WHAT TO DO IN THE EVENT OF A GEOSYNTHETICS FAILURE?: AN ACTION PLAN

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Abstract: As the Geosynthetics industry continues to grow and innovate failures will continue to occur. Whilst unfortunate, failures offer a great learning opportunity provided they are handled correctly. Proper handling and investigation will also provide insurance companies with the correct information on which to base an accurate decision relative to coverage and rapid payment. Two case histories are reviewed. The first involves a PVC liner in a very large evaporation pond that was handled correctly and in which the failure process was well-defined. The second involves an HDPE lined slurry pipeline which was not handled correctly and in which the complete liner failure could not be defined. In the latter case only a fraction of the insurance claim was paid.

Keywords: Geosynthetic, failure, insurance, liner, testing, HDPE, PVC

INTRODUCTION

Geosynthetics is still a young industry. Not surprisingly, in a maturing industry, failures occur, and they will continue to occur, but hopefully at a decreasing frequency as we learn from the earlier events. Unfortunately, not only are owners and engineers unwilling to discuss their failures, the failures are not handled or investigated in a way that is amenable to a full understanding of the problem. While this might be a tolerable loss of knowledge to the industry it can become a serious financial loss to the owner if insurance coverage is denied due to insufficient knowledge. An insurance company is within its rights to deny coverage based on there being incorrect or insufficient knowledge to fully explain how accidents and damage occurred. The key, therefore, is to provide the correct information to the appropriate people as soon as possible.

Typical failures involving geosynthetics include: cover soil and waste sliding on lined slopes, retaining walls falling down (presently a very high failure rate), pond liners leaking and generating whales (also frequent), floating covers cracking, studded concrete protection liners blistering and pulling away from the wall, and sewer tunnel and pipe liners collapsing. A leaking heap leach pad liner has been known to make a marginally profitable mine quite unprofitable.

When a failure occurs be proactive. Start a log book. Take pictures. If possible do not move anything. If anything must be moved label it, handle it carefully, and store it in a safe location. Do not damage any fracture faces. If large pieces have to be cut mark them with match lines. At the same time contact your risk management department, insurance adjuster, insurance company, insurance broker and attorney. This will initiate a claim file and an investigation to determine cause, assess coverage liability, and to make payment if the failure is covered. During this investigation loss adjusters will bring in appropriate independent geotechnical and/or geosynthetic materials experts. These experts should ideally see the as-failed condition of the structure, as should the claims adjuster assigned by the insurance company. It is the adjuster who will determine whether the failure is covered and who will determine the cost of remediation, based on the results of the failure analysis and policy contract liability. So a coordinated failure investigation performed in parallel with repairs will allow the fastest return to regular operations and the most efficient and accurate resolution to the claim.

The claims adjuster and relevant geosynthetics expert(s) should be on site as soon as possible to ensure that no relevant evidence is overlooked and that all necessary samples are taken. There is nothing more frustrating for expert and claims adjuster than being called in some time after the event and trying to rely on hearsay, damaged samples, and incomplete sampling. In such cases it may not be possible to reconstruct failure events to fully support the owner and to determine which insurance carrier is responsible for damage payments. Coverage may even be denied.

Therefore, having contingency plans for dealing with accidents and damages in relation to making the repairs and advising the insurance companies will ensure that the correct people are present at the appropriate time, that the proper samples will be taken and stored correctly, and the proper information will be collated. Repairs will not be delayed. Valuable information will not be overlooked or lost. Not only is this important for insurance purposes, but quite often the owner learns more about his/her process or system, thereby increasing efficiency.

Two case histories may best illustrate the need for responsiveness, good records, and cooperation.

