Construction of the wall of the k128 Alto Magdalena way, with site material and monodirected geotextiles.

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ABSTRACT

The design of soil reinforced walls is a topic of special importance in the development of infrastructure projects, mainly because of the possibility of using materials from nearby excavations, which, without the use of Geotextiles, could not be used as filling material allowing compensated designs and minor environmental effects.

In this work, was studied different configurations of the structure, different inclinations of face and how they faced site conditions not initially planned in the approach of the bridge that was replaced with a soil reinforced wall, which would allow the construction of the road structure.

To understand the contribution of the inclusion of the Geotextile, different modeling were carried out looking for minor deformations, improving the construction processes and a stable and durable structure without the need for deep foundations. The modeling was carried out with monodirectioned geotextiles, reducing costs and allowing greater resistances to be used, based on an understanding of the mechanical functioning of the structures.

The filling material of the wall came from the excavations adjacent to the construction site, so the design was adjusted to the mechanical properties of the available material, without the need to import materials from distant sites.

RESUMEN

El diseño de estructuras en suelo reforzado, es un tema de especial importancia en el desarrollo de proyectos de infraestructura, principalmente por la posibilidad de utilizar materiales provenientes de excavaciones cercanas, que, sin la utilización de Geotextiles, no podrían ser utilizados como material de relleno, permitiendo diseños compensados y menores afectaciones ambientales.

En este trabajo, se muestra la evaluación de diferentes configuraciones de la estructura, diferentes inclinaciones de cara y como se enfrentaron condiciones de sitio no previstas inicialmente en el planteamiento de la estructura tipo puente que se remplazó con el muro en suelo reforzado, que permitiera la construcción de la estructura vial.

Para comprender el aporte de la inclusión del Geotextil, se realizaron diferentes modelaciones buscando menores deformaciones, mejorar los procesos constructivos y una estructura estable y durable sin la necesidad de realizar cimentación profunda. Las modelaciones se realizaron con Geotextiles monodireccionados, disminuyendo costos y permitiendo utilizar mayores resistencias, a partir de la comprensión del funcionamiento mecánico de las estructuras.

1. INTRODUCTION

The Alto Magdalena road links the towns of Girardot - Honda Puerto Salgar, where a large part of the intervention consists of the geometric expansion and improvement of the route.

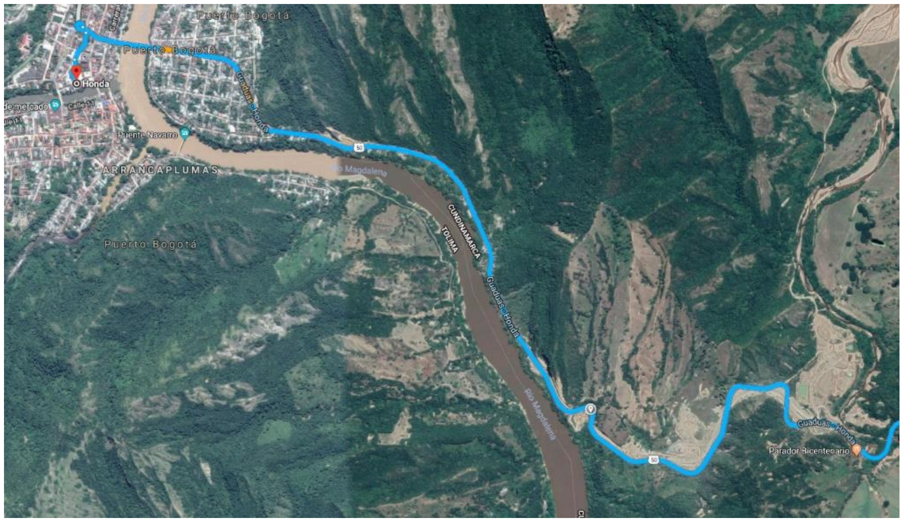


Figure 1 project location

The wall to be treated, the use of the methodology for walls in reinforced soil, included in the Manual for the design with Pavco Geosynthetics, was proposed and is located at Kilometer 128 of the road, whose abscised start from the city of Girardot . The alignment of the road borders the mountainous area that forms the valley of the Magdalena River, which serves as a border between the departments of Tolima and Cundinamarca.

Within the initial alignment of the track, a V-shape is presented, generating a low speed zone and defective alignment for the passage of large cargo vehicles.

Figure 2 Construction zone

To improve the alignment of the track, the construction of a bridge-like structure was contemplated, to eliminate the curve of the path, leaving a straight alignment of better specification. Subsequently, within the analysis of alternatives that was studied for the development of the project, it was determined that the use of a specific bridge, to generate the improvement, was very expensive, due to the foundation of the structure and the execution times of the project. via; Therefore, an analysis of alternatives was initiated, including concrete walls, granular fillings and mechanically stabilized floor walls.

