Geosynthetics: Leading the Way to a Resilient Planet – Biondi et al (eds)

Some current topics regarding geomembrane liners and floating covers for water storage reservoirs

M.A. Sadlier*
Geosynthetic Consultants, Australia

ABSTRACT: Current issues in the renovation of water supply reservoirs by the replacement of old geomembrane liner and floating cover systems with new systems are discussed. Topics include sampling and testing, underdrain systems, material choices, floating cover access for maintenance and the impact of conductive geotextiles on leakage rates.

1 BACKGROUND

In Australia and New Zealand many water storages and service reservoirs were renovated around the year 2000 and were fitted with geomembrane liners and floating covers based on flexible polypropylene (fPP). These fPP materials whether reinforced or not reinforced have suffered greatly from degradation as a result of their exposure to solar radiation and exposure to chlorine compounds in the stored water.

As a result there has been a need to inspect, sample and evaluate these materials and their state of degradation. This has also generated a lot of work to renovate these reservoirs and fit them with new liners and floating cover systems.

Aspects of the work including material selections were discussed by Sadlier and Frobel (2018) and this paper discusses other contemporary aspects of these reservoir renovation works.

2 SAMPLING AND TESTING

The liners and cover materials are generally in operating clear water reservoirs containing treated and usually disinfected water. Because the aged fPP materials have become difficult to clean and seam properly there has been a reluctance to take larger samples that would require substantial repair that may affect the operation of the facility. Larger samples provide an opportunity for tensile, tear, puncture and other mechanical testing.

In many cases smaller and less obtrusive samples have been taken from weld flaps and under perimeter batten bar fixings (See Figures 1 and 2) and this has required the use of tests such as Oxidation Induction Time (OIT) and High Pressure Oxidation Induction Time (HPOIT). These analytical tests use small samples the size of a thumbnail to assess the remaining anti-oxidant capacity of the material and the OIT method is applicable to materials with mainly phenolic anti-oxidants and the lower temperature HPOIT is applicable to materials with mainly hindered amine anti-oxidants.

The fPP materials generally used hindered amine anti-oxidants and that makes the HPOIT test the appropriate method to use. Although not often specified at the time these

*Corresponding Author: sadlierma@gmail.com

DOI: 10.1201/9781003386889-31

Figure 1. A small cover material sample taken from a ballast tube partly under a batten bar.

Figure 2. A small liner material sample taken from under a batten bar. This floating cover had many small marked holes which had been caused by embers from a grass fire.

fPP materials generally had HPOIT values in the order of 100 to 150 minutes when new and we often see values now of around 50 minutes in sheltered samples and less than 30 minutes in exposed samples. At these low HPOIT values it is clear that these fPP materials are close to the end of their useful life.

3 LINER UNDERDRAIN SYSTEMS

Many of these reservoirs were originally constructed in fairly rural settings on the periphery of cities and towns and as populations grow they are often being encroached upon by urban environments. This has driven a need for demonstrated control of water leakage and this has resulted in these renovations seeing more and more use of double liner systems for better leakage control.

In some cases an existing concrete liner might be utilised and in others the old liner might be sufficiently effective to function as a secondary liner. There have been other projects where a choice has been made to install a complete new double liner system. See example in Figure 3.

Figure 3. A reservoir with the old discoloured fPP liner being used as a secondary liner. The white material on the floor is a drainage geocomposite and the black material on the slopes and the floor is a conductive non-woven geotextile with a unit mass of about 350 gsm.

These double liner systems have an underdrain system based on a geonet or geocomposite drainage layer and will often make use of conductive materials such as special conductive geotextiles to facilitate electronic leak location surveys. When conductive geotextiles based on graphene coated needled non-woven geotextile fabrics are used and heavier grades are available, they may be adequate for drainage on slopes without the need for a geonet as well as providing the other protective cushioning benefits of a heavy non-woven geotextile.

Where a reservoir has an existing gravity underdrain pipe under the embankment that will be tested and utilised if effective. However, because of the difficulties involved with properly grouting the annulus around a pipe new under embankment bores are not used and a down the slope pipe with a bore pump installation is used instead. See Figure 4.

The conductive geotextiles based on needled non-woven geotextiles are quite robust and easily installed with overlaps seamed by a wedge welder. However, supply situations have occasionally made them unavailable, and a few projects have used a needle punched composite with a 150 gsm non-woven geotextile base and a thin conductive film of polyethylene. This has required a separate drainage layer and has been much less robust than the heavier conductive non-woven geotextile.