CASE 1: EVAPORATION POND LINER

The first case involves a PVC geomembrane lining in a 100 ha brine evaporation pond. Because the process solution was not generating the required yield at the outlet end the owner hypothesized that the liner was leaking and valuable product was being lost. With about 150 mm of salt precipitate on top of the liner the owner surveyed for eddy patterns in the precipitate and used dye to define the locations of leaks. When the hard crystalline salt precipitate was removed from the liner there were found to be many linear cuts up to about 50 mm long in the liner. The long chisels used by workers to harvest sections of ice from the pond had sharp ends about 50 mm long.

The owner claimed the loss of brine was the result of these holes in the liner, and hypothesized that the holes were an act of vandalism with the hole being made just before the ponds were put into service. Therefore, since a construction all risks (CAR) policy was in place the damage should be covered by the construction insurance carrier. The owner separately carried operations insurance. However, the construction insurance company refused covered, hence the owner informed the operations insurance carrier of the problem. Therefore, it became very important to the operations insurance carrier to determine how and when the damage was made. A detailed investigation was required. They were not trying to evade the claim, but wanted a clear picture of how the damage was caused.

The owner had made a detailed map of the locations of all cuts found and a few samples were taken. The operations insurance carrier assigned a claims adjuster who immediately visited the site to review all of the documents, photographs, and samples associated with the failure that had been carefully generated and maintained by the owner.

During the site visit the adjuster noticed mushroom-shaped salt structures in the pond with the flat tops of the mushrooms just proud of the surface of the liquid brine. Such loss of brine surface area would clearly affect the evaporation rate of the brine and thus the chemistry of the process. There were no such mushrooms in previously built ponds. Another difference discovered in the new pods was the lack of a clay cushion layer between geomembrane and shaved salt subgrade. Thus these were single geomembrane lined ponds while previous ones had been single composite lined ponds. This turned to be a significant difference.

Immediately after the site visit the adjuster hired a geomembrane liner expert, a chemical process expert, and a mechanical modelling expert from a local university. All experts subsequently visited the site at the same time with the full cooperation of the owner. The precipitate was about 600 mm thick at the time of this visit (Peggs, 2003).

The owner had marked locations where he felt there were holes in the liner. Chisels were used to remove precipitate to within about 150 mm of the liner and the balance removed by hand. Plant workers were seen to be using the same chisels on other areas of the precipitate. At the indicated locations there were indeed cuts from 10 mm to 50 mm long in the liner. In some places the chisels had clearly directly punctured the liner but in most places the chisels had not contacted the liner. Samples were taken and the liner repaired.

Microscopy of the cuts did not show the two edges to be pointing downwards as they would have been had they been punctured from the top, and as demonstrated at the known chisel punctures. In most of the cuts one edge was turned down and the other turned up indicating that the “cuts” were, in fact, shear breaks. Thus, they were not the result of vandalism or sabotage using chisels to puncture the liner at the end of construction.

It was ultimately determined that the holes were actually made during the chiselling of the precipitate to expose the liner, as the geomembrane was tightly confined between the precipitate salt and the smooth shaved salt subgrade. As the chisel impact occurred a crack was propagated downwards through the hard crystalline precipitate. Because the impact was not absolutely vertical the precipitate under the inclined chisel was displaced (sheared) downwards. This shear displacement passed through the tightly confined geomembrane into the equally hard substrate salt. The lack of a clay cushion layer under the geomembrane precluded the dispersal of the shear forces within the geomembrane.

After considerable effort the chisel impact process was reproduced in the laboratory and generated breaks with the same geometrical profiles as those in the field. Thus, wherever there was thought to be a hole in the liner one would be generated by the excavation and investigative procedures. Therefore, since the holes were made during the operating period of the ponds the claim for construction damages was denied.

Separately it was shown that the formation of the precipitate mushrooms played a major part in the cause of the poor product yield from the evaporation ponds. In addition there was some leakage through the liner through holes made as precipitate was harvested to control its depth, as a dividing berm was constructed to control flow rate, and as a protective cover layer of salt was placed on the side slopes. Because there was no clay layer under the geomembrane (a cost-cutting measure) the leak flow rate was higher than normal (compared to previous ponds with clay layer) and the flow eroded the salt under the liner thereby enlarging the path through the salt, removing support for the liner, and causing the hole in the geomembrane to grow.

