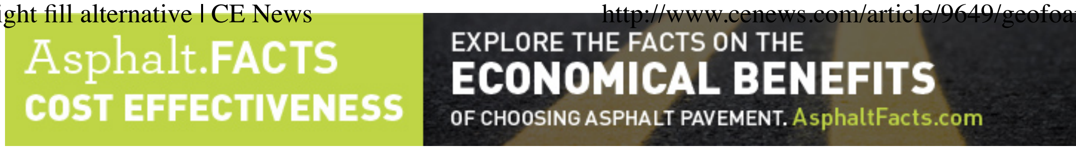

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GEOFOAM: A LIGHTWEIGHT FILL ALTERNATIVE

March 2014 (/toc/332) » PROGRESSIVE ENGINEERING

Applications and design and construction considerations for EPS geofoam.

Nico Sutmoller

Geofoam is a rigid, engineered, lightweight fill material typically made of expanded polystyrene (EPS). For fills, a key advantage of EPS geofoam is its low weight — approximately 1 to 2 percent the weight of soil. Typical densities for

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EPS fill are between 0.7 and 2.85 pounds per cubic foot, therefore maintaining a predictable compressive strength that is suitable for many structural applications (see “Geofoam physical properties”).

Today, geofoam is fully recognized and accepted as a lightweight fill alternative and has seen increased use in commercial and residential applications. Since the first installation of geofoam in 1965 (see “A short history of geofoam”), numerous projects around the world that have relied on the material to solve construction problems.

Given EPS geofoam’s low weight, strength, and ease of use, more project teams are using it to solve regular construction challenges in five basic applications:

To widen the Pacific Street Bridge over I-680 in Omaha, Neb., Hawkins Construction excavated the soil between the existing abutment and soldier piles then formed and extended the abutment wall using EPS geofoam as lightweight backfill for the bridge approach.

1 — Lateral load reduction on structures

EPS geofoam significantly reduces lateral loads on retaining walls and building foundations. The material has an extremely low Poisson’s ratio (0.05) and high coefficient of friction (0.6), which helps enable placement of blocks in a way that replaces the sliding soil wedge above the angle of repose. By replacing the active wedge with EPS geofoam, which can be completely free standing and self-supporting, project teams can save as much as 75 percent of total project costs compared with traditional concrete walls designed to retain soil.

Using EPS geofoam also reduces labor and material costs without the need for over excavation, and requires much less robust forming, reduced structural steel and concrete wall thickness, and fewer footings. The material also can reduce or eliminate the need for geogrids or mechanical tiebacks. Project teams are able to construct a retaining wall with EPS geofoam paired with a lower-cost fascia (which acts more like a fence). Another key advantage of using the material in retaining wall applications is the allowance for taller walls in narrower right-of-ways. This reduces time and cost spent on property acquisition, as well as minimizes lane closures and encroachment into wetlands or neighboring properties.

An abutment project example is the widening of the Pacific Street Bridge over I-680 in Omaha, Neb. Typically, crews would have removed and replaced the existing abutment walls since they were not designed to withstand increased lateral loads induced by fill for additional lanes. To avoid the cost and effort associated with this

Geofoam physical properties

EPS geofoam offers predictable engineered values, which simplifies design and construction. The material is commonly available with compressive resistance values ranging from 316 to 2,678 pounds per square foot at 1 percent deformation (the conservative elastic limit stress). As long as combined dead/live loads are under this strain threshold, the material will not creep or experience plastic yield.

Because geofoam has a closed-cell structure, it does not readily absorb water, making it suitable for below-grade applications.

The material is durable and doesn’t require maintenance under normal conditions throughout its service life. The material is inert and highly stable — it will not decompose or produce undesirable gases or leachates. It is not affected by freeze-thaw cycles, moisture, or road salts so it is suitable for use in demanding environmental

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method, the project team from Hawkins Construction instead excavated the soil between the existing abutment wall and soldier piles. Workers then formed and extended the wall, using approximately 2,000 cubic yards of EPS geofoam as lightweight backfill for the bridge approach.

At the KBS Hospital in Dixon, Ill., Bill Brown Construction used geofoam to simplify construction of the building's foundation walls, creating a zero lateral load backfill using only four truckloads of geofoam in place of 50 truckloads of gravel. This saved hauling costs and greatly reduced construction traffic and truck staging.

2 — Soft soil remediation

Ground with soft soils or soft clay makes construction difficult. These soft surfaces are notoriously poor foundations for many projects, and can require extensive remediation. Instead of choosing costly (surcharging) and time-consuming remediation of soft soils, projects of all sizes can install EPS geofoam, which provides high load support while maintaining a low weight.

conditions.

EPS geofoam is recyclable, and project teams can order the material with recycled content. When a geofoam project has reached the project life span, the material can be reused in other projects, as is the case with reconstruction of Millennium Park in Chicago and Maggie Daley Park where approximately 1,100 cubic yards of geofoam will be reused.

In areas of high seismicity, engineers are recognizing the advantages of using geofoam verses traditional fills. For example, studies from the University of Utah have shown that for buried utilities such as natural gas pipelines, geofoam can be a compressible, protective cover during seismic events. Similar results have been observed in Japan.

