

EPS GEOFOAM PROVIDES

Novel Infrastructure Solutions

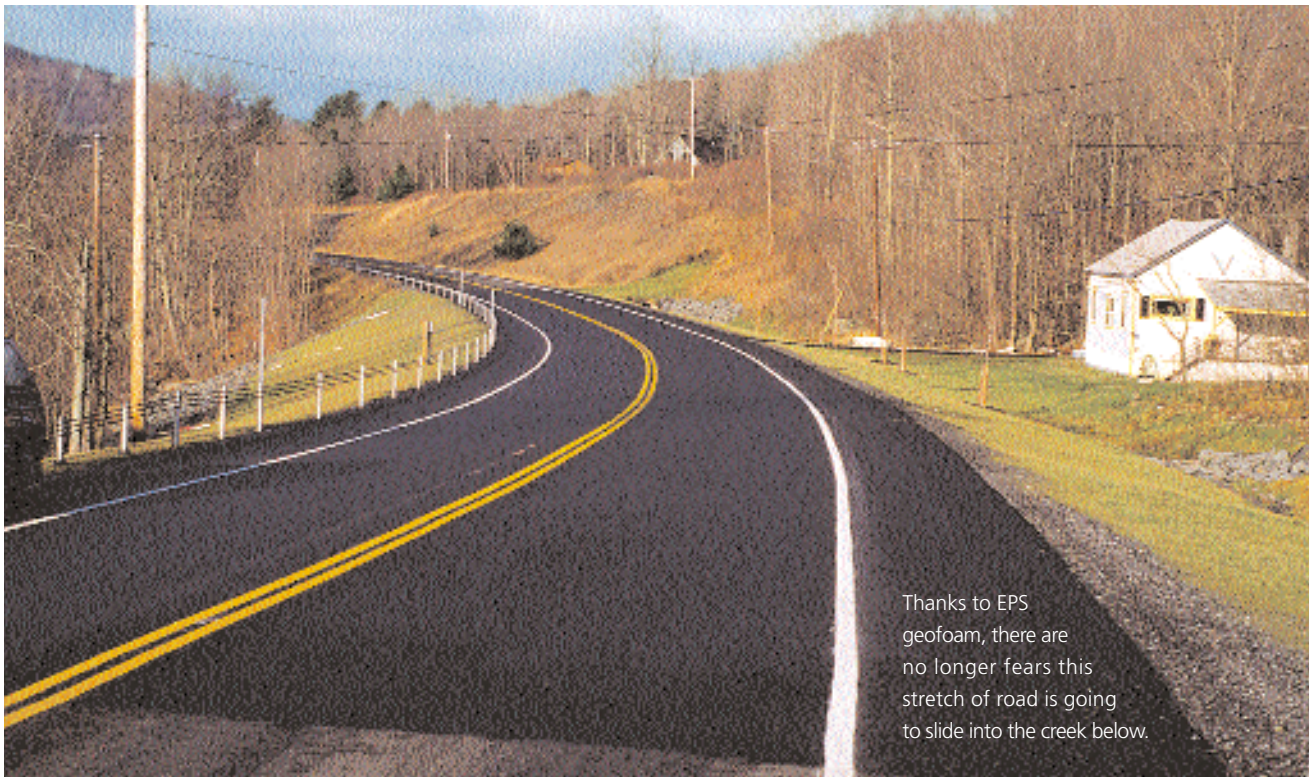


Photo D. Negusse

Thanks to EPS geofoam, there are no longer fears this stretch of road is going to slide into the creek below.

By Anthony Capkun

The use of expanded polystyrene (EPS) geofoam as a highway construction material recently celebrated its 30th anniversary, but despite the past three decades, the United States is only just beginning to tap into its potential. All that is about to change, however, as practitioners, owners, and engineers begin to learn about the advantages offered by this material.

