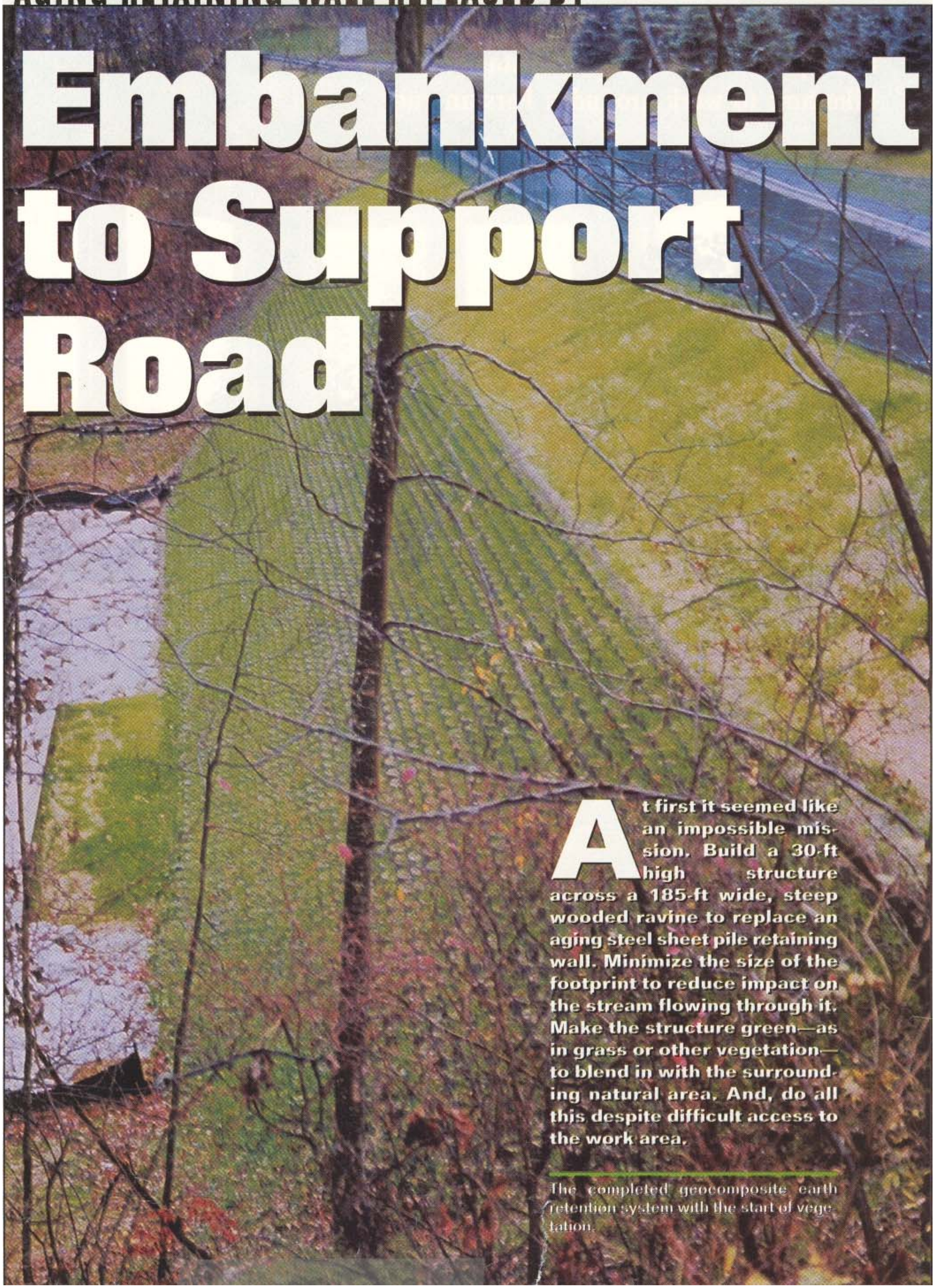
AGING RETAINING WALL REPLACED BY

Embankment to Support Road



At first it seemed like an impossible mission. Build a 30-ft high structure across a 185-ft wide, steep wooded ravine to replace an aging steel sheet pile retaining wall. Minimize the size of the footprint to reduce impact on the stream flowing through it. Make the structure green—as in grass or other vegetation—to blend in with the surrounding natural area. And, do all this despite difficult access to the work area.

