Loose bag or concrete protection liner (CPL): Batten bars or CPL embedment strips?

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ABSTRACT: In the mine process, wastewater treatment, and sea water desalination industries steel tanks are being replaced by geomembrane-lined concrete basins as a cost-saving measure. Liner seals to concrete structures are made mechanically with stainless steel batten strips or by welding the liner to CPL strips embedded in the concrete. The liners are typically installed as large loose bags with metal batten bar attachments to the concrete around the top, and occasionally at intermediate heights on the wall. Unfortunately, it is difficult, particularly in floor/wall corners, to fully support the liner so it functions as intended solely as an unstressed barrier. Improved performance can be obtained by using a CPL with special corner profiles and welding integrity features. The CPL is held in place on the concrete surface.
Batten bars are often the locations of leaks and require special attention. For instance the intent is not to torque the bolts as much as possible, thereby inducing a quilted profile in the strip, but rather to compress the gaskets under the batten bar uniformly so they do not exceed the elastic deformation limit.
The use of a CPL embedment strip appears to offer a more assured seal than a batten bar. However, it is critical to have the strip fully embedded in the concrete and without any voids that can provide a leakage pathway along the underside/concrete interface. The butt joint ends and chamfered corners of the strip must be welded to avoid leakage. In both cases the CPL and batten strips should not bridge cracks in the concrete and design should ensure there are no 90º corners close to the sealing strips that might cause the liner to be pulled out from under the strip, or for the weld to be sheared.

1 INTRODUCTION

One guiding principle for all geomembranes is that they function solely as fluid barriers. This is particularly important for high density polyethylene (HDPE) with its high coefficient of linear thermal expansion and its susceptibility to stress cracking (SC). Therefore it is important that a geomembrane be fully supported by the subgrade/substrate so it is not a load-bearing member of the lining system. The facility being lined is often a concrete tank or containment structure with limited access. As the water level is raised and lowered in service the liner can be moved by water flow forces, or even as the liner tends to float if its density is less than the contained fluid.

Such liners have been conventionally welded in situ, including on vertical and underside horizontal surfaces. This is very difficult, tiring work leading to many leaks. In high circular containers a reinforcing batten strip may be used to hold the geomembrane in place approximately every 5 m, clearly not the optimum procedure due to the additional holes in the liner that need sealing.

Another procedure, for the thinner (<1.0 mm) and more flexible geomembranes is to prefabricate the liner and to drop it into the tank as a bag. However, getting good fits to corners, pipe boots, and fittings can be quite challenging, often requiring detail repairs in locations where overheating of multiple repairs should not occur.

One initial solution to this concern was to weld anchoring studs (Figure 1) on the back of the sheets and to make the sheet the former of the inside wall of the tank Figure 2. When poured the concrete would cure around the studs and hold the liner and concrete in the desired intimate contact. Such a product has become known as a Concrete Protection Liner (CPL). Depending on liner thickness welded joints would be overlap fusion or fillet extrusion welded. The studs had to be removed accordingly. They were typically ultrasonically welded to the back of the sheet.