Geofoam has an established track record worldwide as a cost-effective engineering solution for difficult embankment stability and foundation settlement applications. One highway construction project close to home employing geofoam is Salt Lake City, Utah's Interstate 15 project, which won the American Society of Civil Engineers (ASCE's) 2002 Outstanding Civil Engineering Achievement. In announcing the selection of I-15, the jury noted the project was completed in just four years (half the time required for traditional approaches) and came in \$32-million under budget. Jurors also noted the job's innovative use of materials, such as lightweight EPS geofoam in the embankments.

Another major U.S. highway project currently using geofoam as lightweight fill for road embankments is Boston's central artery/tunnel

The density of geofoam is a key index parameter for specification, estimating engineering properties, QA and performance correlation. Manufacturers commonly produce EPS geofoam at densities in the general range of 12 kg/m³ to 30 kg/m³ (0.7 pcf to 1.9 pcf) but any intermediate density can be specified and produced. The unit price and strength of geofoam increase with density, which forms part of the product label. For example, EPS19 designates EPS geofoam of 19 kg/m³ (1.2 pcf) density.

project known as ‘The Big Dig.’ EPS geofoam is used for nine permanent embankment fill applications in the I-90/I-93 interchange complex, just south of South Station.

Across the Atlantic, a 250,000 m³ (about 325,000 cy) of geofoam were used in 120 projects in Norway between 1971 and 1991—mostly for road embankments, bridge approach fill, and retaining wall backfill. Performance records and durability evaluations of samples exhumed after years in service show roads and embankments constructed using geofoam continue to do their jobs with lower-than-conventional construction maintenance.

On the other side of the globe, over 1 million m³ (1.35 million cy) of geofoam were used in 1665 projects between 1985 and 1995 in Japan. In 1995, the material was used in 400 projects, the majority of which involved embankments with about five percent used for retaining walls.

Although slow to get off the ground in this country, statistics like these from around the world and our own backyards are beginning to accumulate and persuade decision-makers. One thing sure to give geofoam a boost in the United States is the recently published ASTM International D 6817, *Standard Specification for Rigid Cellular Polystyrene Geofoam*, which represents a useful reference for material properties.

“Our neighbors to the north in Canada have been using geofoam since the early 1980s, and their provinces have developed their own specifications,” adds Andre St. Michel of BASF Corp., one of the EPS resin suppliers.

Coupled with proven performance in industrialized nations around the globe, like Norway, Canada and Japan, geofoam’s explosion in the United States is at hand.

“Block molders in the United States are poised to make inroads in this application of EPS,” says Jim Whalen, technical marketing manager for Plasti-Fab Ltd. and chair of the Technical Committee for the EPS Molders Association (EPSMA).

Getting to know geofoam

EPS geofoam describes low-density cellular plastic foam solids used in geotechnical applications. The material has been used in road and

airfield pavements and railway track systems, beneath refrigerated storage buildings, sports arenas and storage tanks to prevent ground freezing and heaving, and in below-ground building segments to reduce seasonal heating and cooling requirements. It can be produced with higher densities to obtain the higher R-values preferred for insulation purposes, as well as to achieve lower deformation.

Expanded polystyrene is typically produced in blocks that can be cut into various shapes and sizes—and a range of densities—to suit specific project needs.

EPS geofoam density—only about one to two percent that of soil and rock—is controlled during the manufacturing process, making it a superior, ultra-lightweight fill material that significantly reduces the stress on underlying subgrades. The lighter load can reduce settlements and can improve stability against bearing and slope failures.

Geotechnical geofoam applications

Road embankments

Geotechnical engineers have long recognized the usefulness of lightweight fill for load compensation. Traditional lightweight materials used in embankment construction include chipped bark, sawdust, dried peat, fly ash, slag, cinders, cellular concrete, shredded tires, and seashells. A major advantage to using geofoam as fill material in embankments is that it can be up to 50 times less massive than other lightweight fills, and can provide the following advantages for transportation infrastructure development:

- maximizing available right-of-way,
- accelerating the construction schedule,
- promoting clean construction adjacent to waterways,
- reducing construction labor, and
- enabling winter construction.

