Case study: use of terramesh to recovery erosions in tailings and water reservoirs

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ABSTRACT: Geotechnical Engineering has been increasingly challenged to develop projects that combine an excellent technique to the short lead time, low cost, high stability and sustainability in the proposed solutions. In this sense, has been in increasingly applicant using geosynthetic elements, once the versatility of this type of material allows the manufacturers make available continuously new products and solutions, with specific properties that best meet the needs of each project. The process of improving the performance of existing products is solid, based on research and the comments of geosynthetic behavior for certain type of work. The case study that will be presented demonstrates Green Terramesh system on recovery of erosions on the banks of a reservoir of water, which has been silted by tailings. The system is formed by association of a metallic mesh reinforcement double hex twist wire steel with low carbon coated with the metal alloy, a front facing the same cloth, associated with a Panel in geotextile, reinforced by steelrods and welded screen, supported by two metallic elements in the form of “French hand”, resulting a high tensile strength and low elongation, with front facing able to develop vegetation. The dredged material was used to fill the sections and it was used a top soil of organic material to allow the growth of vegetation. On the base, it was used a mattress base with gabion blocks, to guarantee the safety and protection against washout at the base. In order to ensure water drainage infiltration it was designed a drain formed by a “geocomposto” and corrugated pipe in polyethylene, with the downstream exit from the landfill.

Keywords: Terramesh, Geosynthetic, Erosions recovery

1 INTRODUCTION

The system of reinforced earth embankments is based on the reinforced soil principle and consists of the introduction of properly oriented traction resistant elements that increase soil resistance and decrease the deformability of the mass. In this method, the overall behavior of the massif is improved as a function of the transfer of stresses to the resistive elements (reinforcements).

In general, soils have high resistance to compression efforts, but low resistance to tensile stresses. When a soil mass is loaded vertically, it undergoes vertical deformation of compression and lateral deformation of extension (traction). However, if the ground mass is reinforced, lateral movements are limited by the reduced deformability of the reinforcement. (DURAN, 2005). This deformation restriction is obtained as a function of the development of tensile stresses in the reinforcing element.

The Green Terramesh element is formed by woven geogrid produced with a double twist hexagonal mesh, type 8x10 (NBR 10514), made from low carbon steel wires, in diameter 2.70 mm, coated with alloy. These wires are further protected by a layer of polymer. The elements are formed from a single screen cloth, which ensures structural continuity between the front facing and the anchor panel. These elements present their front facing composed by the hexagonal double twist mesh, reinforced by five rods of steel, low carbon (BTC), of diameter 3.4 mm, with the same properties of the wires used in the making of the mesh, for a 450 g/m^2 coconut fiber biomanta or a flexible, three-dimensional, polypropylene (polypropylene), 10 mm thick, by a 16 cm x 16 cm mesh electro-welded reinforcement panel with steel bars corrugated steel of 8.0 mm in diameter and finally by two triangles of corrugated steel with 8.00 mm in diameter and inclination of 45°, for positioning of the front facing. Figure 1 illustrates the element used in the project in question.

For the assembly and installation of this elements, the same type of wire used for the making of the meshes was used for mooring and pulling operations, in the diameter of 2.20 mm and in the approximate amount of 2% on its weight.

The Reno mattress, used as a protection at the base of the front facing, was produced with hexagonal double twist mesh, type 6x8 (NBR 10514), made from low carbon steel wires in diameter 2.00 mm, alloy coated. These wires were further protected by a layer of polymer and the mooring wires were of the same type as the meshes. To fill the Reno mattress were used stone blocks of stone from 15 to 20 cm in diameter.

For internal drainage, corrugated tube was drilled in high density polyethylene and external diameter of 101 mm, associated to a geocomposite (11.0 mm thick) with three-dimensional polypropylene filaments core, heat-sealed to two non-woven polypropylene geotextiles.

