Concrete Technology Improves Stormwater Runoff Detention

by John Sedenquist

Emulating nature, emerging post-construction urban site stormwater management practices seek to control, catch, contain, treat, and infiltrate runoff from stormwater and snowmelt. Ponds, swales and buffer zones, and permeable pavements are typical ways of controlling post-construction site runoff. Conventional construction methods use granular pervious fill materials to create these runoff detention controls.

Recent innovation in foam liquid concentrate technology provides a new, more sustainable geotechnical fill solution for improving stormwater runoff detention management: the production of pervious forms of cellular lightweight concrete (PCLWC). PCLWC technology improves runoff detention, providing more detention capacity than typical granular pervious fill or lightweight aggregate solutions, while imparting less impact on native soils, eliminating compaction testing and pre-loading for project area settlement mitigation, and significantly reducing carbon dioxide emissions and heavy metal contamination to area wetlands and waterways.

Pervious cellular lightweight concrete is a permeable, engineered material with a portland-cement base, containing small, open, air cells uniformly distributed throughout the concrete. The use of PCLWC in urban post-construction stormwater management practices provides improved runoff detention over granular pervious fill or lightweight aggregate materials.

Cellular Concrete Geotechnical Fill Materials

Cellular lightweight concrete fills have a long and established track record of success, providing value-engineered solutions when standard fill materials are too heavy, site access is limited, or project schedules must be contracted.

Developed in Scandinavia, typical cellular lightweight concrete fill is an engineered, impermeable lightweight material with a portland cement base containing small, closed air cells uniformly distributed throughout the concrete. More precise control of the volume of these air cells, produced mechanically by means of special foam liquid concentrate agents, was introduced in the years following World War II, resulting in relatively stable air cells (bubbles) and controlled density for a broad range of load-reducing geotechnical fill needs – from 20 to 120 pounds per cubic foot (PCF) [320 to 1920 kilograms per cubic meter].

Unlike typical cellular lightweight concrete geotechnical fills, PCLWC is a permeable, open-cell, lightweight concrete, able to stabilize soil without disturbing or redirecting natural water flow. The use of PCLWC in urban post-construction stormwater management practices provides improved runoff detention over granular pervious fill or lightweight aggregate materials.

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Geofoam SP is an engineered, aqueous concentrate specially formulated to yield a stable, voluminous, micro-bubbled foam. When blended with cementitious slurry, the foam enables the production of pervious cellular lightweight concrete (PCLWC), a permeable, open-cell, lightweight concrete able to stabilize soil without disturbing or redirecting natural water flow.

Comparing PCLWC to Other Fills

Typical granular pervious fill materials have a detention capacity of about 2.4 gallons per cubic foot [320.7 liters per cubic meter]. If 1,000 gallons [3,785 liters] of stormwater runoff detention is required for the project, approximately 380 cubic yards [290.5 cubic meter] of native soil must be replaced or topped with granular pervious fill material.

By comparison, PCLWC has a detention capacity of 4.8 gallons per cubic foot [641.3 liters per cubic meter]. For every 1,000 gallons [3,785 liters] of detention required, only 210 cubic yards [160.5 cubic meters] of native soil needs to be replaced or topped with PCLWC.

To minimize settlement, granular pervious fill materials are often installed in lifts, with each lift achieving 85% compaction. While compaction reduces settlement, it also reduces the detention capacity of the compacted granular pervious fill material. Many urban sites can require pre-loading of project areas for settlement mitigation, extending project schedules.

An on-site foam generator adds fixed volumes of air at a fixed pressure to create the micro-bubbled foam, which, when blended with a cementitious slurry, enables the production of PCLWC.

PCLWC is self-leveling and naturally achieves 100% compaction, eliminating settlement with no reduction in runoff detention capacity. It maintains its shape and detention capacity following placement and will not liquefy during a seismic event. Pre-loading for project area settlement mitigation is not required when using PCLWC. Unlike non-contained or non-homogeneous fill materials such as soil or aggregate, PCLWC provides the added benefit of gaining a 2-to-1 point-load-distribution edge.

Where native-soil project loads are a concern, typical granular pervious fill materials, which weigh approximately 110 pound per cubic foot (PCF) [1,760 kilogram per cubic meter], can be replaced with higher-cost, lightweight aggregate pervious fill, which weighs only about 90 PCF [1,440 kilogram per cubic meter]. To prevent settlement, lightweight aggregate pervious fill materials are often installed in lifts, with each lift achieving 85% compaction. In some urban setting where native soil loads are a concern, even lightweight aggregate pervious fill materials must be reduced. In these cases, as the lightweight aggregate pervious fill material is reduced, its detention capacity is also reduced and most likely will not meet project specifications.

The controlled density of PCLWC supports a broad range of load-reducing geotechnical fill needs – typically from 20 to 35 PCF [320 to 560 kilogram per cubic meter], which is significantly lighter than lightweight aggregate fill options. PCLWC is 80% lighter than typical granular

A highly fluid, self-leveling material, pervious cellular lightweight concrete (PCLWC) can be pumped long distances, with typical installation rates exceeding 100 cubic yards per hour.

pervious fill options and requires 45% less volume, saving excavation and installation expenses and eliminating compaction and testing costs.

