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STUDY OF ALTERNATIVE TECHNOLOGIES FOR RESIDUE DISPOSAL (RED MUD)

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Abstract

Environmental agencies are becoming increasingly stringent and restrictive in release areas for disposal of industrial residues and mining tailings. Because of this, studies are being conducted to enable the maximum use of areas already licensed and impacted with residue disposal. The alternatives considered are aimed at disposal of a greater volume of residue in a smaller area, increasing the lifetime of existing disposal systems. This paper presents a comparative study of residue disposal alternatives in a dam operated by the conventional method (residue in pulp). The alternatives studied use filtering the residue to reduce the amount of water in that for final disposal. Lifetime comparisons were made between the use of conventional method, dry stacking and dry disposal, in addition to tests for characterization of the dry residue to disposal.

Introduction

The insoluble residue generated during the alumina production by the Bayer process, in the clarification step, is called red mud. Depending on the quality of the deposit of bauxite used for the alumina production, the generation of red mud on dry basis per ton of alumina produced can range from 0.3 t, for high quality bauxites (high aluminum content) to 2.5 t for low quality bauxites. The amount of red mud generated worldwide annually by the alumina production is in the order of millions of tons and grows ever more. This residue is usually disposed in large areas designed especially for this purpose, requiring large investments of alumina industry in acquisition of areas and management of disposal systems.
Moreover, it has become increasingly difficult to obtain license of areas for this purpose. Thus, the alumina industries have sought alternatives for disposal that allow make the most of areas already licensed.
The disposal methods called "Dry Stacking" and "Dry Disposal" may offer a significant gain in the use of land for red mud disposal.

Description of the problem

The unity of CBA - Companhia Brasileira de Alumínio located in the municipality of Aluminum, SP, has a dam of red mud disposal, called Palmital Dam, in which the disposition occurs currently by the conventional method in which the residue is launched with approximately 35% of solids content.
CBA intends to operate this dam until at least 2030, reaching 2040 with an annual residue generation of 1,002,750 tones / year on dry basis. With the available volume of 10,124,586 m³ for disposal by the current method, calculated from the topographic and bathymetric surveys conducted in January 2012, considering the mass of residue generated annually of 1,002,750 tones / year on dry basis, the lifetime of Palmital Dam with the current method of disposal is estimated at 7.5 years, with a final solid content of 60%, which results in a horizon of operation until June 2019. However, the present dam may not be raised for environmental and/or licensing questions. Therefore, a study was conducted to evaluate alternatives for extending the lifetime of the Palmital Dam.

Description of the Dam

The residue disposal system of Palmital Dam has two structures: the main dam and the auxiliary dam.
The main dam has a compacted embankment of clay soil, with around 90m in the maximum section and is currently crested at El. 875,0 m, with 6,0 m wide. The upstream slope has na inclination of 1V:1,5H, with its face protected by a riprap layer. The downstream slope is composed by riprap, with inclination of 1V:1,7H.
The spillway system is in concrete structure, located in the left edge, with the base in El. 871,5 m.
The auxiliary dam has its embankment also in compacted Clay soil and riprap, with the crest in El. 875,0 m and 6,0 m wide. The upstream slope has 1V:1,2H of inclination till El. 858,0 m and from this elevation, the inclination is 1H:1,6V. The downstream slope has 1V:1,7H of inclination.
The last raising of main and auxiliary dams was constructed in 2010, when the crest was raised in 17m, from El. 858,00 to El. 875,00 m. For both structures the raising was made by the downstream side of the embankment.

Available areas for residue disposal

Considering the lack of area for residue disposal, in special because of difficulty in obtain environment licenses, CBA is looking for new techniques, in order to allow occupy better the already licensed areas.
Due to that, CBA is studing techniques to deposit the residue in the marginal area of the current reservoir, as illustrated by the Figure 1.

Disposal alternatives studied for extending the lifetime of Palmital Dam

Two methods of disposal were studied for extending the lifetime of Palmital Dam, whose are described following.

<u>"Dry Stacking"</u>

"Dry Stacking" disposal method is known to be a disposal method of dry or semi dry residue. It consists in the disposal of residue in thin layers, alternating fronts launching, enabling cicles of launching and drying, with the evaporation of the free water present in the residue and consequently its drying.
For the application of this method, it is necessary use drum filters to dewater the residue before launching.

