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Geosynthetics

Stormwater detention using geosynthetics

A new take on sound-barrier walls

Geosynthetic reinforcement *Is it magic?*

Building bridges the GRS way

IFAI publication

Geosynthetics-based underground stormwater detention system.

Geosynthetic materials play a major role in new underground stormwater detention system

By Terence G. Sheridan, P.E.

Introduction

Stormwater management is an ever-increasing expense on site development projects.

Stormwater detention ponds are designed to protect against downstream flooding and environmental degradation. The standard of practice is to ensure that post-development flow from a site does not exceed the pre-development rate for a given storm event.

Where land is expensive, detention systems are located underground. Traditional underground detention systems are comprised of pipes, pipe arches, and concrete vaults. A new underground stormwater detention system has been developed that combines a number of different civil engineering disciplines.

Geosynthetic materials play a major role in critical components of this new stormwater detention system.

Traditional stormwater systems

Corrugated metal and plastic pipes are the most common materials used in underground stormwater detention applications. These flexible pipes transfer stresses to the surrounding soil and rely on ring compression and soil arching for structural integrity.

Design standards are based on tightly controlled structural backfill properties and compaction efforts. Given AASHTO and state DOT gradation requirements, particularly those related to the fines content (silt and clay), most flexible pipe projects require imported backfill.

A new system

A new underground stormwater detention system creates a large storage chamber utilizing geosynthetics, stone, and concrete slabs.

Essentially, a geotextile or geomembrane liner system is installed within an excavation. Around the perimeter of the excavation, walls are constructed with geosynthetic reinforcement and open-graded stone to create a large underground chamber. Inlet and outlet pipes extend through the perimeter liner system and wall face into the open chamber.

PROJECT HIGHLIGHTS

Roosevelt Manor

OWNER
City of Camden (N.J.) Housing Authority

CITY ENGINEER
Remington Vernick Engineers

PROJECT ENGINEER
PS&S Engineers

GENERAL CONTRACTOR
Haines & Kibblehouse Inc.

STORMWATER SYSTEM
GeoStorage Corp.

INSTALLER
CETCO Contracting Services Co.

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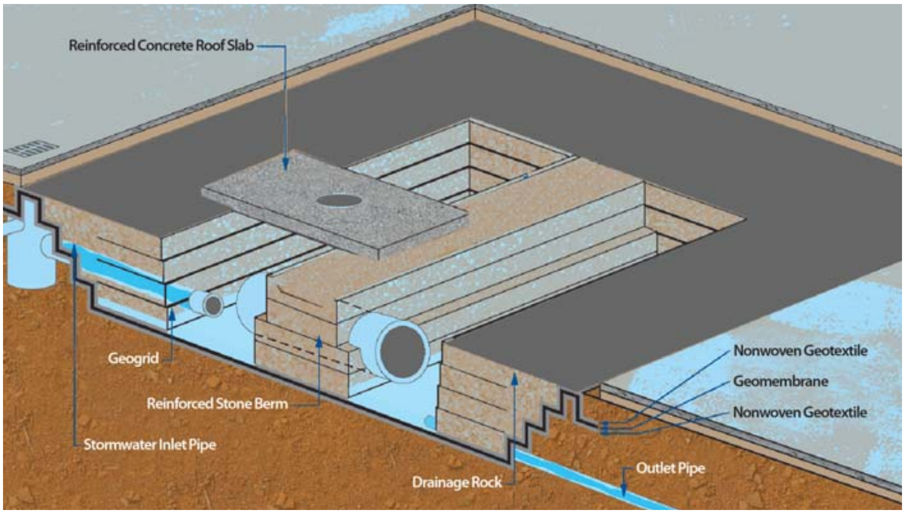
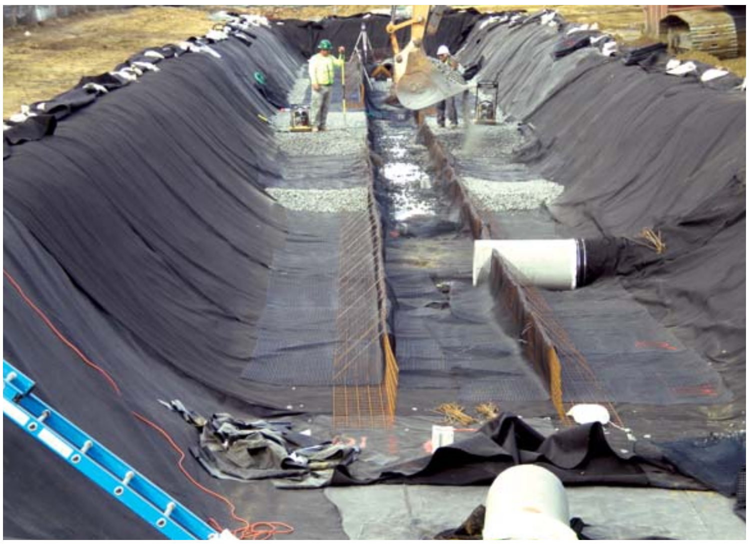
Photos courtesy of GeoStorage Corp.



