Malcolm Drilling Company
Ground Improvement Division

Jet Grouting

MEGA-Jet

Seattle, Washington
Sound Transit U230

Improvement Overview

In 1996 the citizens of Seattle approved a new mass transit system that would connect Seattle — Tacoma International Airport with the University of Washington. Sound Transit's U230 contract will expand an existing section of rail with twin tunnels between downtown Seattle and Capitol Hill to interface with the U220 Contract that connects the University of Washington. Malcolm Drilling's scope included construction of three soil improvement break-in/break-out blocks to assist the Tunnel Boring Machines (TBM), providing the impermeable strengthened structure necessary for the TBM to mine within at critical juncture points.

M-Jet Grouting Technology

Malcolm's proprietary M-Jet technology expands on current super jet techniques and uses a unique array of jetting nozzles to erode and combine grout with native material to form a cemented homogeneous structural element. While normal jet grouting processes fall victim to severe fluid head losses, the M-Jet system utilizes a highly refined balance of pressure and flowrate to efficiently construct large diameter structural elements. Effectively balancing the flow, pressure, and fluid properties of the injection media has resulted in creating columns of up to sixteen (16) feet in diameter. Mounted on a Bauer BG15H drill machine, the M-Jet system has performed to depths of over 85 feet at angles greater than 25 degrees off vertical. Installation of deep battered large diameter jet grout columns is critical when the project staging areas are limited.

Ground Conditions

Work commenced on the U230 Contract at the Capitol Hill Station, 2 miles east of the heart of Seattle. Grouting was specified from depths of 30 to 80 feet below existing grade. Preliminary boring logs revealed hard silt/clay and very dense sands with SPT blow counts in excess of 50 for the majority of the planned treatment depths. Soils of this nature are not normally considered groutable nor require any form of ground improvement. However, the highly variable geology included interbeds of erodible granular soils that could potentially run and convey soil/water into the excavation during mining.

Test Program

For each distinct area, Malcolm Drilling first performed a test program to assure stabilization of the break-in/break-out structure. Each test program included the installation of six test columns using various grouting parameters. In conjunction with wet soilcrete grab samples the columns were cored and analyzed for strength, continuity and size throughout the highly variable soil profile to enable selection of the optimal grouting parameters. Some of the recovered core consisted of naturally cemented, native Glacial Till (non grouted) that was difficult to distinguish from grouted soil. Phenolphthalein was applied to the samples to aid in differentiation, as it turns pink on contact with cement grout. Unconfined compressive strength of grouted soils averaged greater than 800psi at 28-day. All cores of native glacial till yielded strengths in excess of 120psi.

Owner

Central Puget Sound Regional Transit Authority

General Contractor

Jay Dee / Coluccio / Michels Joint Venture

Geotechnical Engineer

Jacobs Associates

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Construction

Construction of the first ground improvement zone began in early-spring 2010 at the Capitol Hill Station's two Southbound tunnels. This single block of treated ground was 80ft x 40ft in plan and 50ft in depth. Upon completion, this work was followed by a ground improvement zone of similar proportion at the opposite end of the station to receive the TBM drives advancing from the University of Washington. The final treatment zone at the Pine Street Station in downtown Seattle is scheduled for completion the fall of 2010.

The complex geology of Seattle's Capitol Hill posed as one of the project's greatest challenges. City street right-of-way constraints were also a significant issue to overcome. The construction requirements were maintained with column diameters ranging from 8 to 12 ft, drill depths up to 86 ft, and drilling inclinations of up to 26 degrees off vertical.

Quality Assurance

A downhole in-situ sampler was placed daily within a fresh column to retrieve a wet grab sample of in-place soilcrete. Cast samples were then tested for unconfined compressive strength.

An electronic data acquisition system monitored and recorded air pressure, grout pressure, flowrate, withdrawal and rotational rates of the drill tool, along with inclination and orientation. The quality assurance program included a redundant manual measurement of ALL parameters obtained electronically. Graphical reports of the electronic data, as well as hand logs, were maintained and distributed daily.

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