Retaining Earth Wall for loading and access platform for heavy mining trucks

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ABSTRACT: Gold Fields is one of the world's largest unhedged gold producers, with annual gold production of approximately 4.2 million ounces from mines in South Africa, Ghana and Australia as well as a developing mine at Cerro Corona in Peru; faced the challenge of constructing a 16.5 meters high retaining wall to create a loading and access platform for excessive vertical and horizontal loads imposed by heavy duty mining trucks approximately 250 Ton truck loaded in its Project Cerro Corona.

The complication associated with such a high earth wall retaining structure, the location in a high risk seismic region as well as the remote site of the mining operation required the use of a system that would combine resistance, flexibility, versatility, cost effective and environmentally friendly.

This article shows a Mechanically Stabilized Earth Wall structure, combining double twisted hexagonal wire steel mesh with polymeric geogrids as reinforcements. The wall combines two types of extensible reinforcements.

Reinforced soil retaining structures have been demonstrating being the ideal option for mining structures.

1 INTRODUCTION

The mining industry in Peru is one of the most important sectors of the economy in the country. This constitutes a sector that generates large capital movement. The Peru was since always a country with mining tradition. Since 1994 the mining industry grow up very fast. Foreign capitals came to Peru and invest huge amount of money to do explorations and make reality projects that were resting because of the low metal price.

With the expansion of the mining industry the last 3 years, consultants companies were developing mining projects and designing mining structures. In 1995 and 1996 the work opportunity increase in good percentage and the construction of different types of structures was required. One of the most important type of structure required was the contain or slope stabilization with soil reinforced.

Retaining earth wall structures built for mining projects are very useful today in Peru. This kind of reinforcing structures consist predominantly of three components.

The front face, primarily a retaining function, which contributes to the aesthetics of the completed structure.

The internal reinforcing layers, enhances the shear properties of the soil enabling large composite reinforced soil structures to be constructed.

The structural embankment, forming the reinforced soil structure. Research and experience has shown that soil with grading varying from 0.02 mm up to 6 mm is ideal for use as structural fill. But it does not mean that others materials, not included in the above classification, are excluded to be used. In much cases in-situ-soil is acceptable fill.

2 PROJECT DESCRIPTION

Cerro Corona Project lies within the Hualgayoc District, north of the Yanacocha mine in the Cajamarca Region of Peru. This open pit project like others require the construction of a Primary Crusher. The crushing is the first step in converting shot rock into usable products, by taking large rocks and reducing them to smaller pieces. Crushing is at some operations more than one step. The Primary Crusher need a retaining wall structure that support the weigh of heavy duty mining truck, approximately the load weigh of this trucks is 250 Tons. Some times the platform structure created with the retaining wall require support two of this trucks.

The retaining wall has to be submitted to constant vibration due to crusher function. The material is crushed inside of the concrete structure. This increases the collapse risk of any structure. Additional to the heavy loads and the vibration of the crusher, the mine is located in a high seismic region. In accordance with Peruvian seismic standards, the coefficient of seismic acceleration had to be 0.4g but the design had to be developed in accordance with Chilean seismic standards, that's mean a coefficient of seismic acceleration of 0.43g. It is a very high coefficient for a structure that its life design is going to be 15 years.

The structure that our company proposed, full fill the high strength solicitation and complied all the standard requirements of the consultant company that was in charge of the project. Combining double twisted hexagonal wire steel mesh with polymeric geogrids to form a superstructure for high walls or slopes. This combination unites the stiffness and constructability of the steel mesh for the facing and the strength and versatility of the geogrid for the reinforcement.

The geogrid used was manufactured from high tenacity, multifilament polyester yarns placed in tension, then co-extruded with polyethylene to form a polymeric strips. The polymeric strips are laid flat in the machine direction and a secondary member of is laid and weld across the full width in the cross direction. The process generates a stable and strong geogrid. While Polyester is the load bearing element maintaining minimal deformation, whilst the polyethylene sheathing maintains both the integrity of the product and encases the yarns protecting them from aggressive environments (such high/low pH) and harsh installation conditions the geogrid is ideal for applications where reinforcement of soils is essential such as MSE walls, embankments over soft soil, steepened slopes, wrapped face walls, lagoon closures, basal foundations and any other geotechnical application in which soils require enhancement. The geogrid has been tested internally and independently in accordance to published standards and will conform to the property values listed below.

A continuous double twisted wire steel mesh panel that forms the reinforcement, the front and top of a gabion style facing section (Fig. 1). The back panel, ends, and diaphragm of the facing section are connected to the main unit during the manufacturing process. The facing section is a rectangular form filled with stone which provides strength and drainage to the structure. This System is fabricated from a soft, tensile, heavily galvanized and PVC coated double twisted wire steel mesh.

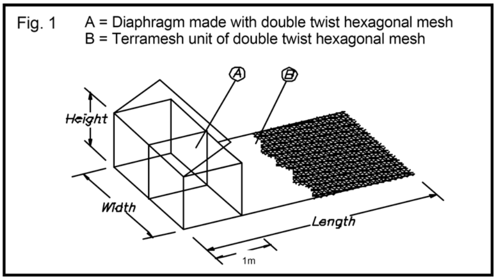

Figure 01 – Double twisted hexagonal wire steel mesh

The inherent flexibility of the system and the high tensile strength of the geogrid, made the perfect combination for the solution. The flexibility of the system allows settlement and consolidation without excessive deformation in the reinforced wall structure and without loss of structural function. The system allow use local soil. The face of the system fill with stone permit s a free draining system. And the cost was the most competitive.