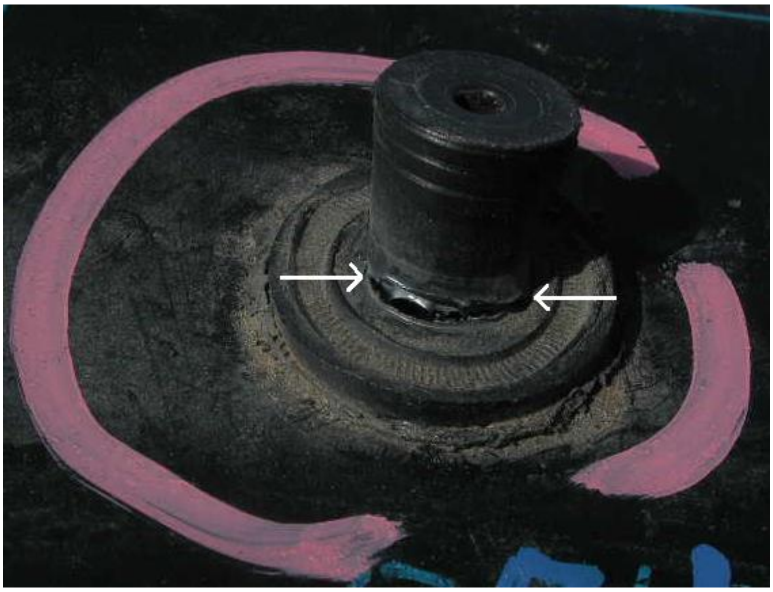

Figure 1. Early weld-on stud, with break.

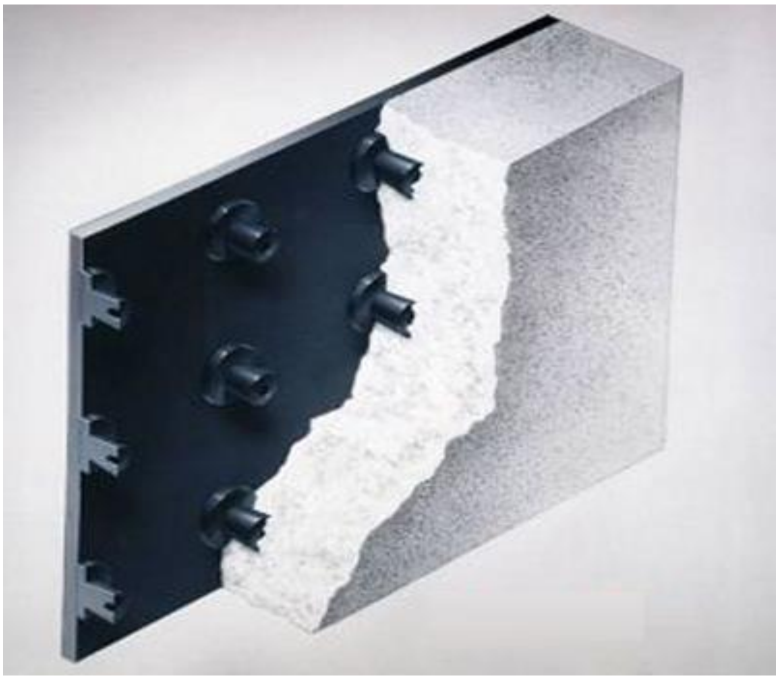

Figure 2. Studded liner – in concrete.

In attempting to transfer such European technology to North America, inappropriate resin selections were made and the welds suffered extensive stress cracking both along and across the extrusion weld beads. In addition the welded studs would separate from the sheet at an ever-increasing rate generating large "blisters" (Figures 3 and 4). Subsequently the studs of many profiles (Figure 5) and distributions were formed integrally with the sheet as the sheet was passed between calendar rolls. The studs were placed with a grid spacing of about 75 mm.

