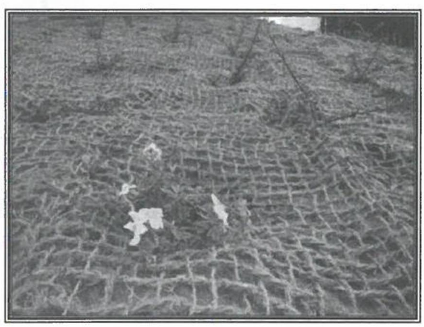

Figure 3 Coconut geogrid

Coconut geogrid – Geotextile made of organic material (coconut) is a natural and 100% biodegradable solution for erosion control using a coconut fiber geotextile mat. Permeable geotextile provides a natural system of assistance (improvement of characteristics) to the soil (soil) and vegetation. Coconut fiber is obtained from the coconut shell. They are naturally strong, durable and biodegradable.

The coconut geogrid (Fig. 3) is a very strong and durable network. Open weaving allows the planting of seeds and vegetation both before and after the installation of the mat, and offers strong support to the vegetation. The lifespan of a coconut fiber mat is four to six years. Period, enough for strengthens with consolidation. After that time, the mat slowly biodegrades. This geogrid has high tensile strength (35 kn/m) and elasticity and can be installed even on very steep slopes around 70 degrees. On steep slopes, which are more prone to erosion, organic geogrid can be placed in combination with metal nets. Organic geogrids are best for protection against erosion through vegetative growth. When vegetation is established, organic geogrids no longer serve as protection. Metal mesh remains permanently as active or passive slope protection. The geogrid can be set up to 60 degrees, with the support of a metal mesh, while the coconut geogrid in combination with metal can also be placed on vertical slopes. [4,6,9]

Synthetic geogrids

Synthetic geogrids are synthetic products (geosynthetics) used to stabilize the terrain. The polymeric nature of the products makes them suitable for use in a country where high levels of durability are required. This type of geogrid is available in a wide range of shapes and (synthetic) materials. In difficult conditions (such as slopes with a critical angle, channels with high flow, etc.), the vegetative cover, even when it is well placed, will not be able to survive under the erosive power of water. Therefore, for the purpose of stabilization and strengthening of the terrain, the law should define the obligation to use (install - install) geogrids or geosynthetic networks and thus increase the resistance to erosion and thus the protection of the natural environment. [3,8,9]

RESULTS AND DISCUSSION

Types of materials – fibers

Primary properties of fibers

In order for the fibers to be further processed into more complex textiles (materials) and for the final products to meet the intended purpose, the fibers must meet certain requirements. Some characteristics reflect the behavior of fibers under the action of external forces and influences. The mechanical properties (characteristics) describe the behavior of fibers under the action of various types of forces and loads. Physical properties represent the response of fibers to various external physical influences, such as the action of heat, various types of radiation, the atmosphere, etc. Another type of feature is related to the appearance of the fiber, its dimensions and surface characteristics. These properties are very specific to fibers - as a form of material, but also different and characteristic of certain types of fibers. The characteristics of this group are also important for processability, and based on them, many differences in the behavior of textile products in application result. Behavior during the action of chemical agents is important for the implementation of various physico-chemical processes, and resistance to certain chemicals is an important characteristic. It is common for numerous characteristics of fibers, on which the possibility of their processing and suitability for a certain purpose depend, to be classified into two groups: primary and secondary properties. [4,6,8,9]

Fineness of fibers

Fineness is a measure of the cross-sectional area of a fiber (Tab. 1). The smaller the surface, the finer the fiber, which means that it is thinner. Therefore, when determining the fineness, it would be correct to determine the size of the cross section. The fibers are very fine, so these surfaces are very small and difficult to measure. Due to this difficulty in determining the cross-sectional size of the fibers, the fineness is expressed by the length of mass, i.e. by the mass contained in a unit length of fiber. [4,6,9,10]

Table 1 Classification of textile fibers

Fine fineness [dtex]	Fiber group designation - according to fineness
More than 7	Coarse fibers
2.4 - 7	Medium fine fibers
1 – 2.4	Fine fibers
0.3 - 1	High Fine Fibers
0.4 and less	Microfibers

Fiber strength

Strength reflects the behavior of fibers under the action of various forces and loads. The stronger the fibers, the more loads they can withstand. The strength must be such as to enable the unobstructed processing of the fibers into various more complex textile products (as intended) and to ensure sufficient durability of those products during their use. In order to find out the strength of fibers, the maximum force that a fiber can withstand is measured. Breaking force [cN]. Different types of fibers differ significantly in strength, which is evident from the above data (Tab. 2). It should be noted that even within one type of fiber there are different types of strength. [4,6,8,10]