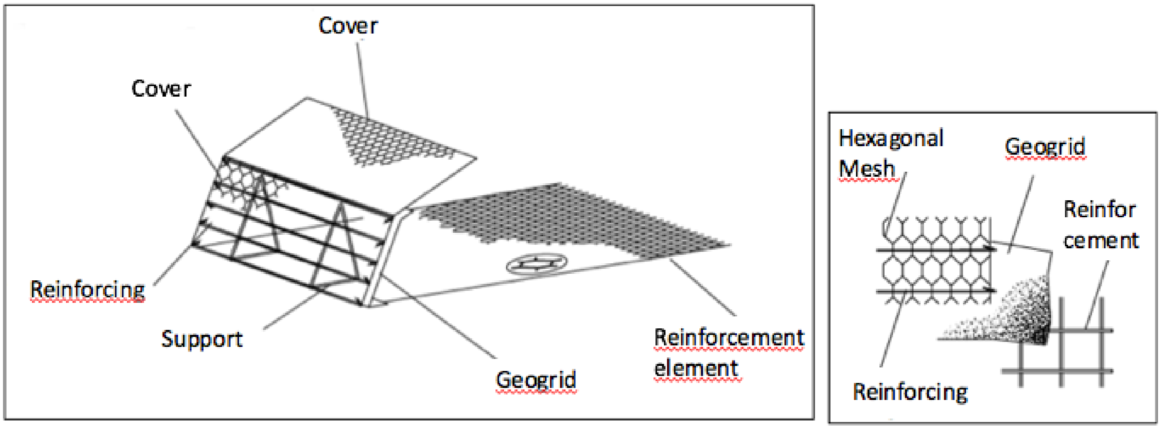

Figure 1. Elements of Green Terramesh.

2 PROJECT DESCRIPTION

From the geological point of view, the recovered area presented granite-tonalitic orthogneiss features, with tectonic contacts due to jerks and metamorphic suites constituted by a set of banded gneisses with laminates, with frequent intercalations of amphibolite and calcissilictic rocks. There are also narrow bands with quartzites and Muscovite schists, ferruginous rocks, which do not show definite relations with previous lithologies. The dominant lithotype was amphibole-biotite-gneiss, regularly banded in scale, generally having a gradation between the various bands.

The geological-geotechnical scenario was defined based on the surveys performed, being composed of cover / residual soils, saprolitic soil of gneiss, saprolite, altered gneiss and gneiss, representing the same profile of alteration and rock textures. It was also sampled in a probe of diabase cutting the gneiss. The sounding record showed rock as saprolite, being the estimated rock horizon in the sections. In addition to these lithotypes there was the registration of an area containing debris from an old landfill related to the access road.

The geological-geotechnical investigations had the objective to characterize the foundation of the region of the study, as well as the loan materials to be used in the proposed solutions. The surveys had a soil horizon of 18.0 to 21.0 m, the rock being between 7.0 and 3.0 m. Deformed and undisturbed samples were collected for characterization of the foundation and verification of the possibility of using material as loan, including the waste from silting.

The laboratory tests characterize the samples collected from the foundation, described by geology as a colluvium, as a silty clay sand, with a mean dry weight of 2.8 g/cm^3. The triaxial resistance test obtained effective parameters of 20.8 kPa and 20° for cohesion and friction angle, respectively. The maximum specific dry weight and optimum moisture content, on average, were 1.65 g/cm^3 and 20.55%, respectively. The plasticity and liquidity limit tests indicated a low to medium (10%) plasticity index, classifying the material, according to the plasticity chart as a low to medium plasticity (ML) silt, with regular workability. Thus, due to plasticity and clay character, as well as resistance parameters, it was concluded that the results were favorable to the use of colluvium material from this region as a loan.

The tests performed on the tailings sample characterized the material as a silty sand. The resistance parameters were cohesion and friction angle of 14.6 kPa and 32°, respectively. The compaction test had maximum specific dry weight and optimum moisture content of 1.53 g/cm³ and 7.2%, respectively.

From the results presented, it was possible to estimate the parameters of the main materials to be considered in the stability analyzes, necessary for the studies to recover slope erosions, as presented in Table 1.

Table 1. Geotechnical Parameters

MATERIAL	γ (kN/m³)	c' (KPa)	ϕ' (°)
Colúvio	17,50	21,00	20,00
Saprolítico Soil	14,00	13,00	31,00
Tailing	16,00	14,60	32,00
Reaterro	19,00	10,50	31,00
Saprolito	20,00	35,00	30,00
Altered Rock	22,00	80,00	40,00
Rock	23,00	150,00	42,00
Landfill	19,00	12,00	30,00

Stability analyzes were developed using Rocscience's Slide software, version 5.0, based on the Limit equilibrium method, based on Bishop's analysis, and adopting the Mohr-Coulomb criterion of breakdown in terms of effective stresses. Maccaferri MacStars 2000 software was also used to check the stability of the wall.

