Greening solutions of Gura Rosiei Tailing Dam

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Abstract: Tailing dams are special hydraulic constructions of retention, of permeable type, and represents all works related to installations of preparing mining masses, on one hand having as a purpose the mechanical treatment of waste water, and on the other hand safe storage generally indefinitely or undetermined, the sterile resulting from ores processing. This paper presents the stability study achieved on the emplacement of Gura Rosiei tailing dam, analysis that is aimed to assess the degree of stability of the three compartments that make up the deposit of tailings. Also proposed greening solutions for improving the management and safety tailing dam are presented. These solutions lead to decrease of risk factor, disappearance of certain sources of environmental pollution and diminish the intensity of others, and also to the integration into the environment of the area occupied by Gura Rosia TMF.

Key-Words: tailing dam, stability, greening, sterile, pollution sources, impact, exfiltration, erosion

1 Introduction

Tailing dams represent a natural configuration or technical arrangement for fine-grained waste disposal, mainly processing sterile, both with varying amounts of free water resulting from the processing of mineral resources and the rinsing and recycling of process water [1], [5], [7], [8]. Three fundamental aspects should be considered when addressing the issue of safety of tailing dams. The first refers to the physical stability, namely breakage dam because of some mechanisms such as: circular sliding, subsidence, backward erosion at discharge water over dyke etc. The second aspect concerns chemical stability, that refers to acidity increase of water (the presence of sulphides in material deposited in the TMF, especially pyrite), which draws heavy metals in solution. The third aspect concerns the fact that it should be considered toxic material loss, by exfiltration. Tailing dams' closure and greening is made in order to ensure the stability of dam, of its additional constructions, as well as integration into the environment of areas under waste mining deposits (tailing dams) [2], [3], [6]. Gura Rosiei TMF is a coastal dam to the inside elevation which consists of a complex of three compartments that worked successively (see fig.1). The height of compartment 1 is 15 m, for the compartments 2 and 3 the height is 45 m, and all have an impression at soil of approximatively 10 ha. The constructive elements of TMF in time and under the influence of environmental factors (rains and wind), and also the lack of maintenance works, had undergone damages and destruction (some of major). Moreover, height reached by the deposit of tailings over functioning has resulted in achieving some values of static and dynamic coefficients of stability at the admissible limit. TMF presents the impact on the environment (water, air, soil), but less good, if a failure occurs due to the loss of stability, will produce impact on human settlements [4], [8], [9].

Fig.1. Gura Rosiei TMF

Thus, it requires certain works, both for release into safety and greening Gura Rosia dam. Sources of emissions generated by activities carried out to Gura Rosia dam are: water discharges; emissions in air; directly discharging of the tailings from dam on the downstream land area of TMF (in case of accidents/failures). The probability of occurring an accident/failure is quantified by coefficients of stability concerning the safety in exploitation of dam. Correlating the results of calculations with in situ observations we believe that this dam is in imminent danger. In relation to the event of occurring a failure / accident at the tailing dams it must be noted that far more serious than the impact upon environmental factors, is the impact on human settlements.

Gura Rosiei TMF, inactive in this moment, represents a pollution source with suspended particles in dry periods by wind entrainment, mass flow being assessed at about 6-14 kg / day / ha depending on the wind velocity and the moisture state of free surface. There are no measurements of pollutants in the area. Although the spontaneous vegetation is observed, however there is an active erosion of the slopes, by the action of water runoff.

2 Analysis of TMF stability

In order to carry out the study of stability there was achieved a number of 10 boreholes in dams' body from which have been sampled disturbed and undisturbed samples from different depths. These samples were subsequently analyzed in the geotechnical laboratory obtaining physical-mechanical characteristics necessary in stability and infiltrates computations. In addition to the calculation of safety factors (stability coefficients) and the capable flow of exfiltration in the two hypotheses (in present and hypothesis of reaching the height about 2 m) the bearing capacity of the land represented by the three dams analyzed, was followed.

