By Scott Wehrmeyer

Geofoam: Providing new solutions to old challenges

Manitowoc, Wisc., is located on the western shore of Lake Michigan and, like many communities in close proximity to bodies of water, was confronted with a common design challenge with the expansion of their existing microfiltration plant. City planners and engineers had to design the new addition with the knowledge that its construction site was located in an area with poor load-bearing soils so common to the area. While more traditional remedies, such as deep pilings, were considered to support the new structure, their cost and construction time proved prohibitive. Thus, after some debate, the decision to use expanded polystyrene (EPS) geofoam was made, providing a timely and cost-effective solution to a common geotechnical challenge.

The building addition to Manitowoc's microfiltration plant is located directly on the shore of Lake Michigan. The overall project dimension was 100 ft. x 100 ft. (30.5 m x 30.5 m). It was comprised of a 50-ft. x 100-ft. (15.2-m x 30.5-m) structural foundation built into the slope of the lakeshore conjoined at its upper elevation with a 50-ft. x 100-ft. (15.2-m x 30.5-m) slab-on-grade pour. The structural foundation houses pumps and other heavy mechanical units, while the slab-on-grade pour provides additional floor space for administrative and operations personnel. Having previously established the indigenous soil's load-bearing capacity, engineers designed a foundation system that would work within the soil's limitations.

For the microfiltration plant project, engineers utilized EPS geofoam to achieve the weight reduction and weight distribution necessary to build on the site without deep pilings. The use of geofoam in the structural foundation and the slab-on-grade pour will be reviewed independently to present a simple and concise analysis of geofoam's problem-solving capabilities in each application.

Structural foundation

The eastern wall of the structural foundation (nearest the lake) is supported by a 9-ft. (2.7-m)-wide spread footing constructed on top of a 12-ft. (3.7-m)-wide by 30-in. (76.2-cm)-thick, 1.5 pcf geofoam fill. The north and south walls are supported by a 6-ft. (1.8-m)-wide spread footing constructed on top of an 8-ft., 6-in. (2.4-m, 15.2-cm)-wide, 1.5 pcf geofoam fill that reduces incrementally in thickness from 30 in. (76.2 cm) to 10 in. (25.4 cm) in the direction of the western wall. Column footings are constructed on top of 20-in. (50.8-cm)-thick, 2.0 pcf geofoam fills.

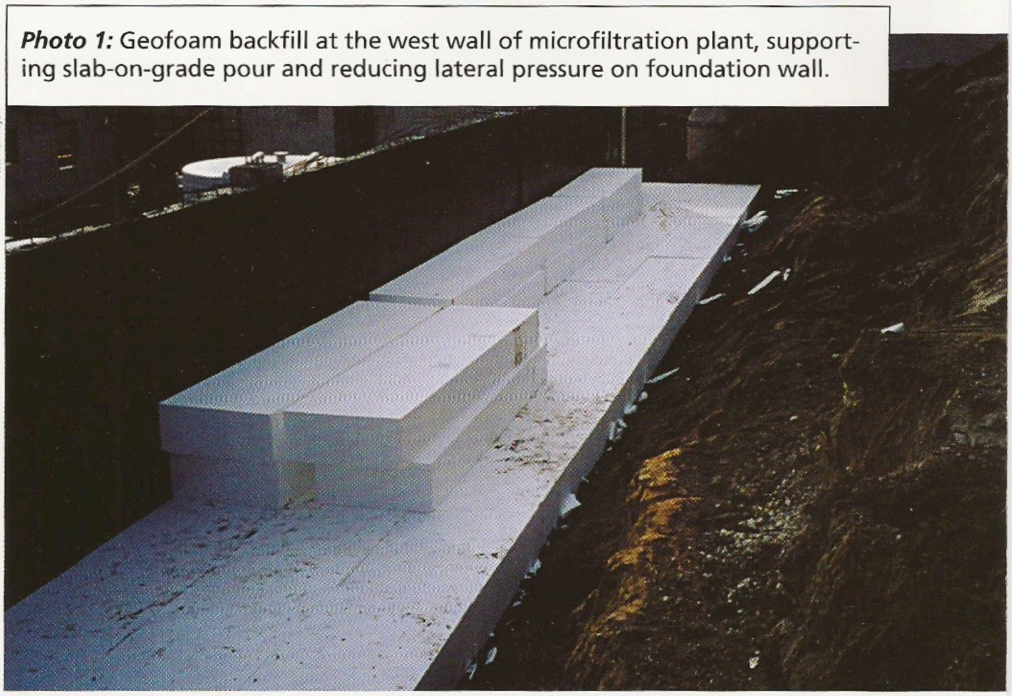
With a density that is only about 1% to 2% of the density of soil, rock or concrete, the EPS geofoam used on this project generated a considerable weight reduction relative to the excavation soils, which weighed in the neighborhood of 130 pcf. In its application as fill under structural footings, lightweight geofoam was able to reduce loads on the underlying soil by slightly more than 300 psf at 30-in. (76.2-cm) thickness, and slightly more than 200 psf at 20-in. (50.8-cm) thickness.

Having achieved significant weight reduction through geofoam substitution, project engineers turned their attention to the distribution of the structural load. Incorporating geofoam fills under the spread footings allowed for the structure's weight to be distributed over a larger area, further reducing the per-square-foot load that the underlying soil must support. Working together, the combination of weight reduction and weight distribution allowed engineers to eliminate deep pilings from their design, producing significant cost and time savings.

Slab-on-grade

The slab-on-grade pour ties into the upper elevation of the west wall of the structural foundation to create a 100-ft. x 100-ft. (30.5-m x 30.5-m) second story. While the soil conditions at this location were an improvement over those nearer the lake, there was still concern about settlement and the exertion of lateral forces against the foundation's west wall. To remedy these concerns, a 100-in. (254-cm)-thick, inverted step fill was specified. Constructed in 5 layers of 20-in. (50.8-cm)-thick geofoam blocks, the fill's first (bottom) layer is 12-ft. (3.7-m)-wide with subsequent layers extending outward from the wall in 3-ft. (0.9-m) increments. It should be noted that

Photo 1: **Geofoam backfill at the west wall of microfiltration plant, supporting slab-on-grade pour and reducing lateral pressure on foundation wall.**



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large inlet/outlet pipes, ranging in diameter from 18 in. (45.7 cm) to 30 in. (76.2 cm), were run through the geofoam fill without any special requirements.

Once again, geofoam's ultra-light weight enabled engineers to work within the soil's limitations without the use of costly and time-consuming piling systems. Additionally, geofoam substitution dramatically reduced lateral forces that might otherwise have negative consequences on the structural foundation's west wall.

Photo 2: The Manitowoc, Wisc., YMCA uses a footing design similar to the microfiltration plant; here, blocks are placed for spread footing and the elevator shaft.

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Since completing the microfiltration plant addition, the city of Manitowoc has used geofoam to provide cost-effective solutions on other construction projects, most notably the YMCA addition, where poor load-bearing soils presented settlement concerns. While undesirable soil conditions are a common driver for the use of geofoam, it is but one area where geofoam's unique mechanical properties have lent themselves to generating innovative solutions to common, and not so common, engineering challenges.

Possessing a decades-long history of success worldwide, geofoam is a relative newcomer to North America. But working alone or in conjunction with other geosynthetic products, geofoam is quickly gaining increased acceptance within the civil engineering community. With its unique problem-solving capabilities and an ever-increasing catalog of end-use applications, geofoam will inevitably play a more significant role in the design and construction practices of the future. GFR

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