Within these analyzes, technical and economic aspects were observed, finding that the best option resulted in the construction of a floor wall reinforced with woven geotextiles.

The final proposal consisted of two faces connected by the reinforcement, one directed towards the existing alignment and the other face towards the area of the Magdalena river valley.

Initially, a structure with an inclination of 75 ° was raised, looking for a lightened slope, which allowed reducing the requests on the Geosynthetic to be used as reinforcement and not significantly increasing the volume of filling material.

This alternative was considered appropriate, until the arrival of the winter season, which showed that, with this geometry, the level of the river could generate undermining of the foundation of the wall, affecting its stability and that of the road, so that it was necessary to start the whole process of calculating the structure's stability.

To achieve a stable structure, and with adequate conditions of stability and foundation, the necessary calculations were made, finding that the structure could have an inclination in its85 ° face and a maximum height of 23m and 2m depth of offset.

Figure 3 Wall in reinforced ground finished

2. OBJECTIVE

Know the economic and environmental advantages of the solutions through soil reinforced with geosynthetics and how this gave solution to the construction of the wall of the K128 of the Alto Magdalena concession, describing its characteristics and benefits

3. GENERAL TOPICS

Reinforced soil walls are flexible containment structures, internally stabilized by the action of placing reinforcements with Geosynthetics.

Reinforced ground walls are an alternative to traditional retaining walls systems (such as reinforced concrete walls, embankments on the ground, gabion walls, etc ...), which allow the construction of retaining walls in places where capacity foundation floor bearing is not sufficient for rigid walls.

These walls are built to laterally retain a certain volume of soil, which undergo a lateral pressure known as soil thrust, this pressure is due to the weight of the soil itself and the dead and living loads that gravitate on the surface of the soil retained.

The design of the Reinforced Ground Walls (MSR) adapts to a wide variety of loads, solicitations, geometry, environmental and landscape aspects. The methodology for designing structures reinforced with Geosynthetics considers three stages.

3.1 Stages

- Design for internal stability: This establishes layer thicknesses and reinforcement lengths.

- Review of external stability: A limit equilibrium analysis is performed to obtain the slip, turn and bearing capacity safety factor which is compared with the established safety factors.
- Type of wall facade and drainage and sub-drainage conditions. Special care must be taken with the drainage system of the walls to prevent the presence of water in the wall and excess pore pressure in the soil mass.

The Design methodology used for walls in reinforced soil is based on the approaches proposed by Whitcomb and Bell (1979), since it is the easiest methodology to handle. It is assumed that hydrostatic pressures are not present in the structure and that the active fault surface is a flat surface defined by the Rankine methodology. It has been defined as 70°, the minimum inclination for the retaining walls, otherwise the case would be that of an embankment or a slope, where the fault surface is curved and the methods used to determine it do not conform to Rankine's . The design principle consists in obtaining reinforcing layers with geosynthetics of certain resistance by means of a limit equilibrium analysis, so that an internally stabilized soil mass is obtained. This ground mass stabilized by the action of its own weight supports lateral thrusts. This is defined as the calculation of internal stability.

In internal stability, the amount of reinforcement is determined that allows the earth thrust, the separation between layers and the length of the layer to be supported by tension and anchorage.

Below are the data that should be known and calculations to be made to reach the final values.

3.2 Values to be determined

- Determine the preliminary dimensions of the wall.
- Dimension the base of the wall.
- This dimension should be reviewed during the external stability analysis.
- Develop lateral land pressure diagrams for the reinforced section. These are made up of the sum of the values obtained for the lateral earth thrust, for dead, live and seismic loads.
- Calculate the maximum horizontal stresses in each reinforcement layer.

For the dimensioning of the reinforcement of the containment structures, the slide computational tool was used to assess the overall stability of the wall.

4. SYSTEM DESCRIPTION

Because the wall is located far from quarries with granular materials, it was necessary to take advantage of the materials coming from the excavation of nearby sectors, where cuts were made for the extension of the road, so it was decided to build a wall mechanically stabilized with woven geotextile and cutting material, allowing a reduction of earthworks and therefore a considerable reduction of costs. In addition, with an abrupt relief, all spaces should be optimized, and a constructive facility offered.

Among the materials present in the area, and which would serve as the foundation of the structure, the following materials were available:

Table 1. Characteristics of soils.

Characteristics	Unit Weight (kN/m^3)	Cohesion (kPa)	Phi (deg)
silty sand	18	15	30
Hor B sandstone	20	25	31
sandstone	20	90	40

For the filling material, laboratory tests were carried out on the materials from the nearby excavations (Table 1), where the predominant material was silty sand, finding that the material would have a weight of 20 kN / m3, a cohesion of 15 kPa and a friction angle of 30 °; This as minimum conditions.

