CONSTRUCTING THE SOLUTION

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Randolph noted that both pad-foot and smooth-face vibratory rollers were utilized to compact the infill materials within the Geoweb® sections. “Once the materials had been compacted in the cells, the system was fully engaged, providing the stability to support construction equipment and compaction operations. The sections went into service immediately, performing their job by protecting the sensitive subgrade from the heavy construction equipment even while the lowest layer of the fill was being placed.”

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Design engineers and contractors faced that challenge during construction of the container storage area for Berths 55/56 at the Port of Oakland, California.
geosynthetic Geoweb with unexpected wet weather threatened to delay the project. Port of Oakland, California • Summer 2000

Geoweb sections are expanded and secured over a non-woven geotextile separation layer.

construction of port facility
PORT OF OAKLAND, CALIFORNIA • SUMMER 2000

DESIGN AND CONSTRUCTION TEAM
Design Engineer: Darius Abolhassani, Harza Engineering Co. (Fugro West), Oakland, California
Design Consultant: Ernie Crowe, ECI Technologies, Milton, Ontario, California
Project Manager: Tom Searsley, McGuire and Hester Contractors, Oakland, California
Presto Distributor: Samuel Randolph, Soil Stabilization Products Co., Merced, California

PROJECT OVERVIEW
Lack of drainage — discovered during excavation — combined with unexpected wet weather threatened to delay the project. However, by employing a 200-mm (8-in) thick layer of crushed concrete, held in place and strengthened by a geosynthetic Geoweb® cellular confinement system, they were able to build a stable, yet flexible subgrade to support construction of the base layer.

This approach cut construction costs by reducing thickness of this reinforcing layer, lowering excavating and spoil disposal costs and allowing use of recycled on-site material as fill. It will also reduce future maintenance and repair expenses, compared to other alternatives.

The work was part of the continuing $560 million Vision 2000 project to expand the Port of Oakland by converting a former 215-hectare (531-acre) U.S. Navy site to a maritime container terminal. The project’s general contractor assigned to build the two berths was Port of Oakland Constructors.

Traffic at the intermodal facility includes tractor-trailer units, with 5,598 kg (11,000 lb) axle loads, and large gantries and cranes, with axle loads of 37,000 to 79,000 kg (100,000 to 212,000 lb). Supporting such loads requires a properly prepared subgrade for the pavement.

THE ORIGINAL PLAN
Initially, the plan was to excavate a total of 46,870 cu m (61,300 cu. yd) near the shoreline of San Francisco Bay to a depth of 1.8 m (6 ft.), prior to bringing in and compacting engineered fill. That work was being done by subcontractor McGuire and Hester. However, about half way through this work, the excavating crews ran into a problem. “Pothole tests revealed large areas of unstable subgrade,” says Tom Searsley, McGuire and Hester’s project manager. “The deeper we went, naturally, the more water we found.”

“We’ve encountered weak subgrades before but never in an area influenced by tides. In the past we would have repaired salt soils by over-excavating the area, covering it with a lightweight geofabric and backfilling with some type of engineered fill. But, common sense told us that such a repair wouldn’t work with the heavy loads of the container handling area,” says Searsley.

WEIGHING THE OPTIONS
A high-strength, stiffening layer was needed against which the fill could be compacted. Harza Engineering (Fugro West) was called in to solve the problem. “We needed a way to stabilize the subgrade within a short depth below grade to minimize the volume of material to be excavated,” explains geotechnical engineer and project manager, Darius Abolhassani, a pavement specialist with Fugro. “We also needed a very stiff, integrally layered system that would allow us to compact the fill above it to 98 percent maximum density required to support the heavy traffic loads.”

Regulations to protect the water quality of San Francisco Bay prevented use of a conventional calcium-based treatment, such as cement and lime, to strengthen the subgrade material. Lime bonds chemically with clay particles to remove excess water and increase strength of the clays. However, there were concerns that the lime could leach into a nearby estuary and threaten aquatic life. Meanwhile, time and labor expenses and disposal costs of excavated material also ruled out use of a flexible geogrid structure to build a suitable bottom layer for the fill.