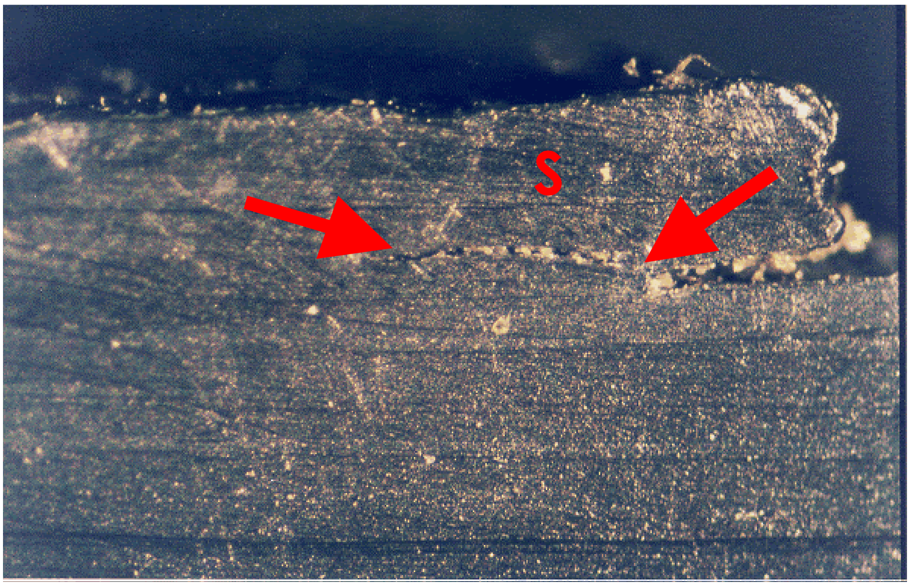

Figure 3. Stress crack between stud weld (S) and sheet bottom.

Figure 4. Blister formation. Blister removed to reveal broken studs.
Orange deposits evidence of leakage

Figure 5. Stud geometries.

As the ambient construction temperatures cycled and panel dimensions changed due to thermal expansion/contraction it was found necessary to accommodate different panel gap widths using “zip strips” as shown in Figure 6. The “H” cross section of the strip allowed for dimensional changes in the plane of the panel. The strip was torn away leaving the butt fillet geometry exposed, but with concrete at the joint covered, for fusion welding. The thinner panels could be overlap extrusion welded as is a conventional geomembrane.