Licensed area = liberated for use

Figure 1 – Delimitation of the current reservoir area with licensing for residue disposal, including the marginal area.

The major contribution and relevancy of this method is present a smaller amount of water in the residue compared with the conventional method. This reflect in better wokability and greater safety of the deposit, and allow the disposal of more residue weight in dry basis for the same reservoir.
For the present study, it was considered that the solid content at launching in this method is 47%, reaching values in the range of 60% after deposit/consolidate.

"Dry Disposal"

"Dry Disposal" consists in the launching, spreading and compaction of the residue with earthmoving equipment. To make this possible, it is necessary dewater the residue before the disposal till a solid content in the range of 75% to 80%.
Press filter technology is applied to achieve this range of solids content.
For this technique, a point that deserves attention is that in the heavy rainfall period, the filtered residue can achieve lower solids content, especially during its spreading and compaction, so this event should be pondered for each region.
For this study, a solid content of 70% was considered for the residue in the rainy season and 78.5% for the dry season. It was considered that 205 of the annual generation of residue will be affected by the rains, presenting solids content of 70%, being the remaining 80% deposited with solids content of 78.5%

Assumptions for the calculation of lifetime

The main assumptions considered for the calculation of lifetime of Palmital Dam for the disposal alternatives presented are:

- True density of the grains of the residue: 2,91
- Mininum horizon of the lifetime study till 2030, with the goal by 2040.
- Launching of residue by the current method (conventional) till the end of 2014, with the start of the deposition by the new method from January of 2015.
- Final solids content for the residue deposited by the "Dry Stacking" method: 60%
- Angle of deposition of the residue deposited by the "Dry Stacking" method of 3°, with the cresto f the deposit in elevation 877.40 m
- Final solids content for the residue deposited by the "Dry Disposal" method:
    - 70% for residue in the raining season (20% of the year)
    - 78,5% for residue in the dry season (80% of the year)

Comparative of lifetime between the disposal alternatives studied

Table 1, following, presents the results of lifetime calculated for each disposal method studied.

Table 1 – Lifetime for each disposal method studied

Disposal Method	Volume of deposited residue (m^3/year)	Lifetime (year)	Date of end of lifetime (beggining in january/2012)
"Dry Stacking"	1.013.493	8,6	July/2020
"Dry Disposal"	748.870	20,2	November/2034

By the results shown in Table 1, it can be observed that the "Dry Disposal" method allows achieve the lifetime horizon desired. It was possible considering steps of disposal, as described following:

- **1st STEP:** Construction of a conquest landfill over natural ground in the left and right edges of the reservoir.
- **2nd STEP:** Dry disposal (forming a stack) of the residue from press filter over the conquest landfill.
- **3rd STEP:** Dry disposal (forming a stack) of the residue from press filter within the reservoir.
- **4th STEP:** Dry disposal (forming a stack) of the residue from press filter over the stack formed in the 2nd step, with final crowning in the limit of the contribution basin.

Figures 2 to 5 following illustrate the steps of disposal considerate:

