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Recent developments in polyethylene geomembranes for use in floating covers

M. SADLIER, Geosynthetic Consultants Australia, Melbourne, Australia

R. TAYLOR, GSE Lining Technology, Inc. Henderson, NV, USA

ABSTRACT: Highly flexible reinforced geomembrane materials are being used for floating cover works where a full range of water level movement dictates that the cover must flex in order to provide the necessary changes in shape. These flexible geomembrane materials are based on polymers with relatively low modulus and low tensile strengths which have been provided with the necessary tensile properties by the introduction of a reinforcement. These materials lack the toughness of the thicker, higher modulus monolithic geomembrane materials such as high density polyethylene (HDPE). Recent polyethylene polymer developments include low modulus highly flexible olefin based polymers that can be reinforced with polyester to provide the required combination of tensile strength and flexibility. However these materials can be welded to the common monolithic polyethylene materials such as HDPE and linear low density polyethylene (LLDPE). This means that designers no longer need to compromise durability and toughness with flexibility since it allows the creation of floating covers that have specific flex zones of the flexible reinforced material with main cover bodies based on the tougher monolithic materials.

1 A POLYETHYLENE HYBRID COVER SYSTEM

For applications which require a floating cover to adapt to changes in water elevation Geosynthetic Engineers have become accustomed to building floating reservoir covers in flexible reinforced materials such as Hypalon (CSPE) and more recently reinforced polypropylene (RPP). The need for flexibility in the hinge zones and the requirement for layflat on the central plate have dominated the membrane selection for floating covers.

For applications where the water remains relatively constant the membrane of choice has been HDPE. The basis for this membrane selection include cost, chemical resistance, durability as well as the confidence that the firm, relatively unyielding surface gives the water quality technicians and the maintenance workers who must "walk on water." A firm abrasion resistant cover gives these individuals the confidence needed to perform their duties.

Attempts have been made to develop composite systems which can offer this durability. Examples have been mechanical and sewn connections between HDPE and reinforced CSPE and PVC. The weakness of these systems has proven to be the lack of durability at the connection between the dissimilar geomembranes.

To meet this objective of flexibility where required, with robustness elsewhere, a hybrid cover system has been used on covers in the United States, Australia and New Zealand. This hybrid system combines the operational flexibility of the tension plate design with the thickness rigidity and security of the materials usually used in a stationary plate design.

The basic flexural design involves the welding of two types of compatible polyethylene geomembranes. The first is a modified co-extruded Linear Low Density Polyethylene (LLDPE). The flexural modulus of this LLDPE geomembrane is about 480,000 kPa. While not as stiff as HDPE it provides a firmer walk surface than the highly flexible low flex modulus geomembranes that are typically associated with tension plate covers. It also provides sufficient flexibility to accommodate the movement and flexing that will occur at the interface of the cover and the side slope.

However LLDPE does not have sufficient flexibility for the repeated flexing at the ballast or rainwater collection trench referred to as the hinge zone of the cover. For this area a reinforced low flexural modulus thermoplastic olefin (TPO) is used. The flexural modulus of this TPO is similar to the low flexural modulus CSPE and RPP reinforced geomembranes at less than 280,000 kPa. The great advantage is the ability to weld it to the LLDPE or even HDPE materials.

Using a solid wedge welding process the peel strength of seams between the two geomembranes are very comparable to that of the parent sheets. The typical seam peel strengths of a LLDPE to LLDPE joint are greater than 250 Newtons and the typical peel values for LLDPE to reinforced TPO seams are similar with typical failure being characterised by peeling from the reinforcing scrim.

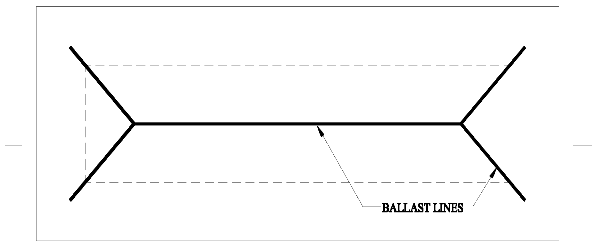

Figure 1. Typical Cover Plan.

