Technical Note

TN 6.50 Thermoplastic Liners for Detention Systems

Overview

StormTech chambers offer the distinct advantage and versatility that allow them to be designed as an open bottom detention or retention system. In fact, the vast majority of StormTech installations and designs are open bottom detention systems. Using an open bottom system enables treatment of the storm water through the underlying soils and provides a volume safety factor based on the infiltrative capacity of the underlying soils.

In some applications, however, open bottom detention systems may not be allowed. This memo provides guidance for the design and installation of thermoplastic liners for detention systems using StormTech chambers. The major points of the memo are:

- Infiltration of stormwater is generally a desirable stormwater management practice, often required by regulations. Lined systems should only be specified where unique site conditions preclude significant infiltration.
- Thermoplastic liners provide cost effective and viable means to contain stormwater in StormTech subsurface systems where infiltration is undesirable.
- PVC and LLDPE are the most cost effective, installed membrane materials.
- Enhanced puncture resistance from angular aggregate on the water side and from protrusions on the soil side can be achieved by placing a non-woven geotextile on each side of the geomembrane. A sand underlayment in lieu of the geotextile on the soil side may be considered when cost effective.
- StormTech does not design, fabricate, sell or install thermoplastic liners. StormTech recommends consulting with liner professionals for final design and installation advice.

Membrane Materials

Polyvinyl chloride (PVC) is an effective liner material for StormTech systems. PVC offers good chemical resistance to contaminant concentrations typical of highway runoff and to chlorides from road salting applications. Non-reinforced 30 mil PVC liners are recommended for StormTech systems. PVC is flexible. It can be folded without damage and is typically prefabricated and shipped to the jobsite. Panels as large as 20,000 sq. ft. can be prefabricated into a 4000 lb panel (30 mil is 0.195 lbs/sq. ft., SG = 1.2). PVC has the versatility to be field solvent welded, taped or field heat welded. A very significant advantage of PVC is that an excavation contractor can install a PVC liner without specialty crews. Solvent welding of seams, patches and pipe boots can all be done by the excavation contractor making PVC the lowest cost liner alternative.

The PVC compound includes fillers and plasticizers to reduce cost and UV inhibitors to extend the service life under exposure to sunlight. Under prolonged sunlight exposures such as in a permanent surface pool, these additives can leach into the pool and reach concentrations harmful to aquatic life. PVC compounds referred to as “fish safe” are sometimes used for surface pond liners and may be considered for StormTech liners. However, since StormTech systems are subsurface, there is no opportunity for UV attack by sunlight. Also, since stormwater is detained for short durations, typically 48 hours or less, there is little opportunity for accumulation of leachates. Therefore, PVC is an excellent membrane material for thermoplastic liner detention systems.

> *Recommended Configuration:* 30 mil PVC with 8-ounce non-woven geotextile underlayment and overlayment, open top with high flow bypass.
>
> *Recommended Restriction:* Do not use for fuel spill containment.

Linear low density polyethylene (LLDPE) is a very inert material that offers excellent chemical resistance and is "fish safe". LLDPE is an effective liner system for StormTech systems, particularly for small projects where the entire liner can be prefabricated in one piece or when using taped seams. LLDPE is flexible up to 30 mil but thicknesses greater than 30 mil should not be folded without potential damage. 30 mil LLDPE is recommended. Extra care should be taken to protect against puncture. A minimum 8-ounce non-woven fabric underlayment and 12-ounce overlayment should be specified. The underlayment should be increased to 12-ounce where water tightness is essential and increased puncture risk exists. Panels as large as 27,000 sq. ft. can be prefabricated into a 4000 lb roll (30 mil is 0.15 lbs/sq. ft.). LLDPE has a specific gravity less than 1.0. LLDPE seams can be taped or field heat welded. Installation costs may increase if field seaming by a specialty contractor is required.