In this case the applied method was of generating sliding surfaces using a polygon representing the geometric trace of sliding surfaces centres in a matrix form with given resolution of incremental step of network. Also the surface radius varies between the minimum and maximum with a given step increment that allows uniform coverage of sliding potential surfaces. Shear parameters (angle of friction and cohesion) introduced for each material constituting the computing section can be isotropic or anisotropic respecting several breakage criteria respectively Mohr-Coulomb (in this studied case), Hoek-Brown, Barton-Bandis etc. [1], [4], [5], [6], [9].

Analysis consisted on verifying the stability in 7 sections of calculation. For each situation there were considered two hypotheses, statically and pseudo-statically hypotheses that include seismic magnitude of emplacement zone (F seismic zone and seismic coefficient Ks = 0,08g). All cases were analyzed by four different methods that satisfy the static equilibrium of forces and moments (Bishop and Janbu) or simultaneously of the forces and moments (Spencer and Morgenstern-Price) (see fig.2).

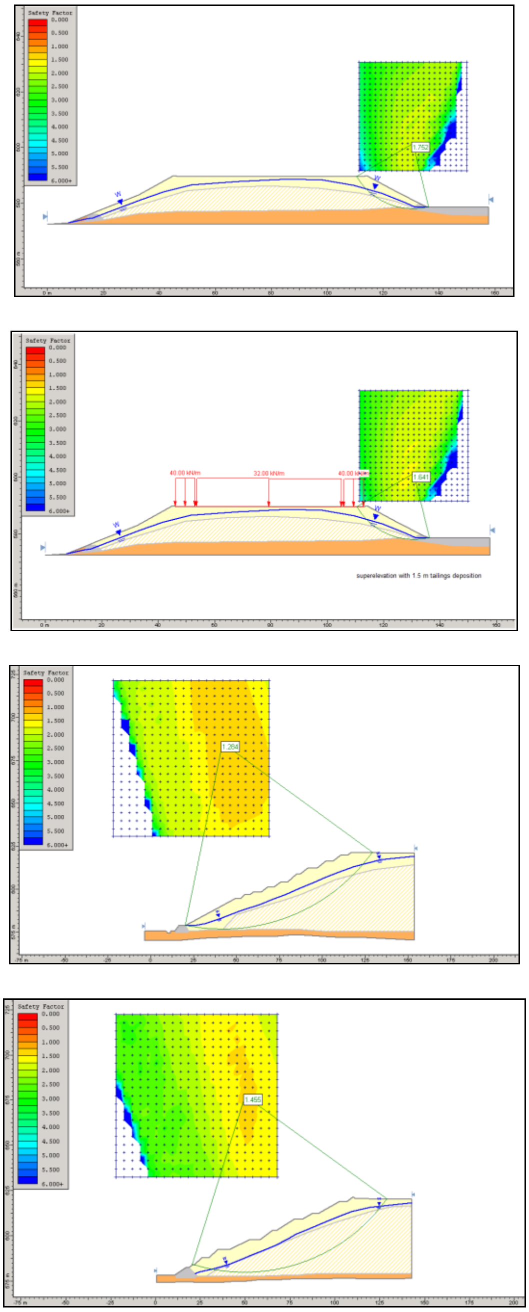

Fig.2. Stability analysis of Gura Rosiei TMF.

3 Greening solutions

The solution proposed for greening the TMF provides a dry variant, without the presence of accumulations of water on its surface; consequently, it is necessary its evacuation without producing an impact on environment. This is achieved by realizing a temporary channel (L = 200 m) that will carry off the pure water and that will grow in depth with decreasing water level, so that water flow does not carry along deposited tailings. After draining of water from dam surface is necessary a certain drying time of the field. Existing drainage system (reverse probe) will be kept in service as backup and emergency system in case of heavy rainfall up to completion of the greening works, when it will be shielded by filling with concrete the entire length.

