Fabricated Geomembrane Institute

FGI Q & A with Dr. J.P. Giroud

From Zero Leak at End of Geomembrane Installation to Zero Leakage in Service

The following questions were received during and after Dr. Giroud's webinar on May 18,2023

Q1: What are the issues to look out for when installing a geomembrane liner on land that has been previously mined but is now rehabilitated, can this be done at all? As an afterthought this application may be for discard dumps or waste rock dumps.

A1: *The question, which is well related to the lecture, refers to the case of geomembrane liner installation on land that may not provide adequate support for the geomembrane due to the possible existence of voids. In this case a geological and geotechnical study is necessary to identify and quantify the possible occurrence and size of voids. Then, at the design stage, it may be necessary to consider the use of one or several layers of geogrid-reinforced soil on top of the land to support the geomembrane liner. A number of papers have been published on this subject. Also, if it is expected that additional voids could be created by leaking liquid, precautions (such as a double liner) should be taken to minimize leakage.*

Q2: Do you think BGMs could be better than PE GMBs for connections to rigid structures?

A2*: Regardless of the type of geomembrane, there is a risk of stress concentration in the geomembrane next to the connections to rigid structures. The presence of geomembrane seams close to rigid structures should be avoided for at least two reasons: (1) the presence of seams may increase stress concentrations, and (2)* *stress concentrations may impact the integrity of seams. Of course, the geomembrane tensile properties govern the ability to withstand stress concentrations. I have addressed this subject in several papers where an analysis shows that an adequate combination of strength and extensibility is required and can be quantified using the concept of co-energy associated with the geomembrane tension-strain curve. This type of analysis shows that some geomembranes have a better combination of strength and extensibility than HDPE and bituminous geomembranes. In conclusion, HDPE geomembranes and bituminous geomembranes can only be compared on a case-by-case basis, and it can be said that some non-reinforced geomembranes such as LLDPE, EPDM, polypropylene, and PVC, may have a better performance next to rigid structures.*

Q3: Why is it important to test in nonradioactive subsurface? Doesn't seem like normal rock would be unsafe radioactively.

A3: *A nonradioactive subsurface was essential for the Proton Decay Experiment reservoir described in the lecture because the water contained in the reservoir was used for a physics experiment, which would have been disturbed by radioactivity, including the extremely low levels of radioactivity that exist in usual rock masses. Therefore, the reservoir was excavated in a salt mass, which is essentially nonradioactive. I want to make it clear that usual rock is totally safe for human beings from the viewpoint of radioactivity and does not cause any damage to geosynthetics. In fact, lining systems using HDPE geomembranes and other geosynthetics are used for the containment of low-level radioactive waste, which is orders of magnitude more radioactive than usual rock.*

Q4: Thank you so much for your amazing lecture. Do you have a case study with Bituminous Geomembrane (BGM)? What are the relevant causes of leakage during service life for a BGM liner.

A4: *Seam failure is a cause of leakage with bituminous geomembranes, and I am aware of cases of such failures. Modern bituminous geomembranes are made with elastomeric bitumen. Therefore, my reply is limited to the case of bituminous* *geomembranes made with elastomeric bitumen. The main weakness of bituminous geomembranes is the decrease of seam strength in the field caused by exposure to high temperatures, such as 60 to 80º C, which are typical for black geomembranes exposed to sun. The seam strength of bituminous geomembranes is mostly due to bitumen and the strength of bitumen, even elastomeric bitumen, decreases significantly with increasing temperature. Therefore, it is important, in the case of bituminous geomembranes, to make sure that the seams are far from locations where tensile stresses may be high, such as steep slopes and connections with rigid structures.*

Q5: For concerns designing a double layer liner system (water between the liners causing movement of the upper liner), would the same concerns be present for the case where the top GMB is a highly stiff, reinforced GMB composite? CCX, a new GCCM product consists of a 10 mm cement-filled geotextile layer, backed by an LLDPE GMB. The cement sets to concrete on hydration post installation.

