

DESIGNER'S FORUM

Using geotextiles in final covers over lagoons

By Gregory N. Richardson

This month, we'll review how the "roads-over-swamps" design method presented in the May column can be used to construct environmental final covers over the soft wastes commonly found in industrial lagoons. This application had its genesis in the many corrective actions that began with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980. On these jobs, the key to successful design is a good understanding of how the sludge's strength at the moment of construction influences the project's design and practical construction requirements.

To illustrate this application's general methodology, we'll review the design I did for three lime-sludge lagoons at the U.S. Department of Energy's (DOE) Gaseous Diffusion Plant in Piketon, Ohio. The shear strength of these "sludges" ranged from 200 to 500 psf. These are not the weakest sludges that have been covered—you can check out papers by Paulson (1989) and Guglielmetti et al. (1995) for excellent dis-

cussions of similar construction on soils an order of magnitude weaker. I also must add that I cannot do such designs without thinking of the late Allan Haliburton and his pioneering work related to embankments on very soft soils.

Project background

The 18 acres of lime-sludge lagoons (consisting of three cells) had collected waste lime from a water-treatment facility at the Gaseous Diffusion Plant from 1954 to 1960. For a short period from 1956 to 1957, chromium-laden sludge from cooling water used in a uranium-enrichment process also was disposed of in the lagoons. **Photo 1** shows an aerial shot of the sludge lagoons before contractors removed nearly 85 million gallons of ponded surface water.

The chromium had been added to the cooling water as a corrosion inhibitor but resulted in the lime sludges being treated as hazardous wastes under the Resource Conservation and Recovery Act (RCRA).

The lime sludge's high pH (7.42 to 9.06) and the chromium's relative immobility were not affecting ground water, but the chromium was directly accessible for uptake by plants and animals. It was necessary, therefore, to place a final cover over the lime sludges that would eliminate this pathway for contamination uptake. Uncharacteristically, it was not essential for the final cover to limit surface water infiltration, since ground-water quality was not an issue. In fact, the Ohio Environmental Protection Agency (EPA) actually preferred a cover that would have a surface depression so it would pond and eventually form wetlands.

Law Engineering, Atlanta, used a dilatometer to evaluate the lime sludges' shear strength at depths greater than 2 ft. Although deeper sludges have shear strengths ranging from 200 to 500 psf, the upper 2 to 3 ft of sludge at the time of testing was too weak to be measured with a dilatometer. To perform the testing, the engineers had to access the freshly drained sludge by laying



Photo 1. The sludge lagoons at the U.S. Department of Energy's Gaseous Diffusion Plant, before contractors removed nearly 85 million gallons of ponded surface water.

U.S. DEPARTMENT OF ENERGY, PIKETON, OHIO

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DESIGNER'S FORUM

sheets of plywood on the lime sludge. The depth to refusal of the manually advanced dilatometer was 7 to 11 ft.

Similar in-situ tests have been performed at other sludge lagoons using vane tests (ASTM D 2573). Such methods are needed because the sludges are too soft to allow sampling and laboratory testing. On this project, the surface of the lime sludges dried significantly during the summer when the lagoons were de-watered, making access relatively easy over this crust. The crust, however, quickly disappeared after the first ponding of rain.

How to design geotextile stabilization

During design, the proposed final cover for the lagoons had a thickness ranging from 2 to 6 ft., based on establishing a minimum 1/2-percent slope. I was contracted to provide the geotextile design to Foster Wheeler Environmental Corp., Oakridge, Tenn.—who was working under contract to the facility manager Lockheed Martin Energy Systems Inc., also based in Oakridge, Tenn. Under my contract, I had to evaluate the strength of the geotextile required (recognizing that any desiccated surface crust would not be present over the long term), provide guidance for placing fill over the geotextile, and review seaming efficiency requirements. (It interested me that many geotextile and geogrid manufacturers proposed free services to Foster Wheeler as part of their hoped-for materials supply contracts.)

My geotextile design examined two possible modes of stabilization failure: localized bearing capacity at the interface of the cover soil and the sludge (discussed in the May column), and the global-stabilization or deep-failure mode. The localized bearing-capacity design simply required that the vertical stress at the sludge interface (caused by both soil cover and equipment stresses) be less than approximately five times the sub-grade's cohesive strength. For typical low-ground contact-pressure equipment (contact stress 0.6 psi) and an assumed sludge shear strength of 100 psf, this required a minimum 12 in. of cover between the dozer and the geotextile, for a factor of safety of 1.0. I recommended a minimum 18 in. of cover for a factor of safety of 1.6. A similar calculation showed that a minimum 36 in. of cover was required for the dump trucks that would bring the cover soil. **Figure 1** shows the simple model used in these two evaluations.

If the shear strength of the lime sludge would reliably increase with depth, as oc-

curs in typical roadway-stabilization applications, we could stop here and simply specify a geotextile that meets the American Association of State Highway and Transportation Officials (AASHTO) M288-96 Class 1 survivability requirements. In this case, however, the lime sludge was known to be weak at depth in many locations within the lagoons. This allowed the possibility of a deep bearing capacity failure and required further evaluation of the required geotextile strength.