The completed geocomposite earth retention system with the start of vegetation.

Those were among the challenges officials of Bayside, Wisconsin, presented to Bonestroo, Rosene, Anderlik & Associates, a Mequon, Wisconsin-based engineering firm. The project involved an embankment that supports Broadmoor Road and the Union Pacific Railroad where they cross Fish Creek in this upscale suburb north of Milwaukee. Periodic inclinometer readings and cracks in the paved road and curb revealed that the soil behind the rusting sheet pile wall, long considered an eyesore, was moving. The sheet pile, wales, and tie rods had deteriorated to the point where repair was uneconomical.

"The fully exposed metal wall, which was retaining the fill that carries the road, was suffering from the effects of years of weathering and nearing the end of its serviceable life," said lead Project Engineer Mustafa Emir.

The village wanted another way to stabilize the embankment.

A DIFFERENT WAY

The engineers responded with an unconventional solution - a geocell-faced reinforced earth embankment- the largest structure of its kind built in Wisconsin to date. It not only met all the challenges successfully, but was easier and faster to build and cost much less than some alternative approaches, including traditional practices.

Using geogrids and granular soil or aggregate, an earth embankment could be built as steep as 0.75H:1V to produce a much smaller footprint than an earth embankment. A face of modular concrete blocks would protect against erosion but offered no way to vegetate the structure. So, the engineers selected the three-dimensional Geoweb® cellular confinement system (Presto Products Company, Appleton, Wisconsin) for the wall's facia.

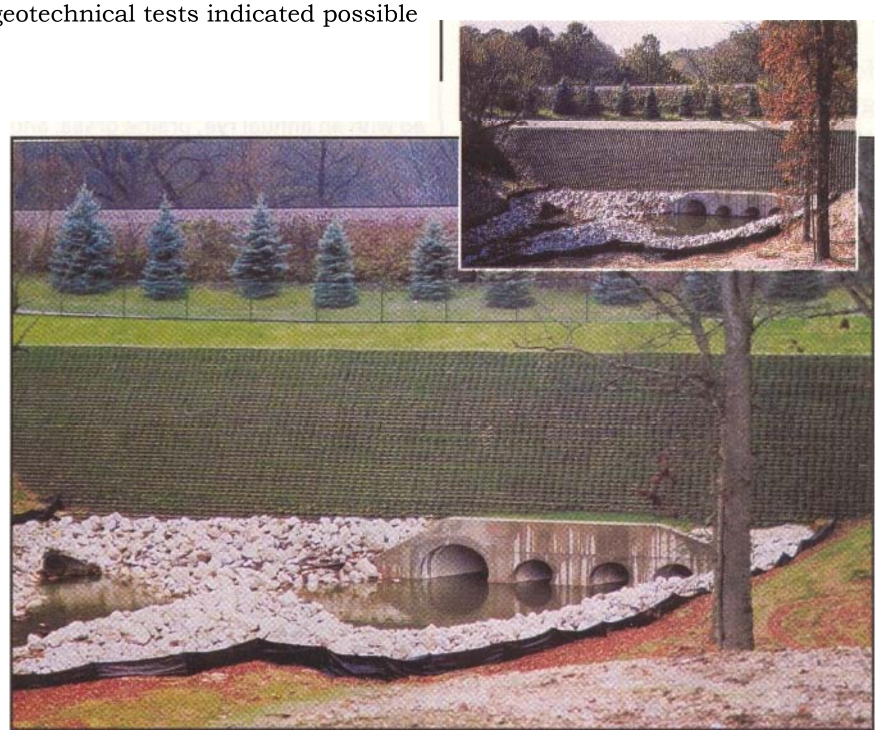
This engineered, polyethylene, honeycomb-like material improves the performance of various infill materials and allows vegetation to grow on the face of the wall. The light-weight sections measure six or eight in. deep and about 8-1/2 ft wide. Once on site, these sections are expanded to about 2-1/2 ft long, placed horizontally, and held open using pins in a stretcher frame until filled. After being attached together using a pneumatic staple gun, they are filled and compacted one course at a time.

"It provided the most cost effective solution while minimizing the fill area in Fish Creek, "reports Emir. "We wanted something we could build relatively quickly and inexpensively. It achieved all our goals."