Retaining wall or abutment backfill

Placing geofoam behind retaining structures and below-grade walls can reduce lateral pressure, lower settlements, improve waterproofing,

Resources

EPS Molders Association

www.epsmolders.org/3-geofoam.html

Geofoam Research Center

College of Engineering and Computer Science
Syracuse University
geofoam.syr.edu/GRC_rt23a.asp

Jutkofsky, W., Sung, T. and Negussey, D., “Stabilization of an Embankment Slope with Geofoam,”

Transportation Research Record, No. 1736, Transportation Research Board, Washington, D.C., 2000.

Negussey, Dawit, “Properties and Applications of Geofoam.” Society of the Plastics Industry, 1997.

Negussey, Dawit, “Slope Stabilization with Geofoam.” Geofoam Research Center, Syracuse, NY: 2002.

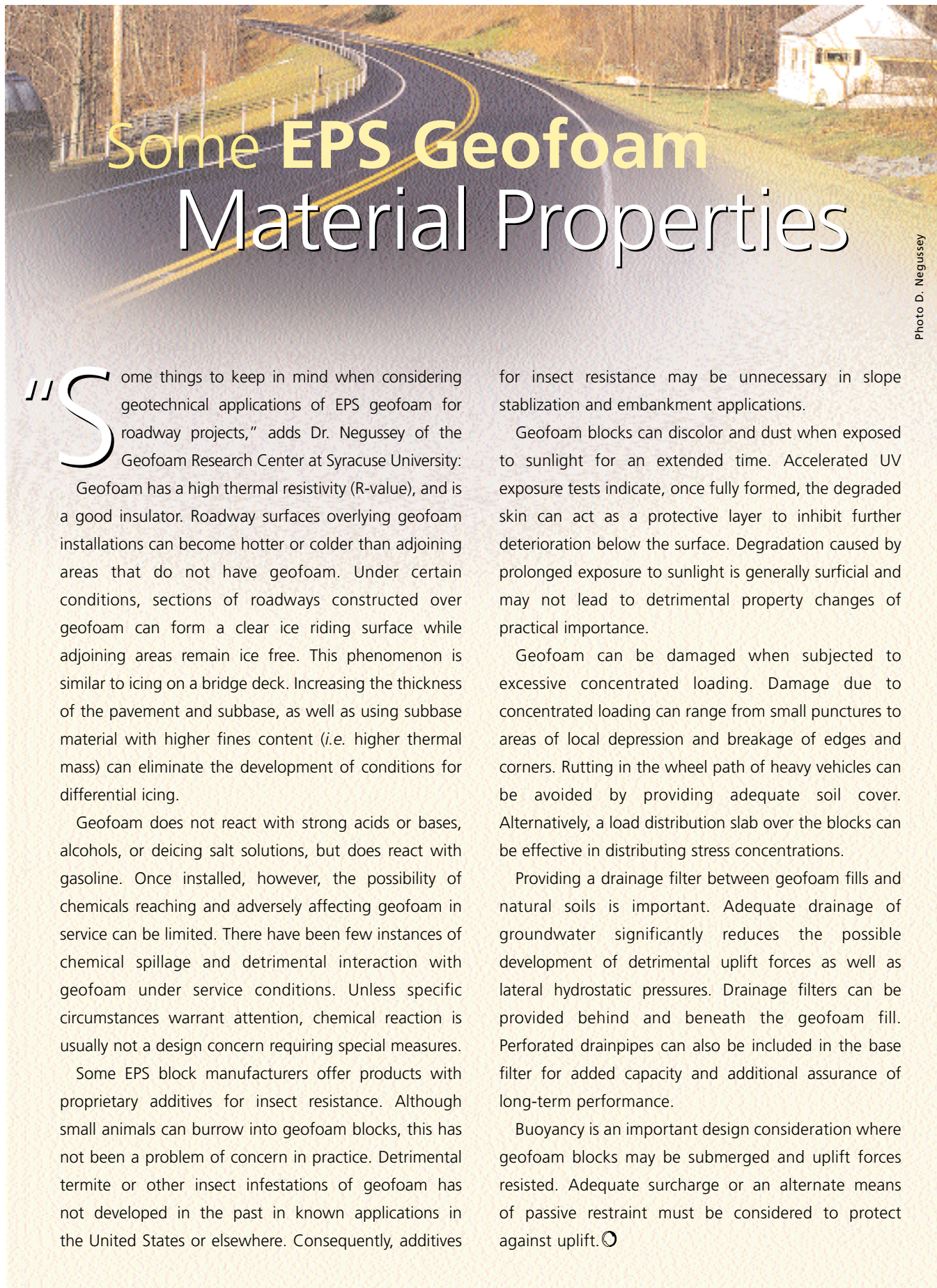


Photo D. Negussey

"Some things to keep in mind when considering geotechnical applications of EPS geof foam for roadway projects," adds Dr. Negussey of the Geof foam Research Center at Syracuse University:

Geofoam has a high thermal resistivity (R-value), and is a good insulator. Roadway surfaces overlying geof foam installations can become hotter or colder than adjoining areas that do not have geof foam. Under certain conditions, sections of roadways constructed over geof foam can form a clear ice riding surface while adjoining areas remain ice free. This phenomenon is similar to icing on a bridge deck. Increasing the thickness of the pavement and subbase, as well as using subbase material with higher fines content (*i.e.* higher thermal mass) can eliminate the development of conditions for differential icing.

Geofoam does not react with strong acids or bases, alcohols, or deicing salt solutions, but does react with gasoline. Once installed, however, the possibility of chemicals reaching and adversely affecting geof foam in service can be limited. There have been few instances of chemical spillage and detrimental interaction with geof foam under service conditions. Unless specific circumstances warrant attention, chemical reaction is usually not a design concern requiring special measures.

Some EPS block manufacturers offer products with proprietary additives for insect resistance. Although small animals can burrow into geof foam blocks, this has not been a problem of concern in practice. Detrimental termite or other insect infestations of geof foam has not developed in the past in known applications in the United States or elsewhere. Consequently, additives