The formation of the mushrooms was an inherent function of the brine flow rate through the pond, increasing as flow rate was increased to allow for loss of brine through leaks, and of the depth of the brine. Once mushrooms start to form, their initiation and growth rates are self-catalyzing, and evaporation surface area is decreased.

DISPOSITION OF CASE 1

The major cause of the problem was assigned to a design error in omitting the clay layer under the geomembrane. This allowed more than normal and accelerating leakage which together with the brine chemistry and related formation of precipitate mushrooms caused the chemical yield to be lower than expected. The chisel shear leaks were clearly made after the start of operations. Since the CAR covered only construction damages, not design or operations damages, the construction damage claim was denied. The operations claim was also denied since it too did not cover design errors and did not cover damage done during the investigation.

These decisions were not accepted by the assured so a four year period of arbitration ensued. Finally the arbitration panel considered the adjuster’s investigation and conclusions to be proper and correct and affirmed that decision.

Despite these findings the owner continued the claim all the way to the Chilean Supreme Court. An additional two year trial ensued and the owner was faced with a second but final unanimous defeat. Therefore, although the final decision was not in the owner’s favour, his prompt actions had allowed a full and complete study of the failures to be made, from which the various components of the failure were fully understood.

The second case was quite different.

CASE 2: HDPE-LINED SLURRY PIPELINE

This case involved a 150 km long buried copper slurry pipeline that was lined with an intimately fitting 6 mm thick HDPE liner. The HDPE liner was constructed by butt welding several lengths of pipe together, removing the squeeze-out beads, pulling the pipe through a reducer at the inlet to the length of steel pipe being lined, pulling the liner through the steel pipe, then allowing the liner to expand back to its original diameter generating intimate contact with the steel pipe.

After a few years in service the pipe became blocked. Attempts were made by pressuring the line both forwards and backwards to dislodge the plug, but all were unsuccessful. The owner, engineer, and pipeline installer rapidly investigated the locations of the blockage(s), cut the pipe, and removed the blockages and other interesting features they came across. Then they called the insurance company that carried their operating insurance. The appointed claims adjuster, therefore, first visited the site as the damaged section of the pipeline was being by-passed with another pipe and as the original pipe sections were being repaired. A plug of mangled liner had been removed from the pipe and stored in one location. Sections of lined pipe and pipe from which the liner had been removed were stored randomly and inadequately (in one case incorrectly) marked in at least two separate locations.

The claims adjuster contacted his polymer engineering and university mechanical engineering experts. The first expert visits to site were made about one year after the event and the initial investigation. While there were quite a few photographs of the investigation many had no identified location. There were reasonable records of plant activities to attempt to dislodge the blockages, and there were reasonable engineering company records of how the different blockages were located, what they were and how they were removed. There were no investigative records from the company that installed the HDPE liner. In fact there appeared to have been only one liner related blockage. Most of the other minor blockages were formed by fragments of a scale about 1 mm thick that had unexpectedly formed on, and exfoliated from, the inside surface of the HDPE. Just prior to the blockage attempts had been made with a hydrochloric acid wash to dissolve the scale. Instead the scale had fallen off the liner surface in large (~50 mm) pieces. Thus the 1m long plug of mangled liner was filled with broken scale fragments, and there was an associated upstream plug of broken scale about 3 m long.

A few incomplete installation QC records and even fewer QA records were found in files. Despite the photographs (more appeared with each interview) and notes there were inconsistencies in locations of features that were found. When the stored pipes and liners were examined there were four particularly interesting pieces.