Underground stormwater detention system schematic.


Geomembrane installed with nonwoven geotextile for puncture protection.

A reinforced concrete roof is installed over the chamber and supported by the perimeter abutments/walls. Finally, the liner system is installed over the stone surface of the perimeter walls before the cover soil brings the site to grade. On larger systems, interior reinforced stone piers can be installed within an expanded chamber to increase the width and storage capacity of the system.

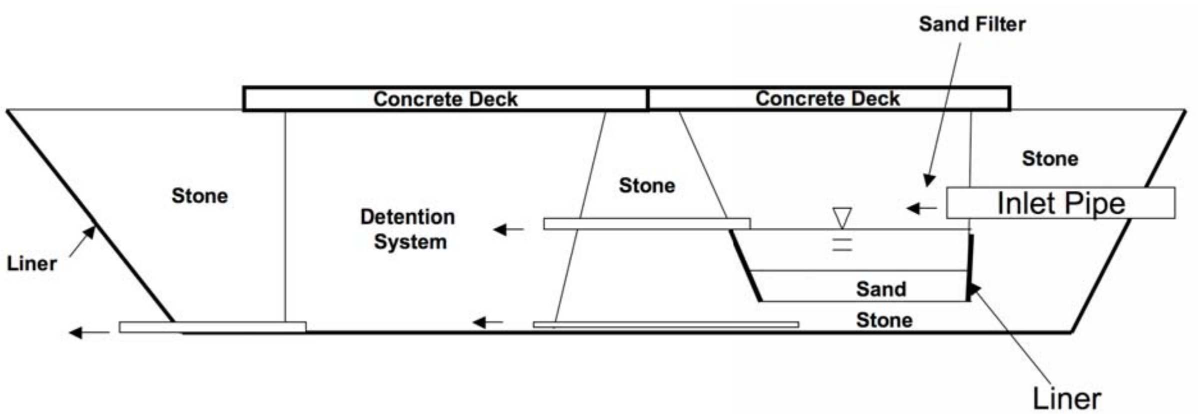
Given the application, water forces are an important consideration. If water drains from the chamber faster than it drains from the backfill, the perimeter walls will experience a rapid drawdown condition. The use of angular, open-graded stone eliminates pore pressures and has the added benefit of increasing storage capacity with a 40% void ratio.

GRS walls

As presented in previous issues of *Geosynthetics* magazine **(see References, page 41)**, the Federal Highway Administration (FHWA) has developed a geosynthetic-reinforced soil (GRS) integrated bridge system in an effort to simplify the design and reduce the cost of basic, single-span bridges.

The abutment walls of these bridge systems are characterized by tightly spaced geosynthetic layers where the spacing is the key design consideration as opposed

Underground stormwater detention system with sand filter



to long-term design strength. Another unique feature of the FHWA integrated bridge system is the placement of the bridge superstructure directly on top of the reinforced abutment. While the elimination of a bearing pad on top of the bridge substructure might be anathema to structural engineers, the performance of full-scale experiments and an ever increasing number of installations verify the capacity of the GRS bearing sills.

The bearing walls of geosynthetic-based underground detention systems function in the same manner as GRS bridge abutments. The elimination of a bearing curb along the wall face reduces costs and speeds construction. The performance of these detention systems complements the data and observations of GRS bridge systems.

Underground stormwater detention systems are typically located below parking lots. Materials that flex or creep can induce stress in the pavement section, which can lead to long-term maintenance problems.

It has been observed that the GRS integrated bridge system eliminates the "bump" commonly observed on traditional bridge approaches where the soil ramp meets the concrete pier. Similarly, a geosynthetic reinforced stone detention system provides a uniformly solid foundation for the parking lot.

The face of the chamber wall is installed utilizing standard "wrap face" construction with welded wire forms to enable compaction to the edge. When a geogrid is used for reinforcement, the stone and geogrid apertures have to be

The bearing walls of geosynthetic-based underground detention systems function in the same manner as GRS bridge abutments.

Geosynthetic-reinforced stone perimeter walls constructed with geogrids and compacted open graded stone.

Precast roof deck panels placed directly on geosynthetic-reinforced walls.
Design note: No concrete grade beam required on bearing sill.

sized to ensure no raveling at the face. Below the bearing sill, smaller stones are installed and a geotextile wrap is used at the face.

