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ECOLOGICAL AND ECONOMIC ASPECTS OF INSTALLATION OF COMBINED HYBRID GEOGRIDS AT MINING WASTE DISPOSAL SITES

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Abstract

Geogrids, with all their specificities in the production itself, their basic division and purpose of use - purpose, is based on the type of material from which they are made and the method of production itself. There are geogrids that are made of synthetic materials, geogrids made of natural materials, and a hybrid type of geogrid, which combines the materials and characteristics of the first two types.

Organic type geogrids have unique characteristics, they consist of biologically and chemically degradable natural fibers. They are designed to hold the soil in place until natural vegetation is established. Geogrids (geotextiles) made of synthetic materials have much greater strength, elasticity and durability.

By combining these types (consumable material) of geogrids (and geotextiles) in the form of a kind of hybrid technology for the production of these products, we obtain useful parameters suitable in the field of environmental protection and the required mechanical and temporal usability. In this paper, we will call such type of geogrids hybrid geogrids.

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

Keywords: Geogrids, geosynthetics, hybrid geogrids, hybrid materials, natural fibers and synthetic (artificial) materials

1. INTRODUCTION

Geogrids provide tensioning for various types of landfills, foundations, foundations of railway lines, roads, steep side earth embankments, transfer of loads on extreme mass terrain, arrangement of deep holes and areas of irregular profiles, covering of trenches, etc.

With their tensile strength, geogrids are suitable for various types of demanding projects. This type of geo-grids are excellent reinforcement elements, as they withstand high tensile loads with very little elongation. This results in immediate connection and coupling of the forces that the geogrid develops on the embankment without basic deformation.

By crossing (combining) different materials, when making geogrids in the form of a certain hybrid technology of making these products, we get usable parameters suitable in the field of environmental protection and the necessary mechanical and temporal usability (longevity).

The basic division according to the type of material from which geogrids are made is synthetic and natural (organic).

Organic geogrids have unique characteristics consisting of biologically and chemically degradable natural fibers. They are designed to hold the soil 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. [1,2,3,4]

Geogrids are most often used in the cover protection composition of landfills, where the cover structure can take over the tension that occurs due to the differential settlement of the deposited waste.

At waste disposal sites, geogrids are most often used to strengthen the sides - the edges under the waste, as well as to strengthen the cover in the zones above the geomembrane (if necessary) (Fig. 1). In geotechnical engineering, they are most often used to strengthen and stabilize weakly load-bearing soil. [1,3,5,6,7]



Figure 1. *Representation of covering (covering) the slope of the landfill with a geogrid*

2. EXPERIMENTAL

Geogrids - materials, types and differences

Geogrids are basically made of polymer materials such as polyethylene, polyester and polypropylene and are characterized by high tensile strength. The original geogrids were made by drilling holes in a sheet of material. Today, such geogrids are made by the so-called extrusion process. Now we have geogrids made of polyester fibers coated with polyethylene. Many unbroken fibers are combined into a thread, which is then woven in longitudinal and transverse directions with a certain distance between the ribs, and the folds are additionally strengthened and then the fibers are coated.

Geogrids (Fig. 2./ a., b. and c.) are most often used to strengthen and stabilize weak soil (mining waste surfaces, etc.). In some cases, the material, the fraction of which is larger than the opening of the mesh, is piled on the geogrid and the material is trapped in the openings of the geogrid and a system resistant to external forces is created.

Depending on the manufacturer, geogrids may differ, but their primary function and mode of operation is the same.

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



Figure 2. *Examples (layout) of different types of geogrids (a., b. and c.)*

The application of anti-erosion geotextiles and geogrids can increase and support the effect of erosion control in areas with particularly steep slopes or with subsoil susceptible to erosion. [1,3,4,7]

2.1. Organic geogrids

The greatest role of vegetation in protecting the slope from erosion and its stabilization is ensured when its surface enables the establishment of a given vegetation and allows water to flow at a certain speed and intensity on the surface, thereby preventing the degradation of the vegetative cover.

They are designed to hold the soil in place until vegetation is established.

An 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 compared to dry weight
- Allows avoiding the loss or dispersion of seeds necessary for revegetation
- Ensures root establishment of plant species
- Allows control of soil temperature by mitigating its natural oscillations: so that extreme temperatures can be mitigated and create a pleasant micro-climate for the growth of vegetation.
- Allows reduction of soil moisture loss

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 allow the bond between them to develop allows for a reduction in soil loss by 90% or more. After degradation, they do not leave any toxic material. [5,8,9]

"Geo-Utah" - Geonetwork of Utah

Jute is an annual plant that requires a very warm climate and a lot of moisture. Jute trees are processed in a similar way to flax. It is grown in India, Pakistan, Algeria, China and the tropical regions of America.

