Impermeable Liner/Synthetic Turf Closures for Landfills

West, CK

Agru America, Inc

Ayers, M.R.
SRS, Inc

Urrutia, J.L
Riley, Park, Hayden and Associates, Inc.

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ABSTRACT: As a response to numerous failures of environmental closures at waste sites, engineers have looked at new approaches in establishing a more physically stable and environmentally sound solution. This latest approach builds off of the success of using exposed geomembranes as a landfill cover and includes significant improvements, such as incorporating an extra protective layer that also serves as a ballast to minimize anchor trenches. The system provides for a more stable and rapid installation while reducing gas emissions, erosion, and sedimentation. The drainage component and small spikes, that are inherent part of the underside of the membrane, allow for installation of the cover on very steep slopes with uniform "gripping" effect on the sub grade. The extra protection layers, composed of highly-resistant UV polyethylene turf plus, sand infill and a woven geotextile, increase the longevity while protecting the integrity of the membrane from physical damage.

1 INTRODUCTION

Exposed geomembrane cover systems (EGCS) have been successfully used for closures at landfills in the United States for several years, but they have their drawbacks. The EGCS represents an initial positive direction in landfill cover system design and construction because the EGCS eliminates stability issues and environmental impacts associated with a soil cover. However, covers using just an exposed membrane have negative aesthetics and require numerous anchor trenches to resist wind uplift. Access can also be very difficult on top of the membrane during post-closure care operations. A solution to these negative aspects of exposed systems has been realized through lab and filed testing of a geosynthetic component system that is presented here.

The waste disposal industry has exposure to significant environmental and economical liability when using traditional techniques of closing waste depositories. The industry is in need of a more effective and reliable cover that exceeds environmental laws and rules. The design approach presented here uses synthetic turf and structured geomembranes for final landfill cover. The system requires minimal anchoring and provides a drainage system that can handle intense wind and rain. The components also work together to allow for traffic access during post-closure care and provide for an aesthetically pleasing surface. This design approach has a ballast/turbulence layer that resists significant uplift forces caused by high wind loads. The internal friction angle and ballast together provide for a highly stable system without expensive anchor trenching. The high internal interface friction also makes it possible for applications on steep slopes.

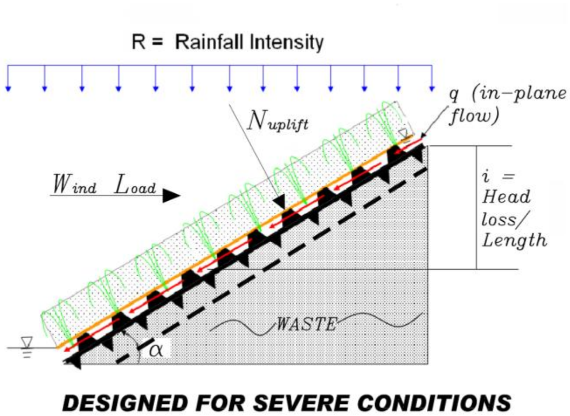


Figure 1. Forces and Flow Diagram

Because of the minimal anchoring and minimal earthwork there is the ability to close in a rapid fashion. This rapid closure, along with the impermeable membrane, can significantly improve collection efficiency.

2 APPROACH

The system deals with similar concepts as the EGCS but goes a step further by combining the impermeable liner with synthetic turf that provides a natural grass like appearance, not unlike the synthetic turf used in athletic fields. The approach is to provide the benefits of an EGCS, but eliminate the negative aspects mentioned previously. This is achieved by providing additional layers of protection (2 geotextiles, turf and infill), higher friction angles, and homogeneous ballast with high drainage capacities. The composite materials presented in this approach use a textured, structured geomembrane to provide drainage of the system for a variety of gradient conditions. The drainage capacity contributes to the stability of the infill, and together with he high friction angles, increases the factor of safety against sliding failure in events of severe rain, earthquakes and gas pressure buildups.

The cover system of this approach significantly reduces emissions from the waste through its ease of installation, and reduces the emission impacts associated with borrow, hauling and soil placement. The geomembrane also forms an “impermeable” layer allowing for higher vacuum applied in an active gas collection system. The higher vacuums can be effectively applied because there is less potential for oxygen to be pulled into the collection system.

