Creating a new thought process to specify geomembranes for heap leach applications

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ABSTRACT:

Along the time, in the ambit of the Mining Industry, the geomembranes and other geosynthetics are becoming a commodity. A commodity is a good for which there is a demand, but which is supplied without qualitative differentiation across the market. This is a situation that will damage the Geomembrane industry, since under this concept any improvement or technological advance is no economically viable and therefore any research in this area will lack of sense. Currently GM13 and GM17 are not regarded as they should be. Originally they were conceived as a generic specification for standard applications: *"This standard specification is intended to ensure good quality and performance of HDPE/LLDPE geomembranes in general applications, but is possibly not adequate for the complete specification in a specific situation. Additional tests, or more restrictive values for test indicated, may be necessary under conditions of a particular application."* This paper deal with a new thought process about geomembrane specification for Leach Pads where the communication between Manufacturers, Designers and Owner plays a fundamental roll.

1 INTRODUCTION

A common heap leach project is in fact much bigger than any other application. Most the pads that are currently operating in the Atacama Desert-Chile are bigger than 1.000.000 m², and their thickness usually are either 1.5 mm or 2.0 mm.

Why not in the range of 1.0 and 2.0? (e.g. 1.2 mm or 1.8 mm) Actually there is not a single technical reason for this limited set of available thickness since:

- The geomembrane to supply for a Heap Leach is not taken from inventory (except for a negligible part).
- Manufacturing any thickness in between 1mm and 2 mm has the same grade of difficulty than the standard thickness does.
- There is no need of special gap adjust or special parts; the thickness is just a continuous function of the resin flow and the surface per unit of time of manufactured geomembrane.

As matter of fact there are good reasons to select thickness in between the standard values. Actually in most cases it will mean the use of thinner material, this is, just what the project needs and not the nearest thicker standard thickness. This potential reduction in the thickness mean:

- Economical savings in the amount of geomembrane weight requested to line the pad.
- Thinner rolls mean longer rolls and therefore less patches and seams.
- More workability of the material that allow a better adaptability of the geomembrane to the surface to cover.

On the other hand, can we say that when a geomembrane meet the standards GM13 or GM17 its performance is just a single variable function of the thickness? As matter of fact this is no true and that could be proved running performance tests in different geomembranes (basically different resins and different additives) like:

- Multiaxial deformation
- Puncture (long Term test)

A high performance resin and a reliable manufacturing process will be able to make the geomembrane exceed the specifications values of a regular one, but using less raw material and therefore decreasing the cost per square meter of geomembrane.

2 SCOPE OF THE PAPER

This paper refers to the polyethylene geomembrane specification for leach pads or any other application where the strains due to the puncturing forces acting over the liner are beyond the elastic behavior of the geomembrane.

3 STRESS AND STRAIN UNDER THE HEAP

To know the working conditions of the pad geomembrane allow better understanding of the qualities that have to have the geomembrane liner.

It doesn't matter what specific type of leach pad we are considering. All they had a common characteristic. Its geomembrane is the armor that keeps the leachate away from the subsoil.

Why an armor? All the armors have in common that they have to endure forces trying to penetrate it, to puncture it, where the main forces always are somehow perpendicular to the surface

Is the thicker armor the best one?
Is the hardest armor the stronger one?

A good armor in general terms is the one able to absorb energy keeping its integrity and protecting its content. To keep the armor integrity is a combination of the base material, the seaming process and the layout design of the armor components.

The workability of the liner decrease when increasing the thickness, and the amount of patches and joints needed during the installation process increase proportionally to the liner thickness.

In other words a good geomembrane pad is going to be the result of the global performance of the installed geomembrane by means of the proper geomembrane specification, the panel layout and the quality of the installation.