for insect resistance may be unnecessary in slope stabilization and embankment applications.

Geofoam blocks can discolor and dust when exposed to sunlight for an extended time. Accelerated UV exposure tests indicate, once fully formed, the degraded skin can act as a protective layer to inhibit further deterioration below the surface. Degradation caused by prolonged exposure to sunlight is generally surficial and may not lead to detrimental property changes of practical importance.

Geofoam can be damaged when subjected to excessive concentrated loading. Damage due to concentrated loading can range from small punctures to areas of local depression and breakage of edges and corners. Rutting in the wheel path of heavy vehicles can be avoided by providing adequate soil cover. Alternatively, a load distribution slab over the blocks can be effective in distributing stress concentrations.

Providing a drainage filter between geof foam fills and natural soils is important. Adequate drainage of groundwater significantly reduces the possible development of detrimental uplift forces as well as lateral hydrostatic pressures. Drainage filters can be provided behind and beneath the geof foam fill. Perforated drainpipes can also be included in the base filter for added capacity and additional assurance of long-term performance.

Buoyancy is an important design consideration where geof foam blocks may be submerged and uplift forces resisted. Adequate surcharge or an alternate means of passive restraint must be considered to protect against uplift. ☉

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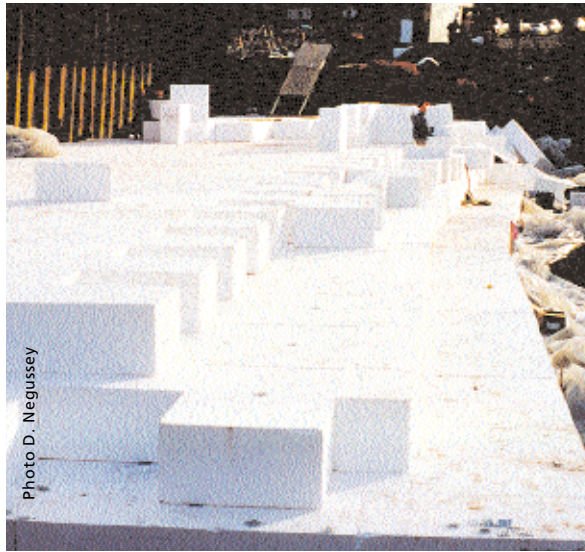


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In the Schoharie Creek project, EPS geofoam blocks arrived on-site on flatbed trailers, and it took about one hour for six workers to unload and install one trailer load of blocks. Workers walked directly on the unprotected blocks, which were installed in layers.

and provides better insulation. The low density and relatively high compressibility of geofoam also can limit horizontal forces against retaining structures during earthquakes.