Liner system

Until recently, most stormwater management systems incorporated a detention system that released the contained stormwater through a controlled outlet with an overflow weir to handle storms larger than the design event.

Today, the preferred practice is to recharge the ground water through percolation where it is feasible. The liner system can be designed accordingly.

Geomembranes can be installed for detention applications and provide superior performance where a reusable water supply is desired. Recharge/retention applications can utilize geotextile liners.

In these applications the chamber floor is accessible for inspection and, when needed, clogged geotextiles can be replaced.

Roof deck

The roof deck, which spans the chamber and is supported by reinforced stone walls, is designed to AASHTO HS-20 bridge standards (Section 3.24.12).

The roof deck is the most expensive component of the system. Recognizing that the deck design is the same whether the chamber is 2ft or 10ft deep, it is clear that a deeper chamber will increase the efficiency of the system. The roof deck can be cast in place or comprised of precast panels.

The top of the system is fixed by the elevation of the lowest upstream manhole/grate. On detention applications the floor is fixed by the elevation of the downstream outlet. On recharge applications depth is limited by the water table or a low permeability soil stratum.

The drainage and grading plan often dictates that the system be buried. Buried systems eliminate concerns about the tolerances of precast panels installed flush with the parking lot surface.

Inspection and maintenance

Site designs focus on limiting erosion through the use of Best Management Practices (BMPs).

However, while BMPs will reduce the suspended solids in stormwater, sediment will still collect in the detention system. The large open chamber of the geosynthetic-based system enables personnel to inspect and maintain the underground system.

As stormwater regulations become more stringent and enforcement more routine, the ability to inspect and remove sediment from underground detention systems will become more important.

Stormwater quality

Sand filters are a time-proven pollutant remover.

However, in underground applications the cost of the concrete vault required to house the sand filter is expensive. As a result, new technologies are entering the marketplace to meet regulatory pollutant removal requirements. These technologies include vortex chambers and filter cartridge systems housed in smaller concrete vaults.

The geosynthetic-based detention system enables the construction of a traditional sand filter within a chamber. The water quality volume can be stored in a geomembrane lined chamber above the sand filter.

The geosynthetic-based underground detention system offers a cost-effective alternative to traditional underground stormwater detention and retention systems.

Large open chamber allows for accessible inspection and maintenance.
Note: No movement/stress in the upper portion of the wall below the bearing sill.

Completed stormwater system installed with manhole for chamber access.

As an option, a Reactive Core Mat® can be installed above the sand layer to decrease its thickness and augment contaminant removal. Where desired a second chamber may be lined to create a forebay that removes sediment upstream of the sand filter chamber. The performance of the geosynthetic based system mimics that of traditional underground sand filters but at a significant savings.

Conclusion

The geosynthetic-based underground detention system offers a cost-effective alternative to traditional underground stormwater detention and retention systems. In addition, this new system requires a smaller footprint.

In the future, as stormwater quality regulations are enacted the large open chamber will offer additional benefits. The chamber allows for easy access, an important feature for owners and municipalities charged with maintaining their stormwater systems.

The chamber also provides access to the geotextile filter should it need to be replaced because of clogging issues. Lastly, the chamber enables the construction of an efficient underground sand filter where regulations require stormwater treatment.

The liner, reinforced walls, and concrete deck comprising this system are well established in the civil engineering market. Ample research exists to support the design life of the materials and the performance of the components.

On even the largest projects the geosynthetics can be shipped on a single truck. The open graded stone is available at the local quarry and the required tonnage will be less than the structural backfill required for an equivalent pipe system. The concrete roof will be shipped from the local precaster and require a fraction of the amount of trucks necessary to ship an equivalent amount of pipe. In addition, the excavation will be significantly smaller than a pipe system. For developers looking to build "green," the geosynthetic option offers many distinct advantages over traditional pipe systems.

Innovation allows construction budgets to accomplish more and stormwater management is a large and growing portion of site development and transportation budgets. By piggybacking on the research and development of existing civil engineering technologies, this new system allows property owners and municipalities to save money on their stormwater detention and treatment systems.

References

U.S. DOT/Federal Highway Administration, "Building the bridge of the future with GRS technology," *Geosynthetics,* Vol. 24, No. 4, 2006, pp. 22-23.

Adams. M., "The GRS bridges of Defiance County," *Geosynthetics*, Vol. 26, No. 2, 2008, pp. 14-21.

Adams. M., Schlatter. W., Stabile. T., "Geosynthetic-reinforced soil integrated bridge system," EuroGeo4–the 4th European Geosynthetics Conference, Edinburgh UK, September 2008, paper number 271.

Author's Note: *GeoStorage Corp. owns patents (U.S. #7,473,055 B2 and international) related to the geosynthetic-based underground stormwater detention system discussed in this article.*

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