Repairs underwater of a HDPE liner by using a bituminous geomembrane of a density more than 1

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ABSTRACT: A case of history will be given of a gold mine in Spain, the Tailing reservoir (TMF) waterproof with HDPE presented various defects (around 256) The mine asking extension, repairs on these defects were requested by the authorities to be fixed to obtain the necessary authorizations to operate and manage the installation.
As a technical solution for the defects found, it was proposed to use a bituminous geomembrane with a density higher than l g/cm3 and an adhesive, which allow each different surface to be glue underwater by a process named vulcanization an also seal the joins.
The solution applies had fixed the defects and had achieved the authorities request to obtain the authorization to operate and manage the TMF.
The article will also describe the results obtain after 5 weeks of installing the solution proposed.
ln conclusion, the article will comment other specific jobs showing example of possible extension of tailings pond in HDPE by bituminous geomembrane with 1,600 km of seams (HDPE/bituminous geomembrane) in North of Canada in a diamond mine. In the same time, we will indicate the lowest temperature for installing and welding bituminous geomembrane and the worst weather conditions for installing bituminous geomembrane.
Another case history will be given for constructing a port in La Reunion Island and for assuming the separation between clear and salt water.

Keywords: Bituminous geomembrane, HDPE repairs, under ·water, Sticking HDPEIBGM

1 INTRODUCTION

This paper will speak about bituminous geomembrane with a density of more than 1 and a special bituminous mastic and their special properties to stick under water in leaving a weight above the joint during 4 weeks by a phenomenon of vulcanization.

1.1 *Components of the BGM*

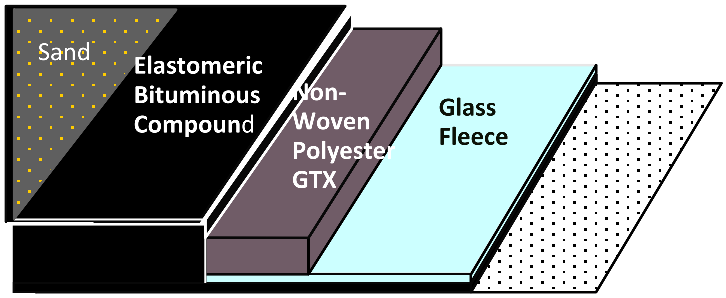

Figure 1. List of the components

The structure of BGM is multi-layered including mainly: a polyester geotextile providing the mechanical resistance and especially the high puncture resistance and a compound initially with an oxydised bitumen and since 1986 mainly with an elastomeric bitumen providing the waterproofing properties and ensuring its longevity by impregnating totally the geotextile.

Manufacturing is done under strict quality control procedures certified under an ISO 9002 quality assurance scheme, under a French and European ASQUAL certification and it is CE marked (European marked).

The factory operates with an ISO 14001 environmental certification.

Some technical characteristics of BGM giving advantages for use in hydraulics:

Permeability at the same level of any other type of geomembrane, around 10^{-14} m/sec. Darcy law permanently at this level, as opposed to bentonitic geocomposites, which are 1000 times more permeable and not permanently impermeable.

Density more than 1.

High puncture resistance.

BGM does not form wrinkles with variations in ambient temperature like HDPE exposed causing problems to the junction outdoors HDPE / BGM for the extension of a pond in HDPE by BGM. For the 2 first example, under water, HDPE and BGM can be joined easily as neither one or the other has no wrinkles.

The manufacturer supplies monitors for training local teams of installers.

1.2 *Bituminous mastic*

Bituminous mastic used is a black, durable plasto-elastic, adhesive and sealant based on bitumen, selected elastomers and resins that adheres on most building materials, even on wet surfaces. Its density is more than 1. It provides excellent adherence on most materials without any primer. The temperature of storage must be maintained at a temperature greater than - 20°C (- 4°F) during the application. Bitumseal is easy to apply and has in general a good adhesion, also without primer, on many substrates. On wet surface allow the nozzle to rest on the surface to push the water away to guarantee a good initial adhesion. Curing/drying varies according to the weather, the layer thickness and the surface porosity; from 12 hours up to a couple of days in unfavorable conditions. After applying, almost immediately enough adhesion is being built up to resist a minor load. Maximum adhesion strength is being obtained after a complete curing.

2 CASE HISTORY: IN SPAIN, REPAIRS OF HDPE POND

“El Valle-Boinás” gold mine is located in the north of Spain, in Asturias province on its Occidental side. The mine Project has a benefit plant and the produce tailings, will be storage on a tailings pond built for this purpose.

Previously to initiate the mining activities, the owner of the project carried out various tasks to adequate the storage area in order to obtain the authorization to operate and manage the facility. At the time start the permitting process, the storage facility was exclusive fill with runoff water from the open pit were the facility is located and rainfall water.

During the permitting process for an extension, the authorities carried out various site visit and requested that additional works were developed to ensure that the facility accomplish all the environmental requirements, which included the correct impermeabilization of the facility.

