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Use of Underground Stormwater Detention Systems

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Roosevelt Manor sits in the heart of Camden, New Jersey's Centerville neighborhood across the Delaware River from Philadelphia. Built in the early 1950's via authorization of President Harry Truman and under the direction of the Camden Housing Authority, Roosevelt Manor broke new ground as an integrated public housing development. Unfortunately, Camden, like many other urban cities, struggled over the last half of the century. Just over 50 years after opening its doors the four acre development was demolished and with HopeVI funding from the U.S. Department of Housing and Urban Development, Roosevelt Manor was rebuilt.

The Spielbergesque homes in this new inner city development bear little resemblance to the post war apartments they replaced. However, below the surface, urban planners faced challenges unique to developments like Roosevelt Manor. Many older cities in the country have combined sewers and stormwater drains that flow to a waste water treatment plant. During large storm events, when the capacity of the treatment plant is exceeded, sewage and stormwater overflow the system directly into the adjacent water body, i.e., the Delaware River. Stormwater management engineers need to limit flow from new developments into the city stormwater system during peak storm events and, at the same time, protect neighborhoods from flooding. Unfortunately, traditional detention ponds are not practical at the core of an inner city where open space is limited. At Roosevelt Manor's Centerville South Redevelopment a patented geosynthetic based underground stormwater detention system was constructed that protects the Delaware River from pollution while maintaining open space without the threat of flooding. This innovative solution is illustrated in Figure 1.

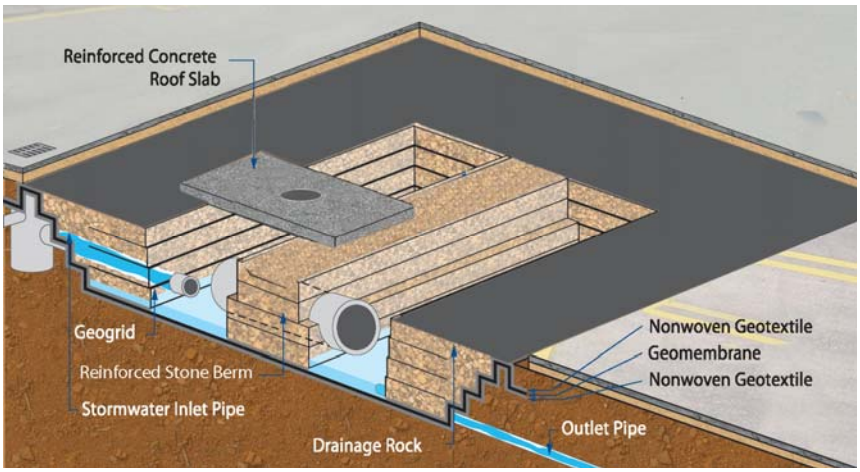

Figure 1. Schematic of GeoStorage® Underground Detention Basin

The geosynthetic based detention system is comprised of a large storage chamber formed by installing reinforced stone walls within a geosynthetic liner system. Essentially, a 30 mil thick prefabricated PVC geomembrane is installed within the excavation and stone walls constructed around the perimeter of the lined excavation over the geomembrane. The stone walls are stabilized with geosynthetic reinforcement at tightly spaced lifts and support a precast concrete roof spanning the interior storage chamber. The porosity of the perimeter stone walls and impermeability of the geomembrane eliminate any build up of pore-water pressure and also provides additional storage capacity. On larger projects an interior pier built in the same manner as the perimeter walls can expand the size of the chamber by supporting the concrete roof panels. At the wall face, the geosynthetic reinforcement is wrapped to retain the stone backfill and welded wire forms are utilized to enable compaction. Inlet and outlet pipes extend through the perimeter liner system and the geosynthetic wrapped stone wall face into the open chamber. The outlet pipe is typically connected to a downstream manhole with a flow control weir containing orifices that restrict flow for all but the largest storm events. Another important feature of this geosynthetic based system is the large chamber enables access for future sediment inspection and removal, an important consideration for the city's municipal department responsible for long term maintenance.