Pavement insulation

EPS geofoam has been used for highway and airport pavement subgrade insulation to reduce maintenance and improve performance in areas prone to severe frost action.

Slope stabilization in the Catskills

EPS geofoam's low density and other material properties came to the rescue of a slope stabilization project on Route 23A in New York State alongside Schoharie Creek in the Catskills.

Dr. Dawit Negusse, director of the Geofoam Research Center in Syracuse University, describes in detail a key application of geofoam in this Route 23A project:

In May of 1995, New York State Department of Transportation (NYS DOT) initiated an embankment stabilization project incorporating geofoam blocks along a section of Route 23A between Jewett and the Town of Hunter in Greene County. The reconstructed section of 23A runs parallel to the creek—a fast-rising, Class 1 trout streambed.

Decades-old reconstruction brings problems into the present

In 1966, the Department of Public Works reconstructed a stretch of Route 23A (Jutkofsky, et al, 2000). The centerline of a gully crossing was shifted about 3 meters (10 feet) toward the creek and was raised by up to 1.5 m (5 ft). The realignment provided, superelevation, increased shoulder width, improved line-of-site, and a higher travel speed. Shortly after construction, however, a 91-m (300-ft) long section of the roadway embankment began to slide slowly toward the creek. Frequent pavement patching was required to seal surface cracks that developed along the roadway.

Slope instability can occur along natural slopes as well as embankments. Major factors that affect stability include; slope geometry, soil properties, ground motion, and surface and groundwater conditions. The rate of slope movement can vary depending on the creep stage and prevailing conditions.

“In 1978, a subsurface exploration program consisting of cased borings with continuous sampling was conducted to determine the soil stratigraphy and observe groundwater levels over time,” explains Negusse. Monitoring the slow movement of the embankment started in 1979.

Data collected over the next 14 years indicated an annual rate of movement of about 15 mm (0.6 in.) per year, and a total movement toward the creek of about 200 mm (8 in.). The zone of movement was detected at 9 m (30 ft) below surface and at an elevation of about 429 m (1407 ft).

Geofoam gets the nod

“Different alternatives were considered to stabilize the slope. Whatever the solution, it had to address a number of concerns or limitations,” says Negusse, adding the creek can be very aggressive, and the 100-year flood stage was about 5 m (16 ft) above normal levels. The creek flow is protected, as is the watershed. Placing a counter berm at the toe would be risky and potentially undesirable. The groundwater lowering approach (lateral drains) was already found ineffective because of the low hydraulic conductivity of the soils.

The potential Route 23A slope failure was identified as deep-seated and approximately circular, meaning any option relying on retention walls or resistance by shear/tension elements was unrealistic. While viable, flattening the slope or reducing the grade meant a return to pre-1966 conditions, which required improvement in the first place. The horizontal curve of the roadway alignment through a valley and at a reach of the creek channel made relocation impractical.

“As the problem became more pressing and the success of conventional alternatives less certain, a new approach of slope stabilization with EPS geofoam became attractive,” says Negusse. Specifically, the soil within the upper portion of the embankment was to be replaced with EPS foam blocks. “In very simple terms, this solution would replace wet heavy soil with super lightweight geofoam of negligible mass at upper elevations. The substitution was to significantly reduce the driving weight upon the deep-seated zone experiencing movement, thereby improving the factor of safety.”

