MULTIURETHANES
Suppliers of grouting materials, equipment and engineering support services

GROUND IMPROVEMENT BY CEMENT GROUTING COMBINES WITH PIPE PILES IN BRIDGE CONSTRUCTION

Author

Peter White, P.Eng.
General Manager

Abstract

A bridge reconstruction project involved driving pipe piles for the new foundations. Disturbances within soil layers at depth caused sinkholes to open up within the construction site.

After a near fatal accident, the pile driving installations were suspended. The solution involved ground improvement through cement grouting with sleeve pipes and special grout additives to minimize migration of cement grout.

Introduction

Reconstruction of the Stenton Avenue bridge over Conrail tracks north of Philadelphia, PA involved demolition of the original structure, driving pipe piles for the new foundations and constructing the new bridge. The demolition operation was accomplished without any difficulty.

As soon as the installation of pipe piles commenced, disturbances within soil layers at depth caused sinkholes to open up within the construction site.

After a near fatal accident when a sinkhole suddenly opened up beneath a supervisor, the pile driving operations were suspended.

Considering construction safety issues and the potential for disaster involving the high-speed Conrail trains which continued to operate through the job site, it was not possible to proceed with the bridge construction as originally planned.

The existence of large pylons supporting high-voltage electrical lines crossing the site further reinforced the need for a cautious approach.

Figure 1 shows the project site looking north across the Conrail tracks during the probe drilling operation.

Ground Conditions

Ground conditions at the job site included up to 35 feet of overburden on top of interbedded layers of dolomite with soil infilling. The underlying bedrock geology was quite irregular, with significant differences in bedrock elevation at various locations beneath the project work site.

Complicating factors included a depressed water table resulting from site topography and proximity to a very old and very deep open pit limestone mining operation. As drilling operations progressed, it became apparent that solution cavities had been created within the dolomitic layers over many years and that ground disturbance due to pile installation was causing the migration of soil into these solution cavities, thus leading to the creation of sinkholes.

Drilling Program

A Davey-Kent DK 100 crawler-mounted drill rig was used for drilling probe holes for site evaluation and grouting purposes. This drill rig enabled the concurrent driving of a drill string and external casing through overburden and unconsolidated ground. After the casing had been seated into competent rock, the drill string was used to complete drilling operations in a conventional manner.

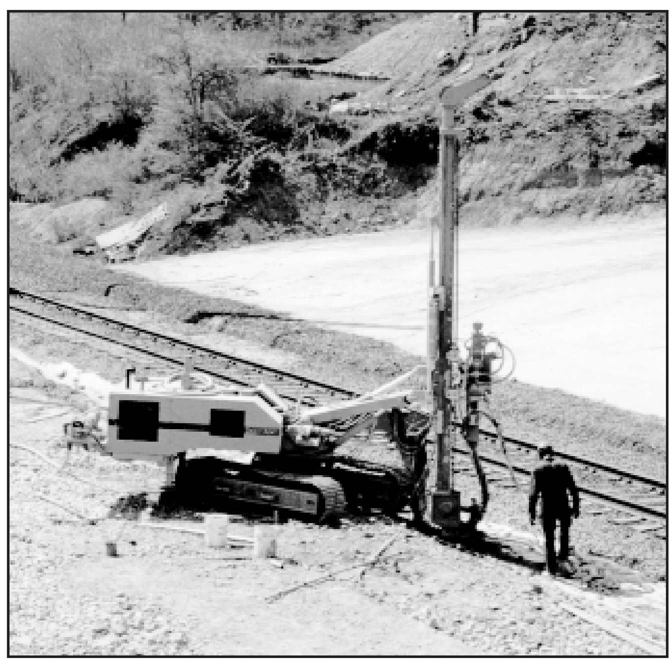

FIGURE 1 - Project Site Looking North

FIGURE 2 - DK 100 Drill Rig in Operation

Figure 2 shows the DK 100 drill rig drilling into limestone after the casing has been installed through overburden.

A number of widely-spaced probe holes were initially drilled across the project site to verify the underlying site conditions. Holes were drilled at least 10 feet into competent bedrock. In most cases, ultimate hole depths ranged between 50 - 70 feet. Voids were encountered in almost all of the initial holes, resulting in loss of flushing air. In many cases, voids were found underlying narrow layers of competent limestone. Voids measured from a few feet up to 10 feet or more in depth.

Sleeve Pipes

Following completion of drilling operations, plastic 1-1/8" diameter sleeve pipes were installed to the full depth before withdrawing the casing and moving to the next adjacent hole. Sleeve pipes were supplied in 10 foot lengths and featured trapezoidal thread connections with an external coupling for fast assembly. Installation time required only a few minutes per hole, so the delay to drilling operations was minimal.

The sleeve pipes were perforated every 20 inches along the pipe length and the perforations were enclosed by an external rubber sleeve. The rubber sleeve served as a one-way valve to allow cement grout to be pumped from the sleeve pipe without the sleeve pipe becoming clogged with grout, dirt or debris.