> Recommended Configuration*:* 30 mil LLDPE with 8-ounce non-woven geotextile underlayment and 12-ounce overlayment, open top with high flow bypass.
>
> Recommended Restriction*:* Do not use for fuel spill containment*.*

Reinforced Polypropylene (RPP), EPDM *and* ***XR-5*** are excellent materials for lining systems due to their flexibility, durability and excellent chemical and UV resistance. Although excellent lining materials, they generally exceed the engineering requirements for typical applications and are higher in cost than PVC or LLDPE. For fuel and oil concentrations normally found in storm water from parking and roadways, PVC, LLDPE and PP are suitable. However, if containment of aggressive contaminants, fuels or fuel spills are anticipated, a liner professional should be consulted. XR-5 in thicknesses of 30 mil or more, with welded seams may be suitable.

Polyethylene (PE) materials are generally inert, offer excellent chemical resistance and are "fish safe". Although ***medium density polyethylene (MDPE)*** liners are widely used for sanitary landfills and fish ponds, they are generally much higher in total cost and are not likely to be cost effective lining materials. ***High density polyethylene (HDPE)*** is not flexible enough to resist puncture and conform to the excavation. Cost aside, MDPE is an acceptable liner material for StormTech systems but should be limited to subgrades that are well prepared, without protrusions and must be field seamed.

Geotextile Materials

6-ounce	AASHTO M288 Class 2 non-woven separation geotextile over the top of stone (ADS 601 or equal)
8-ounce	AASHTO M288 Class 2 non-woven geotextile for use as protection layer for PVC, RPP and LLDPE (ADS 801 or equal)
12-ounce	AREMA Chapter 1 Part 10 Category "Regular" non-woven geotextile for use as protection layer for LLDPE and other PE membranes (ADS 1201 or equal)

Seaming Options

1. ***Prefabricated vs. Field*** Prefabricated seams are preferable to field seams for all liner materials whenever possible.
2. ***Solvent Welded*** PVC only, low cost
3. ***Heat Welded*** Costly, require trained seamer, for all liner materials
4. ***Taped*** Cost effective, M50-RC Gray distributed by Titus Industrial Group recommended, single sided, 4" width, for all liner materials. No water tightness data is available.
5. ***Overlapped*** Not water tight, no leakage rates available, suggest 4 ft overlap for all materials.

Pipe "boots" are used to seal pipe penetrations through the liner. Boots can either be prefabricated by the liner fabricator or field fabricated by the contractor. The boot is then solvent cemented, heat welded or taped to the liner. A pipe clamp is normally used to seal the boot around the pipe. Seaming and sealing pipe boots at low temperatures (32° F minimum) requires preheating of the material.

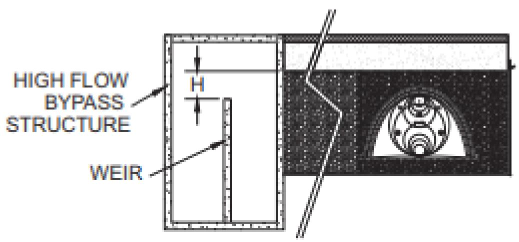
Design

General The design of a lined system must be performed by the consulting engineer and, at minimum, requires knowledge of design storage, peak flow rates and maximum seasonal high groundwater elevation. This information is used to design the peak flow control structure, maximum liner height and groundwater control (if necessary).

High Flow Bypass A high flow control is an important component for any lined system. The high flow control is designed to pass the peak flow while ensuring that the liner is not overtopped. The control structure can be an upstream high flow bypass or a downstream overflow structure. In both cases, a high flow weir, very similar to the high flow control in a pond outlet control structure, is normally used. The high flow weir should be sized such that the water surface elevation based on the maximum head on the weir is less than the top of the liner. Additional freeboard should be provided.

In a typical upstream bypass design, the calculated depth of flow over the weir (H) is subtracted from the maximum water surface elevation in the chamber system to establish the weir crest elevation. The storage in the chamber system associated with the weir crest elevation may be a design constraint. The designer may choose to increase the weir length and therefore decrease the flow depth to establish a higher weir crest.