Reduction of Carbon Dioxide Emissions

The use of PCLWC for stormwater runoff detention significantly reduces project carbon dioxide emissions. Projects with volumes exceeding 10,000 cubic yards [7,645 cubic meters] of detention fill use an on-site PCLWC batch plant that produces and pumps cementitious slurry, with trucking needed only for the delivery of cement. Such was the case in Queens, New York, during construction of Citi Field, new home of the New York Mets. More than 17,000 cubic yards of PCLWC were batched on-site, eliminating the need for a fill-truck staging area outside the stadium and removing more than 1,000 trucks from the Van Wyck Expressway, Grand Central Parkway, and other borough streets.

For projects with volumes of 10,000 cubic yards [7,645 cubic meters] or less, PCLWC production also happens on site, by treating slurry manufactured at a local ready-mix plant and delivered and discharged by transit mixer to the hopper of a job site concrete pump. Engineered foam liquid concentrate (which enables the production of PCLWC) is injected into the delivered slurry in the pump hose – not the transit mixer. This method expands the volume of the delivered slurry about 3.8 times (one seven cubic-yard slurry load producing 27 cubic yards of PCLWC), eliminating up to 55% of the trucks required (and the accompanying road traffic congestion), had a granular pervious fill option been used.

Other Sustainable Attributes of PCLWC

Both PCLWC batching methods can incorporate ground granulated blast-furnace slag or fly ash in the slurry mix design without adversely affecting PCLWC performance. The use of these post-industrial byproducts in PCLWC production eliminates the need to landfill these materials and reduces the need for virgin materials in PCLWC production, and the environmental impacts from the extraction and processing of these virgin materials.

Testing by Middle Tennessee State University documents the ability of PCLWC to enhance the environment by filtering contaminants that can adversely affect soil and water.

Various chemicals and solids were placed on PCLWC specimens and then rinsed with increasing amounts of water – 0.5 to 30.0 inches [1.27 to 76.2 centimeters] – over a given surface area. Testing results showed PCLWC filtered 78% of the hydrocarbons and heavy metals. Testing for oil retention resulted in 97% of oil remaining on the PCLWC specimen.

PCLWC creates an ideal environment within its cell structure to aid in the natural breakdown of environmentally unfriendly materials. Hydrocarbons – such as oils – are a food source for many naturally occurring bacteria and fungi. The cell structure of PCLWC allows these microorganisms to feed on the retained oil and biodegrade it into simpler chemical components, which are released harmlessly into the atmosphere.

Conclusion

PCLWC technology improves the detention of stormwater runoff, providing 45% more detention capacity than typical pervious fill solutions while imparting less impact on native soils (45% less excavation required), eliminating compaction testing, and significantly reducing carbon dioxide emissions and heavy metal contamination to area wetlands and waterways.

As communities struggle to strike a balance between economic growth and environmental issues, innovative construction materials can provide effective solutions for improving stormwater runoff detention and support sustainable urban development. Adopting PCLWC technology adds an important detention practice to your urban stormwater management toolbox. *uwm*

The use of PCLWC for stormwater runoff detention significantly reduces project carbon dioxide emissions. On-site material batching requires trucking only for the delivery of cement, eliminating the need for a project fill-truck staging area and removing heavy, round-trip dump truck traffic from urban streets and thoroughfares.

About the Author

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About Cellular Concrete LLC

Cellular Concrete LLC engineers integrated, smart foam liquid concentrate solutions for construction, mining, and manufacturing applications, applying research, innovation, and technical expertise and support to help specifiers, contractors, mining professionals, and manufacturers expand markets, improve quality and job site safety, and reduce project/environmental costs.

The innovative Cellular Concrete LLC product line includes protein, synthetic, and protein/synthetic blend liquid foam concentrate formulations for use in insulated concrete roof deck and floor construction, low slump and lightweight concrete applications, and mining and geotechnical applications, including pervious cellular lightweight concretes.

The engineered foams are designed to release their unique physical properties only when mixed with the cementitious materials and a chemical reaction occurs. Construction professionals find Cellular Concrete LLC's smart foam liquid concentrates to be the most stable preformed products in the cellular concrete industry, durable cell structures not affected by long pump runs, extended mixing, or most fly ashes or ground granulated blast-furnace slags.

Smart foam liquid concentrate products include:

- Mearlcrete – for low-density, insulated concrete roof deck and floor applications
- Geofoam – for low-density geotechnical construction applications
- Mearlcell 3532 – for pre-cast construction applications
- Geofoam MM – for surface tailings disposal and backfilling
- Geofoam SNP – for geotechnical, grouting, and tremie applications
- Geofoam SP – for pervious geotechnical applications, and
- CellFlow – for the production of CLSM materials (aka flowable fill).

Cellular Concrete LLC also sells foam generation systems designed specifically for producing consistent foam for cellular concrete production, including jobsite-tough tank generators, tankless auto generators, and portable lab-foam generators for producing accurate results in the laboratory.

More information about smart foam liquid concentrates and Cellular Concrete LLC is available online at:
www.cellular-concrete.com.

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