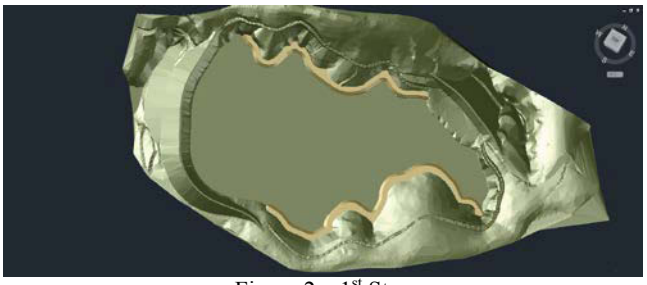

Figure 2 – 1st Step

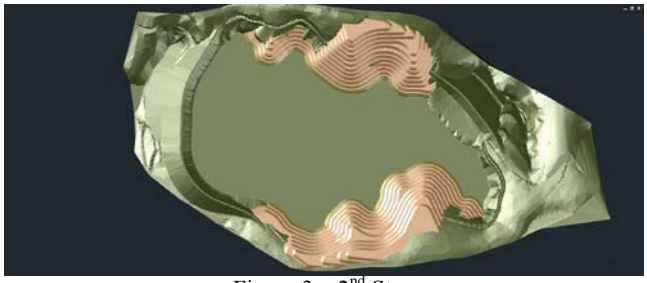

Figure 3 – 2nd Step

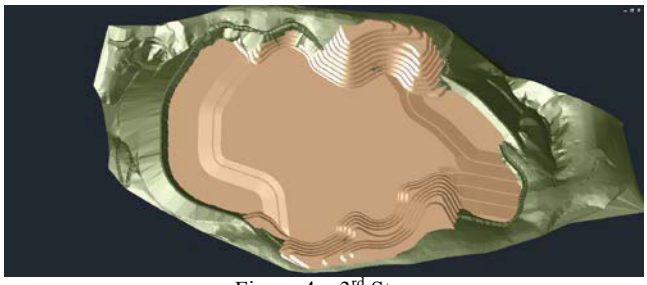

Figure 4 – 3rd Step

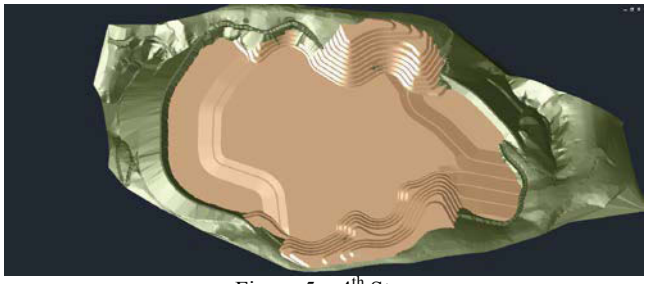

Figure 5 – 4th Step

Stability analyses were developed in sections indicated in Figure 6, with strength parameters estimated for the materials of the foundation (phillite), landfill of dam, for the conventional residue already deposited in the dam reservoir and for the residue from press filter (Table 2)

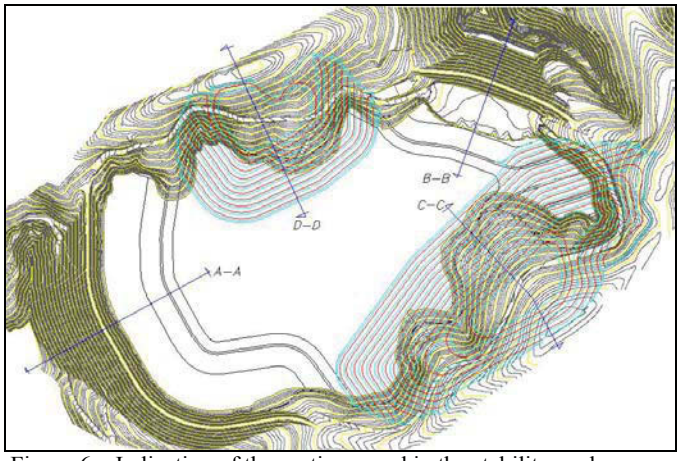

Figure 6 – Indication of the sections used in the stability analyses

Table 2 – Strength parameters estimated for the materials

Material	Specific gravity (kN/m³)	Cohesion (kPa)	Friction Angle (°)
Fundation (phyllite)	20.00	170	29
Dam landfill	20.00	40	25
Residue filtered by Press Filter	17.41	50	27
Residue of dam reservoir	17.16	5 in the top plus 1/m	-

In the residue from press filter, a pore pressure generation factor ru of 0.25 was considered.

The analyses were performed using the software Slide 5.0 and presented safety factors above of the minimum required, of 1.5. Table 3 presents the safety factors found in the stability analyses preformed.

Table 3 – Safety factor found in the stability analyses

Section	Safety Factor
A-A	1.64
B-B	1.57
C-C	1.77
D-D	1.51

Final Considerations

The study of evaluation of alternatives for extension of Palmital Dam lifetime developed concluded that the disposal by the "Dry Disposal" method allows a bigger horizon for the operation of the dam.

However, it is noteworthy that the studies were conducted with estimated data, which must be validated by:

- Field investigation in the inside of the reservoir in order to know better the properties of the deposited residue, like the strength, permeability and deformability, as well as laboratory tests on this material;
- Pilot tests with press filter;
- Laboratory tests in the residue from press filter from pilot tests.