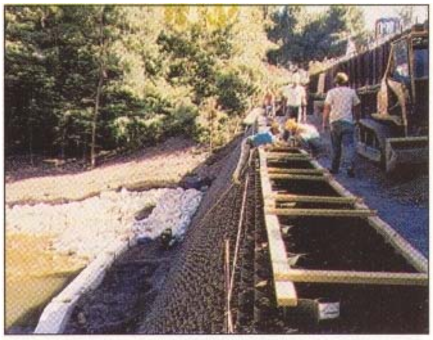
"By confining the infill, the cells increase the shear strength and stiff-ness of the compacted infill," notes Scott Bordeau, formerly with Geo-Synthetics, Inc., which supplied the cellular confinement system for the project. "By allowing the non-cohesive infill material to reach its full compressive strength it results in a very efficient soil matrix." The high frictional resistance between infilled layers creates a stable, composite structure that behaves as a monolithic gravity mass, which can flex to conform to differential settling. This flexibility was important on this project, since geotechnical tests indicated possible settling once the wall was built.

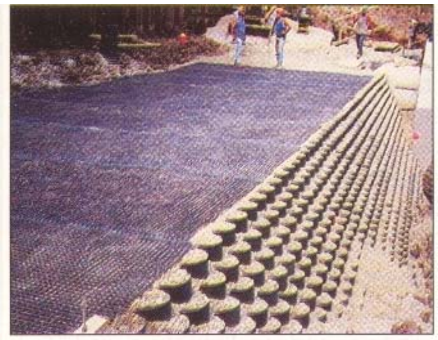
Top: The first layers of the 150-ft wide geocell-faced reinforced earth embankment are constructed to cover an aging sheet pile system.
Below: On the upper wall layers, infill was dropped 10 to 12 ft from the road above by a front-end loader.

The project featured the use of Geoweb GW30V with green, non-perforated facia panels and 6-in. deep cells. Each section measures eight cells from side to side and three cells front



Right: The completed geocomposite earth retention system with the start of vegetation.
Inset: After completing the 30-ft wall height, the base of the wall below the waterline was armored with 24-in. diameter rock riprap as protection from high water currents.





Left: A stretcher-frame is used to keep the Geoweb wall sections open during the infilling process. Center:The facia is checked for proper elevation, and section alignment and setback before positioning subsequent layers. Right: Biaxial geogrid reinforcement layers are laid between the cellular layers in two-ft lifts or every fourth course.

to back with perforated interior cells. "These perforations improve drainage and increase friction between the cells and the aggregate infill," explains Bordeau. "Strata 400 biaxial geogrid, sandwiched between the cellular layers in two-ft lifts (every fourth course), reinforced the earth embankment, which was made of a self-draining blend of sand and small gravel.. This type of wall remains structurally stable under its own weight and known externally-imposed loads."

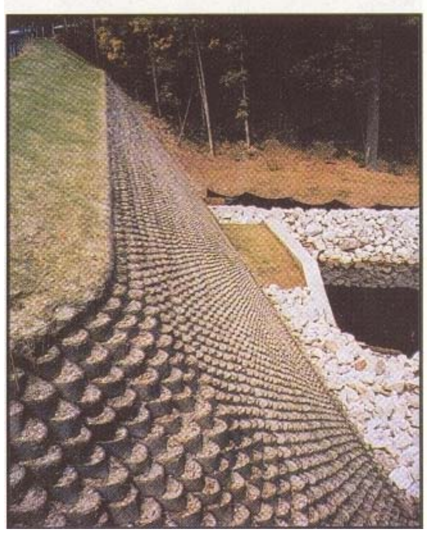
The trapezoidal wedge-shaped structure, which included an enlarged four-pipe culvert to increase storm water flow capacity, measured 65 ft wide at the base and 185 ft wide at the top with a 4,100-sq ft face. The base extended 19 ft in front of the existing sheet pile wall.