Figure 1 shows what appeared to be a section of liner overlapping another section of liner. Attempts to pull the overlapping piece off, even with a pick-up truck, were unsuccessful. The overlap was cut and the two pieces were found to have been welded together by an overlap weld not a butt fusion weld. It appeared that the outside of one piece had been heated then pushed inside the other piece (of the same wall thickness and diameter) and been expected to make a satisfactory joint. However, the inside piece had collapsed under the compressive hoop stresses, thereby causing the joint to leak and to allow slurry to access the interface between HDPE liner and steel pipe. Such a situation could have caused the liner at other locations to collapse. It was difficult to believe that this piece had come out of the steel pipe.

Figure 1. Marking overlapped liner before separating

The mangled liner (Figure 2) was examined. It appeared that the two long “ears” at one end had been inverted from their original positions alongside the main body of the mangled plug. Clearly this piece had torn out of the liner from somewhere else in the pipe. However, no search had been made for such a location.

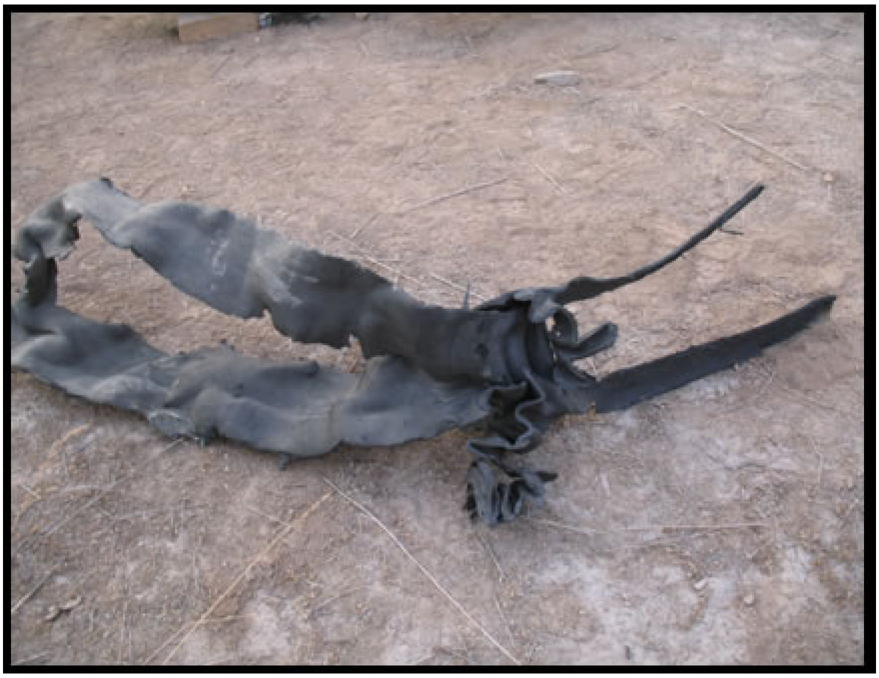

Figure 2. Large piece of broken HDPE liner that caused blockage

An unusual “beak” section of liner was found, with no markings (Figure 3). It had been present in the pipeline in this condition for some time since there were slurry and scale abrasion marks on the outer surface. However, no matching part to this piece was sought or found.

Figure 3. “Beak” fracture in HDPE liner

There were photographs of collapsed liner at flanges between steel pipe sections but there were no samples found or made available in this first site visit. Many sections of partially collapsed almost completely collapsed liner were also seen, as shown in Figure 4.

Figure 4. Collapsed HDPE liner

It was evident that there had been leaks through the liner, that slurry behind the liner had probably resulted in the liner collapsing, and that in one case a large piece of liner had torn away and caused the main pipe blockage. All of these features were present in a relatively short length of the pipeline which also happened to be the lowest elevation of the pipeline, and just before it rose (downstream) to the highest elevation. All features probably occurred sequentially during the failure event, which happened very quickly, and which caused a rapid shutdown of the pipeline. Thus, most materials were in the same abraded condition that they had been at the time of the blockage, However, their geometrical profiles were either as they were at the time of the failure or as modified by the higher applied forward and reverse pressures when trying to break down the blockage. Thus, it was very important to know exactly the locations where each feature was found and which end of the sample was upstream and which was downstream. It was clearly extremely important to know from where the mangled piece of liner originated, and whether it moved in one direction or another, or both, during the pressure events