Figure 4. An underdrain water extraction system with a down the slope pipe with a bore pump.

Figure 5. Holes in a conductive composite made by workers walking on it. These required patching to ensure adequate conductivity.

4 GEOMEMBRANE LINER AND COVER MATERIALS

Whilst high density polyethylene (HDPE) might be expected to dominate as the liner material of choice due to its cost advantages there other materials being used such as 1.1 mm thick reinforced polyvinyl chloride with elvalloy plasticisers (PVC/Elvalloys). Bitumen geomembranes and coated fabric geomembranes are being considered if a new secondary liner is required.

All of these materials lie a lot flatter on the underdrain or subgrade with less wrinkles than HDPE and this has a positive influence on the quality of the subsequent work on primary liners and floating covers. Sometimes on sites with tight access the narrower (2-3 m wide) rolls are helpful and larger panels can be fabricated if required.

For the floating covers the PVC/Elvalloys are often being used in a 1.5 mm thick grade and reinforced chlorosulphonated polyethylene (CSPE) is still preferred on occasions. The PVC/Elvalloy materials are formulated to be suitable for both potable water and direct sunlight exposure. There are other PVC materials for water reservoir floating covers that have different formulations for the top and bottom coating layers.

A detailed discussion of the available materials was given by Sadlier and Frobel (2018) and will not be repeated here.

The fPP materials have not been considered recently because of their poor performance in the past. However there is now some interest in the newer formulations of fPP driven partly by the cost advantages offered and partly by the availability now of extended accelerated UV testing by QUV of up to 40,000 hrs. This interest has so far only extended to putting some large sample materials out at existing reservoirs for both water and sunlight field exposure and evaluation.

5 FLOATING COVER ISSUES

Access onto covers for maintenance remains a concern. Access is needed for water sampling and to clear leaves and other debris from the pumps or foot valves in floating sumps. The anti-skid surfaces on the walkways are much better than previously but there is still a reluctance to have personnel working on the cover.

Although there are openings for surface water release the ponding of surface water can be clearly seen along with the associated collection of leaves and debris.

Figure 6 is an example of a cover with floats for tensioning each side of the ballast lines and additional floats for walkways. These often have openings in the float paths intended to allow surface water to move around and enter the ballasted trench area for collection and removal. Prevailing winds can cause the water to pond and windblown dirt and soil collect at those locations and make the ponding worse.

Figure 6. A floating cover with foam floats for tensioning and other floats for access walkways.

Especially on older floating covers there is a reluctance for personnel to use the access walkways to remove the leaves, soil and debris. There is also a reluctance to empty the reservoirs in order to carry out necessary maintenance and cleaning. In Figure 7 it can be seen how this can lead to substantial growth of undesirable vegetation.

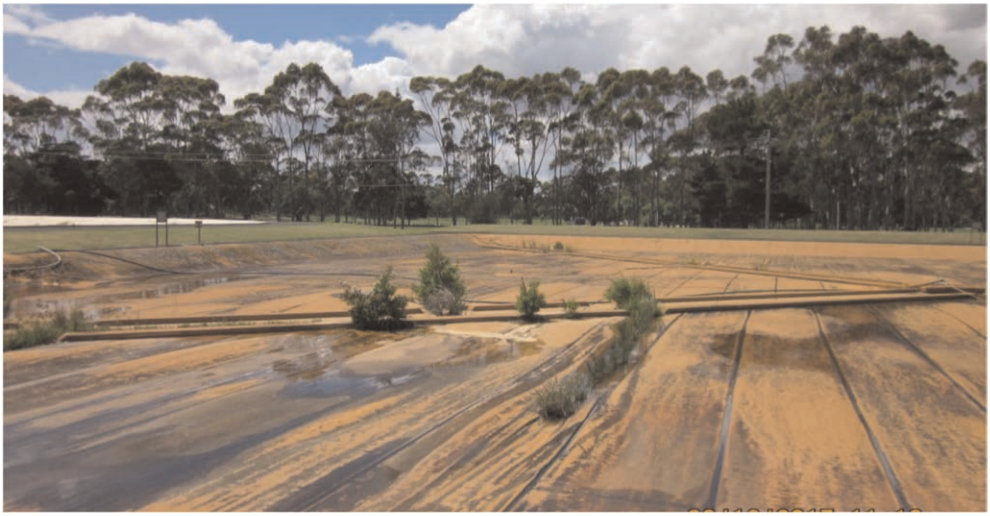

Figure 7. A 30 year old CSPE cover where a lack of maintenance has allowed vegetation to grow.