3 DESIGN CRITERIA

The method utilized for the analysis was the equilibrium limit, this method consists of taking in considerate several positions for the possible fail surface and for each one of them determines the value of the active force, for equilibrium of forces with this is possible to determined the critical position of the fail surface and the maximum active force.

4.1 Global Stability

The verification of the global stability is an analysis of a slope reinforced or not reinforced.

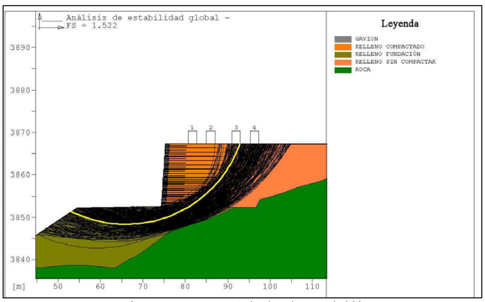

Figure 02 – Global Stability

4.2 Internal Stability

The verification of the internal stability allows that the user defines the design of the retaining walls, it means in these analysis we will determine the length of the reinforcement units.

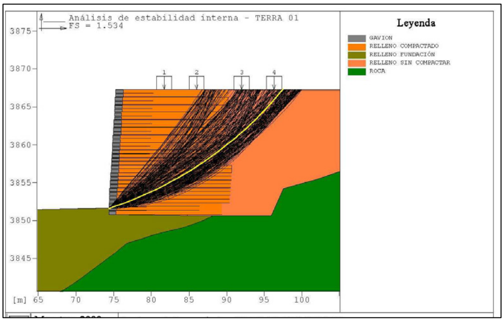

Figure 03 – Internal Stability

4.3 Bearing Capacity, Base Sliding, Overturning verification.

This kind of stability analysis considered all the structure or part of this one as a monolithic wall composed for blocks that form the retaining wall

The verification of this stability consist in three analysis of stability realized in retaining walls:

-Bearing Capacity verification.
-Base Sliding verification.
-Overturning verification.

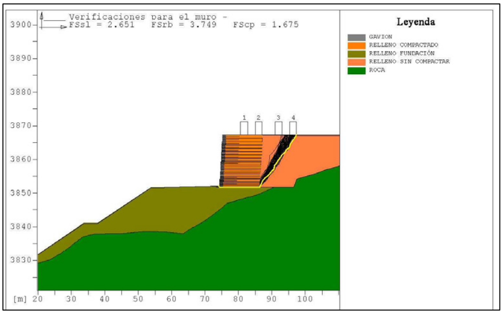

Figure 04 – Retaining walls stability

The methodology utilized by the Software employs the method simplified of Janbu and Bishop.

Both methods refer to the Mohr-Coulomb fail criteria.

$$\tau = c + (\sigma - u)\tan(\phi')$$

τ = Maximum tangent tensile
c = Cohesion
σ = Normal pressure
u = pore water pressure
ϕ' = Friction angle.

4 CONSTRUCTION PROCEDURE

The system combine two elements the polymeric geogrid and the double twisted hexagonal wire steel mesh panel (from now denominated panel). The panels must to be assembly placing all the elements in the right position. It is necessary wire for tie operations of assembly and installation of the panels.

Tie the lateral faces to the base panel and frontal panel, alternating single and double loops to each unit, in this way It will form an open box. The edges should be in contact still under traction forces.

Place each unit panel in its final position. Tie the units to each other along of all places of contact .

Fill with stones and surpass the high of the elements by 25mm to 50mm, do not exceed the 50mm to facilitate closing the element. A Non-woven Geotextil has to be placed to separate and filtrate the soil, it would lie between the panels and the structural soil.

Figure 07 – Geotextile installation

Compact the backfill with 0.20 to 0.30m high layers. Compactation should reach 95% Proctor Modified.

Befote unroll the geogrid verify the direction of the installation based on construction drawings.

Figure 08 – Geogrid installation

Follow the same procedure layer by layer to get the height specified.

Figure 09 – Final structure

5 CONCLUSION

The structure present advantages that other alternative does not have. A drainage system has to be placed in the back of the gravity structure to guarantee the parameters of the structural backfill. The primary reinforcement is the polymeric geogrid, it is the one that is going to take the shear stress in case of a eventually failure.

The panels of double twisted hexagonal wire mesh, in this case perform to prevent local failure, and to obtain a vertical front face. But the reinforced tail of steel mesh was designed to get a minimum anchorage and to built a flexible front face.

The durability of the structure, in accordance with the BS8006 can be designed to 120 years. The vertical spacing reinforced of the mesh panels are 0.5 m in all the structure. The polymeric geogrid reinforcement is placed with 0.5 m spacing in the lowers layers and 1.0 m in the upper layers.

There is one MSEW structure build in Peru, and the performance is perfect. Even combining two types of reinforcements.

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