The equation for a rectangular weir is:

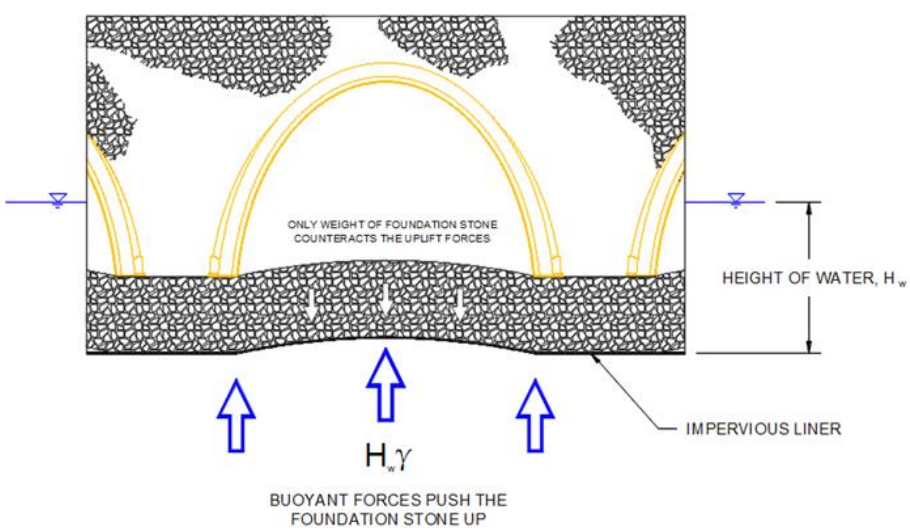


$$H = (Q / (C_d \times L))^{2/3}$$

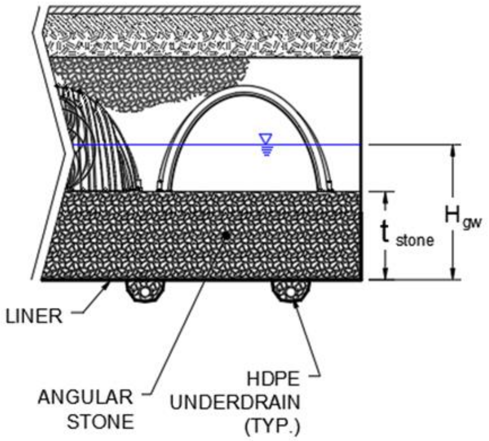
Where:
- Q = flow over the weir (cfs)
- C_d = discharge coefficient = 3.3
- H = Depth of flow over crest (ft)
- L = length of weir (ft)

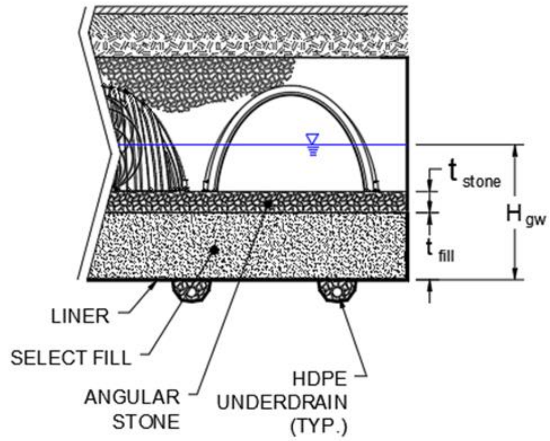
In a typical downstream overflow design, the designer may incorporate one or more low flow orifices into the high flow weir wall. The weir crest is established as described above but hydraulic losses from the inlet to chamber to the outlet structure may need to be considered. Losses may be factored in by lowering the weir crest or increasing the liner freeboard.