A5: *As I said in the lecture, two liners can be placed directly on top of each other only if they are sufficiently ballasted to prevent uplift of the upper liner by pressure of the fluids that could accumulate between the two liners. Alternatively, a drainage layer can be placed between the two liners, thereby forming a double liner system, provided that the drainage layer is connected to an outlet and has sufficient flow capacity to promptly evacuate the collected fluids. To completely answer the question, I should add that the above principles are applicable regardless of the stiffness of the upper liner. Also, a composite liner (that is a liner comprising several components) is a single liner provided that the components are properly bonded together and, therefore, do not separate.*

Q6: Due to the high compressive & bending strength, would it be OK to install the CCX directly over the existing GMB?

A6: *This is an extension of the preceding question. If CCX designates concrete attached to a geomembrane and if the concrete and the geomembrane are properly bonded together, the CCX can be considered a single liner. Then, if a CCX is placed on another liner, the situation is that of a liner placed directly on another liner. As indicated in the lecture, if two liners are placed directly on top of each other, there is a risk of uplift of the upper liner by fluids that accumulate between the two liners. It should be noted that predictable failures are not guaranteed to happen but, if a predictable failure does happen, it is guaranteed that the designer of the failed liner will be found liable. Therefore, failures that are predictable must be considered seriously and measures should be taken to avoid these failures.*

Q7: I agree that zero leakage should not be specified because it is almost impossible to obtain and effectively prove. However, do you think specifying design and installation leakage rates could lead to less than expert installation, including installation repairs and affect owner selection of contractors/installers?

A7: *This is an important question. In other words, should we specify an impossible goal hoping it will stimulate excellent design and excellent installation? I think that this approach may be counterproductive because it may lead the owners to have unrealistic expectations and it may generate misunderstandings. I think that the best approach consists in: (1) specifying an appropriate maximum rate of leakage for the specific project; and (2) using appropriate means to meet the specified rate of leakage, such as adequate design, excellent installation, strict construction quality assurance, and electrical leak location. Also, in the case of a performance failure and subsequent litigation, a zero-leakage specification would not be defensible.*

Q8: The NYS regulations for double-lined landfills understand there will be a small leakage. How do you ensure ZERO leakage?

A8: *If the nature of the project and its environment require that the leakage into the ground is as close to zero as possible, then a double liner system is required. However, this is not sufficient. Here are some of the required conditions: (1) the primary liner should be a composite liner consisting, for example, of a geomembrane and a bentonite geocomposite (also called GCL), and, as any composite liner, it must be ballasted, which is always the case in landfills thanks to the mass of waste but requires a ballasting layer in liquid containment facilities; (2) the leakage collection and detection layer should have adequate flow capacity to ensure that the liquid pressure on the secondary liner is as low as possible; (3) the secondary liner should be a composite liner consisting, for example, of a geomembrane underlain by compacted clay and/or a GCL; (4) all of the selected materials should be first-class materials; (5) the design should be such that the number of appurtenances and liner penetrations is minimized; (6) the design should be such that the geomembrane seams are subjected to stresses as low as possible and, in the case of polyethylene and polypropylene geomembranes, the number and length of extrusion seams should be minimized; (7) the design of geomembrane connections to rigid structures should be reviewed by the geomembrane installer and by an engineer with experience in geomembrane installation; (8) the configuration of the liners should be reviewed by the electrical leak location provider to ensure that electrical leak location can be implemented; (9) earthwork and ground surface preparation should be carefully executed under strict supervision; (10) strict construction quality assurance should be implemented; (11) electrical leak location of both geomembranes should be implemented immediately after their installation and after placement of overlying materials; (12) operation and maintenance of the facility should be carefully planned and implemented, in particular an operation and maintenance manual should be developed, which includes regular inspections and repairs if needed; (13) in the case of landfills, waste placement should be implemented in a way that does not damage the liner system; (14) in the case of liquid reservoirs, filling and emptying operations should be minimized and carefully monitored; and (15) all participants (designer, earthwork contractor, geomembrane installer, quality assurance provider, electrical leak location provider, regulator, owner and operator) must be first-class professionals. This list may not be complete.*

Q9: Merci infiniment Dr. Giroud for this great presentation. Should the precautions to be taken for cover systems be the same as for liners to reach the objective of zero leakage in service?

