Stability Analysis of the Second Site of the Sarcheshmeh Heap Leaching

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ABSTRACT: The second site of the Sarcheshmeh valley leach facility extends over 300,000 m² which may eventually reach heights of nearly 90 m, is situated in the west side of the mine. This paper discusses the stability analysis of heap leaching structure. Hence, it is important to be able to assess the bonding properties of the interface between the geomembrane and inclined surface. The bonding strength results from friction, cohesive forces or combination of the two. Thus the interface friction between texture and smooth HDPE geomembranes and granular soil of cushion layer was investigated by a series of shear box tests. A conventional limiting equilibrium technique based on Carter and Janbu methods was employed using STABL and CLARA softwares. The results of analysis indicated that some profiles along the valley might not be stable due to PLS (Pregnant Leach Solution) level in the heap and blast vibrations.

1 INTRODUCTION

Slope stability is an extremely important consideration in the design and construction of heap leach piles. The task of the designer therefore is to minimize the ongoing construction costs of this kind of structure by maximizing the volume of material that the facilities can contain without unduly risking failure (East & Valera 2000).

The second site of the Sarcheshmeh heap leaching is a lined valley leach facility that extend over 300000 m² on a steep valley situated in the western side of the mine which contain 6 million m³ of low grade copper ore.

Liner systems placed to contain the Pregnant Leach Solution (PLS) often introduce low interface friction angles along the base of the ore heap. Certain geometric shapes associated with valley fills can produce ore heaps for which the heap slopes are stable but the entire ore mass is not.

The most probable causes for geomembrane liner failures under high fill-load conditions, based on post-failure review of available literature, second-hand verbal information, and site or photo observations of 12 known heap leach pad slope failures that have occurred since 1985 (Breitebach, 1998). Another more than 16 failures that have occurred as recently as 2003 are not included due to insufficient information to confirm these failures.

This paper presents the potential for massive heap failure by performing the results of stability analyses using low interface friction angles derived from laboratory test data and a sample cross section typical of some valley fill heap constructed in steep terrain.

2 MECHANISM OF FAILURE

The critical failure surface and factor of safety depend upon the shear strength of the weakest material in the heap, liner and subsoil system. For synthetic materials, the critical failure surface and factor of safety may depend upon the frictional resistance between the ore and geomembrane or between a sand blanket and the geomembrane.

Slope failures on geomembrane liner are far less than the three main conditions of instability before or during heap leaching:

a)- sliding along the slope due to low value of the interface friction of the granular veneer with the geomembrane,
b)- tensile tearing of the geomembrane, normally at the crest of the slope where the force is maximum,
c)- failure of the anchorage of the geomembrane when its maximum pull out strength is achieved, Figure 1 (Goure et al., 1998).

This paper is focused on condition “a”, establishing the strength characteristics of the geomembrane and second cushion layer interface. Figure 2 illustrate the details of the liner system at Sir-chesmeh heap leaching.

The bottom lining system of the heap is composed of 2 sections: one section constructed over the rock, which consists of a 0.3 m compacted impermeable.
clay layer that play as a "second liner", and another section constructed over the second liner and comprises a 0.2 m thick fine grained protective "cushion layer".

The 1.5mm HDPE geomembrane liner is laid on the cushion layer. Another cushion layer constructed over the HDPE liner that comprises a 0.2 m thick fine-grained protective. Over the second cushion layer perforated HDPE pipe, was placed within collection ditches with sized gravel, surrounding the pipe to prevent plugging by fines. Finally, the liner was covered with 350 mm of select granular material.

2.1 Laboratory studies

Critically important for the proper design of geomembrane-lined side slopes of heap leaching sites, is the soil-to-geomembrane shear strength.

A number of site-specific conditions must be addressed in order to have realistic results, for example: the type and gradation of soil to be placed, the moisture condition during test, the normal stress to apply, the time for saturation and/or consolidation, the strain rate to use during shear, and the deformation required to attain residual strength, (Koerner, 1999).

The shear strength developed at a geosynthetic interface is dependent on both the normal stress applied to the interface and the displacement at the interface. Several authors (Seed et. al., 1988; Byrne 1994) have indicated that most geosynthetic interface are strain softening.

Quick direct shear tests of that interface were performed with the material prepared at a range of dry densities and moisture contents representative of the as-placed condition.