Figure 3 shows plastic sleeve pipes being installed through the drill casing following completion of drilling operations.

After assessing site conditions, it was decided to eliminate the use of an external casing grout and to allow the loose soil to close around the sleeve pipe after withdrawal of the drill casing. It was considered that any casing grout would migrate a long distance from the sleeve pipe being installed, would delay drilling operations, and might also jeopardize the drilling and sleeve pipe installation of adjacent holes.

Grout Formulation

Grouting operations proceeded away from drilling activities to minimize the potential for inadvertent contact between the two operations. In addition, a special cement grout formulation was developed for this project to provide a high-yield, low-strength, low-mobility, inexpensive grout mix as follows:

- water 18.75 USgal
- superplasticizer 10 oz
- bentonite 4 lbs
- Type I cement 1 sack
- Celbex 653 ¼ lb

By using a high water content, a high grout yield per sack of cement was achieved. The superplasticizer ensured that the grout materials were properly dispersed before leaving the mixer and that a low grout viscosity was obtained. Bentonite was used to stabilize the grout and to minimize the potential for grout to bleed. Celbex 653, a powdered cellulose admixture, was used to achieve thixotropic properties to the grout following placement in order to minimize the travel of grout away from the sleeve pipe ports.

Grouting Criteria

It was deemed inappropriate to create a dense, high-strength grout, which is frequently required on other grouting projects. Specifically for this site, the principal requirement was only to stabilize the soil sufficiently to allow the large Barber drill rig to be operated safely on the job site without sinkholes being created.

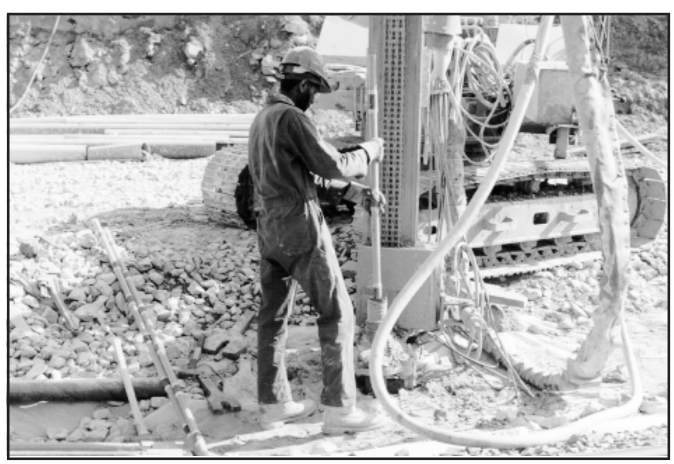

FIGURE 3 - Plastic Sleeve Pipes Being Installed

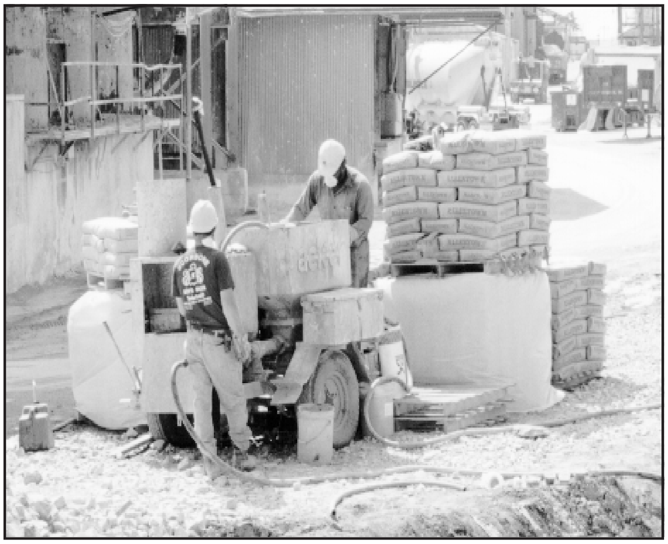

FIGURE 4 - Colloidal Grout Unit in Operation

Grouting operations were intended to create weak lenses of grout within the existing limestone and soil layers which would not otherwise have any significant influence on the ultimate foundation design or installation requirements for the pipe piles. By using Celbex 653 as a thixotropic admixture, the intent was to minimize permeation by the grout into the soil and thereby minimize grout consumption.

Grout Plant

Figure 4 shows the Acker 4 ft^3 diesel-hydraulic, colloidal mixing unit in operation. This unit was self-contained with a colloidal mixer, agitator and moyno grout pump. Each of the grout ingredients were pre-measured in suitable containers to accommodate a one-sack batch of grout. Grout output was in the range of 1 - 2 ft^3 per minute, which was sufficient to balance the rate of drilling progress. Grout was discharged from a central location through 1 inch grout hoses to the required locations on the job site.

Grouting Operations

Typical grouting operations are shown in figure 5. The initial pipe piles can be seen in the background with an array of plastic sleeve pipes installed in the foreground.

The grouting equipment consisted of a slotted packer pipe with pot packer rings at either end to isolate the slotted pipe within the plastic sleeve pipe. The length of the slotted packer pipe was varied according to site conditions and could cover two or three sets of sleeve pipe perforations at one time in order to maximize grouting productivity.