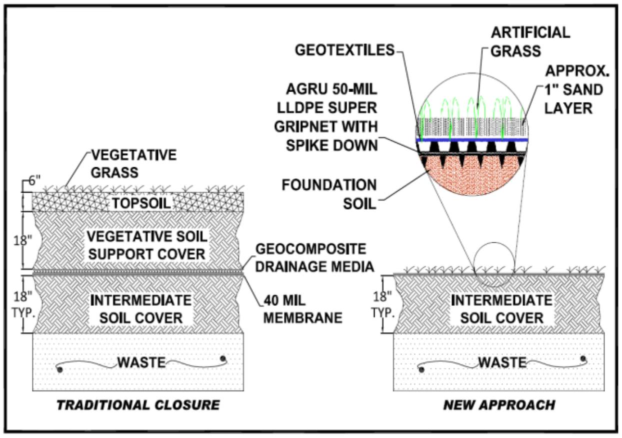
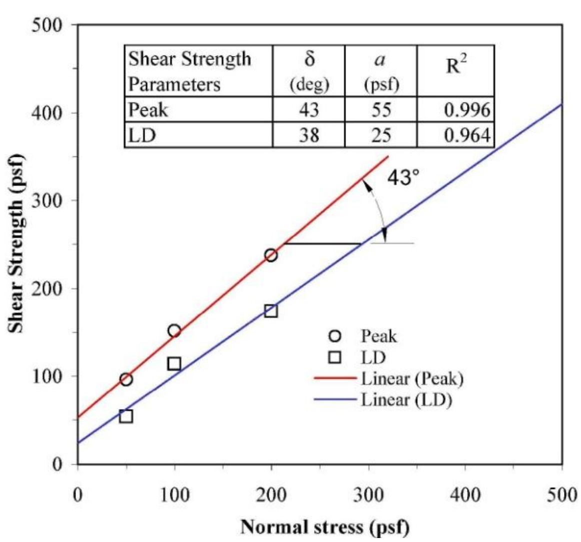


Figure 2 System Comparison

The drainage component and spikes are inherent part of the membrane and allow for installation of the cover on very steep slopes with uniform “gripping” effect on the sub grade. The extra protection layers, that are composed of highly UV resistant polyethylene turf plus sand infill, increase the longevity while protecting the integrity of the membrane from physical damage.



Shear Strength Parameters	δ (deg)	a (psf)	R^2
Peak	43	55	0.996
LD	38	25	0.964

Figure 3 Interface Friction Results

The turf component also provides important stability function. In addition to the ballast retention, it lowers the suction factors related to wind velocity when compared to exposed geomembranes. This is because of the non-laminar flow produced and the porosity of the turf that results in negative ground pressure at high velocities basically pushing the materials against the sub grade.

3 APPLICATION

Laboratory test and field trials have been performed to evaluate the application as a cover system at landfills and Brownfield closure. These facilities are typically required to be closed with a final cover consisting of layers of soil and geosynthetic materials. The purpose of the cover is to prevent exposure of the waste to the environment, to enhance collection of landfill gas, and to minimize infiltration of storm water, which results in leachate in the landfill.

This system can provide much better stability from sudden failures such as sliding and washout, and from long term failures caused by soil and wind erosion. Facility owners and operators of the above mentioned closures can potentially realize significant cost savings by constructing a cover system with the synthetic grass that does not require the vegetative maintenance and soil grading and replacement that are common with traditional closures.

This synthetic grass/impermeable layer is particularly applicable to sites when the landfill slopes are too steep to allow for the placement of soil on top of the liner, when cover soil cannot be purchased, when erosion is a concern, when the landfill may be expanded vertically at a later date or simply to allow the construction of rapid closures to control emissions and odors.

The cover system of this approach is designed from the bottom up with a lower impermeable layer placed over the soil intermediate cover comprising: (1) a drain liner geomembrane with studs incorporated in the linear low density polyethylene sheet that serves as the transmissive layer (AGRU US Patent No. 5.258.217); (2) the synthetic turf that is engineered with polyethylene fibers with a length of 2.0 to 2.5 inches tufted into two fabrics of woven polypropylene geotextiles, and; (3) a sand layer approximately 0.5 to 0.75 inches that is placed as infill to ballast the material and protect the woven fabrics and grass fibers from UV degradation.

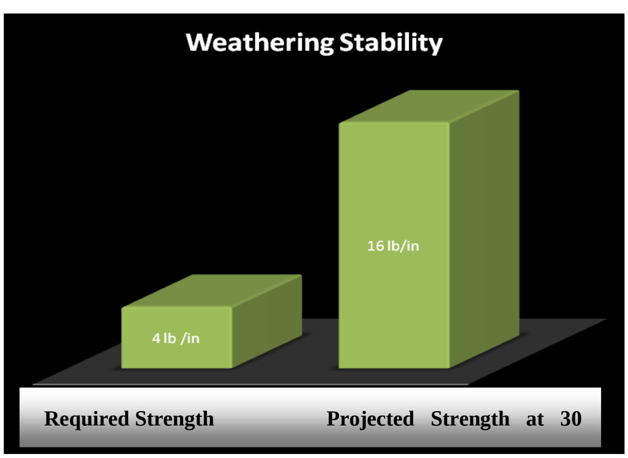


Figure 4 Weathering of Turf Yarn

The permeable turf percolates at different rates, such as approximately a rate of 180-gallons/sq ft/hr (0.2 cm/sec) or faster. During a rain event, the rainfall will penetrate quickly through the sand infill and drain directly in the geocomposite drainage system below. This allows minimizing erosion and maintaining stability of the sand infill. The infill is also held in place by the unique honeycomb structure of the synthetic grass that contains the sand and reduces the potential for the infill to mobilize in saturated, flowing conditions.

