v. 3, n. 8, 2023

Journal of
Engineering
Research

METHODOLOGY FOR SIZING DRAINAGE CHANNELS WITH HDPE GEOCELLS FOR WIND AND PHOTOVOLTAIC FARMS

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Abstract: Currently, our society has a strong preference for the use of renewable energy sources due to their benefits in terms of pollution, generation of toxic gases or waste emitted into the environment. Globally, the most common alternative sources are solar and wind energy, converted into electricity on large farms. Due to their large extensions, during periods of rain these regions can concentrate large volumes of water, generating erosion, and can "wash" the foundations, putting the cementing of structures at risk. This problem is usually solved with the execution of a surface drainage system, however, as it is generally located in regions far from cities, which makes it difficult to implement conventional solutions in reinforced concrete, gabions, rockfalls, etc. In this work, the methodology to be used for the correct dimensioning of drainage structures through the use of high-density polyethylene (HDPE) geocells will be demonstrated, as well as the main benefits that these structures present in relation to conventional drainage structures.

INTRODUCTION

As a general rule, whether in mining, landfills, photovoltaic plants, wind farms, or urban drainage, channels are usually lined with reinforced concrete or stone materials. Therefore, the construction costs of these structures consume high percentages of the total investment in new infrastructure and water maintenance. These costs also include the scarcity of stone material that can make stone or concrete works unfeasible, with little flexibility to adapt to possible deformations of the ground, construction and/or maintenance deficiencies due to poorly trained labor in the region, etc.., which can cause leaks. in structures, geotechnical and erosive damage, in addition to a reduction in carrying capacity due to reduced transport flow, which can become significant repair or recovery costs, which greatly compromises the viability of hydraulic projects.

It is in this scenario that geosynthetics become an alternative of great interest for irrigation projects, conduction and / or drain. Specifically, materials such as high-density polyethylene (HDPE) geocells are available, which make it possible to eliminate the use of steel in reinforced concrete structures and also reduce the thickness of the concrete or aggregate layer, such as gabion or masonry boxes, forming structures. with "relative" flexibility to conform to complex shapes and slightly irregular surfaces.

HDPE GEOCELLS

HDPE geocells are geosynthetic materials developed by the US Army Corps of Engineers and consist of a set of HDPE strips connected by a series of ultrasonic weld beads. Extending out, the interconnected bands form walls of a beehive-like "cellular confinement" structure that can be filled with materials such as vegetation substrates, gravel, mortar, or concrete.

The use of HDPE geocells in channel and surface drainage projects has grown at a rapid rate, largely due to the great advantages geocells offer over conventional structures. For example, HDPE geocell liners eliminate the use of reinforcing steel, form placement and removal, construction, and expansion joints.

GEOCELL LINER SYSTEM

When filled with concrete, HDPE geocells form a protective layer heavy enough to withstand the tensile forces generated by the transported flow, sufficiently resistant to abrasion (directly related to the compressive strength of the concrete used) and due to the presence of highly flexible geocells, capable of adapting to different open channel geometries as well as possible deformations in the foundation.

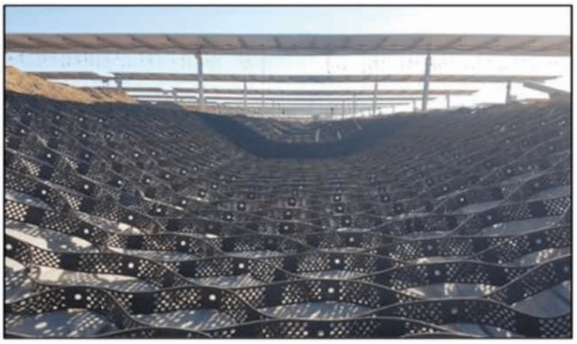

Figure 1.- HDPE geocells used in channel protection.

The success of protective channel lining using concrete-filled geocells has led this alternative to increasingly ambitious applications, such as the construction of structures to withstand high-velocity flows. Unfortunately, these applications in some cases have been accompanied by poor quality materials, out of specification (eg GRI GS15) or without the correct properties to properly interact with the fill material, producing satisfactory results in some cases and, in most of the cases, adverse results.

GEOCELL SELECTION CRITERIA

The use of channel protections including HDPE geocells is not new, either for open channels, channels with energy dissipators, calming basins, surface drainage structures, as well as drainage in closure of landfills and mines.

However, it is important, to avoid failures, to know the Critical properties when calculating and specifying geocells, such as:

Perforations and texture of walls. Being polymeric materials, geocells do not adhere to concrete, so they need characteristics to be able to work together with it, mainly to avoid the loss of blocks during the life of the structure. To guarantee this interaction between the filling material and the walls of the geocells, they must have both perforations and a texture that guarantees this blockage and that it cannot be removed with simple efforts, either by extraction or pressure.

Geocell size. To guarantee this mechanical interlock between the concrete and the walls of the HDPE geocells, the shrinkage of the concrete installed inside must also be controlled. The shrinkage of the concrete block is directly related to the size of the geocell, since the larger the size of the concrete block, the greater its shrinkage. The important thing is to define the size of the geocell so that the shrinkage of the concrete is less in the depth of the texture, in the form of a diamond, stamped on the walls of the HDPE geocell.

Geocell height. For its application in open channels, the CIRIA report "Design of reinforced grass waterways (1987)" is widely used, which suggests the use of a certain filling height depending on the flow velocity, based on the results of hydraulic tests performed on articulated and semi-articulated block linings. This study recommends the use of coatings up to 200 mm in height, when subjected to velocities equal to or greater than 7.0 m/s. For stone fill scenarios, the concept is similar.

CHANNEL PROTECTION DESIGN WITH GEOCELLS

For the dimensioning of the canal protection structures, it is extremely important to determine the magnitude of the active forces and the abrasion generated by the fluid to be transported by the hydraulic structures. For this reason, the verification of the stability of the channel protections with geocells is carried out mainly through two analyses, the first of shear resistance and the following of verification of the permitted speeds.

For the determination of the shear stress of the structures, formula 1 can be used, which is presented below.

$$\sum Fx = F_1 + \gamma ALsen\alpha - F_2 - \tau_0 PL = 0 \qquad [1]$$

Where:

y : volumetric weight of fluid. (kN/m^3);

A : wet area. (m^2).

A : Length (m).

τ_0 : Shear strength. (kN/m^2).

P : wet perimeter. (m).

In addition, depending on the location of the farms, there are other parameters that must also be considered in the dimensioning of the drainage structures, such as the deformations, resulting from the installation on surfaces in soils with low load capacity, and under pressure, derived of the concretion of precipitate behind the geocell lining, either by accumulation of surface water or by a rise in the water table.

SUCCESSFUL WORK CASES

Next, some work cases carried out where HDPE Geocells were used to replace reinforced concrete structures.

Figure 2.- Photovoltaic plant in Brazil. The largest plant in operation in South America.

CONCLUSIONS

There is a wide variety of geocells on the market, it is up to the designer to select the most appropriate material, given the adversities of each project, to determine the best type to consider. Among the main advantages of using HDPE geocells, we can mention the speed of installation and the absence of specialized labor for the execution, which, even generating a higher initial value in the purchase of materials, compared to conventional structures, the final return of it. the investment can reach up to 50% savings for the client.

Currently, several researchers have actively supported the execution of works in this area, in order to provide customers with detailed technical information and calculation processes, as well as materials made with the best available resins, ensuring good performance and long-term durability. A long list of successful works provides the confidence to calculate and construct hydraulic drops safely and with the certainty that the great advantages of HDPE geocells, in this type of application, will last over time.

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