A9: *The examples I presented in the lecture are reservoirs of water where the pressure on the geomembrane is applied by several meters of water. A geomembrane used for landfill cover is only subjected to runoff water when it is exposed or water conveyed by a drainage layer. The resulting water pressure on a geomembrane cover of a landfill is, therefore, very low compared to the pressure exerted on the geomembrane liner of a reservoir. As a result, the precautions recommended in the case of reservoir liners do not apply to landfill covers.*

Q10: What are the considerations for calculating tensile stresses for load bearing geomembranes constructed over a void (mined out land that has been rehabilitated)?

A10: *The first step is to conduct a geological and geotechnical study to evaluate the possible frequency and size of voids. Also, it is important to understand the mechanism of void formation. For example, in a case history presented in the lecture, the voids in the karstic limestone were plugged with a clayey soil. Therefore, it was imperative that leakage into the ground be as close as possible to zero; hence a double liner system. Now, if the presence of voids cannot be avoided, it is not possible to rely on the geomembrane alone to bridge the voids. The use of one or several layers of geogrid-reinforced soil is then required.*

Q11: What is your opinion of using PVC geomembrane in an application where it will be exposed to intense sunlight? Though claimed by manufacturers to be UV stabilized with carbon black, older practice was to use HDPE where exposed to sunlight. Is that still appropriate or can PVC achieve reasonable life spans (a few decades).

A11: *It is sometimes considered that PVC geomembranes are not recommended for applications where they are exposed to solar radiation, whereas approximately 80 large dams have an exposed PVC geomembrane on their upstream face as the only watertight barrier. Clearly, PVC geomembranes can be used exposed in critical applications. However, it should be noted that the PVC geomembranes used on large dams are different from the relatively inexpensive 1 mm thick PVC geomembranes used in low-cost applications. The PVC geomembranes used in large dams are typically 2 to 3 mm thick, their color is light grey to reflect a fraction of solar radiation, and they contain plasticizers with high-molecular mass. As a result, the PVC geomembranes exposed on the upstream face of large dams have a service life of approximately 25 years in the worst cases and of, at least, 42 years for the oldest large dam in service with an exposed PVC geomembrane; furthermore, the predicted service lives are 30 to 90 years for exposed PVC geomembranes on dams currently in service.*

Q12: What is an acceptable method for bonding geomembrane edge terminations to concrete structures? Have leakage issues been identified from synthetic embedment strips with geomembranes attached by extrusion welding?

A12*: I do not know cases of leakage associated with embedment strips. However, I have investigated a case of systematic failure of extrusion seams next to anchor trenches: 13 of the 14 extrusion seams exposed to wind action exhibited severe cracking with several cracks penetrating the entire thickness of the HDPE geomembrane (2 mm) resulting in leakage. It was a poor design to have an extrusion seam next to an anchor trench, because the seam was subjected to repeated bending when the geomembrane was uplifted by gusts of wind, which caused the cracking. The conclusion of this investigation is that there is a risk of extrusion seam failure if one side of the seam cannot move (because it is anchored) and the other side of the seam is exposed to repeated movement. This may be the case if an HDPE geomembrane is attached to an embedment strip using an extrusion seam and is subjected to repeated actions such as wind gusts* *or waves. Another method for connecting geomembranes to concrete structures consists of using batten bars (also called batten strips). The parameters that have an impact on their performance include: bolt spacing, stiffness of the batten bar, gasket stiffness and compression, concrete surface condition, etc.*

Comments from Webinar Attendees:

- Thank you so very much JP. Awesome lecture.
- Thank you for all the work you have done over the decades.
- Excellent presentation!
- Simply awesome presentation. Thank you, JP.
- Honored to have attended this live webinar!!
- Thanks for the great presentation.
- Excellent presentation, thank you!
- Would love to see today's speaker come back to talk about electrical leak surveys. Excellent presentation today!
- Great Job. Good Webinar.
- Great presentation. Much experience shared with us today.
- Outstanding!
- Well done lecture.
- This was an excellent presentation.
- Dr. Giroud you are a Legend in the field! Thank you so much for presenting.
- Excellent presentation.
- Thank you for a great presentation.
- Thank you for the great presentation.
- It was an excellent presentation.
- Dr. Giroud's presentation should be a requisite for any firm involved in geosynthetic design and installation!

REPLY by JP Giroud: *Thank you everyone for the nice comments and for the excellent questions. Reaching the end of my career, it is my mission to contribute to education. I express my gratitude to the organizers of the webinar, Tim Stark and Jen Miller, for making possible this contribution to education.*