Due to the conditions of space limitation, foundation conditions and proximity of the Magdalena River, a geometry with an inclination in the face of 85 ° was required; obtaining that the structure would have a free height of 23m and a depth of displacement of 2m.

With the height of the structure and the materials available for filling and those present for the foundation of the structure, the use of Geosynthetics with high strengths was required, but due to the origin of the materials that would make up the body of the wall, the use was ruled out of Geogrids, since the material to be used was predominantly sand, which does not allow the formation of interlocking between granules and Geogrid

The fillings of the structure were compacted to 95% of the modified Proctor test and reinforced with woven geotextile layers with resistances between 50 KN / m and 300 KN / m with the separations and lengths shown in Figure 4. All fillings carry a drainage system conformed by geocomposite.

As protection against erosion and photodegradation of the Geotextiles, all faces were vegetated with permanent mat, seeking the establishment of vegetation; In this way you are more friendly with the environment and the wall is integrated into the natural environment of the site.

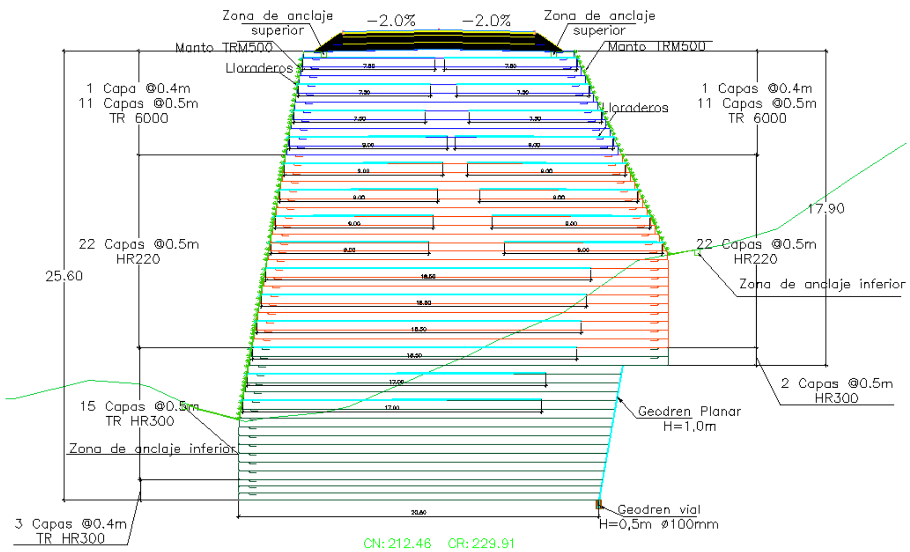
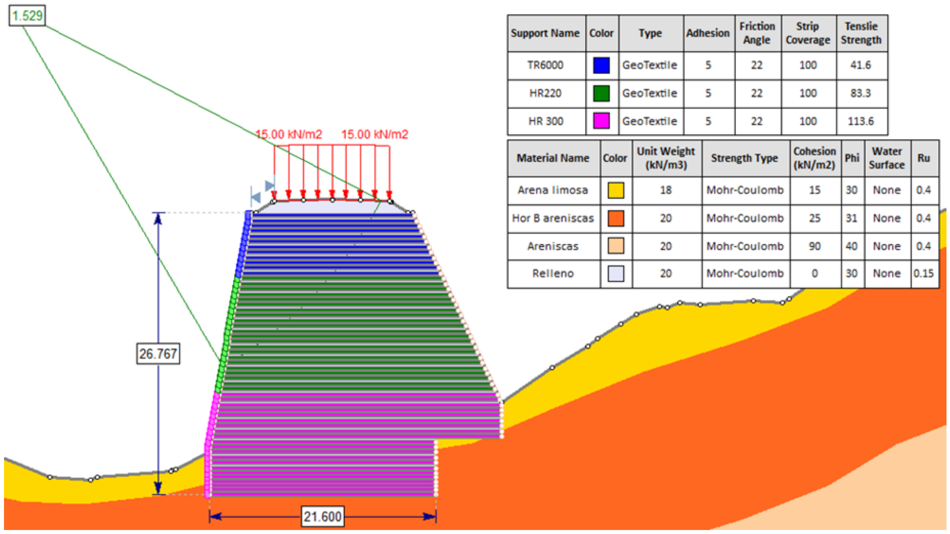


Figure 4 Critical Section of the Reinforced Soil Wall

Given the topography conditions, and the curve presented by the existing road, when taking the same shape of the relief, the reinforcement of both sides of the structure was required, without allowing the placement of a large volume between the wall and the natural terrain.