Through the works of systematization, a new form of the dam will be ensured and a stable slope of 1:3 and on the upper surface of dam will achieve a platform with a slope of 1 % to downstream. The volume of tailings from the top of dam, compartments no. 2 and 3, will be excavate on depths of h = (0 - 5) m, it will be transported and levelled on the surface of compartment no.1 bringing all compartments at the same level. The excavated, transported, levelled and compacted volume of tailings from TMF to achieve the final shape of dam is approx. 300,000 m^3. At the completion of systematization and reprofile works, will be carried out on the platform dam, approx. 15 m from the edge of the slope, four drillings with length of 35 - 40 m equipped with piezometric pipes for hydrostatic level monitoring from the body of dam. The total area of dam (slope and platform) is 22 ha and will be covered by the following layers: impermeable layer of 1 mm thickness of the geomembrane; geocomposite drainage layer of with small pipe-lines; layer of sterile material of 35 cm; topsoil layer of 15 cm thickness fertilized and seeded with grass.

Fig.3. Achievement of closure and greening layers of Gura Rosiei TMF

Through the works of achieving safety, and greening of Gura Rosia TMF, the causes and sources of pollution on the environment are not completely eliminated. One part, in the majority of them, is eliminated and others reduced in intensity. So, the lake is capsulated only on its free surfaces, eliminating the entrainment of fine particles in the shape of dust, under the action of wind gusts and leakage of tailings material, under the action of rains that can pollute soil and water around the dam location. At the same time the amount of water infiltrated into dam body is reduced considerably. This fact leads to increase the stability of TMF and reducing exfiltration of contaminated water from the body of dam. However the dam remains in contact with the natural terrain on a surface of approx. 15 ha composed of its bottom and side surface which rests on Daroaia hill. Through these surfaces will permeate in the TMF a certain quantity of water from springs and groundwater, but also will produce a heavy metal pollution of the upper part of soil from these surfaces and groundwater in some areas.

4 Conclusion

Gura Rosiei TMF design and construction was done in a period of time in which compliance and protection environment and human communities was more permissive and less supervised. This fact has led to create a dangerous materials deposit, which expands on large areas of land and large time periods and can produce major impacts on the environment and human settlements in the area.

Gura Rosiei TMF is the first deposit of this type in Romania where for closure and achieving safety are used geosynthetic materials (geomembrane and drainage geocomposite) for isolation and encapsulation of dangerous material in dam body. This study was based on in situ observations, geotechnical drillings and chemical analysis of samples taken. Because of the depth that is not very large, drillings could not emphasize a hydrostatic level except the areas with high level of humidity; these areas are represented by certain sandy dust insertions form of a lenses that assign very difficult the water. These zones are not continuous and cannot define a hydrostatic level of the reference. All situations were analyzed by four different methods that satisfy the static equilibrium of forces or moments or simultaneously both forces and moments. The resulting safety factors are relatively close to values in standard measure ($Fs \geq 1.4$) for static analysis, and under dynamic conditions (pseudo-static) are to the equilibrium limit. Due to reduced capacity to release water from pores, the material decanted is still in saturated state (debits seepage are low) and it is assumed that the foundation ground composed of terrace deposits of

Abrud River clogged at the interface with decanted material, unable to drain naturally the excess of moisture from dam body.

The conclusions and results of stability study are the base of the choice of the solutions, methods and materials used in the greening project and achieving safety Gura Rosia TMF. For hydrostatic level monitoring from dam body of will be mounted on the platform of dam four piezometric pipes, and for monitoring the stability of any possible horizontal or vertical movement, at the end of greening works should be installed eight surveying marks, so: four surveying marks on the dam platform, one near each piezometric pipe; three surveying marks on the slope of dam; one surveying mark in natural field on the slope that dam supports.