Figure 2 shows a STABL5 analysis of cover soil placement using a small dozer and neglecting the geotextile. STABL5 provides a listing of the driving and resisting forces for the critical circles so a geotextile can readily be incorporated (Figure 3). Note that STABL6 allows the inclusion of reinforcing material. Oddly enough, the presence of the reinforcement does not change the location of the critical failure surface in the STABL program.

The analysis showed that the geotextile's minimum tensile strength would be 970 lb/in. for a 200-psf-shear-strength sludge, and 360 lb/in. for a 300 lb/in.-shear-strength sludge (FS = 1.3). Law Engineering believed that +300 psf was a reasonable assumption for the shear strength of the lime sludge at depth. Based on this, the geotextile's re-

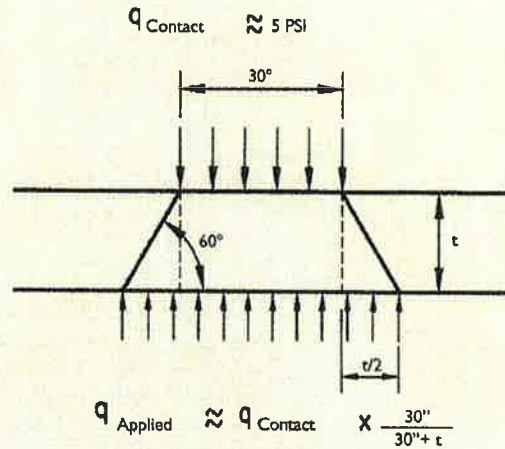


Figure 1. The model used to evaluate low-ground dozer-contact pressure.

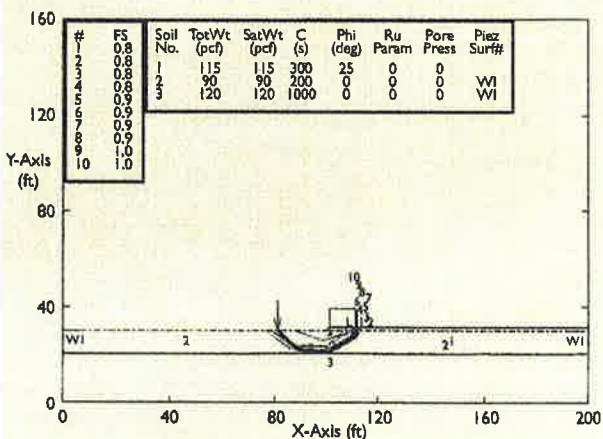


Figure 2. A STABL5 analysis of cover soil placement using a small dozer and neglecting the geotextile.

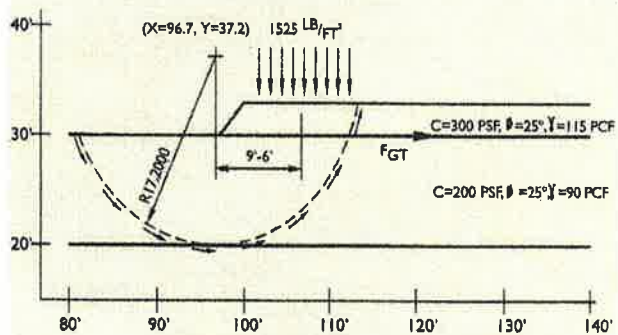


Figure 3. STABL5 provides a listing of the driving and resisting forces for the critical circles so that a geotextile can readily be incorporated into the project's design.

quired wide-width tensile strength was set at 500 lb/in., per ASTM D 4595, and assuming a typical minimum 60 percent seam efficiency. Because I was concerned about a potential remolding of the lime sludge, I further stipulated that the geotextile's required tensile strength had to be obtained of strain at less than 5 percent.

Project construction

The 18-acre-lagoon closure required nearly 100,000 yd² of geotextile, and almost 12 miles of seams. Fortunately, the pH of the lime sludge was not too high to preclude the use of conventional geotextiles. Carthage Mills, Cincinnati, supplied the geotextile and Flint Industries Inc., Statesboro, Ga., designed the seams. This project also demonstrated the benefits of open communications between a designer and a project's possible suppliers and contractors. Because representatives for Carthage Mills knew the project's design hinged on the actual geotextile developing strengths of 300 lb/in x 300 lb/in at the limiting seams, they deviated from the project specifications and proposed using a geotextile that was 400 lb/in. by 600 lb/in. Next, Flint demonstrated that its crews could seam this material to achieve a seam strength greater than 350 lb/in. It describes this unusually efficient seam as a double-stitched "J" seam, and it's the most efficient that I've ever seen. The better seam allowed us to relax the geotextile-strength requirement, which was important because the DOE wanted the geotextile almost immediately after the contract was awarded. This was definitely a fast-track project.