Long-term weathering has always been a concern for LLDPE. To achieve a design life of 20 years the geomembrane has been co-extruded with a highly UV stabilised cap layer. The UV stabilisers are proprietary compounds based on Hindered Amine Light Stabilisers (HALS) rather than simply carbon black. Furthermore the cap layer has been manufactured with a light tan colour to prolong the life of the heat stabilisers. An additional benefit is that the lighter colour gives rise to significantly less thermal expansion and contraction.

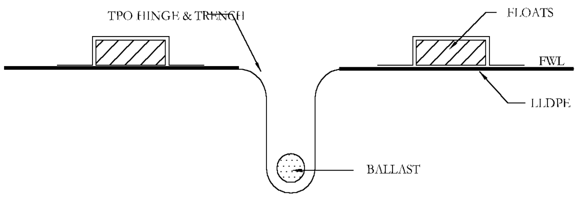

Figure2. Typical Hinge Section

Its excellent lay flat characteristics allow for superior drainage of rainwater to the ballasted collection trench. For anaerobic and odour control covers the layflat allows uninhibited gas flow to the collection pipes

The TPO has also been manufactured with a highly UV resistant upper cap layer. Again the UV stabilisers are proprietary compounds based on Hindered Amine Light Stabilisers (HALS) rather than simply carbon black.

As a result of the difference in the flex modulus between the two geomembranes a natural trench definition is formed at the junction of the two. With the hybrid system the floats are no longer necessary to define the ballast trench and can now be used merely to provide additional positive floatation to balance the negative weight of the ballast in case of a puncture

2. EXAMPLES

2.1 *Luggage Point*

The Luggage Point water re-use lagoons are situated near Brisbane, Queensland, Australia and are intended for storage of treated water which is being used by nearby industrial facilities.

The highly treated water, which is stored in two lagoons, must be protected from all sources of contamination. The lagoons are based on earthen embankments lined with a HDPE geomembrane liner and fitted with floating geomembrane covers for evaporation and contamination control.

The project featured the innovative use of geotextiles, geopipe, flexible geomembrane liner systems and geomembrane floating covers based on new materials which enabled it to be developed and built within the constraints imposed by the site which included very poor soil conditions. Conventional storage options using tanks presented many difficulties with the poor soil conditions.

The two lined and covered lagoons were built using the hybrid system for the floating covers. Construction took place during 2000 and the covers have functioned well in service.

Figure 3. Completed Luggage Point Covers. Note hinges same colour as main plate.