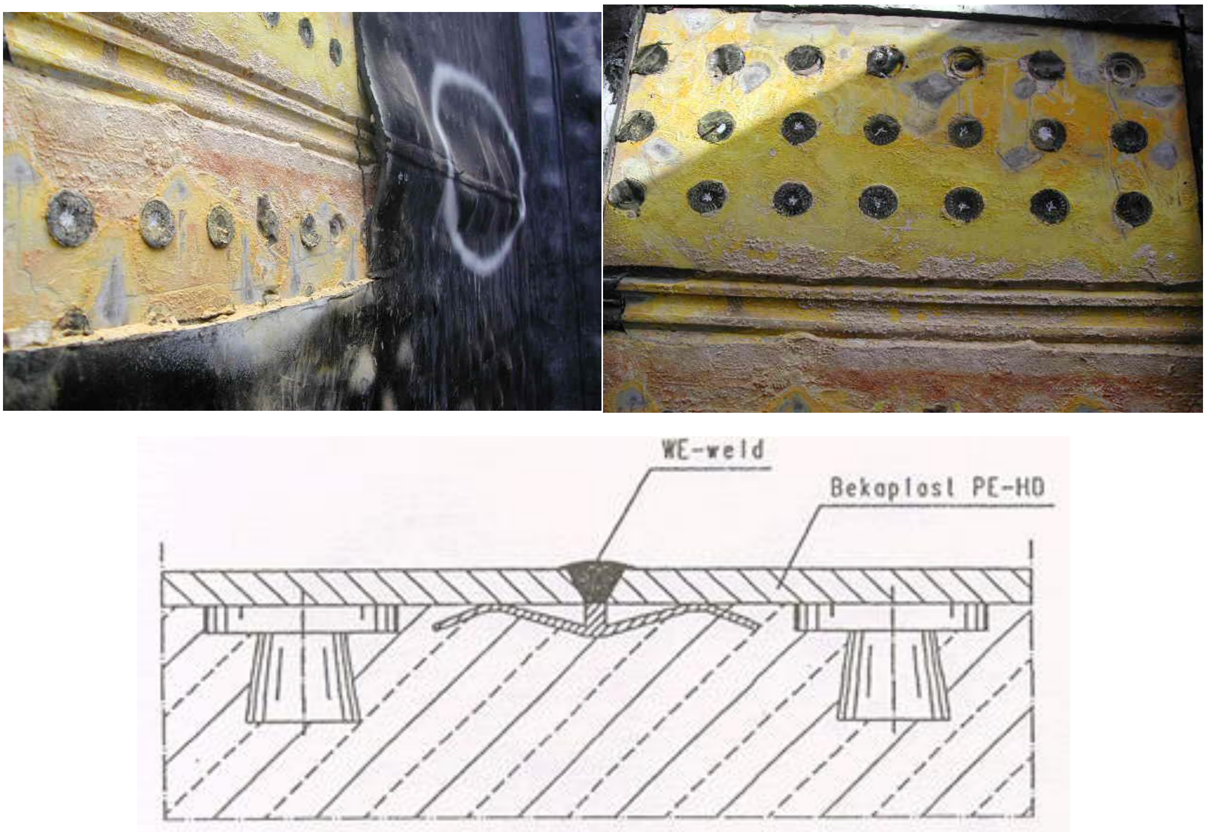

Figure 6. Zip-strips between panels. Yellow/orange deposits evidence of leakage.
Note, profile of studs angular.

Also found impossible to complete in the subgrade was a prepared pattern of drainage channels where the most likely feature to leak (the welds) would be located, again due to panel expansion and contraction. See Figure 7.

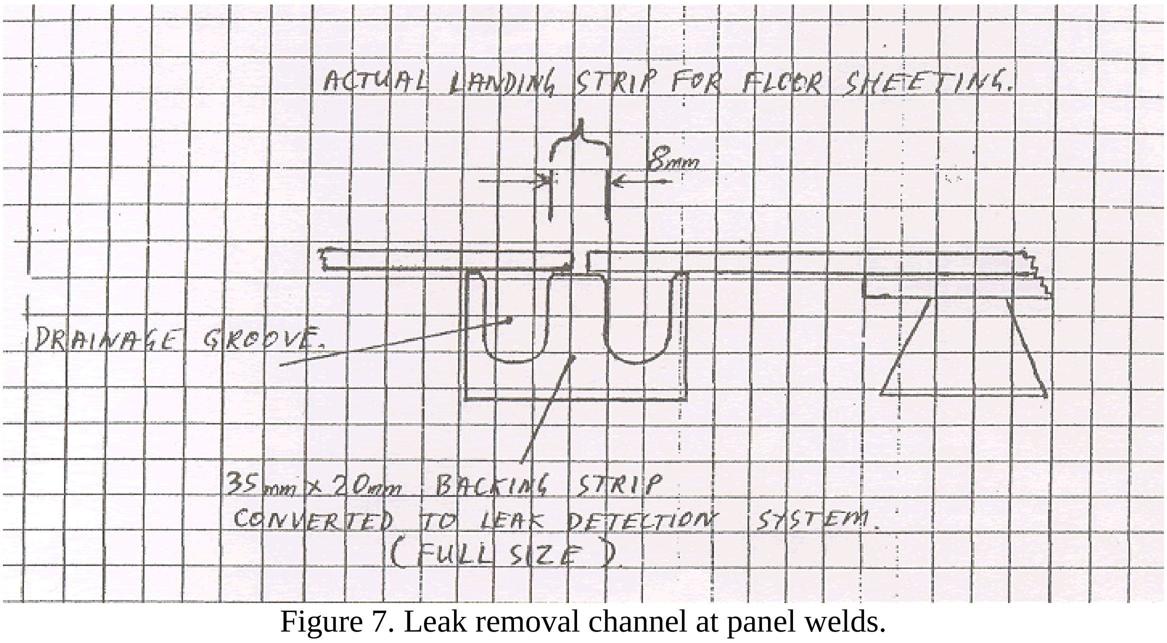

Figure 7. Leak removal channel at panel welds.

The difficulty of extrusion welding inside and outside corners of benches, particularly the latter, have been clearly demonstrated in many projects, hence the need for corner fittings (Figure 8). These corner problems cannot be resolved by heating and bending a strip of material which is welded to the parent material since proper substrate support cannot be assured.