2.2 Method and results of shear testing

Test methods to determine the bond strength at a geomembrane soil interface fall into the two broad categories of pullout tests or direct shear tests.
Direct shear testing is dominant since, among other things, there can be difficulty in interpreting results from pullout tests on extensible materials.

Essentially there are five basic methods which can be used for direct shear testing, (Ingold, 1992): fixed shear box, free shear box, large base shear box, central base shear box, and partially fixed shear box.

In this research, the method of fixed shear box was performed. This method employ ASTM D5321. This standard on direct shear evaluation of geosynthetic-to-soil, or geosynthetic-to-geosynthetic, recommends a 300 mm x 300 mm square shear box, in which the geomembrane is mounted on a rigid block which is placed in lower half of the shear box. The upper half of shear box is filled with soil which is sheared over the geomembrane below. Measured peak strength of the smooth and textured geomembrane and second cushion layer interface carried out at normal stresses of 0.5, 1.5, 2, 2.5 and, 3 kg/cm². A straight line of cushion layer interface carried out at normal stresses of 0.5, 1.5, 2, 2.5 and, 3 kg/cm². A straight line constitutes the Mohr-Coulomb failure envelop gives adhesion of 0.5, 1. 1.5, 2, 2.5 and, 3 kg/cm².

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A conventional limiting equilibrium technique, based on the Carter and Janbu approaches were employed by using STABL and CLARA softwares for 2-D and 3-D analyses respectively. For non-circular failure surfaces the analyses were conducted using a two-dimensional software of Carter method of slices. The tree-dimensional representation of the base and basal sideslopes used in the stability analysis, one of these results is shown on Figure 5 by CLARA software

Assuming the simultaneous mobilization of peak strength over the entire sliding surfaces, the predicted factor of safety from the 2-D and 3-D analyses lies within the range of about 1.3 to 1.6, for the zones of saturation above the liner lower than 2 m.

In a number of cases, instability has been due to build-up of high level of PLS in the heap from poor heap drainage or high rates of infiltration due to high rates of leachate application or rainfall (Breitenbach, 1998).

The results of analysis by STABL and CLARA indicated that some profiles along the valley might not be stable due to PLS level in the heap and blast vibrations. So the collection system within the heap must be designed to maintain zones of saturation above the liner at levels as low possible to provide adequate stability and minimize the risk.

The other controlling factor for the stability of the second site of heap leaching was the interface friction between the geomembrane and the heap in the area of the toe. For providing a satisfactory factor of safety an area of HDPE about 150 m from the toe was identified as requiring textured liner instead of smooth liner, with its higher angle of friction. The geometrical configuration of the heap area dictate to perform textured liner from the toe to a point ap-proximately halfway up the valley side.

3 STABILITY ANALYSES

At Sarcheshmeh, high density polyethylene (HDPE) in heap leaching is placed in direct contact with cushion layer. This will lead to a component of gravitational force acting in the plane of the geomembrane, which can cause it to slide down the inclined surface. Consequently it is important to be able to assess the bond properties of the interface between the geomembrane and inclined surface. The bond strength which can be made available may be frictional, cohesive or combination of the two, (Karimi Nasab el. al., 2001). Heaps may also fail by sliding along a high slope leach pad because the saturated solution layer in the blanket over the geomembrane results in a significant increase in interface friction with adjacent materials versus the same geomembrane with a smooth surface.

4 CONCLUSION

- The site is variable and complex and the results of the analysis do not necessarily apply to the whole site,
- Stability analyses indicate that a textured liner is required from the toe to a point approximately halfway up the valley side.
- The presence of fluid pressures acting along all or portions of potential failure plane has the consequence of reducing stability.
- Proper drainage of leach solution above the geomembrane is critical in the performance of the heap leaching project.
- With complex pad geometries as second site of the Sarcheshmeh heap leaching, some trial-and-error searching is necessary to locate the more critical sections.
Guianally the desired target of safety is above 101.5 to provide sonic num gin forenoon

Figure 3: Potential ground failures in a wet ore heap

Figure 4: Geometrical configuration of the Sache dump heap 14

Figure 5: Critical failure of 1 D stability analysis by CLARA software Fs=1 S uni Fs=0.789 for the zones of saturation above the line, lower than 2 in and more than 4 in respectively
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REFERENCES