Due the fact that the defects were located below water level, it was impossible to use the custom techniques to fix a HDPE system, this issue lead the search to new solutions taking care of:

The material chosen needs to glue to an existing HDPE material, even under water.

The proposed material should present the same properties, of watertightness, than HDPE.

Material and installation methodologies should granted the perfect impermeabilization of the TMF.

The solution presented to the owner consisted in, using an asphaltic base geosynthetic material and its chemical union to the HDPE by a process named vulcanization using an adhesive capable to work under water and ensuring the sealing between surfaces.

This solution covered the prior requirements and allowed to fix the defects founded.

2.1 *Methodology*

To install and fix the defect founded, it was prepared a worked methodology between the engineering, the manufacturer and the owner:

2.1.1 *Initial review*

Previously, an inspection of the areas for defining the location and the number the existence of defects

This task was performed by a scuba diver team which located the defect underwater in 3D, indicating the deep and the size. While on surface the defect were topographic marked.

This review was done in sections of 2-3 meters and was defined two types of defects depending on size and geometry. It was named “breaches” those defects bigger than 20 cm with a longitudinal geometry, including those with a L setting; in the other hand were named “leakage” those defects no higher than 10 cm with a circular or semicircular geometry.

During the initial control were found 13 “breaches” and 19 “leakage” in two areas of 130 and 250 linear meters.

2.1.2 *Repairing*

To repair the defects founded during the initial review, it was proposed the following methodology:

- The scuba diver will relocated the defects according with available data from the initial review,
- He will mark the area leaving 1 m on each side of the axis in where the defect is located by using two ropes,
- The scuba diver will reconfirm the deep of the defects located during the previous review and will left a distance of 0.5 m (min) below defect location; this will be used to define the length of the geosynthetic patch up to its final position, which will be located a minimum distance of 0.5 m from the top of the slope.
- On surface, a point will be done at the define length and a central axis will be drawn to center the patch,
- While the material is cut, a scuba diver will clean around the defect to ensure the correct vulcanization process
- Surrounding the defect will place a thick and abundant cord of adhesive (2kg/m^2, attending to site engineer criteria to ensure the maximum seal of the defect,(see figure below),
- On the perimeter of the piece and up to the water level will be place a finer cord which purpose is to avoid possible undesired movements of the piece (see figure below),
- Once the piece is ready, it will be center on the sign already made, the area should be clean and the adhesive applied. The piece will be fixing to the berm mechanically by using a thread bar (30 x 30 x 30 on a U form).
- The piece mechanically fix will be slide down the slope and the scuba dive will be place it properly,
- Finally, the operative on surface along with the scuba dive will place a certain number of sandbags on the axis of the defect, one of the sandbag must be on top of the defect, and the others on the perimeter,
- The sandbag schemes propose will remain in place at least 4 weeks, to ensure the chemical vulcanization process between the different products.

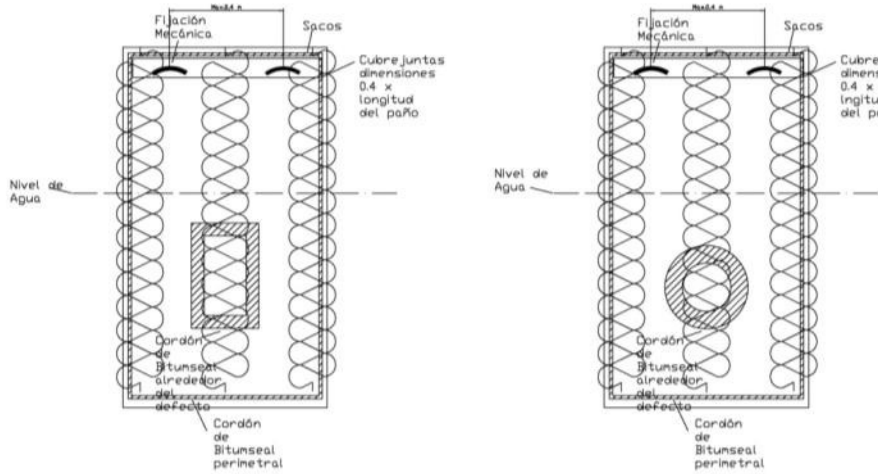

Figure 2. Material piece configuration

The mechanical fixes will be seal by welding a piece of BGM on top of the thread bar, by using this will be ensure that no infiltration will pass through this point. The dimension of the fixes and the sandbags lines can be modified according with the dimension of the piece and are left to the site engineer criteria.

According with the methodology describe above, was fixed 100% of the defects detected.

Following a serial of pictures showing the reparation process are presented:

Figure 3. A repai

Figure 4. Area of preparation

Figure 5. Final result of a repaired defect

2.1.3 *Further actions*

Once the Works were done after 6 weeks an inspection was carried out to verify the status of the repairs.
The objective of the inspection was to verify that the sealing and the joins between the materials were produced as was expected, and also to ensure that the defects repaired did not presented any failure that will lead to a poor sea of the defect.
A scuba team performed an inspection of the repairs according with the following criteria already establish:

- The sandbags are always at the same position,
- There is no change on the patch surface,
- The patch was seal, there were no opening joins between materials,
- There were no lateral displacements.