4 SELECTING THE GEOMEMBRANE

Selecting the right geomembrane should be a three step process:

1. Theoretical evaluation.
2. Judgment of the theoretical evaluation by experience.
3. Performance Testing to confirm "2"

However many times it is just a one step process based in the experience in similar projects:

Why? Because nevertheless how detailed was the evaluation made by the designer, he will try to call for a standard geomembrane specification, answering just three basic questions:

1. HDPE or LLDPE
2. Textured or Smooth
3. 1.5 mm or 2.0 mm

- Have the design possibilities be so restricted?
- Which is the cost of select 2 mm thickness instead 1.75 mm thickness?
- There is an over cost because the use of a nonstandard thickness?
- Is it possible increase the performance of the liner and at the same time to reduce its cost?

Actually this situation is some sort of vicious circle since the designer just chooses for his design what the industry offer to the market and the industry just respond to the demand. So, what we need?... ¡communication!

5 GEOMEMBRANE THICKNESS

The thickness of a Polyethylene geomembrane in a Blow film Line, is a property that is function just of the extrusion rate and the geomembrane's surface production rate. Therefore, there is a continuous range of thickness that is possible to produce between the natural limits of the production line, usually in the range of 0.5 mm to 3.0 mm.

Given this, is it not a waste of material and resources, besides all the disadvantages of using a thicker liner to use the closer thickness bigger than the proper one determined by the designer engineer?

Yes! As matter of fact it is a waste of resources and an indirect way to build a weaker pad.

So far our attention was just on the manufacturing process and how it is possible to make just what is needed; but what about the liner performance? Are all the geomembranes the same? Are all the formulations the same? Then, just knowing that the liner meet GM13 or GM17, is just the thickness the only variable that we can control?

As matter of fact the answer is "No". Performance test allow the Engineer to differentiate between all the set of liners that meet the basic standard GM13 or GM17 and therefore is not just the thickness the only variable that he can control.

Of course "performance test" are not free, and some of them are expensive, however their cost is meaningless compared with the savings that it is possible to obtain specifying the adequate liner. A high performance polyethylene formulation is not much expensive than a basic GM13 or GM17 specification, however the savings for the project could be considerable since the reduction of the thickness is in general terms proportional to the reduction in cost.

In the preceding lines the performance was associated just to the formulation; however height performance values are also related to a premium manufacturing process where the standard deviation of the properties is low enough to make the product more reliable. Therefore the safety factor of the geomembrane properties could be reduced without reducing the safety factor of the design but the project costs.

6 RECOMMENDED PERFORMANCE TESTS

There are many accepted methods to evaluate the performance tests of a geomembrane however there is the need to define a battery of tests methods to evaluate the behavior of the geomembrane during the service life:

ASTM D5514 - 06 Standard Test Method for Large Scale Hydrostatic Puncture Testing of Geosynthetics.

This method incorporates two basic procedures:

A first one (method A) using manufactured test pyramids or cones as the base of the testing apparatus. This procedure is intended to create comparable data between laboratories, and can be used as an index value for the specification of the material .

The second procedure (method B) adequate for geosynthetic design incorporates site specific soil or other material selected by the user as the test base of the testing apparatus.

ASTM D5617 - 04 Standard Test Method for Multi-Axial Tension Test for Geosynthetics.

This test method covers the measurement of the out-of-plane response of geosynthetics to a force that is applied perpendicular to the initial plane of the sample. Usually it is associated just to LLDPE since is used in GM17 as an index property.

Multiaxial can be also used in HDPE geomembranes and actually in any polymeric unreinforced geomembrane. Even though it is not a representation of the real work conditions of the liner, it could be consider as the ASTM procedure that best represent how the geomembrane will perform under differential settlements and subsidence.

7 LARGE SCALE HYDROSTATIC PUNCTURE

ASTM D5514, method B is a very fascinating test, where it is possible to know the real puncture resistance of the liner under the real conditions.

However ASTM D4833 - 07 Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products, usually just called "Puncture Resistance" is erroneously considered as a good reference of the durability of the liner under the puncture action of the heap. As matter of fact in many designs where the deformations are limited into the elastic range this could be true. However under the huge loads represented by the heap, where the final shape of the liner is just going to be determined by the equilibrium between the overliner/ore and the subgrade, the flexibility and no the resistance is going to be the key for the real "Puncture Resistance".

