Integral solution to control the slope erosion problem at Las Vegas, Tingo Maria - Pucallpa Highway, Perú

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ABSTRACT: Serious erosion problems were presented at the 22+800 to 23+900 km of the Tingo María-Pucallpa Highway- Las Vegas Sector. They were caused by both the intense precipitations existent in the zone and the area nature, producing big gullies that compromises slopes and part of the highway.

An integral solution, by using geosynthetics with soil bio-engineering was the result of the analysis, which considered into the solution, a fast with energy dissipaters encharged of collect the rain water and to lead them through the benches dissipating energy and high speeds of flow up to the foot of the slope.

Keywords: Geo-Celullar Confinement System (GCCS) , soil bioengineering, slopes re-vegetation.

1 INTRODUCTION

The Lima-Pucallpa highway is one of the most important axes connecting Lima, the Capital of Peru, with the Peruvian Central Amazon Rainforest. "Las Vegas" Sector was one of the critical segments of this route, since his stroke reaches Eastern Andes Chain "Divortium Aquarium", which runs on the line of this route.

Given the characteristics of the final stretch, the road embankment has 2 slopes (one North and another South) of considerable height, which had been eroded due to deforestation thereof, and high rainfall, which had been subjected during its operation.

"Provías Nacional", highway national public authority, commissioned the engineering study of slope stability, erosion control and water management to Hidroenergia, a consulting company, who proposed an integral solution that includes the use of geosynthetics and bioengineering soil. The Puente Chino Consortium led the project, and the work was executed in 2008.

2 OBJECTIVES

This paper will:

- Introduce the slope stabilization, erosion control and water management innovative alternative that was used as an integral solution to the erosion control problem of the sector "Las Vegas".
- Submit the monitoring and performance of the system since its execution date.
- Suggest some measures of maintenance and improvements for future applications.

3 PROPOSED SOLUTION

3.1 *Reshaping the Slopes*

To cover the full height of 50 m, it was necessary to reshape 5 (five) terraces or benches of 10 m each, these terraces were worked with internally reinforced soil slopes with high stregth synthetic geogrids and low deformation; because the slopes were V: 1, H: 1.75

3.2 *Slopes' Revegetation*

Having performed the geotechnical stability analysis of internally reinforced slopes, it was necessary to define the slope surface erosion control system, this was defined with the slope´s revegetation, using both foreign and native species, to ensure the establishment of an adequate and appropriate vegetation of the area.

A 400 g/m2 coconut biodegradable erosion control mat, 100% organic, should be used over the reve - getation, in order to protect the seeds until the germination is permanently set.

3.3 *Water Management*

At the foot of each bench a gutter collection of surface runoff is designed, leading them to a fast flow, and then lead it to lower levels.

These "fast" must have energy dissipaters, to finally dispose of the dissipated energy water supply, so it would not cause erosion at the foot of the slope.

These "fast" were designed to be executed with geo-cellular confinement system + Concrete, as shown in the photo panel.

3.4 *Geo-Cellular Confinement System Features*

Geo-Cellular Confinement System (GCCS), consists of laminated strips of textured High Density Polyethylene (HDPE), jointed in alternated seams conforming a tridimensional structure.

The manufacturing process of the strips is by extrusion, and the thickness of the wall including the texturing is 1.52 mm ± 15% (Test ASTM D5199).

HDPE laminar strips are joined together by ultrasonic welding at 3 points per inch. The stress resistance of the seams are tested for 10,000 hours (just over one year and two months of continuous voltage) according to the method of ASTM D 2990 test.

The HDPE laminated textured strips walls should be perforated with 10 mm diameter perfoartyions, which are arranged in rows of phase staggered type. The total area of perforation should be between 19% - 28 % of the total area of the bands that conform the GCCS,

The GCCS could be infilled with different type of materials which fulfil thhe following functions:

- With vegetal floor: The perforations in the wall, allows passage between the cells of plant roots, making possible a better grip of the vegetative system with topsoil layer contained in them, especially in heavily steep slopes also facilitates drainage throughout the system.
- With Concrete: The perforations in the wall allows greater entanglement during concrete´s placement within GCCS, this also allows a rapid and uniform distribution between cells and an interlocking that increases resistance against pulling forces which are calculated (the case we are dealing with) for a resistance of 31 kN measured by the extraction test.