A jute geonet (fig. 3) is used to cover slopes and protect against erosion. Jute yarns are thick with pronounced 3D characteristics and provide a series of mini-barriers, reducing the rate of water runoff. The openings of the jute net prevent the displacement of soil cleaners.

Geogrid woven from jute has an excellent ability to shape and follow the contours of the soil on which it is placed. It absorbs water up to almost 4-5 times its dry weight, storing rainwater and preventing soil separation. In wet conditions, its flexibility increases due to water absorption.

Jutana geogrid provides surface stability on steep slopes and slopes with an angle of about 45 degrees. When the vegetation starts to grow, it takes over the role of a jute geogrid.

Coconut Geogrid

Geotextile made of organic material (coconut) is a natural and 100% biodegradable solution for erosion control using a geotextile mat made of coconut fibers. The permeable geotextile provides a natural support system (improvement of characteristics) to the soil (soil) and vegetation.

Coconut fiber is obtained from the husk of the coconut. They are naturally strong, durable and biodegradable.

Coconut geonet (fig. 4) is a very strong and durable network. The open weave allows for seed and vegetation to be planted both before and after the mat is installed, and offers strong support to the vegetation.

On steep slopes, which are more prone to erosion, an organic geogrid can be installed in combination with metal or synthetic nets. Organic geogrids achieve successful erosion protection through vegetative growth. When vegetation is established, organic geogrids no longer serve as protection. The metal or synthetic mesh remains permanently as an active or passive slope protection. The geogrid can be placed up to 60 degrees, with the support of the metal grid, while the coconut geogrid combined with the metal grid can be placed on vertical slopes.

As shown, organic geotextiles are a very useful means of protecting a steep slope until vegetation takes over and permanently protects it.



Figure 3. *Jute geogrid*



Figure 4. *Coconut geogrid*

2.2. Synthetic geogrids

Synthetic geogrids are synthetic products (geosynthetics) that are used to stabilize the terrain. The polymer nature of the products makes them suitable for use in the 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 well established, will not be able to survive under the erosive force of the water. [3,4,6]

2.3. The main environmental aspects of their application include:

a) Reducing the exploitation of natural resources: Using hybrid geogrids significantly reduces the need for natural aggregates (sand, gravel). They enable soil stabilization with thinner layers of material, which directly reduces the need for excavation and transportation of raw materials.

b) Support for vegetation development: In contrast to fully synthetic nets, hybrid varieties with natural fibers act as "mulch" - retain moisture, regulate soil temperature and provide a stable basis for plant growth. In that (natural) process, the key items are:

- Biodegradability: The natural parts of the net decompose over time without toxic residues, leaving behind a developed root system that takes over the function of stabilization.
- Preservation of the ecosystem: They prevent erosion and habitat degradation during construction works. [4,5,6,10]

3. RESULTS AND DISCUSSION

Application and durability of hybrid types of geogrids

Surface erosion can cause damage and instability that can lead to failure/sliding of the landfill (mining waste) cover. For situations where there is less risk of erosion, even the vegetative cover is sufficient in itself as protection. The natural (organic) type of usable fibers allows for the planting of seeds and vegetation both before and after the installation of the geogrid and offers strong support to the vegetation.

Once vegetation is established, organic geogrids no longer serve as protection. This is where synthetic materials in geogrids come in, which significantly improve tensile strength and permanent active and passive protection - strengthening the slope of the landfill.

The lifetime of organic - plant fibers in the geogrid varies, mostly, in the range of 3-4 to 10 years. The lifespan of synthetic fibers is very long and generally exceeds 100 years. [4,6,10]

4. CONCLUSION

Geogrids and organic geotextiles are a natural and 100% biodegradable solution for erosion control using coir or jute fiber geomaterial mats. They are designed to hold (stabilize) soil material in place until natural vegetation is established.

The installation of these efficient systems (geogrids, geotextiles, geomembranes...) which foresees the protection and stabilization (strengthening) of the surfaces (slopes) of landfills (dumps/ mining waste) and other mining facilities, where the covering layer also depends on the deposited material, size and shape.

As a possible solution for savings in many cases, where an efficient result is required in terms of ecology, safety and protection on the ground, there is a hybrid approach to the production of geomaterials. By using (hybrid) combined types of materials (organic and synthetic) in geogrids/geotextiles, we can solve seemingly contradictory requirements in their application.

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