The slotted packer pipe was raised and lowered by steel pipes and connected to the grout delivery hose from the grout plant. Subsequently, a special high-pressure hose assembly was used to replace the steel pipes to further increase grouting productivity.

Subsequent Operations

The effectiveness of the grouting operations in improving site conditions was evident as soon as intermediate holes were drilled between previously grouted holes. The occurrence of loss circulation problems and open voids decreased remarkably when drilling intermediate holes. Subsequent grout consumption rates were also significantly reduced.

Upon completion of drilling and grouting operations, the Barber drill rig returned to site and was able to safely install the required pipe piles without the hazard of sinkholes opening to surface at random. Pile installations were not impeded as a result of the placement of cement grout and bridge construction work subsequently proceeded as originally planned.

Acknowledgments

MULTIURETHANES wishes to acknowledge **PENNDOT** engineering personnel and their consultants for deciding to implement the author's technical recommendations which resulted in the resumption of construction work in a safe manner and within the contractual framework of the project as originally specified and designed. **MULTIURETHANES** also acknowledges the staff of the contractor, **CATOH INC.** of Weedsport, NY, who was responsible for the successful execution of the grouting and pipe pile installation portions of the Stenton Avenue bridge reconstruction project.

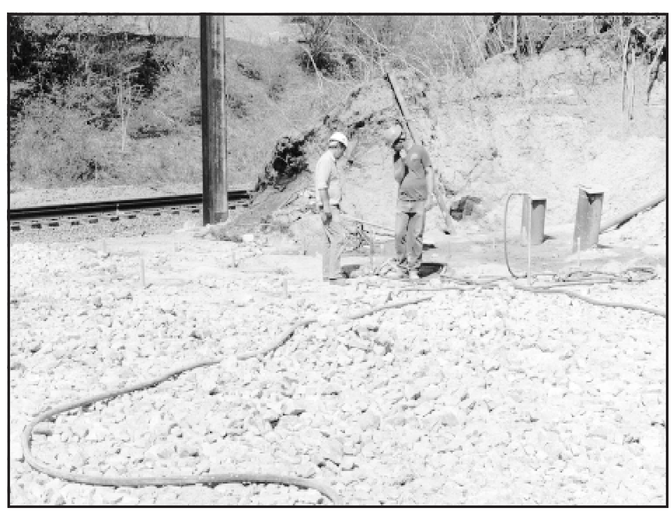

FIGURE 5 - Typical Sleeve Pipe grouting Operation

COMPANY OVERVIEW

WHO WE ARE

Since 1988, **MULTIURETHANES** has become a leading supplier of injection materials, equipment and accessories used for soil consolidation, water cut-off and grouting of rock fissures in mining and tunneling applications. In municipal and heavy utility applications, our products are used for the repair and/or waterproofing of concrete structures.

THIS DOCUMENT

This technical paper provides an example of a geotechnical grouting application undertaken with products and services supplied by **MULTIURETHANES**. Additional technical information on specific grouting materials and application techniques is available from **MULTIURETHANES**. For additional information, call to obtain one of our ENGINEERING REFERENCE MANUALS.

WE'RE HERE TO HELP

Specialist advice for your grouting projects is available from **MULTIURETHANES**. We encourage you to consider our specialists part of your engineering team, providing technical assistance to ensure that your grouting projects are both cost effective and successful. For groups interested in learning more about grouting operations, **MULTIURETHANES** offers technical seminars on various grouting topics.

ON-SITE EXPERTISE

Where possible, **MULTIURETHANES** provides on-site technical assessments to determine project requirements and recommend appropriate grouting materials, equipment and techniques for specific site conditions. Specialists from **MULTIURETHANES** are available to provide training to those with limited grouting experience.

CALL TOLL FREE

1-800-663-6633

VISIT OUR WEBSITE

www.multiurethanes.com

ACTIVITIES

- Pressure Grouting
- Cement Grouting
- Soil Stabilization
- Water Cut-Off
- Sewer Rehabilitation
- Concrete Restoration
- Crack Injection
- Waterproofing

APPLICATIONS

- Potable Water Tanks
- Municipal Services
- Underground Utilities
- Hydro Dams
- Mines and Tunnels
- Geotechnical

PRODUCTS AND SERVICES

- Polyurethane Resins
- Acrylate Resins
- Microfine Cement
- Sleeve Pipes
- Grouting Equipment
- Hydrotite Waterstop
- Multi-Paste Sealant
- Injectable Tubing
- Quality Control
- Engineering Services

Canada
6214 Kestrel Road
Mississauga, Ontario L5T 1Y9
Tel: (905) 564-7650
Fax: (905) 564-7998
Toll Free: 1-800-663-6633
email: mme@multiurethanes.com

USA
PO Box 127
Buffalo, NY 14207
Tel: (716) 842-0066
Fax: (716) 842-0055
Toll Free: 1-800-663-6633
email: usa@multiurethanes.com