



Design of geomembrane protective rainsheets

While driving through the San Joaquin Valley on a recent vacation, it was apparent that the farmers of that region were particularly adept in the use of very large protective tarps over mountains of god knows what. While we can debate the “geo” aspect of such designs, the use of geomembrane rainsheets to protect granular leachate collection systems is essential in many contemporary landfill designs. It is equally apparent that many engineers are not as familiar with this application as the California farmers. This article will attempt to review alternatives to rainsheets, the design of rainsheets, and operational considerations regarding rainsheets.

The dilemma and alternatives

A newly completed landfill leaves acres of sloped granular leachate collection system or soil operational (protective) cover soil exposed to the elements. With ensuing rains, the resulting surface erosion can reduce the thickness of the leachate collection system or operational cover below regulatory minimums or allow unwanted sedimentation to clog the leachate collection system. Alternative solutions to covering these surfaces with rainsheets have included the following:

- Hydroseeding and application of erosion control matting such as straw or jute base products. This is particularly beneficial if a fine grained operational cover soil layer is used. Obviously, this is less suitable for application to sand or gravel surface layers.
- Application of certain sludge such as primary or secondary sludge common to paper mills. The authors are not aware of the use of waste water treatment sludge in this application.
- When daily tonnage allows, placement of a 5 ft. lift of MSW over the entire surface as rapidly as possible. This is particularly attractive for bioreactor landfills that require additional leachate for recirculation.

Failed efforts include geotextile and asphalt impregnated geotextile covers. Given the swing in East Coast precipitation the past two years from record drought to record

wet, the designer cannot anticipate the actual potential for short term erosion.

Rainsheet geomembranes

Rainsheets are just large tarps, so it is understandable that the majority of applications have used the same materials large tarps are fabricated from. The most commonly used “tarp” materials include 10 to 15 mil scrim-reinforced polyethylene geomembranes such as Griffolyn by Reef Industries Inc. of Houston and Dura-Skrim by Raven Industries of Sioux Falls, S.D.

Geomembrane manufacturers also provide 20-mil polyethylene membranes that are economical enough to serve as rainsheets. Dollarwise, the goal is to install a rainsheet for less than about \$9,000 per acre (\$6,000 rainsheet cost plus the cost of anchorage/ballasting).

Depending on the type of membrane, rainsheet panels have been seamed by sewing, thermal welding, and taping. Sewing is performed using a common prayer seam in the same manner used to seam the upper geotextile in a drainage composite. The stitch must be adjusted to develop approximately 60% of the tensile strength of the rainsheet. Sewing is particularly effective on the scrim-reinforced materials. While “Duck” tape may have saved NASA, it is

not suitable for joining rainsheet panels. However, a truck tarp repair tape manufactured by The Tapecoat Company of Evanston, Ill. (Type G-25) has worked well.

Rainsheet design

A previous three-part series in Designer's Forum (see references) reviewed design considerations for exposed geomembrane covers. In this application, the geomembrane has a longer service life and must have a tensile strength adequate to resist large uplift forces. The exposed geomembrane covers can have dimensions exceeding 50 ft. between anchorage points. Rainsheets are similar in function, but rely on tightly spaced anchorage points to reduce the tension in the membrane cover.

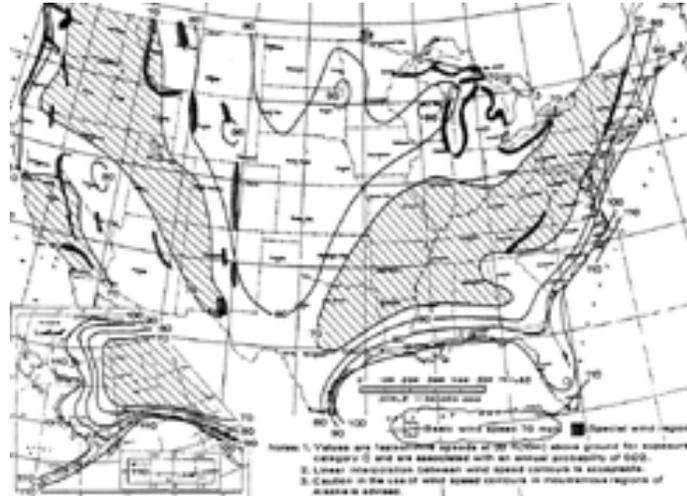
Like the anchorage for exposed geomembrane covers, the anchorage for rainsheets must resist the uplift caused by winds blowing over the landfill. Guidelines for evaluating the wind uplift force have been provided by both Wayne and Koerner 1988 and Giroud et al. 1995. Both of these papers rely on the earlier work performed by Dedrick 1975.

