Benefits and Cost Advantages of Fabricated Geomembranes

Some geomembranes are flexible enough that they can be factory seamed into large panels, folded, transported, unfolded without creasing or damage, and field seamed and tested as necessary. These geomembranes are relatively thin, flexible, and are mainly produced by calendaring, lamination, and extrusion manufacturing processes. In short, calendaring uses a series of hard pressure rollers to form a thin sheet of plastic material, e.g., a geomembrane. Lamination involves constructing a geomembrane by uniting two or more layers of material, e.g., two plastic sheets with a fabric or scrim in the middle. Extrusion manufacturing is a process used to create a thin plastic sheet by forcing heated plastic through a die of the desired thickness.

If the geomembrane is not flexible, folding can crease the geomembrane, which can result in a weakness that can be the location of possible cracking and/or accelerated aging.

Geomembranes that can be factory fabricated and folded reduce field seaming, installation time, cost, field-testing and patching, thus improve overall quality. In addition, revised field testing procedures, e.g., air-channel testing (Stark et al., 2004), can reduce the number of destructive samples that are cut from the completed liner, saving time and cost. This can result in a completed liner that has fewer destructive samples and patches than a field assembled geomembrane liner. The reduction of installation time and testing is particularly important in harsh environments, which can extend the "field installation season". The installation season is greatly extended for projects in which the fabricated liner is large enough to line the entire area without having to perform any field seaming. These "drop-in" liners are less expensive than field assembled liners, have no patches due to field destructive sampling, and all of the seams are constructed in a clean and controlled environment.

Fabricated geomembranes also allow a more modular construction approach. In other words, the liner system is a module that is simply installed using several panels or modules and field seamed to create the desired containment system. Modular construction results in less resources having to be committed to one location for an extended period, e.g., deployment, welding, and testing equipment. Modular construction also adds more predictability to a project by reducing weather, transportation, site access, testing and data interpretation, and labor issues.

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The quick deployment of prefabricated panels allows large areas of the prepared subgrade to be covered quickly to prevent degradation due to weather and installation operations. Quick deployment of the prefabricated panels also allows large areas of a geosynthetic clay liner (GCL) to be covered quickly to prevent or limit premature hydration of the bentonite which can render the GCL unsuitable because of low shear strength and high compressibility of the hydrated bentonite. Commonly after completing only one field seam between two factory-fabricated panels, the area covered exceeds one acre in a short period of time.

Folding of 30 mil. factory fabricated geomembrane panels.

The size of the fabricated panel is usually limited by shipping constraints. It is common to ship panels that weigh 4,000 lbs but panels as heavy as about 6,000 lbs have been frequently shipped (Stark et al., 2006). For rare applications and/or sites, panels as heavy as 9,000 lbs have been fabricated and shipped. Panels that weigh 6,000 lbs. have different dimensions that vary based upon geomembrane thickness. For example, a 6,000 lb. panel of 30 mil PVC can be fabricated into panels 150 ft. x 210 ft. A 6,000 lb. panel of 30 mil Ethylene Interpolymer Alloy (EIA) can be fabricated into panels 150 ft. x 180 ft.

Factory v. Field Seaming

Seaming of fabricated geomembranes is usually accomplished using thermal fusion for production seams and solvent or hand-held thermal equipment for patching depending on the type of geomembrane. Factory prepared seams are usually more consistent than field seams because of the problems that can develop with field seaming, such as wind, dirt, precipitation, temperature fluctuations, variable clouds, crew changes, subgrade conditions, etc. Factory seams result in fewer failed destructive tests and less

Folded and rolled fabricated geomembranes.

patching because they exhibit more consistent shear and peel strengths. This results in a better completed liner because patches to repair locations where destructive samples were taken are difficult to make as good or leak free as the primary weld that was cut out for testing. Because of the consistent quality of factory seams, a lower testing frequency is recommended for factory seams than field seams, e.g., one per 500 feet lineal feet for field seams, of a thermally welded seam. For example, the Fabricated Geomembrane Institute (www.fabricatedgeomembrane.com) prepared a guideline on testing frequency for factory seams which specifies the following requirements for qualification and production factory seams:

- Pre- and Post-Qualification Seam Testing

Trial seams shall be at least 6 ft long using the same equipment, operator, and conditions anticipated during production welding. Trial seams will be tested in both shear and peel strength using either ASTM D 6392 (heat welded) or ASTM D 6214 (chemical welded).

- Production Seam Testing

During production the testing frequency is once every shift change or every 4 hours of production, which ever is more frequent. Trial seams shall be at least 6 ft long using the same equipment, operator, and conditions anticipated during production welding. Trial seams will be tested in both shear and peel strength using either ASTM D 6392 (heat welded) or ASTM D 6214 (chemical welded).

Review of the above factory seam testing frequency guideline reveals that a destructive sample from the middle of a production panel is not required. The rationale for this is that years of experience factory fabrication has shown that factory seams are more consistent than field seams probably due to the controlled, clean, favorable, and constant welding conditions in the factory. This allows welding equipment and settings to be verified before and after seaming instead of during welding because the factory conditions do not change significantly. As a result, the pre and post production seams are of similar quality as the production panel seams which obviates the need to destructively sample the middle portion of the factory panels.

