Ground Improvement by Compaction Grouting

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Project Overview

Project location:	Century Freeway, Los Angeles, California.
Construction period:	August, 1996 - August, 1997
Owner:	California Department of Transportation (CalTrans).
Engineer:	CalTrans.
General contractor:	Denver Grouting Services, Inc.
Scope of work:	Approximately 6500 cy compaction grouting
Contract value:	$7,700,000

Background

In March of 1995, major sinkholes occurred along a new 4 mile section of the I-105 freeway between the San Gabriel and Los Angeles Rivers in Los Angeles, CA. The sinkholes were attributed to infiltration of soil into the storm-drain system through insufficiently sealed pipe joints. This worsening situation represented a major safety hazard to high-speed traffic and heavily loaded trucks. CalTrans issued a multi-phased contract to Denver Grouting Services, Inc. (DGS) to: (1) stabilize the sub-soils and fill voids along alignments of Corrugated Metal (CMP) and Reinforced Concrete (RCP) storm-drain pipes beneath the freeway pavement, (2) repair leaking pipe joints, (3) mitigate liquefaction-potential along the pipe alignment under one of the pump-station structures, and (5) install water and observation wells for subsequent ground water draw-down testing.

This freeway was built 40 ft. below surrounding ground levels, which required a major water-pumping system to be installed at the time of construction (1993). The drain pipes were installed 15 to 20 ft. below the highway slab level, which meant the drain pipes were actually 60 ft. below the original ground level. The groundwater table was less than 5 ft. below the freeway pavement in some areas.

Solution

Compaction Grouting was the method chosen to stabilize the soils surrounding 14,460 l.f. of RCP and CMP storm drains, and to densify liquefiable sands beneath one of the pump structures. Storm-drain sizes included 24, 30, 36, 42, 48, and 54-inch diameters.

Geotechnical Conditions

The storm drains were installed through alluvial deposits consisting of medium sand, silty sand, silt and clayey silt layers which varied in thickness along the alignment. A mixture of these native soils had been used as storm-drain "trench" backfill at the time of construction. In general, very low densities and voids existed around storm drains where they were below the groundwater table, and soil infiltration was maximized. Fluctuating water tables had also

affected the remaining alignments to varying degrees, creating unacceptable densities and created some localized voiding. Because depths of the CMP and RCP drains varied between 15 and 20 ft. (below the road surface), it was determined that the ground improvement program should extend from a minimum of 5 ft below the storm drains invert to a up to within 5 ft. of the freeway pavement. The work was to be performed with minimal disruption of traffic .

Cut-off Criteria

The grout injection cutoff criteria included:
Maximum 1/2-inch allowable pavement uplift or 1/2-inch storm-drain deflection. A predetermined volume of grout per 1-ft. stage. Maximum grout pressure "at the header" of 450 psi, or A sudden 50 psi drop in pressure, indicating soil shear or grout travel was occurring.

Equipment

The Compaction Grout equipment employed met the requirements of CalTrans to minimize its operational "effects on traffic" and involved "The Denver System" as developed by DGS, including:
Mobile Grout Batch Plants
DGS 2015 Mobile Grout Pumps
DGS 2" I.D. Grout Casing, 3-ft to 5-ft. lengths
DGS Grout Casing Retrieval Systems
Specialized Casing Driving Systems

Testing and Performance

Pre-treatment and post-treatment CPTs were placed at 50 foot intervals along the storm drain to confirm soil density improvement. Post-treatment CPT values within the treated zone were required to average 50 tsf, with no values less than 20 tsf.

A comprehensive program to monitor surface and structure movements during grouting was also employed. Multiple manometer and optical laser survey systems were utilized for pavement surface measurements, while four-quadrant, dial indicator systems (accurate to 0.001 in.) were utilized inside the storm drains to monitor displacement movement.

Payment Terms

Payment for the Compaction Grouting portion of the contract was based on results of the post-grouting CPT tests (see typical pre- & post-CPT results, Fig. 1).

Per the contract, DGS would have been required to re-grout (at DG expense) any areas that did not meet the minimum post-grouting requirements. No such re-grouting was necessary along the almost 3 miles of treated storm-drains.

Acknowledgments

DGS would like to thank CalTrans for the opportunity of working with their engineers from the Los Angeles Office on this precedent-setting project. We would also like to thank all the subcontractors who performed their work in a professional manner, and all the DGS staff who gave so sacrificially of their time and family commitments to make this project such a resounding success.

Other Similar Projects

While the CalTrans project is the largest "Pipe Stabilization/Ground Improvement" project that Denver Grouting Services has performed to date, numerous similar applications have been completed over the years, a partial list is as follows:

City Of Evansville, Indiana

Sewer Repair Project, 1986, $1.2M
Black & Veatch, Project Engineers, St. Louis, MO.

Severe bell and spigot failures were allowing soil piping to cause huge sink holes to occur along 1,200 l.f. of a 6 ft. diameter main sewer line and threatening a major operational problem with the Cities wastewater system. Depth of cover (22 ft.) and soil conditions (saturated silts) prevented economical repair using excavation methods.

A variety of Grouting techniques were employed to repair the line, including Compaction Grouting to stabilize and realign the pipe and its joints. Cement slurries and epoxy grouts were utilized to repair and seal broken bellied joints. Seven years post repair reports indicated the pipe was performing well, inspection communications with DGS were discontinued at that time.

Greater Houston Waste Water Program (GHWP)

Almeda Project, 1995 - 1996, $2.3M
J.E. Pate Engineers, Houston, TX.

An 80 inch diameter storm sewer was tunneled 40 ft. below the alignment of Almeda Highway in saturated silts. Soil piping was causing extensive sinkholes to occur and threatened to cause major breaks in the RCP. Two miles of pipe and highway were stabilized using compaction grouting. Cost savings to alternative repair methods on this project set the stage for CalTrans and other subsequent projects.

City Of Richland, Washington
George Washington Way Project, 1997, $1M
Shannon & Wilson Engineers, Richland, WA.

Project involved densifying 1 mile of an improperly compacted backfill over a recently installed sewer line. Specifications were "performance" based similar to the CalTrans project.

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