With the application for landfill covers, the anchoring system normally associated with exposed geomembrane covers at landfills will not be required. The primary deterrent to wind uplift is the turbulence created by the tufted grass fibers and is supported by the ballasting with approximately 0.5 to 0.75 inch of sand infill which produces a weight of up to 10 pounds per square foot. The infill is held in place in these wind conditions by the structure of the polyethylene fiber yarn tufted to the lower geotextiles. This geometry traps the sand to anchor and ballast the turf product to the surface covered by the synthetic grass.

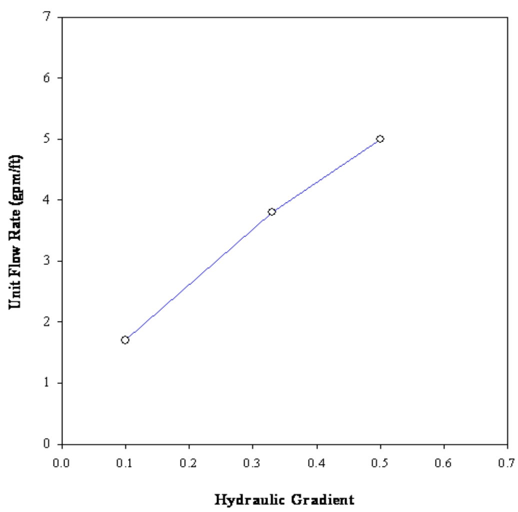


Figure 5 Flow Capacity

The selection of the chemical composition of the synthetic grass/impermeable membrane is a critical element of the design. The polymer should resist the effects of exposure to sunlight, which generates heat and contains ultraviolet radiation. The polymer yarns should not become brittle when subjected to low temperatures. The selection of the synthetic grass color and texture should be aesthetically pleasing for the given geographic region. With the appropriate selection of materials the polyethylene grass filaments should have an extended operational life of at least 60 $^{+/-}$ years.

4 FIELD PERFORMACE EVALUTION

To further evaluate the potential advantages of the system, a field trial was performed that involved capping an approximately 6-acre area at a municipal waste landfill. The objective was to verify the results of laboratory results and gain an understanding of any adverse effects on the system when applied in “real world” application. The area was capped using a combination of the components defined above and provided in the patented system known as ClosureTurf^{TM}. The system was exposed to over 100 inches of precipitation and intense rain events of up to 3 inches per hour on several occasions. Heavy gusting winds estimated to be in excess of 40 miles per hour were reported at the site. A tornado also was reported at the facility, but no detail was available for wind speeds at the trial area. Observations at the facility indicate that the geosynthetics has remained stable and there has been no erosion of the infill material.

During the evaluation period, closure areas at the landfill that were not capped with this system required re-grading, re-vegetation and mitigation of silt impacted areas. Over this same period no maintenance of the 6-acre trail area was required.

Subsequent to this paper tests have been done showing wind resistance in the range of 120mph and rainfall that shows events of 6.7” per hour in short bursts can be handled with zero to minimal sand loss. Armoring of down chutes incorporating a mixture of concrete and sand can substantially increase the performance of liquids in the chutes.

5 CONCLUSION

This composite material represents an innovative and economic approach to hazardous waste closures, solid waste closures and other environmental containments, with many advantages over traditional closure methods.

Based on the laboratory and field analysis there are many potential environmental and economic advantages to the cover system of this approach, such as:

- Eliminates a typical ongoing erosion and siltation problem.
- Improves the factor of safety against failure.
- Not susceptible to failures caused by gas buildup under membrane.
- Reduces methane emissions because of its ease of covering as soon as final grades are reached.
- Reduces emissions from soil haul and placement operations.
- Provides layers of weathering protection and physical damage protection of membrane.
- Can withstand post-closure light vehicle traffic.
- Conserves soil use and reduces land disturbance because there is no need for borrow material.
- More environmentally reliable and durable than a Subtitle D soil and vegetative cap.

- Reduces annual operation and maintenance requirement while providing superior and consistent aesthetics.
- Reduces the post closure maintenance costs of the cover.
- Can potentially withstand hurricane-force winds.
- Allows for steeper waste pile slopes, because there will not be soil stability problems either thru earthquakes or gas pressure build-up.
- Reduces infiltration thru the cap. The hydraulic head on the impermeable layer and subsequent infiltration into the waste are minimized by the drainage system and lack of soil cover.

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