Regarding the determination of the safety factors, in terms of effective voltages, the following general assumptions were considered:

- Isotropic and homogeneous materials
- Circular round slope global rupture
- Safety factor (FS) minimum of 1.50 for normal groundwater table (SFN), as recommended by the ABNT / NBR 11682: 1991 Standard for Slope Stabilization
- Global rupture for reservoir level in current and operational condition - FSmin of 1.50
- Verification as wall of gravity for the foundation - FSmin of 3.00

3 RESULTS AND DISCUSSIONS

The Green Terramesh is formed by an external facing properly sloped (70°) to facilitate the development of the vegetation. Its front face consists of, in addition to other elements, a panel in geomanta (synthetic) or biomanta (biodegradable), to avoid the escape of the fines of the ground and, at the same time, to allow the growth of the vegetation. It has the advantage of having a minimum environmental impact, due to its external facing with vegetation cover, similar to a natural slope, and to be an alternative when there is a shortage of rock blocks in the place. In this case study, it was still possible to use the material of the reservoir (silted material) as a backfill core.

The pieces of wall used were of size 7.0 x 4.0 x 0.60 m, with geogrids for reinforcement of 13.0 m extension. The backfill was proposed with the material of the tailings itself, characterized by laboratory tests. Planting vegetation on the front wall was designated as optional, since will be largely drowned when the reservoir reaches its operational level. However, the adoption of vegetation planting was adopted and was carried out by hydrosedeeding, making possible the growth of the same on the frontal surface of the wall. During the execution of the backfill, near the frontal face, was used vegetal or organic soil, of clay character.

To ensure safety and protection against overlap in the base a Reno mattress with gabion blocks was implanted at the base of the system. In order to ensure the drainage of the infiltration water in the backfill, a drain formed by geocomposite and corrugated polyethylene pipe was provided, with outlet downstream of the landfill. This internal drainage was only foreseen for the period in which the level of the reservoir is lowered, having no more functionality when it is operating at its normal level. For the drainage of surface runoff a final slope of 1% in the backfill was provided in order to conduct the water to the dimensioned channels.

The implementation of the wall was carried out concomitantly with the backfill. The lateral closure was done with Terramesh itself, in the natural slope region, and in the connection with the concrete bus of the Hydroelectric Plant a geotextile was installed as a transition, in order to avoid the passage of fines. In the region of junction with the bus anchorages or similar were not foreseen, which does not affect the stability of the structure as a whole, since it is the reinforced landfill the main factor that acts in the stabilization.

Stability analyzes performed indicated safety factors between 1.65 and 1.95, and an example of the evaluations performed was presented in Figure 2.

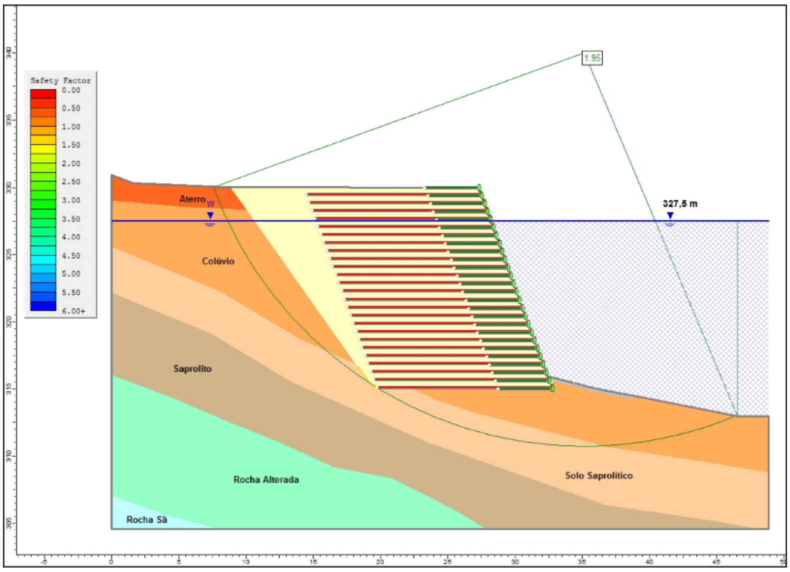

Figure 2. Slope Stability.

The system presents the same technical advantages of the gabions, as flexibility, permeability, monolithic and executive facility, besides being a very economic solution since it allows the use of local soil to compose the reinforced massif. In addition, the system has additional advantages such as tensile strength, good adhesion to the ground and high capacity of not deforming over time under constant tension and dynamic loads. The terramesh walls are ideal for works in which it is necessary to reach great heights and great resistance to overloads.

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