Accessories

GCCS guarantee its effectiveness with the combination of the following accessories:

Tendons

Made in high strength polyester which has to be passed through the slit or the central hole of the cells before to expand and fixed sections double mooring the dead anchor, which in this case was a PVC pipe with d = 4" thick wall, and that was placed inside an anchor trench depth of 0.50m by 0.30m wide (this ditch was filled with the same material from the excavation, compacted and finally finished with concrete).

The Tendons linking anchor to the ground on the entire length of the slope from the dead anchor and support the structural stress peaks in the processes of scour and settling system during start system service, choosing the type of tendon used is conceived by the calculation of stresses and loads to be withstood.

Figure 1. Concrete Infill Geocellular Confinement System Scheme. Perforations shown should be 19% - 28% of total strip area.

Clip ATRA

A device made of HDPE, which were placed at the ends of ½" diameter rebar stakes and whose arms in a "T" with hooks directed downwards, have the function to grab the cords on mooring as cross as a way means of restriction and transfers of efforts. See Figures 2 and 3

Figure 2. Clip ATRA and corrugate iron stakes.

Figure 3. Tendons Passing through slot eye.

Stakes

These are ½ " rebar rods, L = 0.75 m, which have at one end the Clip Atra, these shall be placed so anchor pattern staked distributed across the horizontal and vertical length of the section to avoid sliding and lifting caused by hydraulic deletions especially last rainy season from December to March, which occur stationary manner in the department of Huánuco.

The density pattern staked and length of cuttings depends on the inclination of the slope, soil type and weight or burden to bear, these are sized to withstand the shear stresses in the flow direction, and the transverse to this.

Nonwoven Geotextile

The Nonwoven Geotextile Class 1, is used as a separator and filter, filling the gap between the concrete and the soil compacted dike.

Alternative Proposal Methodology

The Alternative of the Geocellular Confinement System, fulfill and exceeded the main features necessary for the proper performance of a fast, and were taken into consideration when choosing the technical and economic alternative viable and they are:

Flexibility: Combination of the hardness of concrete with the flexibility of geocells.
Durability: System Warranty for 10 years of useful life period of 50 to 100 years
Ease of construction: Does not require skilled labor
Speed of construction: Progress of 1000 m2 per day

It can be seen lined with geomembranes horizontal underdrains that collect rainwater and lead through perforated pipes 10" to energy dissipaters or fasters, for disposal at the foot of the slope.

The strength of the flow dissipates quickly without causing erosion at the foot of the slope, so that the proposed alternative solution in the objective, which was to channel the rain water surface on steep slopes and long distances, is fulfilled.

The slopes have been reforested with mantle of coconut fiber 400 g/m2 on organic soil, which had been stockpiled in areas adjacent to the work.

Before and after the placement of mantle of coconut fiber of 400gr/m2 an hydro seeding on organic soil and on it was made.

4 CONCLUSIONS

- The Geocellular Confinement System is versatile and easy to install for hydraulic works.
- The yields for this specific work were in the order of 700 to 1000 m2 per day.
- Flexible slabs require no gaskets or formwork.
- The system mainly uses the material available in the work area.
- Installation does not require skilled labor.
- The system replaces conventional applications of gabions, reinforced concrete and riprap, when there is no stone material and rock.
- They are easily adaptable to other applications where flexibility or ability to accommodate ground deflections are an important feature to consider.
- Verify the exact amount of concrete used, not incurring waste.

5 PHOTOGRAPHIC PANEL OF THE WORK

Below pictures are displayed during project implementation:

Figure 4. Conformation of embankments

Figure 5. Conditioning downspouts for fast.

Figure 6. Installation of the geo-cellular confinement system in fast.

Figure 7. Installation of energy dissipaters

Figure 8. Hydraulic energy absorvers

Figure 9. Energy absorvers working during construction (1)

Figure 10. Energy absorvers working during construction (2)

Figura 11. Revegetation in process – Las Vegas 2009

6 TRACKING

Two years after executed the project it has been able to appreciate the proper performance of the geo-cellular confinement system, where no signs of any type of failure given the flexibility offered by the system unlike conventional systems is given as the for masonry structures commonly employed.

Figure 12. Gully Nº1 – October 2011

REFERENCES

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