Following the studies carried out we propose: (1) in the case of Gura Rosiei TMF after reprofiling the length of slope is great sometimes reaching 120 m, therefore it is necessary to add transversal the drainage geocomposite using three types of materials (wood, metal and polypropylene) having aging and deterioration time very different. Guidelines of geosynthetic materials producers are that the length of slope inclination on which are mounted should not exceed 35 - 40 m. Thus, for higher lengths of slope, it is advisable to carry out, before the mounting of the membrane, berms intermediate having the width of 3.5 m. These are fitted with guard channels at the intersection of berms with slope, canals with longitudinal slope toward sides where slopes close. Intermediate slopes between berms will have higher slopes, but general inclination will be the same as in the project. Geomembrane will be better anchored to each berm, avoiding overstretching and breakage; (2) international practice in the field of geosynthetics not agree their use widely to closure, ecological and achieving safety works release of such deposits (higher length of slopes on inclination).

Accordingly, dam waterproofing will be done either with geomembrane, but it will reconvert slopes through the introduction of intermediate berms or some other more secure method from viewpoint of used material. For the environmental factors air, water, soil, the followed indicators will be: environmental factor air (quantity of suspended powders mg/m^3/30 min (high winds) and sedimentable powders mg/m^3/month); environmental factor water (clarified water quality discharged from dam: will be establish: pH, tenor in suspension, fixed residue, sulphates, CCO-Cr, heavy metals (Cu, Zn, Pb, Fe, Mn), ammonium, chlorides); environmental factor soil (at the start of greening works will be made at 5 cm and 30 cm depth analyses of tailings from deposit, soils from side and soils downstream of dam, for which it will establish: pH, humus, sulphates, heavy metals - Cu, Zn, Pb, Fe, Mn).

References:

[1] Blight, G., Steffen, D., Geotechnics of gold mine waste disposal. *Current geotechnical practice in mine waste disposal.* ASCE, 1979, pp. 1-52.

[2] Brinkgreve, R.B.J. 2005. Selection of soil models and parameters for geotechnical engineering application. *Proceedings of Geo-Frontiers Conference, ASCE,* Austin, TX, January 24-26, American Society of Civil Engineers, USA, 2005, pp. 69-98.

[3] Desai, C.S., Shao, C., White, D., Davis, S., Stability analysis for consolidation and dynamic response of mine tailing dam. *Proceedings of the Fifth International Conference on Tailings and Mine Waste '98*, Fort Collins, Colorado, 26-28 January 1998. A.A Balkema Publishers, Rotterdam, the Netherlands, 1998, pp. 193-200.

[4] Gens, A., Alonso, E.E., Aznalcóllar dam failure. Part 2: Stability conditions and failure mechanism. *Géotechnique*, 2006, 56 (3), pp.185-201

[5] Martin, T.E., E.C. McRoberts, Some considerations in the stability analysis of upstream tailings dams. *Tailings and Mine Waste '99*, Fort Collins, Colorado, 1998, pp. 287-302.

[6] Martin, T.E., McRoberts, E.C., Some considerations in the stability analysis of upstream tailings dams. *Proceedings of sixth International Conference on Tailings and Mine Waste '99, Fort Collins, Colorado, 24-27 January 1999*. A.A Balkema Rotterdam, 1999, pp 1-17.

[7] Morgenstern, N.R., Geotechnics and Mine Waste Management – An Update, *Proceedings of ICME/UNEP Workshop on Risk Assessment and Contingency Planning in the Management of Mine Tailings, Buenos Aires,* November, 1998, pp.172-175.

[8] Sengupta, M., Environmental Impacts of Mining: Monitoring, Restoration and Control, *Lewis Publishers,* Boca Raton, 1993.

[9] SC West Construct Company SRL Baia Mare, Proiect Tehnic, Închiderea şi ecologizarea minei Roşia Montană, judeţul Alba - etapa I iazul de decantare Gura Roşiei, Baia Mare, 2008.