6 LEAKAGE RATES

Based on North American data Peggs and Giroud (2014) suggested a range of action leakage rates for water supply reservoirs which included a suggestion for an expectation of leakage of around 2600 litres/hectare/day for a water depth of about 5 m.

A collection of ten of the recent renovation projects in South East Australia discussed above have seen PVC/Elvalloy geomembrane liners installed over geocomposite drain systems with existing compacted clayey soils, concrete liner or old geomembrane retained as a reasonably effective form of secondary liner. In terms of surface area the reservoir sizes have ranged from 3000 sqm to 10,000 sqm with effective depths of in the range of 4 to 8 m.

The majority of them used a conductive geotextile to facilitate an electronic leak location survey by the Spark or Arc Method (ASTM D7240 or ASTM D7953 respectively) and others had water introduced to enable a dipole water puddle or water lance leak location survey (ASTM D7002 or ASTM D 7703 respectively). All had independent third party quality assurance inspections.

Due to privacy concerns, we are not able to publish exact details but observed leakage rates were all less than 150 litres/hectare/day and in about half the cases less than 100 litres/hectare/day. Whilst these adapted secondary liners might not have been perfect these leakage rates are indicative of what can be achieved with good quality control and a conductive geotextile to facilitate an electronic leak location survey.

Points of weakness for leakage in renovation of these old reservoirs are seen to be the old concrete structures and the geomembrane liner fixings to the old structures such as shown in Figure 8. The concrete can be cracked, porous and rough providing a poor surface for an underwater batten fixing. Sometimes surface grinding of the concrete is enough but on other structures a coating with something like a smooth sprayed polyurethane is required and there are other structures that are best replaced.

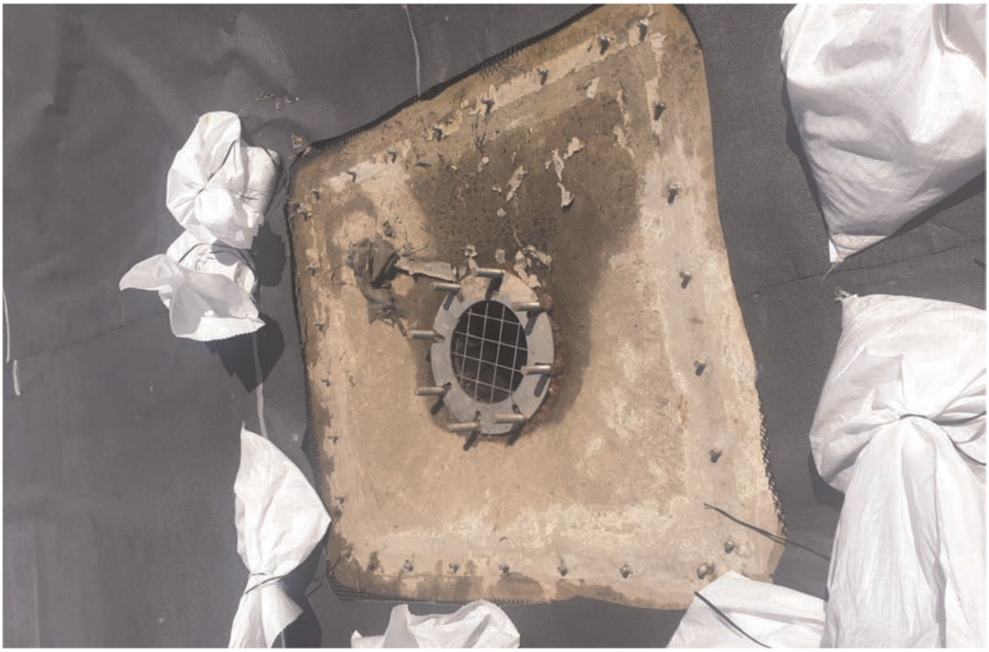

Figure 8. An old concrete structure for a scour outlet.

7 CONCLUSIONS

This paper has discussed a number of contemporary issues in the renovation of existing water supply reservoirs by the installation of new geomembrane liners and floating covers. Topics have included:

- Sampling and evaluation of existing materials
- Underdrain systems and options for removal of leakage water
- Liner and cover materials
- Cover design, access and maintenance
- Conductive geotextiles and the impact on leakage rates

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