Earth dam project using structural geogrids for tailings pond

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ABSTRACT: Sinaycocha Mining Company SA. has developed a project called tailings deposit Sinaycocha 1, located in central Peru. The project consists of an earth dam built in two stages. In the first stage, the dam was designed as a homogeneous earth dam with a maximum height of 26 meters. In the second stage, the dam was heightened by the upstream method, relying on two different foundations as follows:The embankment of the first stage; and the tailings stored. In the last case the treatment of the dam's foundation was done by Jet Grouted columns and biaxial and uniaxial geogrid in the base of the dam, to improve the geotechnical conditions of foundation of the dam. The basin of the second stage was waterproofed with a HDPE geomembranes to control the infiltration of contaminated fluids which are discharged into the tailings storage.

1. INTRODUCTION

In some parts of central Peru, there are narrow valleys and gorges with rugged topography, which do not provide acceptable characteristics to develop tailings storage projects. Given that limitation, the projects are carried out considering special challenges to overcome the shortcomings of the natural terrain to be used to store tailings as the tailings deposit Sinaycocha 1.

The tailings deposit Sinaycocha 1 was designed to be built in two stages. In the first stage, the dam consists of an earth embankment of homogeneous type, located on a terrace of a hillside on the left Sinaycocha valley at an altitude of 4200 aslm.

In the second stage, due to adverse topographical conditions of the surface, the dam was heightened by the upstream method. In addition the design relied partly on the embankment of the dam of the first stage and partly on the tailings stored in the deposit. For this purpose, it was necessary to treat the foundation consisting of tailings with Jet Grouted columns, and biaxial and uniaxial geogrids which were installed at the base of the dam and over the jet grouted columns previously mentioned The basin of the second stage was sealed with HDPE geomembranes to control chemical effluents that are discharged into storage along with the tailings from the metallurgical plant.

2. THE PROJECT LOCATION

The project is located in the central region of the Cordillera of the Andes of Peru, at an average altitude of 4200 aslm, in the province of Concepcion, Junín department.

3. THE PROJECT DESCRIPTION

This paper describes the planned work of the second stage according to the following:

a) The foundation treatment
   A sector of the dam is founded largely on the embankment of the first stage, and tailings storage (Figures 1 and 3).
   The other sector of the dam is built upon tailings stored (Figure 1) in the first stage of the project. In this case the foundation was treated by Jet Grouted columns embedded in tailings, and biaxial and uniaxial geogrids installed at the base of the dam and in the upper level of the columns (Figure 2).

b) Second stage of the dam:
This is constituted of a reinforced embankment with a vertical wall formed by gabions on the external face. The gabions are reinforced with layers of mesh (Terramesh ® type), distributed in the earth embankment.

The main characteristics of the dam design requirements are:

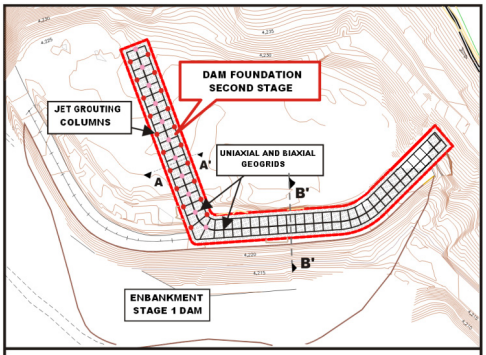
a) Geometry
- Height of the dam 7.0 m
- Down stream slope 0.25H: IV
- Upstream slope 1H: 1V

b) Loads
- Horizontal force exerted by tailings
- Seismic Load, considering seismic coefficient of 0.14 g

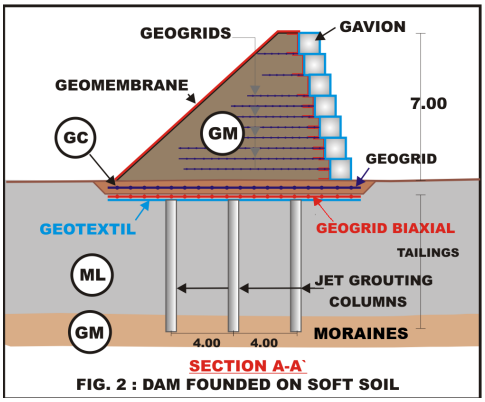
c) Stability of the tailings of pond
Minimum factors of safety are:
Static Condition FS minimum:≥1.5
Seismic Condition FS minimum ≥1.1

4. GEOTECHNICAL CONDITIONS OF THE FOUNDATION AND EMBANKMENT

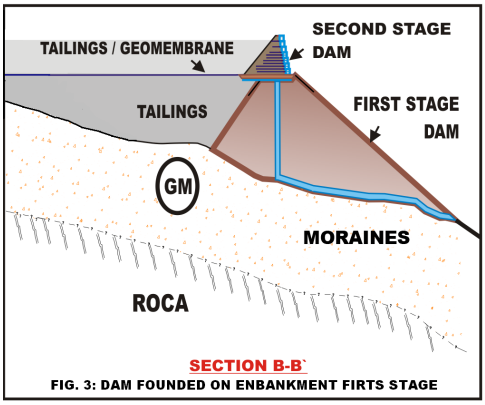
The first stage dam is built on thick moraine. The second stage dam is built upon two types of materials. A sector is supported on columns of tailings improved by Jet Grouting and layers of uniaxial and biaxial geogrids. The other sector is built on the embankment of the first stage of the dam and on the tailings.