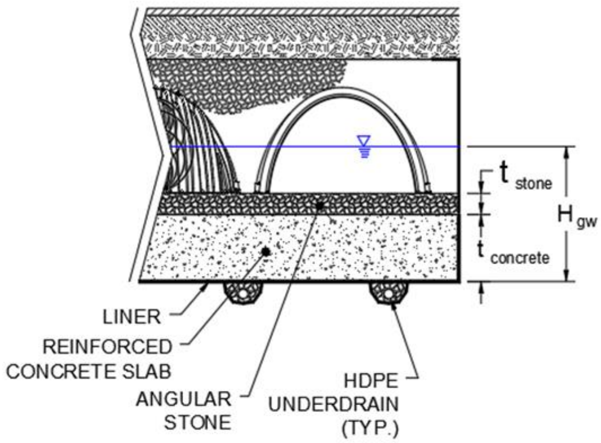
Buoyancy ADS recommends against installing lined chamber systems below groundwater. Although the total weight of a chamber system generally exceeds the buoyant force, a limiting stability condition may result when the buoyant pressure exceeds the resistance pressure directly under the chamber. This could result in a heave of the bedding under the chamber leading to instability.



To prevent adverse impacts from ground water, where gravity discharge is possible, ADS recommends the installation of an underdrain system under the liner. Where there is a potential buoyant force, ADS recommends a sufficient bedding thickness, such that the weight of bedding exceeds the maximum buoyant force. The additional bedding thickness can be either increasing the foundation stone or adding a combination of foundation stone and select fill beneath the feet of the chamber and inside the liner to counteract these uplift forces.



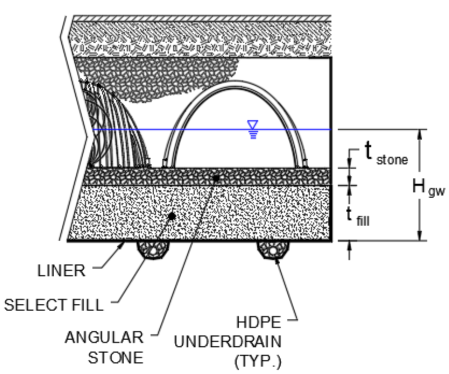




The bedding thickness calculation is simplified by ignoring any structural contribution from the liner and reinforcing material and considering only the weight of the stone or stone/fill in the thinnest area of the bedding, which is located under the chamber.

The relationship between bedding thickness and maximum allowable groundwater elevation is:

Select Fill and Foundation Stone Option



H_{gw} x (62.4 lb/ft^3) = [(γ_{stone} x t) + [(γ_{fill} x t)] / SF

Where:

γH_{gw}= height of groundwater above liner bottom (in)

γ_{stone} = bulk density of bedding stone (lb/ft^3)

t_{fill} = thickness of fill bedding (in)

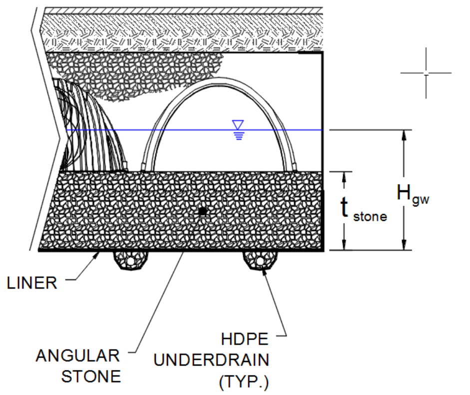
t_{stone} = thickness of stone bedding (in)

SF = safety factor (1.25 typical minimum)*

The bulk density of the open graded stone bedding materials varies from about 75 lbs/ft3 to over 100 lbs/ft^3. The bulk density of select fill materials varies from about 90 lbs/ft^3 to over 120 lbs/ft^3. Without specific bulk density information for the stone actually used, ADS recommends using not more than 75 lbs/ft^3.

* The consulting engineer may apply a lower or higher safety factor.