THE STABLE SOLUTION
For these reasons, Harza recommended the use of the perforated Geoweb® system. This three-dimensional cellular confinement system confines infill, significantly improving its load-support performance. The system produces a stiff, flexible base that stabilizes subgrade or base materials. It is designed to distribute localized subgrade contact pressures over a larger area and control differential and total settlements, even on low-strength subgrades, like those found in this project. The cell wall perforations provide frictional interlock with the infill material and improves lateral drainage, resulting in better performance in saturated soils. The system is easy to install and eliminates the time and expense of over-excavating and placing large quantities of aggregate.

VERSATILE CHARACTERISTICS
“We had used this system before to temporarily stabilize weak subgrades for supporting construction equipment,” Abolhassani says. “But, we had not used it for soils with such low load resistance as the Bay Mud, with such heavy traffic loading and for such a large area. The characteristics of this system made it ideal for this project.”

“In load support applications, the Geoweb® system is normally installed in the base layer which is located at the top of the fill materials,” says Geoweb product supplier Samuel Randolph, Soil Stabilization Products Co. “However, as this project shows, the system can also be used to provide a stiff layer at the base of the fill where it contacts an extremely soft subgrade. The Geoweb system offers a way to compact the fill, otherwise impossible, and provides protection to the subgrade from the heavy and high-frequency loads above.”

ENGINEERED TECHNOLOGY
Civil engineer Ernie Crowe, ECI Technologies, Milton, Ontario, prepared the preliminary design for the Geoweb® system. An expert in this technology, he points out that the Geoweb system adds apparent cohesion to cohesionless materials, including poor quality, less expensive on-site granular fills. In university tests, a single 200 mm (8-in) deep cell increased the apparent cohesion of sandy soil or crushed stone by 1.5 to 3.0 tons per sq. ft.

When concentrated or distributed loads are placed on the system, the cells mechanically restrict lateral displacement of the infill. “The cells also keep the fill material in a state of compression, so that it’s very, very difficult to move the loaded material sideways,” Crowe says. “Frictional interaction between the infill and the perforated cell walls also controls lateral movement of the fill. You end up with a truly reinforced zone that allows the infill to transfer vertical loads laterally across the system. This, in turn, reduces the peak loads transferred to the subsoil immediately below it and reduces the potential of the subgrade to fail.”

This three-dimensional system can also increase the life of a load support project. “Various full-scale cyclic loading tests have shown that the number of load applications required to produce a given permanent deflection of an unconfined aggregate base are increased by a factor of 10 to 15 when the aggregate is confined in the Geoweb system,” adds Crowe.

THE FINAL DESIGN
In developing the preliminary design for the subgrade stabilization project, Crowe prepared eight sections representing various traffic loading and soil bearing capacities and using 200 mm (8-in) deep, perforated Geoweb® sections. Based on that information and a comprehensive pavement analysis, Abolhassani drew up the final design that called for installing 19,788 sq. m (213,000 sq. ft) of the cellular confinement system. He recommended over-excavating the areas of weak soils to a depth of 467 mm (1 1/2 ft) below the Geoweb layer and covering this area with a nonwoven geotextile to separate the Geoweb system’s infill material from the underlying mud.

The design featured the use of crushed concrete infill, recycled from building footings and other concrete structures that once stood on the Navy facility.
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The project manager, Tom Seeley, McGuire and Hester Contractors, Oakland, California.

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Dealing with the soft native “Bay Mud” subgrade wasn’t the only challenge in getting the Port of Oakland’s Berths 55/56 up and running. The huge cranes used to lift the containers on and off the ships—the world’s largest container cranes at the time—had to travel by ship across the Pacific Ocean from Shanghai, China, to Oakland, Calif., in the fall of 2000. That meant slipping beneath San Francisco’s Bay Bridge, an event that attracted worldwide media attention. By adding extra ballast to the ship and lowering the passage to coincide with an unusually low tide, the feat was accomplished with just 635 mm (25 inch) to spare (between the top of the cranes and the bottom of the bridge).