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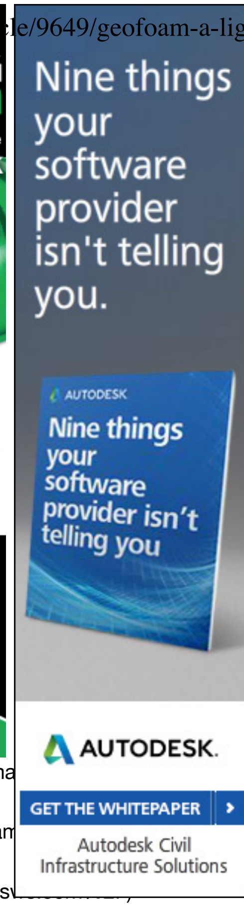

One such project was the renovation of the city hall in Renton, Wash. New handicap ramps were required to meet building codes. The building is surrounded by extremely soft soils, so the ramps needed a very lightweight foundation to avoid post-construction settlement. After evaluating various traditional fills, the city chose EPS geofoam. Merlino Construction installed 5,000 cubic yards of geofoam, which played a role in project completion two months ahead of schedule and nearly $600,000 under budget.

To enable a shallow over-excavation of high-organic-content soils, Walsh Construction used EPS geofoam blocks as fill to widen the I-80/I-65 interchange in Gary, Ind.

Another example was the widening of the I-80/I-65 interchange in Gary, Ind. The project site at the south end of Lake Michigan had soft glacial soils. The Federal Highway Administration (FHWA) recommended a net-zero load calculation of the roadbed to prevent post-construction settlement. To enable a shallow over-excavation of the high-organic-content soils, Walsh Construction used EPS geofoam blocks as fill.

In addition to providing a solid foundation for the roadway, geofoam use reduced construction truck traffic on congested roads. Transporting the geofoam required 32 flatbed truck loads, which was equivalent to more than 400 dump truck loads of traditional earthen fill. A six-member crew working four- to five-hour days was able to install 700 cubic yards of EPS geofoam in one week.

“There’s really no comparison to using traditional fill,” said Gary Walsh, Walsh Construction site supervisor. “There are no lifts needed. We just unloaded the blocks and it installed fast.”

The first levee application in North America was done in Suisun, Calif., by Steelhead Constructors of Palo Cedro. The project, owned by the California Department of Water Resources, had unacceptable settlements over the years resulting from the addition of traditional fill to restore the levee to its original grade. The inclusion of geofoam in 1999 enabled the project team to bring the levee to its desired grade without adding weight, and to complete the project in four weeks.

3 — Slope stabilization

EPS geofoam’s low weight makes it an excellent option for stabilizing steep slopes without the need to change the final slope geometry. Because the material is much lighter than other fills, it greatly reduces the weight of a slope’s driving block and lowers the risk of costly and dangerous slope failures.

Additionally, since slope stabilization generally happens on steep and uneven terrain, using EPS geofoam simplifies construction since crews can move and place it without heavy earthmoving and compaction equipment, greatly speeding up the construction schedule.

A short history of geofoam

Geofoam dates to the early 1930s when scientists developed a way to commercially manufacture polystyrene. A German company called I.G. Farben is often cited as the developer of polystyrene.

The world’s first known geotechnical application of EPS Geofoam was on a project in Norway in 1965 to prevent frost heaves from occurring on a large freeway. The first documented geotechnical project in North America was the installation of the Trans-Alaska Pipeline, where geofoam was used for both utility protection and insulation.

Decades later, the 14th Green at Coeur d’Alene Resort in Idaho took the product even further by using EPS fill to install a floating green in its lakeside golf course. Golfers tee off on solid ground and take a boat out to putt on the floating green.

In 2001, the first North American bridge approaches using EPS fill were constructed for the Buffalo Road Bridge in Warsaw, N.Y., and the I-15 project in Salt Lake City. The Salt Lake City job, still the largest documented geofoam project in the United States, used approximately 120,000 cubic yards of EPS geofoam.

In 2005, the building industry released ASTM D6817, Standard Specification for Rigid Cellular Polystyrene Geofoam.

In 2006, the Federal Highway Administration designated geofoam as a priority, market-ready technology, with a deployment goal that the material will be a routinely used lightweight-fill alternative on projects where construction timelines are a concern.

The first geofoam slope stabilization project in North America was designed by Yeh and Associates and completed in 1989, where a section of US 160 near Durango, Colo., had failed, causing a lane closure. Approximately 850 cubic yards of geofoam was used and installed in a short period of time, allowing the road to be reopened to traffic quickly.

Other examples of slope stabilization projects that used EPS geofoam for slope repair include U.S. 101 near Willets, Calif.; U.S. 50 near Montrose, Colo.; Window Rock Highway, Ariz.; and State Highway 12 near White Pass, Wash.

4 — Lateral and dead load reductions over buried utilities

Buried utilities frequently are not designed to have additional loads placed on them, so the utilities either have to be moved or upgraded at great expense to accommodate new construction. Instead, geofoam can be an ideal option to reduce dead and lateral loads on underground pipes, culverts, and tunnels, while at the same time providing high thermal insulation values that protect against temperature fluctuations. Geofoam also can protect utilities during seismic activity by reducing in-situ vertical/lateral stresses.