Increased Foundation Stone Option

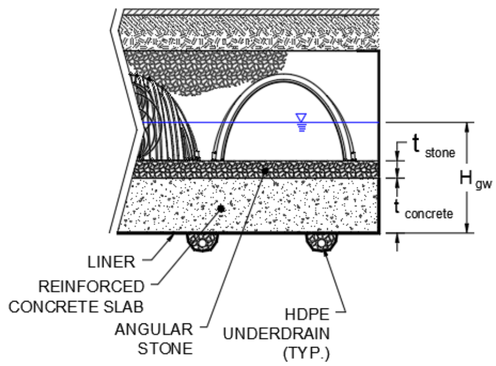


H_{gw} x (62.4 lb/ft^3) = [(γ_{stone} x t) / SF

Where:

γH_{gw}= height of groundwater above liner bottom (in)
γ_{stone} = bulk density of bedding stone (lb/ft^3)
t = thickness of stone bedding (in)
SF = safety factor (1.25 typical minimum)*

Reinforced Concrete Slab



Alternatively, an engineer can design a reinforced concrete slab. The slab should be designed to handle the uplift forces from groundwater while transferring live & dead loads to the underlying material.

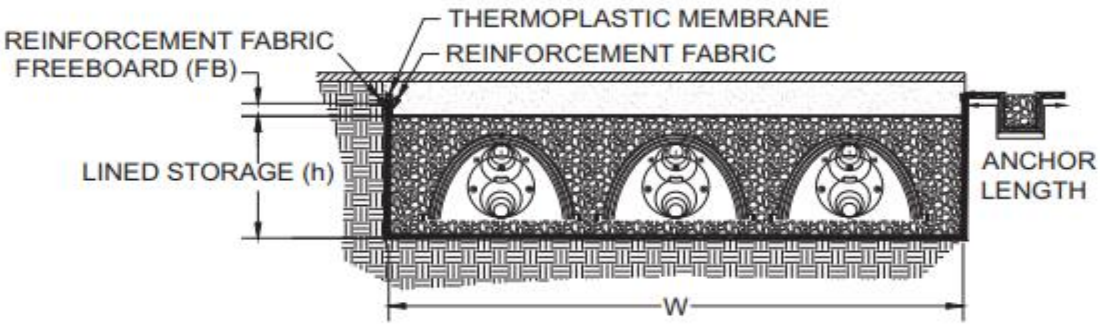
Installation

Installation should be in accordance with the liner manufacturer's instructions. Associations representing membrane materials have developed installation standards and other support documents for the respective lining materials. Visit their web sites for additional information.

- PVC Geomembrane Institute, University of Illinois, web: http://Pgi-tp.cee.uiuc.edu/forweb
- "HDPE Geomembrane Installation Specification" by the International Association of Geosynthetic Installers. Revised February 2000: http://www.iagi.org/specifications.htm

PVC and LLDPE liners should not be installed at temperatures less than 32° F or on windy days. Wind can catch the liner and be extremely dangerous to laborers. Stones and other protrusions should always be removed from the excavation. Rolling or compacting is recommended to knock down any remaining protrusions. The non-woven underlayment fabric is then placed in the excavation, the membrane placed, and a fabric reinforcement placed over the membrane. Liners are flapped by laborers to get air under the liner to enable easy drag across bed. Corners are generally formed by folding or "pleating" excess liner material.

An “anchor trench” about 12” deep by 12” wide may be dug around the top of the excavation to anchor the top of the reinforcement fabric and thermoplastic liner at the top of the excavation. Stone should be placed carefully to avoid puncture from long free falls. Similarly, additional care must be taken when spreading and compacting bedding stone to prevent stones from puncturing the liner during construction.



Estimating Liner Material

Liner fabricators require dimensional details to design panels and provide firm material quotations. The liner and reinforcing fabric quantities should include sidewalls and extra material for anchoring during installation. The excavation contractor should use care not to over excavate since a larger excavation would require additional liner materials.