The wind uplift pressure (at sea level), S_e , for a given wind velocity is expressed as follows:

$$S_e \text{ (Pa)} = 0.6465 V^2 \text{ (m/s)}$$

$$S_e \text{ (psf)} = 0.00124 V^2 \text{ (ft./s)}$$

Figure 1. Maximum service wind velocities.



This force decreases with increasing site elevation (i.e., the force is greater near the beach than in the mountains). Also, the force is greater on areas that are more exposed to the wind (i.e., the force is typically greater on the upper portions of landfill side slopes versus the more protected landfill bottom areas). A general guideline for maximum service wind velocities is provided in **Figure 1**. Designs based on lesser wind velocities are commonly justified due to the short service life of the rainsheet. A design speed of less than 40 to 50 mph is not recommended. This produces a calculated uplift pressure of between 4.3 and 6.7 psf (0.32 Pa).

Anchorage for the rainsheet is commonly provided using sandbags and/or tires. **Photo 1** shows both tires and sandbags incorporated in an anchorage system. Note that ropes are required on side slopes to maintain proper spacing of the anchors through the short service life of the rainsheet. For 60 lb. (27.2 kg) sandbags, the 6.7 psf uplift pressure requires bags spaced on 3 ft. centers! This is approximately 4,800 sandbags per acre, which is obviously cost prohibitive at a cost of about \$2 to \$3 per bag installed. Given that the average passenger car tire weights only 20 lb. (9.07 kg), the contact pressure from a tire lying flat on a rainsheet is less than 5 psf. Thus, the mathematics would require tires placed tread to tread. One significant disadvantage of using whole tires is that they cannot legally be placed within the waste as the landfill advances over the rainsheet. The use of split tires would allow their burial but increase the cost of using tires. Both tires and sandbags require cabling and cable anchorage to maintain their position on landfill side slopes.

Field performance has shown that spacing sandbags (or half sandbags and half tires) on a spacing of 7 to 10 ft. on center (Note that this is a greater spacing than the wind uplift calculations would indicate.) will perform with little to no damage in winds up to about 40 mph—within the typical maximum annual wind speed of most inland locations. Some damage, however, would be expected beyond 40 mph. This would likely be satisfactory for a 1 to 2 year service life, particularly if portions of the rainsheet are being removed from service with advancing operations (i.e., the exposed area is constantly being reduced).

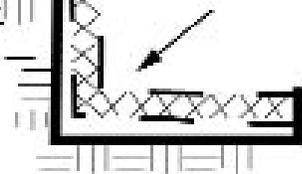


Photo 1. Typical anchorage system.

An alternative to tires and sandbags is the use of proprietary earth anchors driven into the underlying sands or operational cover. Cost and the obvious concern regarding accidentally driving anchors through the liner have limited the use of such devices. Additional alternatives considered include the use of water filled geomembrane tubes. However, the target cost of \$9,000 per acre limits creative alternatives.

Operational considerations

The rainsheet provides a potential hydraulic barrier and slip surface if allowed to remain over the landfill systems. However, experience has shown that trafficking the rainsheet with a trash compactor can shred the membrane and eliminate the need for its removal. Whole tires that were used as anchors must be collected as the waste advances and not be buried. One of the most important operational responsibilities is prompt repair of minor tears to the cover to prevent wind entry. Repairs can be performed quickly and economically using the truck tarp repair tape mentioned above. This reliance on operational repair of the rainsheets cannot be overstated. This is the primary reason that most liner installers resist giving warranties for rainsheets, since operations are out of their control.

Summary

The use of geosynthetic rainsheets offers one alternative for the protection of the landfill leachate collection system prior to waste placement. Such systems are predictable in their performance and not dependent on rapid vegetation growth. It is, however, not practical to design such rain covers for maximum winds, so the potential for damage to the system is real. Generally, we find that rainsheet systems are disliked when present and sorely missed when omitted. ■

References

- Dedrick, A.R. 1975. "Air Pressures Over Surfaces Exposed to Wind-II. Reservoirs." *Transactions of ASAE*, vol. 18, no. 3.
- Germain, Ann, Houlihan, Michael and Richardson, Gregory N. 2001. "Exposed Geomembrane Covers: Part 2—Geomembrane Selection." *Geotechnical Fabrics Report*, vol. 19, no. 1.
- Richardson, Gregory N. 2000. "Exposed Geomembrane Covers: Part 1—Geomembrane Stresses." *Geotechnical Fabrics Report*, vol. 18, no. 7.
- Richardson, Gregory N. 2000. "Exposed Geomembrane Covers: Part 2—Geomembrane Restraint." *Geotechnical Fabrics Report*, vol. 18, no. 8.
- Wayne, Mark H. and Koerner, Robert M. 1988. "Effect of Wind Uplift on Liner Systems." *Geotechnical Fabrics Report*, vol. 6, no. 4.