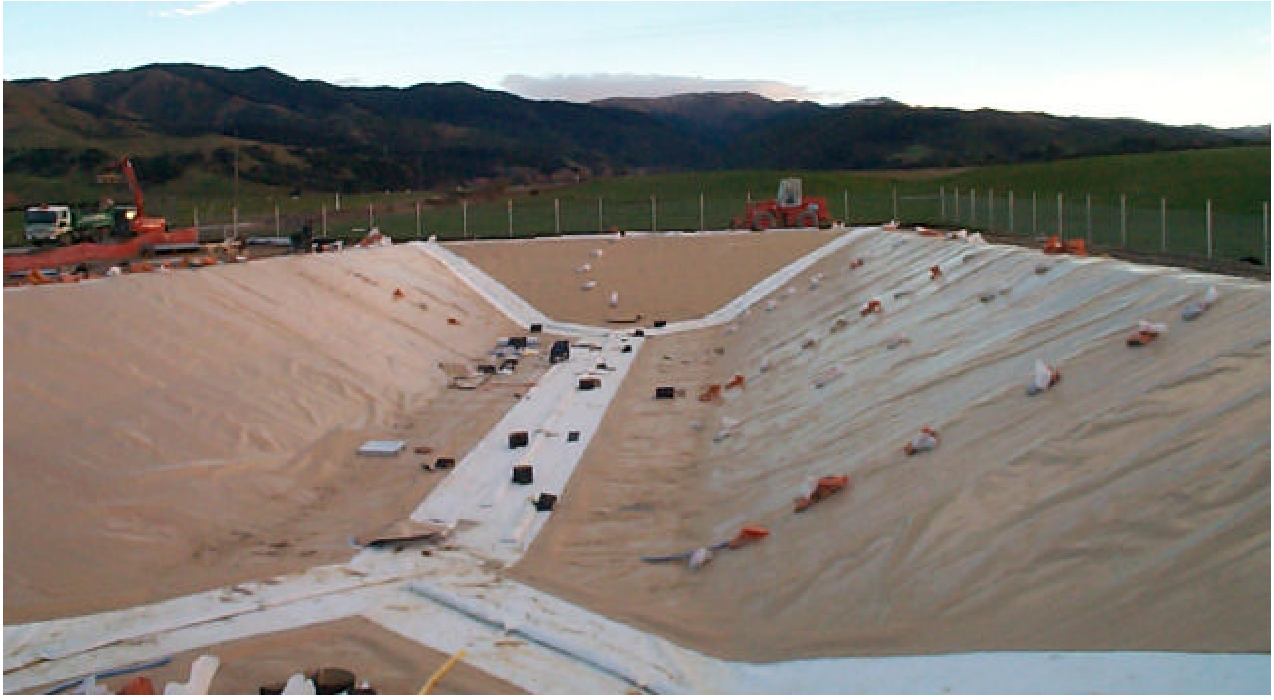

Figure 4. Waimate Reservoir during construction

2.2 *Waimate Reservoir*

This is a town water supply reservoir for Waimate which is in the centre of the South Island of New Zealand some 180 km south of Christchurch. The reservoir was built as a replacement for an open concrete tank. The reservoir is based on cut and fill earthworks with a HDPE geomembrane liner and the polyethylene hybrid floating cover system. It was constructed in the middle of 2000.

As a water supply cover this reservoir is used to provide an even flow of water to the town drinking water supply. The cover can fluctuate by as much as four meters on a daily basis. The scrim reinforced TPO hinge has provided the flexibility, strength and durability to ensure confidence in a projected twenty year service life.

2.3 *Tartaric Acid Storage*

This is a treatment and storage pond for tartaric acid solution used in the wine industry located in northern California USA.

Figure 5. Waimate Reservoir on completion

The odours from waste water generated at this plant were deemed offensive to nearby residential areas and the cover was installed to collect the odorous gasses and allow them to be disposed of without odour by flaring The waste water pond for this facility is approximately 8 meters deep with steep 2 to 1.5 side slopes. This design generated 2.4 meters of excess material on each side during the filling process. The use of the reinforced flexible membrane in the water collection troughs allowed this excess membrane to flow into the trench without developing wrinkles that had the potential to interfere with gas and rain water collection.

Originally this project was intended to be a temporary facility since it was intended to construct a new completely self contained waste water treatment system. As a result cost saving measures were adopted which included the elimination of extra fittings such as access hatches, floatation and inflation fittings. Additional cost savings were achieved by using black HDPE since it was felt that the extra expansion wrinkles could be tolerated on a temporary facility.

This facility was constructed in 1998 with a turnaround of some 2 months from the initial request and, despite its temporary origins, it has been operated to full capacity ever since its installation.