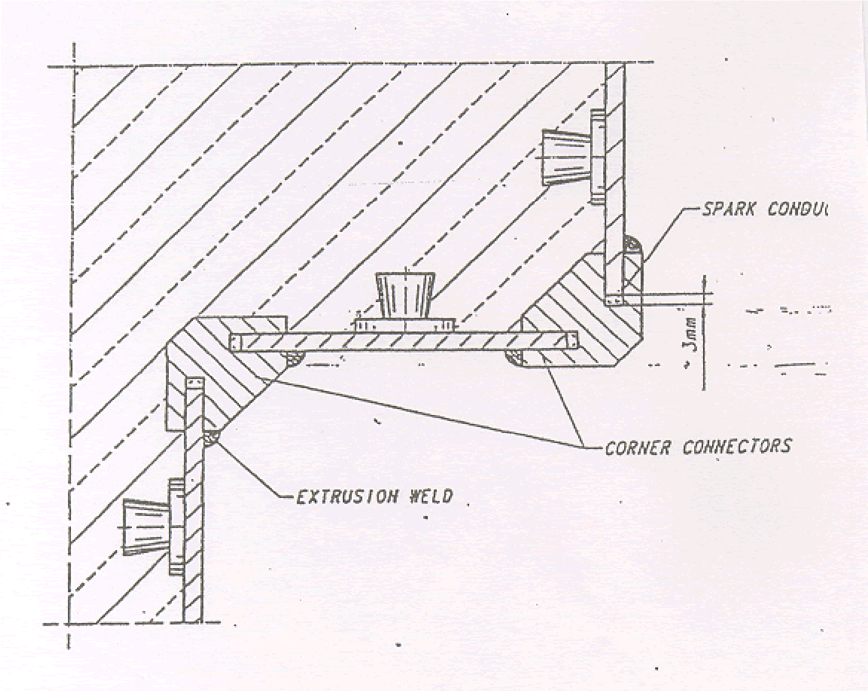

Figure 8. Corner fitting.

2 SEALING TO CONCRETE

Geomembranes have been attached and sealed to concrete structures mechanically with stainless steel batten bars typically with bolts every 150 mm for liquid containment or every 300 mm in air. However, CPL-like embedment strips with profiles such as shown in Figure 9 are increasingly being used. It is assumed the continuous weld between geomembrane and embedment strip provides a more assured weld than the point-to-point bolts of the batten bar seals. This is not necessarily so.

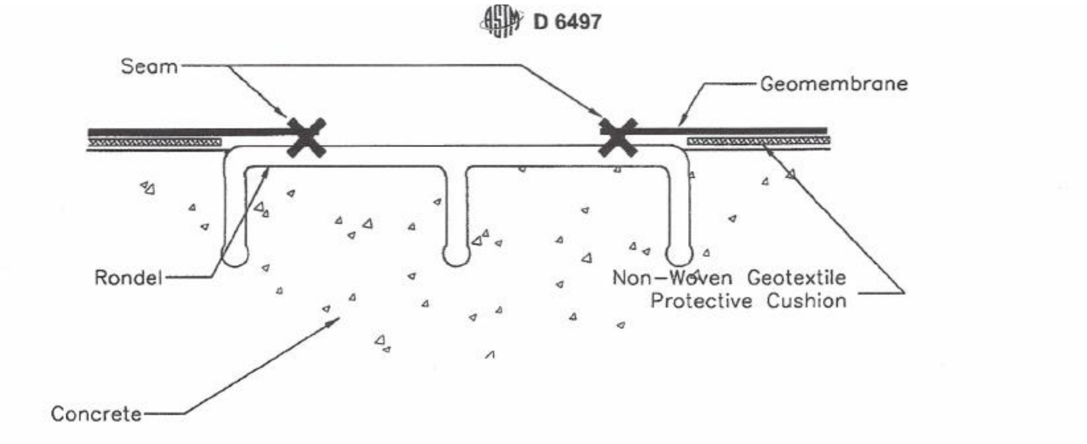

Figure 9. Embedment strip. (rondel)

When using a CPL embedment strip to make a seal to concrete the strip should be uniformly and well supported with no void space (Figure 10) between the underside of the strip and concrete. The HDPE strip will not bond to the concrete so it needs to be in intimate contact with the concrete. Joints across the strip must be welded down to the concrete (Figure 11) as should beveled corner joints (Figure 12). A crack under the strip (Figure 13) may not be sealed.