In a given liner area, the quantity of field seams required for a fabricated geomembrane may be up to 80% less than that required for a field assembled geomembrane. This reduces the potential problems associated with field seaming and the cost and duration of field installation.

Fabricated geomembranes are especially advantageous for smaller projects because the fieldwork can usually be completed in one day. For example, a 2-acre pond can be completely installed

Canal lined with factory fabricated geomembrane.

(with 2 to 3 field seams), tested, patched, and certified in one day. The savings on a small project include a smaller crew being required compared to a field assembled geomembrane, which equals a smaller mobilization cost, less equipment, and less detail work because the panels are formed to model the area that is to be lined than is required for a field assembled geomembrane project. Generally a field-assembled geomembrane will require a second day of work to complete the testing and detail work. Thus, smaller projects tend to accentuate the advantages of fabricated geomembranes compared to field assembled geomembranes.

Estimated Installation Cost

The following project illustrates the difference in installation costs for factory-fabricated material versus field-assembled geomembranes. In general, field assembled geomembrane material is frequently the same or less expensive than geomembranes that can be fabricated. However, the installed cost is usually higher for field-assembled geomembranes because of the greater installation time and field-testing costs. This is illustrated using a two million square foot canal liner near San Lucas, California. The pricing was developed for the canal that has a width and length of 48 feet 6.3 miles, respectively. The canal sideslopes are 4H:1V. The two products considered for the project are a factory fabricated 30 mil reinforced LLDPE geomembrane and a field assembled 40 mil unreinforced HDPE geomembrane but other materials could have been used. This project is only used to illustrate the relative installed costs and not for current pricing of these materials. By utilizing a fabricated geomembrane for this project, the end user was able to save approximately $0.04 cents per square foot because of the reduced length of field seaming and subsequent reduced number of days on the project for the Installation Contractor. The costs are based on 40 mil geomembrane rolls that are 22.5 feet in width, which would have required 71,488 lineal feet of field seams. This large amount of field seaming would increase exposure of the project to weather and require that all seams be made in the canal prism exposing the seams to dirt, water, and other contaminants.

The fabricated geomembrane panels were assumed to be delivered to the project in custom sized panels fabricated for the variable dimensions of the canal. The canal dimension is 48 ft wide, which necessitated a 57 ft wide by 300 ft long panel. By utilizing this custom panel size, the field seams for the project totaled only about 5,300 lineal feet. With this reduction in the quantity of field seams, the overall cost for installation, which does not include the material cost difference between the 30 mil and 40 mil geomembranes being considered, was about $100,000 less for installation of the fabricated geomembrane option. More importantly, the challenging geometry of the canal was easily accommodated using prefabricated panels instead of having to line the turns with partial rolls of rolled material.

Applications for Use of Factory Fabricated Geomembranes

Because fabricated geomembranes are flexible, installed quickly, can be resistant to UV exposure and hydrocarbons, etc., they can be used for a variety of challenging projects. The table below provides a summary of the range of applications in which they can be used.

Summary

The use of fabricated geomembranes can facilitate installation of a containment system, closure cell, final cover system, sports turf barrier, floating cover, e.g., over a leachate pond to reduce precipitation and leachate volume, pond liners, e.g., stormwater or leachate, and gas collection systems because of the large reduction in field seams and installation time. In addition, the use of prefabricated panels and fewer field seams results in the liners being completed with fewer destructive sample patches than if geomembrane rolls of 23 ft. width are used.

Fabricated geomembranes also result in lower installation and CQA/CQC costs because of the use of large factory fabricated panels that reduce the amount of field personnel time and excavation contractor costs. Finally, fabricated geomembranes have more consistent seams than field assembled geomembranes because the majority of the seams are created in a controlled temperature, cleaner, and low moisture environment, and fewer field seams result in fewer destructive samples and fewer potential leak paths. **L&W**

Geomembrane Type	Aquaculture	Baffle Curtain	Canals	Decorative Ponds	Golf Course Lakes	Harsh Environments	Irrigation Reservoirs	Landfill Covers	Landfill Liners	Mine Tailing Ponds	Hydrocarbon	Fertilizer Containment	Sewage Lagoons	Sports Field Under Liner	Tank Liners	UV-Stable Liners	Wastewater Lagoons
EPDM	X	X	X	X	X		X					X				X	X
Ethylene Interpolymer Alloy		X				X		X	X	X	X	X			X	X	
HDPE	X		X		X	X	X	X	X	X	X	X	X			X	X
Hypalon – CSPE	X	X	X			X	X									X	X
LLDPE	X		X	X	X	X	X	X		X	X		X	X		X	X
PVC	X		X	X	X		X	X	X	X		X	X	X	X		X
Reinforced LLDPE	X	X	X	X	X	X	X	X		X	X	X	X		X	X	X
Reinforced PP	X	X	X		X		X	X				X	X		X	X	X

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ACKNOWLEDGMENTS

The authors acknowledge the many helpful review comments provided by industry professionals including Chris Eichelberger of American Environmental Group, Ltd., and Stuart Lange of Lange Containment Systems, Inc.

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