Figure 2. PVC geomembrane installation over underground chamber

Figure 3. Perimeter wall construction at pipe penetration

Figure 4. Stormwater detention chamber

Figure 5. Stormwater detention system roof installation over chamber

Figure 6. Roosevelt Manor with underground stormwater detention system below street

When the geologic and native soil conditions allow, stormwater from the chamber can percolate into the groundwater. In these recharge/retention applications a non-woven geotextile is specified instead of the PVC geomembrane around the geosynthetic based system. After a thorough review of the site conditions at Roosevelt Manor an impermeable detention system was selected to contain the 100 year storm event. A 30 mil PVC geomembrane was installed along with non-woven geotextiles for puncture protection. Watersaver Company in Denver, Colorado supplied the PVC geomembrane and pipe boots. The geomembrane was custom fabricated in the plant to match project specific dimensions and eliminate field welding which resulted in a faster, higher quality, and simpler installation with the highest degree of quality control.

Construction started on the first detention system in the Autumn of 2009. After excavation of the native soil to create the underground chamber was completed, trenches were cut below the inlet and outlet pipes. Strips of PVC liner were placed in the trenches and the pipes were installed on a 6 inch stone bed to the limits of the chamber walls. Prefabricated PVC boots were clamped around the pipes at the sidewalls of the excavation and the PVC liner was solvent welded to the skirts of the boots and the trench liner. An 8 oz/sy Geotex® 861 non-woven geotextile from Propex was installed below and above the PVC liner to protect it against puncture from the subgrade and stone backfill. Wall construction commenced with geogrid layers spaced between 9 inch lifts of compacted 1 ½" stone. The geogrid, supplied by Luchenhaus® Technical Textiles, was draped over 18" high welded wire forms with the overhanging geogrid wrapped back into the wall when the stone layer was flush with the top of the form. Wire brackets, spaced at two foot intervals, fastened the top front of the "L" shaped wire forms to the flat bottom. These brackets stiffened the face of the wire wall and allowed the stone to be compacted up to the wall face. Immediately below the bearing pad the stone size and geogrid spacing were reduced and a geotextile was included in the wrap facing to prevent raveling. Finally the precast concrete roof panels, manufactured by Rahns Concrete, were placed directly on the top of the stone reinforced chamber walls and the liner system was extended from the perimeter anchor trench to the concrete roof to encapsulate the system. This detention system has a storage capacity of 15,100 cubic feet and was completed in 7 days with a 4 man crew and a superintendent. A 966 Caterpillar Loader was used to deliver stone to stockpiles around the perimeter of the excavation where a 330 Caterpillar Excavator fed the stone to two track skids in the hole. The liner was installed in one-half of a day with a two men crew

dedicated to the pipe boots for the entire day. The chamber walls, 4.5 feet high and comprising 767 square feet of face, took 6 days to complete and the precast roof was installed in less than 3 hours.

Two other underground storage systems were of similar size were constructed in the same manner at a slightly faster pace as the crew became acclimated to the construction process. These other systems are also located in Roosevelt Manor. In these two systems a stone placement box was added to the operation to create a moving stockpile and reduce the stone waste factor. The Housing Authority of the City of Camden supervised all construction at the site and with other city agencies will be responsible for the inspection and maintenance of the stormwater management system.

PS&S Engineers worked closely with Camden's consultant, Remington Vernick Engineers, and Haines and Kibblehouse Contractors to design, bid, and construct the detention systems on time and within budget. The GeoStorage® Underground Stormwater Detention Systems, installed by CETCO Contracting, saved money, time, and space. Gary Riebel, Haines and Kibblehouses's project manager said "*We excavated and laid the pipe for three systems and Cetco followed right behind us with the installation. We covered and paved the first system right after handing the last system over to Cetco.*" Rebecca Koze, PS&S's project engineer commented "*this was a tight site so the smaller footprint and flexibility of the GeoStorage® System was helpful in the design and it gave the contractor more room to work*".

PVC geomembranes have been used for many years to line above ground detention ponds and geosynthetic reinforced walls are common place along highways and in commercial and residential developments. In addition, simple span concrete bridge decks, identical to the geosynthetic based chamber roof, are a fundamental feature of our nation's transportation network. All of these technologies are well established with time proven design procedures and long track records. At the Roosevelt Manor redevelopment these technologies were combined underground in a unique and novel configuration to provide an innovative stormwater detention solution for this site.

In summary, the Centerville Neighborhood Revitalization Plan includes Five Star Rated row homes, duplexes, and stacked town homes, a solar energy system to power common areas and a state of the art stormwater management system to protect against flooding and pollution of the nearby Delaware River. Geosynthetics and their related applications comprise the components of the underground detention system at the center of the stormwater plan. New materials and new technologies are integral to the rebirth of Roosevelt Manor. The new century is full of Hope in Camden.

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