Photos 2 (this page) and **3** (page 22) show the contractors field-seaming the geotextiles as they placed the rolls. Note that, as usual, they used a white thread that was readily visible for inspection against the black geotextile. In some areas, the contractors accomplished the seaming by creating working platforms from which they could seam panels and accordion-fold them. These panels were then winched by excavators across the wetter areas. You have to admire the ingenuity of some contractors.

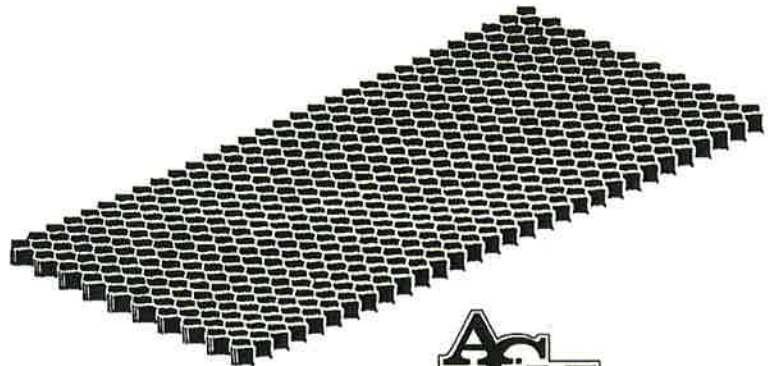
Workers placed more than 12,000 truckloads of cover soil over the geotextile using a "fingering" method to avoid excessive mud waving of the lime sludge. **Photo 4** (page 22) shows a large dozer placing soil over a previously placed soil lift. A smaller dozer was required to place the initial soil "fingers" and initial lift. Concern for bearing-capacity failure was so great that Foster Wheeler limited the movement of trucks over the sludge at all times. On average, the final cover thickness exceeded 6 ft. Flint's crews secured the geotextile around the perimeter of the lagoons in an anchor trench. Because of the lack of available material, they back-filled the anchor trench with grout, instead of compacted soil as designed.



Photo 2. Contractors field-seamed the geotextiles as they placed the rolls.

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Photo 3. The field crews used a white thread to hand-sew the material so that it would be readily visible for inspection against the black geotextile.



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Photo 4. A large dozer placed soil over a previously placed soil lift. A smaller dozer was required to place the initial soil "fingers" and initial lift.

The project was completed after just two months of construction with no major construction difficulties or claims. Although I can say "no major construction difficulties," some portions of the lagoon were so unstable that workers often wore safety lines and would unexpectedly break through the crust and sink up to their armpits. Flint's crews

were able to produce field-seam strengths ranging in from 362 lb/in to 484 lb/in. GeoSyntec Consultants, Atlanta, tested the seams at every 100,000 ft² of geotextile.

Following placement of the cover soil, contractors planted winter rye grass (**Photo 5**, page 23). The grass was replaced this spring by planting native prairie grasses.

(The ecological planning that went into the vegetation deserves a column of its own.) The prairie grass will be mowed once a year; one-third will be burned annually to maintain the prairie ecosystem. The Ohio EPA is very supportive of this effort, since it supports the state's goal of environmental reconstruction.

If you're part of the geosynthetics community, you will benefit by joining the North American Geosynthetics Society (NAGS). NAGS is a professional society dedicated to the advancement of geotextiles, geomembranes and related products, and their applications. Whether you're an academic, in government or in the commercial sector of the field, there's great value to being a member. Here's what your peers have to say:



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Summary

The geotextile stabilizer used in this project played a critical role in allowing the economical closure of the lime-sludge lagoons. It's important to note that the role (and strength) of the geotextile reinforcement becomes increasingly critical as the strength of the sludge decreases. I was extremely impressed by the quality of field work on this project. I give 70 percent of the credit for the success of such projects to contractors such as Flint and 30 percent to engineers like me.

As always, I am looking for good projects to include in the Designer's Forum. Please contact me (e-mail greg@gnra.com) if you have an idea for a column.

GRI

Gregory N. Richardson, Ph.D., P.E., is principal for G.N. Richardson and Associ-

ates, Raleigh, N.C., and the technical advisor for this column.

References

Paulson, J.N. (1989) "Geotextile-Assisted Soft-Site Stabilization," Geosynthetics '89 Conference Proceedings, Industrial Fabrics

Association International, St. Paul, Minn. Gugliemetti, J.L., Koerner, G.R. and Battino, Frank S. (1995) "Geotextile Reinforcement of Soft Landfill Process Sludge to Facilitate Final Closure: An Instrumented Case Study," Proceedings of the 9th GRI Conference, Philadelphia.



Photo 5. This photo was taken in late September 1996, after construction was completed.

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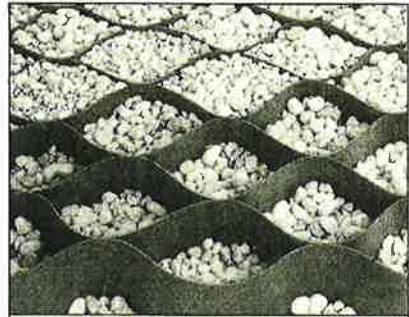
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