Details of construction

The existing embankment was excavated along the downslope side of a sheet pile wall to a depth of approximately 5 m (16 ft). During excavation, the top of the sheet pile wall moved about 0.5 m (2 ft) toward the creek and groundwater was visible in the opening where the sheet pile wall separated from the soil on the upslope side. Holes were drilled through the sheet piling near the bottom of the excavation to relieve the water pressure.

At the required excavation grade, about 0.5 m (2 feet) of crushed stone was placed on the subgrade and roughly graded to design elevation with a bulldozer. The stone extended from the face of the sheet pile wall to the downslope face of the embankment. A 150-mm (6 in.) perforated drainage pipe was installed within the crushed stone, as a longitudinally collector along the sheet pile wall with laterals perpendicular to the wall and extending to the face of the embankment. The crushed stone surface was fine-graded to a specified tolerance of ± 0.5 percent using hand rakes.

EPS geofoam blocks arrived on-site on flatbed trailers. On average, it took about one hour for six workers to unload and install one trailer load of blocks. For quality control purposes, some blocks were randomly selected from each shipment to be measured and weighed. This way, block density was determined and compared to the specified value.

Workers walked directly on the unprotected blocks, which were installed in layers with each layer oriented at 90 degrees from the underlying layer to promote interlock. Although galvanized steel binder plates were used between block layers, subsequent research has established binder plates can be unnecessary.

As additional block layers were placed, crushed stone drainage material was placed between the geofoam fill and the sheet pile wall. The crushed stone behind the geofoam fill served to intercept and lower the groundwater by discharging through the crushed stone drainage blanket and drain pipe below the geofoam fill. Plywood was used to protect the geofoam surface from construction traffic. Small motorized wheelbarrow with wide tires was used to place the crushed stone without inducing large contact stresses on the geofoam surface.

EPS geofoam was cut from full-sized blocks and used as forming for a 100-mm (4 in.) concrete slab. Binder plates were used to secure the side forms. Wire mesh was placed and workers rough screeded the concrete as a final finish. The geofoam forms were then removed and reused elsewhere. Insulating blankets were placed over the slab while curing in the cold weather. The side slope of the geofoam fill was backfilled with soil cover up to the level of the slab as the concrete was curing.

Between 0.6 m to 1.2 m (2 ft to 4 ft) of graded, crushed-stone subbase was placed above the slab. The sheet piling was removed using a vibratory hammer and additional crushed stone drainage material was placed into the void between the EPS geofoam fill and the retained slope, as the sheet piles were extracted.

“The construction of a 225-mm (9-in.) thick asphalt pavement and installation of guardrails heralded the end of the project in

1996,” says Negussey, adding, “Approximately 2800 m³ (3700 cy) of geofoam was used for the Route 23A slope stabilization project, resulting in a net reduction in driving weight of approximately 500 kN/m of slope (33 kips/ft).”

After some 30 years of geofoam experience in diverse service conditions, there are virtually no reported cases of detrimental degradation or damage over time.

Lessons from Schoharie

“Late fall and winter construction became feasible mainly because geofoam installation does not require fill placement and compaction in thin lifts,” explains Negussey. The blocks were placed

manually on arrival without having to stockpile them elsewhere on-site. The quality assurance (QA) process involved weighing and inspecting randomly selected whole geofoam blocks upon unloading. “The result was a reduced need for construction equipment, staging area and no loss of material from testing,” says Negussey.

“Since final paving and completion of the project in April 1996, observation of sensors installed during construction indicate deep-seated movements in the Route 23A embankment have ceased,” adds Negussey.

“EPS geofoam successfully stabilized a difficult slope in an environmentally sensitive area of New York State. Construction was completed rapidly and, occurred mostly during the winter season,” says Negussey. “The construction material, rate, and time of construction were all uncommon, but because of the conditions and limitations at Route 23A, there was no simpler, more effective remedy than EPS geofoam. ☉

*Did You Know?*

Spray plastic foam sealants applied on-site expand to fill energy-wasting, air-infiltrating gaps around electrical outlets and plumbing pipes.



Vinyl siding is significantly lighter than some other materials, like brick or fiber cement, saving fuel during transportation to job sites.