The set of figures 1, 2, 3, 4 shows an ASTM D5514, method B test, performed over a 1 mm LLDPE geomembrane located over a subgrade of coarse material.

Figure 1. The test area (60 cm diameter) was divided in two sectors. One with geotextile and the other with coarse gravel.

Figure 2. The liner is placed over the test area.

Figure 3. The pressure dome is installed over the liner and slowly pressure is increase until 100 psi during 24 hours.

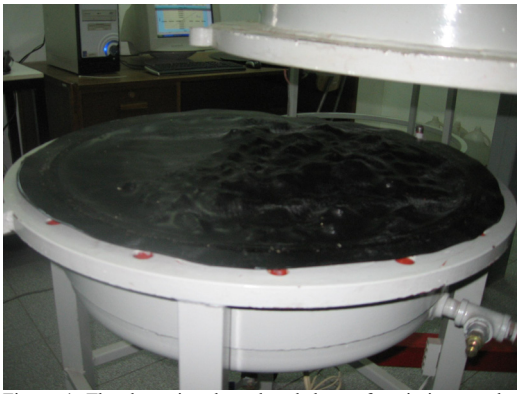

Figure 4. The dome is released and the surface is inspected. The liner looks like a replica of the surface. No a single filtration exist along the process.

Figure 5. The multiaxial deformation in a LLDPE geomembrane, smooth or textured 9see figure 6) easily exceeds the GM17 standard >30%

Figure 6. Multiaxial perform of an LLDPE double textured liner.

8 MULTIAXIAL TEST

ASTM D5617 on the other hand figures 5 and 6, even thought is not as realistic as ASTM D5514 is a good representation of the behavior that the liner will have under the heap in case of a subsidence occurs. The capability of keep the integrity in this case is very important since the subsidence, in case of failure in the liner will act as a sump with all the consequences it could have.

Multiaxial test also shows that the myth of the poor elongation capabilities of the nitrogen Textured materials is false. As matter of fact the performance of the textured material is quite close to the smooth material (both cases over 60% for a regular LLDPE geomembrane Figure 6).

9 CONCLUSION (ON THE WAY TO A NEW MANNER OF SPECIFY GEOMEMBRANES FOR HEAP LEACH APPLICATIONS).

Heap Leach pads are quite special, not just because its size or the way that the geomembrane works but because the liner has to be understood in a totally different way.

Most the design methods are going to be surpassed by the reality of the huge dimensions of the heap leach pad. And no model is going to be good enough by it self. Performance test is needed or a very high Safety Factor is going to be present increasing the thickness of the liner.

When the designer through the theory and the experience has a good idea of the range of thickness and polymer is needed for the liner, then is the moment of the final selection by means of performance testing for the different products available.

The manufacturing specification then can be created using the fingerprints of the selected material:

Tensiles, under ASTM D6693; Tear resistance, ASTMD1004; Index Puncture resistance, ASTM D4833 are linear functions of the thickness, so they can be estimated easily for any value in between 0.5 and 3.0 mm. They should be specified under a specific confidence level (i.e. 98%).

Other values like modulus 2%, ASTM D5323; Carbon Black content, ASTM D1603; carbon black dispersion, ASTM D5596; oxidative induction time, ASTM D3895 / ASTM D5885; Stress Crack Resistance (NCTL), ASTM D5397, are dependant of the formulation and therefore independent of the thickness, i.e. they are a constant.

On the other hand Oven Aging and UV resistance are usually regarded as formula related however is the author opinion that more research is needed here so that make relevant the comparison of different manufacturers.

This new conception of the geomembrane specification will stimulate to the development of new products, new technologies and will give to the geomembranes the status of an engineered material, leaving behind the idea of a “black plastic without holes”.

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