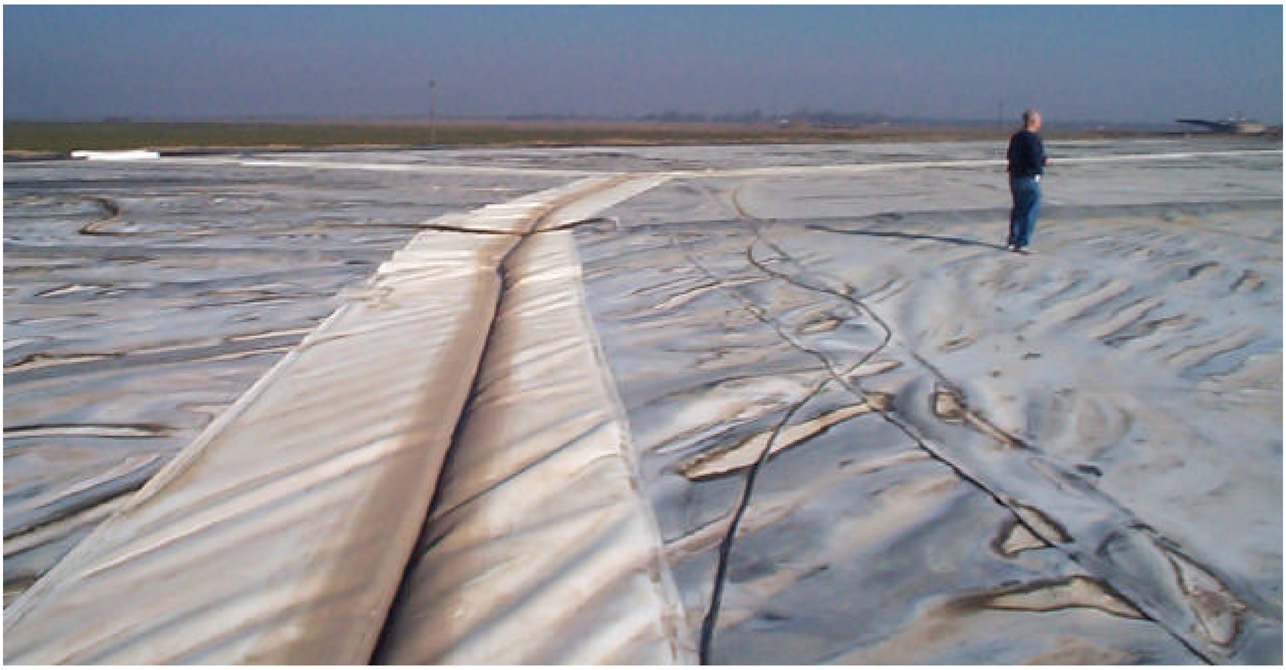

Figure 6. Tartaric Acid Plant Cover

3. CONCLUSIONS

The Luggage Point project is an example of a project where geosynthetics and their capabilities have been instrumental in achieving a viable solution for a project requirement which was difficult to satisfy conventionally. It illustrates a maturing of geosynthetic use from substitution of conventional materials to a situation were geosynthetic capability is a key part of successful solution development.

These floating cover projects have taken advantage of developing polyethylene geomembrane technology to enable covers to be built with stiffer and thicker materials and still provide the full level fluctuation capability usually associated with designs based on more flexible reinforced geomembrane materials.

This means that designers no longer need to compromise durability and toughness with flexibility since it allows the creation of floating covers that have specific flex zones of the flexible reinforced material with main cover bodies based on the tougher monolithic materials.

These projects have been built under design and construct contractual arrangements based on specified performance parameters. These design and construct arrangements have enable the contractor to employ innovative materials and systems to the benefit of the client and the community at large.

4. AKNOWLEDGMENTS

The Luggage Point project was built by Beltreco Ltd as the design and construct contractor with Brisbane City Council as the ultimate client.

The Waimate Reservoir project was built by Norcros Building Products (NZ) Ltd as the design and construct contractor with the Waimate Council as the ultimate client.

The Tartaric Acid Plant cover was built by GSE Lining Technology under a design and construct arrangement directly with the project owner.

REFERENCES

Schader L & Taylor R.., 1993. Geomembrane Floating Covers: Technology for the Nineties, Geosynthetics ’93, IFAI, Vancouver, British Columbia, Canada 1161-1172.

Harris, M, Russel, J & Sadlier, M.,. 1994. Innovative Geosynthetic Based Wastewater Treatment Systems, Fifth International Conference on Geotextiles, Geomembranes and Related Products, Singapore. 1057-1063.

Frobel, R & Sadlier, M. 1997. Geomembrane Properties - a Comparative Perspective, GeoEnvironment 97 Conference, Melbourne, Australia.

Sadlier, M, Sieracke, M & Taylor , R. 2001. Luggage Point Water Re-Use Lagoons Geosynthetics 2001 Conference IFAI, Portland, USA, .263-277.