The inspection carried out showed that 100% of the patches were without any defects, well-sealed and without lateral displacement. Only to mention that a line of sandbags was out of place due the welding of the mechanical fixation.

3 EXAMPLES OF REPAIRS

3.1 *In Peru, repairs on dam watertight with a HDPE*

This Mine is extracting polymetallic complex that produces concentrates of copper, zinc, molybdenum, silver and lead. Situated at 400 km by road North East of Lima and at an altitude of around 4,300. The temperature meets between-2ºc and + 20ºC. For increasing the level of the dam of 15 m from the current level, it was necessary to construct new access on the right stirrup. During the construction, there used a blowing-up from which projections damaged the HDPE of 2 mm installed on the upstream face of the dam in the last phase. By plan of deposit, and by administrative requirement, it was needed to patch as soon as possible.



HDPE out of water was repaired by the traditional method: a second sheet HDPE of 2 mm of thickness joined to the first by traditional welding. These repairs were realized up to 50 cm on water.
Several options were valued for the possible repairs of damages for the HDPE under the water:

To lower the water level to repair the sheet.

To construct a wall in the water like dry dock.

To form beach and to withdraw re-washes once consolidated.

Finally, it was decided to use a method of repair used in Spain, which was consisting of using patches of BGM, welds to the HDPE by means of an adhesive mastic.
The process was similar to this described above: adhesive bituminous mastic with permanent weight above the joint during 4 weeks to guarantee a permanent contact between the 2 liners HDPE and bituminous geomembrane. The weight was by means of sand bags.

The consultant found the following inconvenient method:

Method of work not standardized.

It is not possible to fulfill a CQA.

It is not possible to verify the behavior the weld under the water.

But our answer is clear: we did tests in swimming pool of such welds HDPE/BGM with mastic and we measure the shear resistance following EN and ASTM standard after 4 weeks, the resistance is less in the membrane than in the joint.

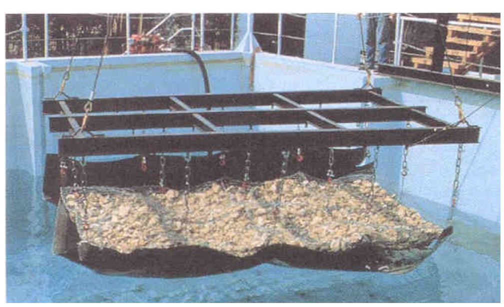

Figure 6. Test

Once obtained all the permissions, they began to realize the inspection of the bank for the evaluation of the damages produced by the blowing-up. During the labors of inspection, there were crossed 170 m of bank, in which they were 31 scratches to repair with 29 patches plus 75 affected meters.

At total, the repairs took 2 days. With the information obtained during the inspection, the BGM patches were prepared. Once cut, they were moved to the zone of repair and were placed with the mastic glue and sand bag.

3.2 *In Saskatchewan, repairs for the EB Campbell dam*



The objective was to protect a layer of clay against the erosion on the upstream face of a concrete dam.

3.3 *Reunion Island – port extension*


BGM was placed on slopes below a rock wall to separate the sea water from the phreatic water level. It was decisive for the Project the fact that was possible to weld underneath the water. (Job 20 years old).

3.4 *Other type of seams*

Other type of seams not under water but with this bituminous mastic to do extension of reservoir or dam watertight initially in HDPE but extend with BGM when the client understands he will be more satisfied with BGM due to no wrinkles, a lot of less defects due to its geotextile inside and as thicker material and possible laying and welding all year.

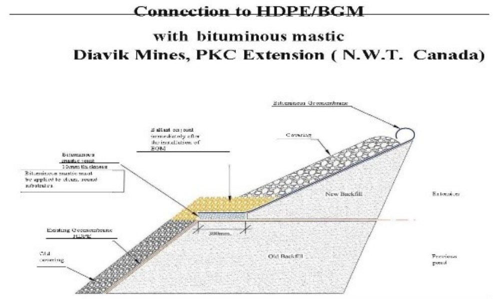

Figure 7 & 8. One example in Diavik Mine (NWT, 350 km of Yellowknife Canada

Cananea copper mine in Mexico (2016/2017) or McKay river landfill in Canada (2011).

3.4.1 *Joint PVC/BGM*

Other example Joint PVC/BGM with bituminous mastic for repairing PVC exposed in Avery windy region, Tunnel under the Channel (storage of polluted water)

4 CONCLUSIONS

After all the work developed can be conclude the following:
It is possible to repair defects on a HDPE liner under water.
The joins between geosynthetic material from different origins it possible throughout chemical process (vulcanization).
The durability and guarantees of the material are maintained along the time.
Hydrostatics pressures generated by the water help to fix the patch to the slope face.

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