This was the first geocell-faced reinforced earth structure for the project's geotechnical subconsultant, Wisconsin Testing Laboratories, Menomonee Falls. Consequently, geotechnical engineer Jeff Smith researched this approach before conducting the subsurface investigation and producing the geotechnical design for the structure. Smith found weak, compressible fill from previous construction that had to be removed. He specified the clean, washed fill material-a mixture of 1/4- to 3/4-in. diameter gravel-and geogrid rein-forcement. "The distance available for embedding the geogrid was limited because the face of the reinforced earth embankment was close to the existing sheet pile wall," Smith says. "So, we increased the number of geogrid layers. We also adjusted geometry of the reinforced earth wall to match the natural embankments on either side."

Subcontractor Cedarburg Landscape (Mequon, Wisconsin) was selected to build the wall, based on the company's experience building modular block retaining walls. "Geo-Synthetics and Presto provided extensive technical assistance in preparing for the project and during construction," says Scott Devereux, president of Cedarburg Landscape. "The biggest challenge was gaining access to the work area."

A guardrail and chain link fence limited access from above the sheet pile wall. To transport material to the bottom, Super Excavators built a road on one side of the ravine. A temporary plank bridge and timbers allowed a track hoe and crews to cross the stream to excavate and bring in construction materials. A flashy stream, which sometimes rose 15 ft following a rainstorm, also hampered initial construction.

The completed wall system is hydroseeded with an annual rye, prairie grass, and flower mixture suitable for blending with the natural wooded ravine setting.



Super Excavators, responsible for the fill materials and backfilling the wall, excavated through existing fill and topsoil down to native hard clay four ft below the waterline for the base of the structure. Then, a granular base material was placed and compacted to 95 percent of Standard Proctor Dry Density to prepare for the first layer of the cellular confinement system. Cedarburg built stretcher frames of two by fours and threaded rods to hold the cells open for infilling. Eight sections were installed at a time, stapled together and aligned with a laser tool. Each subsequent layer was set back about 4-1/2 in. to produce a 0.75H: IV wall face batter.

All Geoweb sections from the bottom of the wall to the top of the culvert (the high-water line) were filled with the specified sand and gravel mixture and compacted to 95 percent density using a walk-behind plate compactor. Next, a geotextile was laid over the wall face to prevent the potential loss of infill from the exposed cells due to water currents.

Using a compact bucket-equipped track loader and rakes, the Cedarburg crew spread and filled all but the outer row of cells with the specified granular material on the wall layers above the high-water line. The outer exposed rows of cells were partially infilled and capped with three in. of topsoil to support vegetative growth. The topsoil was stockpiled on a side of the ravine and

The flexibility of this cellular confinement system was important on this project, since geotechnical tests indicated possible settling once the wall was built.

hand-carried in five-gallon pails to fill the outer cells. Once the wall was completed, the portion below the waterline was armored with 24-in. rock riprap.

Devereux supervised the five-man crew that installed the cellular confinement system. That part of the pro ject, which began in late August, was completed a month later. Previous experience building modular concrete block retaining walls was a big help, he says. Still, it took him and his crew a few days to get comfortable with construction procedures.

Devereux says, "It's important to build the stretcher frame very accurately. Once we worked out the bugs, things went real smooth. The system was very simple to install and we were able to build five 150-ft long courses in a typical day."

During construction of the lower part of the wall, a trackhoe and clamshell bucket were used to place the infill for spreading. However, about halfway up, the only way to do that was to dump the material from the road above, a drop of some 10 to 12 ft, using a front-end loader. To prevent the geogrid from shifting under the impact, it was pinned well and weighted with stone.

The easy-to-handle cellular confinement system sections paid off in several ways, Devereux notes.

"Carrying the individual sections up the steep slope of the ravine was a lot easier than lugging 100-lb concrete blocks by hand," he says, "especially in 80° and 90°weather. We were also able to use a smaller crew and build more wall in a day than with a modular block system and the guys weren't burnt out when they went home at night."

Once the final course was completed, the earthen wall was topped with clay fill that was shaped to a 2:1 slope. This slope and the wall itself were hydroseeded with an annual rye cover crop and a permanent mixture of native prairie grasses and flowers. One man, secured in a safety harness, did the job using a hose as he walked up and down the wall.

The result pleased all those involved in the project-the engineers, village officials, and the contractors. "Before the end of fall, the vegetation had taken hold and the wall looked really great," Emir says. "It was very reassuring to see the project come together so well, despite the fact that this was the first time any of us had worked with a cellular confinement system."

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