Support Name	Color	Type	Adhesion	Friction Angle	Strip Coverage	Tenslie Strength
TR6000		GeoTextile	5	22	100	41.6
HR220		GeoTextile	5	22	100	83.3
HR 300		GeoTextile	5	22	100	113.6

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kN/m2)	Phi	Water Surface	Ru
Arena limosa		18	Mohr-Coulomb	15	30	None	0.4
Hor B areniscas		20	Mohr-Coulomb	25	31	None	0.4
Areniscas		20	Mohr-Coulomb	90	40	None	0.4
Relleno		20	Mohr-Coulomb	0	30	None	0.15

Figure 5 Global stability evaluation of the Critical Section of the Reinforced Soil Wall

Another important element in the construction of this wall, was the need for the construction and passage of a Box Culvert, under the wall, so it was necessary to adjust all the reinforcement layers, so that the layer that started immediately above the structure in particular, it will adjust so that the reinforcement is continuous and an effect of adequate distribution of the stresses is generated, avoiding that the difference in stiffness and settlements between the wall and the structure in particular, generates damage or unwanted deformations in the structure, affecting the pavement structure of the track.

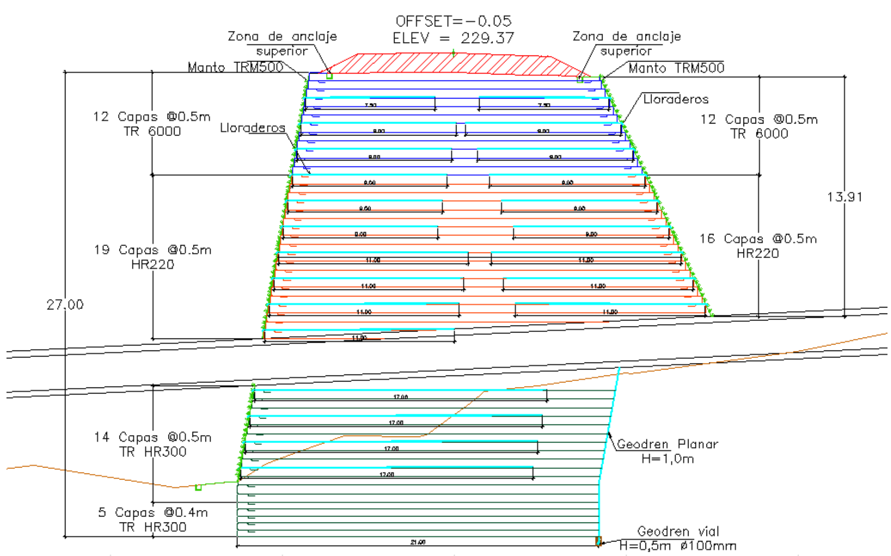


Figure 6 Critical Section of the Reinforced Soil Wall with box culvert

Currently the structure is finished and in operation. In total, just over 50,000 m2 of woven geotextile and 10,000 m of geosynthetics were used for drainage.

Additionally, the construction of an extensive drainage channel system was carried out, seeking to control the water paths in times of surface runoff, and that this generates material drag, which in the future could cause inconvenience in the stability of the area.

Figure 7 State of the Wall before placing the facade in erosion control mantle

For these channels, Geomembrane in high density polyethylene (HDPE) was used, due to the fact that due to the nature of the soil, carrying out the construction in concrete, could be inadequate, since an element without flexibility, on a terrain that can present deformations, it could fracture, losing its functionality quickly; Therefore, an element of high flexibility such as the Geomembrane was suitable for the construction of the system.

5. CONCLUSIONS

- For the construction of the structure, reinforced walls with woven geotextile tensile strength of 50 KN / m and 300 kN / m were designed and constructed, using the floor of the cuts made in the project, with fines content less than 30% and of low plasticity.
- A correct adjustment between the topography, reinforced structure, climatic conditions and drainage systems and runoff control, was essential to avoid effects or interferences that will generate problems during construction and operation.
- With the reinforced embankments an improvement of the geometry of the track was obtained and an adequate interaction with the ravine was carried out, without generating damages or environmental damages. Additionally, using material from the site, achieving minimal environmental impact, ensuring geotechnical stability, minimizing earthworks and constructive ease.
- Currently, projects are concerned with a greener construction and with greater care for the environment. With the construction of walls in reinforced soil the minimum impact of the environmental environment was achieved, ensuring the geotechnical stability of the work.
- In addition to direct savings, the benefits of using solutions with Geosynthetics as environmentally friendly construction techniques allow minimizing the exploitation of stone materials, fuel savings, earthworks, etc. The carbon footprint can be reduced by 20-80% by minimizing the CO2 generation of the project. Remember that to stop consuming 1 gallon of Diesel is to avoid generating 10.1 kg - CO2

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