Table 2 Fiber strength under normal conditions

Fiber	Fiber Strength [cN/dtex]	Fiber	Fiber Strength [cN/dtex]
Raw cotton	3 – 4.9	Viscose - standard type	0.7 – 3.2
Linen	2.6 – 7.7	Viscose - HWM type	2.5 – 5
Hemp	5.8 – 6.8	Polyester (PES)	4.6 – 9.5
Juta	3 – 5.8	Polyamide (PA)	2.5 – 8.3
Ramia	5.5	Acrylic (PAN)	2 – 4.5
Silk	2.4 – 5.1	Modacrylic (MAC)	2.5 – 3.5
Wool	1 – 1.7	Polypropylene (PP)	3 – 7.5
Asbestos	2.5 – 3.1	Glass	6.3 – 7.2

Division of fibers according to origin

According to the origin, all fibers can be classified into two groups - a group of natural and a group of artificial fibers. Within its group, natural fibers are divided according to the type of natural source in which the fiber is formed, and in the group of artificial fibers we distinguish fibers from organic polymers and fibers that are made of inorganic material. Fibers from organic polymers are usually further classified according to the origin of the polymer, where it is important to distinguish artificial fibers from natural polymers and artificial fibers from synthetic polymers.

- Natural fibers: - vegetable: fibers from seeds, fruits, bark and leaves; - animal: hair, wool and silk and - mineral: asbestos.
- Man-made fibers: artificial silks: viscous copper nitrate and nitrate, copper, acetate; - cellulose wool and - protein fibers: animal and vegetable.
- Synthetic fibers: polymerization and polycondensation. Natural fibers - Plant fibers.
- The main ingredient in plant fibers is cellulose. [8,9,10]

CONCLUSION

Geosynthetics have proven to be the most efficient material of wide application. Its building elements provide great quality and multi-purpose use in civil engineering, building construction, mining, environmental protection.

Geogrids and geotextiles made of organic material are a natural and 100% biodegradable solution for erosion control using geomaterials mats made of coconut fibers. Organic geogrids have unique characteristics, consisting of biologically and chemically photodegradable natural fibers. They are designed to keep the land in place until vegetation is established. Geogrid or permeable geotextile provides a natural system of assistance (improvement of characteristics) to the soil and vegetation.

The installation of these efficient systems (geogrids, geotextiles, geomembranes...) in various branches of the ecology and industry and their expediency directly depends on the materials from which they are made. The application and selection of types and materials in road construction is important for (savings) improvements in the field of faster, safer and more efficient construction of road. It also refers to the protection and stabilization (strengthening) of surfaces (slopes) of landfills and other mining facilities, where the cover layer depends on the deposited material, size and shape too. [4,6,9]

As a possible saving solution in many cases, where an efficient result is required, both on the ecological and on the construction, safety, field security plan, there is a hybrid approach to the use of construction materials. Namely, by using (cross - hybrid) different types of materials in the production of geogrids or geotextiles, we can solve the seemingly contradictory requirements in their application. [4]

Special attention in further development should be paid to the use of new natural materials and hybrid technology (type) of geomaterials, as products of the future.

ACKNOWLEDGEMENT

Study research II & III - Preparing a topic for the Doctoral (- Doctoral dissertation)/ Scientific work.

REFERENCES

1. Bogićević, M. (2008) Construction. Belgrade, Serbia.
2. SRPS EN ISO 10318: (2015) Geosintetics - Terms and definitions. (ISO 10318: 2015).
3. Jovanović, M. (2019) Study research II (Doctoral dissertation): "Geosynthetics - purpose and application (in mining)", University of Belgrade, Technical Faculty in Bor.
4. Jovanović, M. (2019) Study research III (Doctoral dissertation): Organic geogrids, University of Belgrade, Technical Faculty in Bor.
5. Nonveiler, E. (1987) Slope sliding and stabilization. School book, Zagreb.
6. Veinović, Ž., Kvasnička, P. (2007) Surface landfills. Internal script. Faculty of Mining, Geology and Petroleum Engineering, University of Zagreb, Zagreb.
7. Zidar, M. (2009) Landslide remediation methods. Faculty of Geotechnics, University of Zagreb, Varaždin.
8. Sandra, L. (2009) Final paper work (PhD): Application of geosynthetics in landscaping - Faculty of Geotechnics, University of Zagreb, Varaždin [k 3 6].
9. Lukavečki, I. (2010/2011) About geosynthetics and applications in landfill remediation"; Final paper work; 1821.
10. Đorđić, D. (2016) Research of deformation characteristics of nonwoven geotextile materials made of polyester and polypropylene fibers" - Doctoral Dissertation.