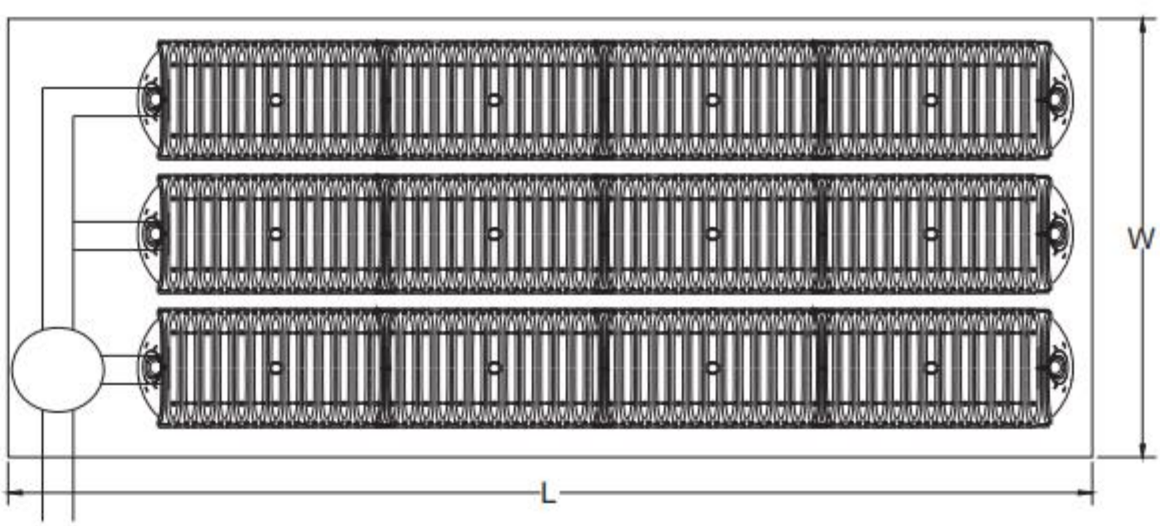
The fabricated sheet size for estimating purposes is calculated as follows:

Panel Size = [W + 2(h + FB + AL)] x [L + 2(h + FB + AL)]

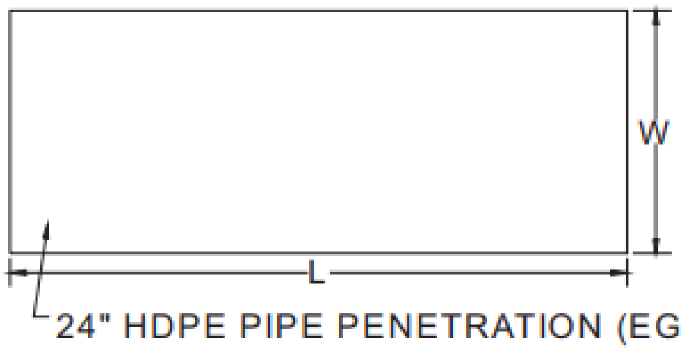
Where:

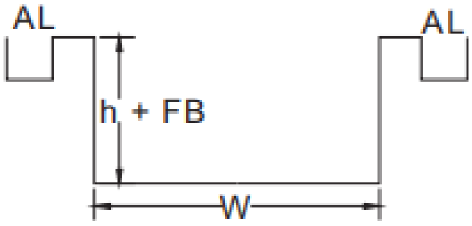
- W = system width from StormTech layout drawing
- L = system length from StormTech layout drawing
- FB = freeboard based on engineer’s advice (0.5’ typical)
- AL = anchor length of membrane and reinforcement to tie back sidewall material during installation and backfill of chambers (4’ typical)

The location and size of pipe penetrations should also be summarized for the fabricator.



Estimating Worksheet:





Panel Size = [W + 2(h + FB + AL)] x [L + 2(h + FB + AL)]