Injection Grouting Preserves Foundation Integrity of Multi-Story Buildings

Owner: Metropolitan Council Environmental Services (MCES)
Civil: Foth Infrastructure & Environment
Grout Consultant: BDA Associates (BDA)
Contractor: Engineering & Construction Innovations (ECI)

Introduction

Metropolitan Council Environmental Services (MCES) is responsible for collecting and treating wastewater from approximately 2.7 million residents in the Minneapolis-St. Paul metropolitan area. Due to growth in the Twin Cities area, MCES determined they needed to construct a 50 foot deep sanitary sewer lift station, modify alignment of gravity sewers and add a 9000 foot long forcemain to handle increased volumes. However, the location of the lift station and alignment of the sanitary sewer was located very close to multiple-story buildings constructed on shallow foundations. At first glance, the situation seemed ordinary, however the presence of shallow groundwater and loose granular, alluvial soils created a challenging situation. Due to the subsurface conditions, dewatering with well points and the installation of vibratory sheet piles was likely to cause settlement of the soils near surrounding buildings and ruled out as a construction option.

Foth, a civil engineering design firm, hired BDA Associates (BDA) to design a grout curtain along an existing six story high commercial building on spread footings approximately 35 feet from the edge of a new caisson installed 50 foot deep lift station. The grouting served to control any settling of the commercial building and to control groundwater for the installation of new gravity sewer maintenance holes for connections to the lift station. AV-100 Acrylamide Chemical Grout from Avanti International was used for the solidification and permeation grouting. Installation of the grout was self-performed by Engineering & Construction Innovations (ECI) – the contractor for this project. The grout was installed using pre-determined cure times through sleeve pipes, packers and a multiple-port manifold. Once installed, the grout allowed for the successful drilling of maintenance holes and micro tunneling for the construction of the sanitary sewer main connections to the lift station.

Project Scope

According to MCES, the 1-GV-461 Relief Lift Station L-81 Project was the final phase of three phases of construction required to redirect five million gallons per day (MGD) of sewage flow from Interceptor 1-GV-461 to the Plymouth forcemains to provide future sewer capacity to the cities of Golden Valley and St. Louis Park. Phase III – 1-GV-461 Relief Lift Station L-81 consisted of constructing 1,200 lineal feet (LF) of 18 inch diameter forcemain and 200 LF of 30 inch gravity pipe to connect previously installed forcemain segments to the lift station, and the lift station to existing gravity sewers. The lift station was constructed within a 37 foot by 39 foot concrete caisson sunken to a depth of approximately 50 feet below the ground surface. To minimize the risk of settling an adjacent six-story commercial building with shallow footings,

soils were solidified between the building and the caisson and in the 30 feet deep open-cut pipe zone.

Subsurface Conditions

The soil borings indicated the site was underlain by up to 6.5 feet of silty sand fill over alluvial deposits to depths of 37 feet, and glacially deposited till. The alluvium deposits mostly consisted of sands and gravels with occasional zones of silts and clays. The till mainly consisted of clayey and silty sand with fewer zones of silts and clays. Groundwater under the site was found in the borings at a depth of approximately 19 feet below the ground surface.

Constructability Challenges

The presence of relatively shallow groundwater associated with loose to medium dense sands created a challenging situation to construct the planned lift station and sanitary sewer gravity pipes. Typically these types of subsurface challenges can be addressed through conventional construction techniques of dewatering well points and driven sheet piling. However, the use of a conventional open excavation process was impossible on this particular project site due to the proximity of the six-story commercial building. Any of the conventional construction techniques could potentially cause settlement of the existing alluvial sands which would in-turn cause physical damage to the building. Damage to the adjacent building was unacceptable. Draw down of the water table during site dewatering could also cause the granular soils to settle due to the loss of hydraulic buoyancy. During installation of driven sheet piles, vibrations from the construction activities would likely cause soil settlement and subsequently damage the adjacent structure. Open trench excavation was not feasible due to the shallow groundwater table. Other conventional methods - such as auger cast piles - were not cost-effective. In addition, significant structural elements would have been abandoned and could pose substantial challenges to future construction.

Grouting Program

As the grouting design consultant, BDA determined that the most dependable solution was permeation grouting with AV-100 Acrylamide Chemical Grout. AV-100 is a chemically-reactive gel that can permeate anywhere water can travel and can cure in controllable set times from seconds to hours. BDA designed the grouting program to minimize groundwater inflows into the planned excavations which allowed for the stabilization of groundwater levels, and subsequently stabilized the bearing soils below the building's foundation. The grout was to extend from the groundwater level to a depth below the bottom of the proposed excavation.

In June, 2015, ECI began implementation of their approved grouting program. The first step of the program was installation of tube sleeve pipes. By drilling large diameter holes using a hollow stem auger to minimum depths of approximately 30 feet, the sleeve pipes were placed and a weak concrete/bentonite mortar was backfilled around the pipes. The sleeve pipes had ports spaced every 15 inches for the full length of the pipe. There were approximately 175 sleeve pipes installed adjacent the caisson for the lift station at the pipe penetrations and 168 sleeve

pipes installed along the sewer pipe alignments. Sleeve pipes were 1-1/2 inch in diameter. There were primary and secondary sleeve pipe rows. Within each row the pipes were installed at four foot on center. The secondary row was offset by two feet creating a staggering of the grout rows. Grouting operations commenced simultaneously as the sleeve pipe drilling and installation occurred.

AV-100 is a two part, one-to-one ratio grout formulation that forms a gel/soil matrix when mixed and injected via pump into the underground soils. Once cured, AV-100 creates an effective, long-lasting, impermeable water barrier and provides superb soil stabilization. The delivery system for injecting AV-100 consisted of a dual component, one-to-one ratio, stainless steel pump connected to a one inch diameter sleeve pipe compression seal packer. AV-100 was pumped at an average of 1-1/2 gpm for each stage with pressures ranging from 10 psi to 45 psi depending on the stage depth. Almost 70,000 gallons of AV-100 was injected during a one month period.

Post Grouting Verification

Post grouting verification was accomplished during manhole installations. Water was not observed in any of the excavations for the manholes with exception of one. Within the one wet excavation, cobbles and gravel were observed at a depth which was a water bearing zone. To remedy the inflow, ECI installed a secondary row of sleeve pipes and reinjected AV-100 which proved successful and dried the excavation.

Conclusion

When present, groundwater can create unique challenges on every project. These challenges can be exacerbated when combined with loose sands and adjacent shallow foundations. The Teams at Foth, BDA Associates and Engineering & Construction Innovations overcame project challenges through exceptional design and outstanding implementation of an effective grouting program. Once injected into the sand soils, the AV-100 Chemical Grout and sand formed a reliable gel/soil matrix that serves as an effective water barrier. The gel/soil water barrier allowed ECI to safely and efficiently construct both the lift station and sanitary sewer lines to depths of approximately 50 feet.