Figure 10. Rough concrete surface with air space (circled) has allowed leakage. Half of top of embedment strip removed.

Figure 11. Joint (arrowed) should be welded

Figure 12. Joint should be welded.

Figure 13. Crack in concrete under the batten strip.

Extrusion welding has to be carefully done since there is no easy destructive test possible on the finished weld. Preheating the embedment strip helps due to it being a large heat sink compared to the geomembrane. And every step should be taken to keep the surface of the strip in the same plane as, and in line with, the geomembrane to avoid the hydrostatic pressure from pushing the geomembrane into a corner and pulling the geomembrane off the strip. (Figure 14)

Figure 14. Geomembrane not supported in corner.

It often occurs that the embedment strip is not adequately heated and the grinding gouges are not melted such that the joint is not a melted, mixed and solidified joint but simply melted extrudate conforming to the profile of the grinding as if a jig-saw puzzle piece. (Figure 15)

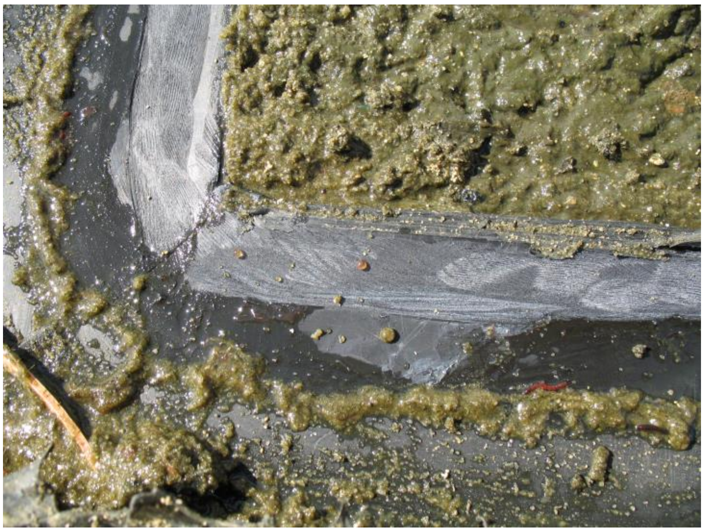

Figure 15. Grinding gouges on unmelted surface.

One difficulty is to adequately compact the subgrade along the edge of concrete structure so as to avoid the potential for differential settlement at the concrete/soil interface. Giroud (1995) recommends a slight slope on the edge of the concrete for better compaction. And, of course, the corner of the concrete should be rounded and covered with cushioning geotextile.

Many of the same considerations apply to metal batten strips/bars (Peggs and Viljoen 2009, Thiel 2009, Wells 1993). The objective is not to clamp the batten strip down as hard as possible so that it is pillowed between bolts. Rather it is to apply a uniform pressure along the strip such that the elastic limit of the gasket is not exceeded. Of course this requires a smooth concrete surface, not the kind of surface shown in Figure 16. And there should be gaskets on both sides of the geomembrane.

Figure 16. Unsatisfactory batten bar support (left) and CPL welds (right).

3 CONCLUSIONS

CPLs provide an opportunity to install a geomembrane/liner in intimate contact with a concrete substrate. Fittings are available to assist with welding at joints in walls and corners.

Care must be taken to allow for expansion and contraction of panels during installation. Embedment strips sealing geomembranes to concrete structures must be carefully installed to avoid air between the concrete and the strip and to avoid steps and ridges that might damage the strip and geomembrane.

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