In Seattle's SR 519 project, Kiewit Construction used geofoam to protect existing utilities, some older than 100 years, by reducing the load placed on them. Poor soil conditions on the project site were partially due to the native soils that were placed in the area decades ago by the Denny Hill regrade, as well as an extremely high water table beneath the existing roadway.

The contractor used EPS geofoam as a structural void fill in concrete forming operations for water channel walls in the Fairfield-Suisun Sewer District, Calif., water treatment plant.

5 — Lightweight structural void fill

Given its low weight, EPS geofoam is also well suited as a structural void fill in concrete forming operations. Crews can easily fabricate virtually any shape or slope, and the material eliminates separate concrete pours for vertical wall sections and topping slabs. Applications include bridge column formwork, stadium seating in auditoriums and sports arenas, stairways, podiums, loading docks, and rooftop pool decks. EPS geofoam can be manufactured into custom-cut blocks in various shapes and sizes to enable contractors to quickly build up these and similar features.

A project example is construction of water channel walls in the Fairfield-Suisun Sewer District, Calif., water treatment plant. Typical construction of such walls involves two-sided forming; filling the void with soil, sand, or concrete slurry; and completing a second concrete pour for a topping slab. To simplify and speed the work, the contractor instead used 90 cubic yards of EPS geofoam. The geofoam blocks constituted half of the form, which simultaneously filled the void, plus easily bore the weight of the concrete topping slab. This enabled a monolithic pour of the channel tops and walls at the same time, which significantly reduced forming labor and material costs and accelerated the concrete pouring schedule.

In garden roofs, geofoam can provide elevation changes and at the same time provide a lightweight, water-resistant, supportive base for liners, soil, irrigation systems, and plants.

Design considerations

As with any construction material, there are design considerations that must be acknowledged where geofoam is used:

• Geofoam is subject to damage when exposed to certain hydrocarbon chemicals or solvents. Consider the presence of these items during construction. If needed, the geofoam can be blanketed with hydrocarbon-resistant geomembranes for protection.

• Geofoam is treated with a fire retardant to avoid the rapid spread of fire. However, EPS geofoam is combustible at high temperatures. Take care when working around geofoam with open flames or high-heat equipment such as welders.

• Geofoam exposed to sunlight for extended periods of time is susceptible to degradation from ultra-violet light, although the degradation does not tend to hinder the product's integrity. Instead, superficial discoloration generally occurs and can be removed by brooming it off or with very light pressure washing.

EPS geofoam's low weight makes it an excellent option for stabilizing steep slopes without the need to change the final slope geometry.

• Given the lightweight nature of geofoam blocks, take care when stockpiling the material on job sites where windy conditions exist. Weight or tie down block stockpiles, as necessary.

• If hydrostatic pressures are a potential concern, drainage around a geofoam assembly might be needed. At times, drainage blankets, pea gravel, or #57 stone is used.

Construction considerations

EPS geofoam changes the traditional soil compaction phasing method in which contractors mechanically compact soil to a percentage of dry density and pay for multiple samples and laboratory tests. Unlike other lightweight fills such as shredded tires or wood chips, EPS geofoam is homogenous, which provides uniform load transfer and eliminates differential settlement. Recent cost estimates of geofoam vary from $55 to $100 per cubic yard, depending on a project's required physical properties.

Although geofoam can be manufactured in many sizes and shapes, standard blocks are typically 4 feet wide by 8 feet long and of varying thickness. Once onsite, contractors can easily trim geofoam to the required dimensions using a hot wire cutter. Some contractors use a handsaw or a chainsaw.

When placing geofoam, the blocks are staggered so their joints are not located on the same vertical plane. At times, the blocks are interconnected with either barbed plates or polyurethane adhesive.

Due to the low density of geofoam, the blocks can be maneuvered by hand or placed with small mechanical equipment. Geofoam is typically placed on level ground with the first course sitting on sand, pea gravel, or any locally available permeable leveling course material.

Cost saving advantages

Using geofoam as an alternative to traditional soil fill or forms in construction has many benefits that lead to overall project cost savings. Benefits of using geofoam versus traditional fills include the following:

• Geofoam fill can be placed easily on projects with tight construction access where the use of larger mechanical equipment may not be feasible.

• Shotcrete, gunite, or soil can be placed directly against geofoam, eliminating the need for expensive forming.

• Construction traffic and import costs are minimized because one flatbed truck of geofoam is equal to approximately 12 dump truck loads of traditional fill.

• Project construction time is reduced because several feet thick of geofoam can be placed in a fraction of the time it takes to place and compact traditional soil fill in the required 8- to 12-inch lifts.

• Less settlement decreases maintenance costs.

• Tight construction scheduling can easily be maintained because crews can install geofoam during any type of weather or site conditions.

Nico Sutmoller is the geofoam specialist for Insulfoam (www.insulfoam.com), a division of Carlisle Construction Materials. He can be reached at nico@insulfoam.com.

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