PLANT
FIG. 1 : SECOND STAGE DAM



SECTION A-A`
FIG. 2 : DAM FOUNDED ON SOFT SOIL



SECTION B-B`
FIG. 3: DAM FOUNDED ON ENBANKMENT FIRTS STAGE

The geotechnical parameters of soils were obtained through field and laboratory testing of soil mechanics.

Table No. 1 shows these geotechnical parameters.

Table No. 1: geotechnical parameters of soils of the dam and its foundation

Material	Density natural KN/m^3	Shear Strength			
		Drained		Undrained	
		C´	Ø´	CU	Øu
Moraine (GM)	20	21	38	35	32
Embankment (GM)	22	20	38	28	30
Tailing (ML)	16	0	32	100	12
Gabión (GP)	24	0	40	0	40
Drain (SP)	20	0	34	0	34

5. THE IMPROVEMENT OF THE GEOTECHNICAL FOUNDATION CONDITIONS

A sector of the dam with a length of 110 meters is founded on saturated tailings of low shear strength and high compressibility. To improve the geotechnical conditions of the foundation, Jet Grouting columns, and biaxial and uniaxial geogrids as layers in the highest level of the mentioned columns (figure 2) were used. The biaxial geogrids distribute the loads of the dam onto the Jet grouted columns, while the uniaxial geogrids increase soil shear strength at the base of the dam.

The biaxial geogrids are of the type BX 1200 with the following main features:

Index Properties	Units	MD Values	XMD Values
*Aperture Dimensions	mm (in)	25 (1.0)	33 (1.3)
*Minimum Rib Thickness	mm (in)	1.27 (0.05)	1.27 (0.05)
Load Capacity			
*True Tensile Strength @2% Strain	kN/m(lb/ft)	6.0 (410)	9.0 (620)
*True Tensile Strength @5% Strain	kN/m(lb/ft)	11.8 (810)	19.6 (1,340)

The uniaxial geogrids are of the type used UX 1500 with the following main features:

Load Capacity	Units	MD Values
*True Initial Modulus in Use	N/m(lb/ft)	1,580 (107,950)
*Tensile Strength @5% Strain	N/m(lb/ft)	52 (3,560)
*Ultimate Tensile Strength	N/m(lb/ft)	114 (7,810)

The Jet Grouting columns of 0.70m in diameter are installed in three rows each 4 metres apart. Each column has a steel rod of diameter 1". The compressive strength of cemented tailings material is 280 kg/cm^2.

6. THE WATERPROOFING OF THE TAILINGS DEPOSIT

To control the infiltration of contaminated liquid from the tailings, the basin of the second stage of the project, was weaterproofed by the installation of a HDPE geomembrane 1.5 mm thick, laid on a non-woven geotextile of 400 g/m^2.

7. STABILITY OF THE DAM

The overall stability of the dam was obtained by applying the method of Bishop-modified, using the Slide V 5.0 program.

Figures 4 and 5 show the results of analysis of global stability for static and seismic conditions of the area where the tailings dam was built.

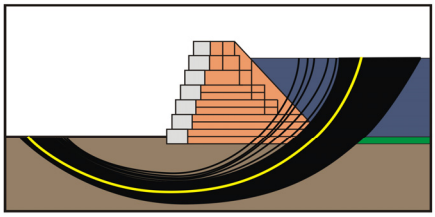


Figure N°4 :
STATIC STABILITY ANALYSIS - SECTION 0+160

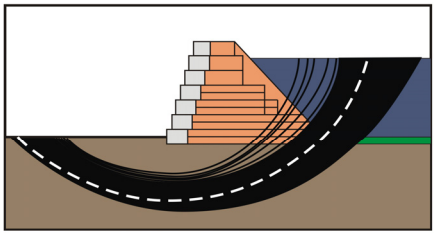


Figure N°5 :
SEISMIC STABILITY ANALYSIS - SECTION 0+160

The following safety factors were obtained:

section	Static analysis	Seismic analysis
Dam founded on tailings	1.5	1.03

The results suggested that the dam is stable.

The following figure shows the deposition of tailings in operation.

The tailings deposit Sinaycocha 1 concluded operations on February 2008 and is in the closing process.

8. CONCLUSIONS

The second stage of the tailings deposit was designed to improve the foundation provided by tailings of low shear strength and high compressibility.The improvement of the foundation was achieved by the installation of Jet Grouted columns, that penetrated through the layer of tailings, and biaxial and uniaxial geogrids at the base of the dam.

The soil foundation works described allowed control over subsoil settlements, and obtained favorable safety factors against sliding of the dam, in static and seismic conditions.

The installation of the HDPE geomembrane allowed controlling the infiltration of effluent from tailings in the basin of the second stage.

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