There were no such records for the individual features, and recollections of the individuals concerned were quite varied. The insurance adjuster suggested that all involved parties meet at a later date and walk the length of the pipe where the failures occurred. This was a costly meeting for all parties, but a general consensus of locations and orientations was achieved. In addition, one of the collapsed flange samples was found but the weld between the end of the HDPE pipe and the flange that was clamped between the steel pipe flange faces had been cut off and could not be found.

The missing pieces of information that remained were:

- The source of the mangled piece of liner – the main blockage
- The matching break for the beak-shaped liner break
- Three collapsed liner flanges.
- Possible reasons for the overlap weld – possibly the original liner leak.

With reference to the overlap weld, it was proposed by other parties that friction welding had occurred during service as the liner broke circumferentially and the upstream part was forced into the downstream part. However, in the dirty wet slurry environment, with equal hydrostatic pressures on both sides of the HDPE liner (after the liner broke), it is inconceivable that even a poor friction weld could be achieved. That being said, it is still difficult to see how a partially successful insertion overlap weld could be made under controlled conditions.

Due to the lack of information and samples the adjuster was very close to denying any claim at all. For the same reason the final report could not be conclusive. The final opinion was expressed that the overlap weld, made during construction (and therefore not claimable under operations insurance coverage) leaked and was responsible for the nearby “beak” break, partial liner collapses, and more serious flange collapses. Some of these features had probably been present prior to the blockage event. The more distant (several hundred metres) upstream mangled liner blockage was a separate event probably resulting from a local partial collapse of the liner and accumulation of a large plug of scale (this was the most upstream feature). It is possible the service pressure upstream of the plug caused the blockage to move down the pipe and to take the adjacent liner with it. Friction between HDPE and steel would be considerably reduced with slurry in the interface and equal pressures on each side of the liner. However, it is also possible that the higher forward and reverse pressures used to try to relieve the blockage were responsible for the break in the liner and its movement to the location where it was found. This could only be clarified by finding and examining the source of the mangled piece. It was a serious omission of the first investigation not to find this location.

DISPOSITION OF CASE 2

Because the overlap weld was a construction problem, a portion of the US$9.5 million claim was denied. The adjuster recommended payment for the cost of replacing the portion of the slurry pipeline damaged by the blockage for the sections properly installed during construction. The extra expenses to avoid shutting down the mine, such as building a by-pass section were also paid. This brought the covered claim damage determined after extensive probing, questioning, and hypothesizing, to a total amount of US$4.5 million, about half the claim.

Proper handling and investigation will ensure the correct and timely insurance investigation with determination of the exact cause of damage supported by strong technical and scientific data. This will make applicability of the insurance policy terms much easier to interpret, thereby accelerating an appropriate settlement.

Often this claim analysis will lead to payments, but as noted above, sometimes payments are declined. However, these days, business owners, insurance companies, and attorneys, want to know exactly what happened – or should want to know. Insurance companies want to know what happened and why they have to pay or not. And the assured wants to know the cause, either to analyze how to improve coverage in his policies, or to take measures to avoid future failures which can only result in improving the efficiency of his process or system.

CONCLUSIONS

Geosynthetic failures will, unfortunately, continue to happen. However, they offer the very best learning opportunity if properly handled and investigated.

Proper handling includes the immediate involvement of your insurance company and geotechnical/geosynthetic experts.

Proper handling includes the maintenance of proper records (logs and photographs).

Proper handling includes the careful oversight of, and lack of, further damage to material evidence.

Proper investigation requires the immediate involvement of the insurance adjuster and relevant experts.

A valuable was lesson learned by all parties.

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