

# Soil Nailing is Designed to Fit

by Marcus H. von der Hofen

Soil nailing has become a popular method to shore excavations and to build retaining walls due to its versatility and cost effectiveness. Generally broken into two categories, temporary and permanent ground retention systems, soil nailing has evolved into many variations. A range of different means and methods have emerged, giving the construction industry an incredibly adaptable shoring system. The importance of a well-seasoned soil-nail team, however, cannot be understated for the success of any project.

Temporary soil nailing is the system that utilizes the nail for a limited time during construction process for ground support. Once the permanent structure is in place, the nails are essentially abandoned. By contrast, permanent soil nails remain in service for the life of the wall. The shotcrete application required during the shoring process can also be temporary or permanent, but not necessarily the same as the nail. Hence, a temporary facing may be constructed with permanent nails or vice versa.

Typically, in basement construction, soil nailing is used as a temporary shoring system and is installed concurrently with the excavation for the basement walls. After the basement has been excavated and the soil nail system is in place, either a mat slab or footings are poured and a permanent cast-in-place concrete or shotcrete wall is installed. If a shotcrete wall is chosen, it can be installed with many different finishes to fit the use of the structure. Typically, shotcrete basement walls are finished with wood or rubber floats to create a sand finish. In temporary soil nailed walls, the structural floors and walls are installed; the soil nailing retention system is no longer needed to support the walls. In some cases, the wall is installed in a top down manner concurrent with the soil nail anchor installation, in both temporary and permanent shoring systems.

In the past, the highway departments often utilized the permanent soil nail wall system with shotcrete lagging, covered with a cast-in-place or precast facing to give the completed wall a cast-in-place look. Now, however, permanent soil nailed walls are being used extensively along West Coast highways and freeways.

Although materials, equipment, and methods vary greatly, soil nail retaining wall construction involves variations of the following very basic steps:

Step 1. Excavate a small height cut (referred to as a lift, often done in sequential manner);

Step 2. Drill, install, and grout soil nail tendons required for the lift;

Step 3. Place geo-composite drainage strips, reinforcing steel, and shotcrete; and install bearing plates and nut; and

Step 4. Repeat Steps 1 through 3 to the final grade of the soil nail wall.



Figure 1: Klemm KR803D drill rig

## West Lake Sammamish Parkway Project

West Lake Sammamish Parkway, located in Redmond, Wash., is a heavily traveled, two-lane highway connecting a largely populated residential area and the 520 Interchange. Growth in traffic volume has required expansion of the intersection. This required the removal of native soils and construction of a permanent retaining wall that ranged from 4 to 21 ft in height (1.2 to 6.4 m). Due to the location of the project, re-routing of traffic was not an option and space was limited. The design the City opted for was a permanent soil nail wall with a permanent shotcrete facing followed by installation of precast panels. It was selected for both cost effectiveness and the ability to perform the work under site constraints.

Soil reports indicated different conditions varying from glaciolacustrine clays to advance outwash sands. The specified soil nails were #10 grade 75 epoxy coated Dywidag threadbar. The soil nails ranged from 25 to 40 ft (7.6 to 12.2 m) deep on this project. Plastic centralizers were attached to the production anchors at a minimum of 8 ft (2.4 m) on center. Three sacrificial verification nails were installed and tested to the ultimate load of 6.4 kips per linear foot (9523.2 kgs/m). The shotcrete is a 4000 psi (28 MPa) 6 in. (150 mm) thick facing with #4 rebar, 6 in. (150 mm) center to center, in both directions. Three feet (0.9 m) wide strips of geo-composite drainage mat were placed vertically between each nail and eventually tied into a permanent drain system.

The drilling contractor chose a Klemm KR803D hydraulic drill rig, which has the capabilities of open-hole drilling or duplex drilling with casing. A high shear grout plant was uti-



Figure 2: First lift close up



Figure 3: First lift (note elevation changes)



Figure 4: Artificial rock retaining system

lized to colloiddally mix neat cement 4000 psi (28 MPa) grout. After the bar was inserted, grout was tremie pumped to the bottom of the hole until full. The shotcrete contractor utilized the wet-mix process employing a western warrior 6 in. (150 mm) piston swing-type pump and a 2 in. (50 mm) delivery system. This system is capable of placing a variety of mix designs and slumps under both short and long pumping conditions.

During excavation of the first lift, removal of stumps and other vegetation along the cut left large voided areas. The solution to this problem was incorporation of a form board into a shotcrete flashing that enabled the contractor to easily create a back form to shoot against in the areas absent of soil. After confirmation with the design engineer, the area behind the shotcrete was then filled with controlled density fill (CDF) after the forms were stripped and allowed to cure before continuing with the excavation of the second lift. Production then continued as planned without incident.

## Tacoma Dome Station Phase II Project

Located in Tacoma, Wash., this project added a new twist to a soil nail system. The contract originally specified a temporary soil nailed shotcrete system with a permanent shotcrete

wall to be placed at a later date. In between these two layers of shotcrete was to be 100% panel type waterproofing system. The shotcrete contractor, along with a local ready-mix concrete supplier, had been running tests on concrete waterproofing products that were added to the mixture proportions. A soil-nail system was designed that incorporated the use of this product in the permanent shotcrete facing, eliminating the need for the panel system. The system included a five-year waterproof guarantee. After three years of service, the system is functioning flawlessly in the rain-ridden Pacific Northwest.

## California Projects

In many cases, a cast-in-place concrete facing has utilized form liners to achieve a fractured fin, cobblestone, or other architectural effect. This has been a very costly and time-consuming means of constructing permanent facing. So, currently, the State of California is installing many permanent soil nail retaining walls with a permanent shotcrete stained, carved-rock appearance intended to blend in with the adjacent geology. This has proven to be a cost-effective, efficient, and aesthetically attractive means of constructing permanent facings.

## Conclusions

Soil nailing is a proven method for shoring for a multitude of different kinds of projects. The choices of means and methods are continually growing. The key to the success of the method lies in designing the systems to meet the needs of each individual project, and the selection of a competent soil nailing team.



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