Cutter Soil Mixing for Cutoff Wall in Seattle

by John Kvinsland and Andy Majewski, Project Managers, Malcolm Drilling Company, Inc.

MDCI RTG 23 and Kobelco BM 500 Installing panels and piles along the Burlington Northern Railroad.

Malcolm Drilling Co. Inc. (MDCI) was awarded a contract in the spring of 2007 to install a cutoff wall utilizing, for the first time, its newly acquired Cutter Soil Mixing (CSM) technology. MDCI began purchasing the necessary equipment to perform this type of work approximately one year prior in efforts to bring a highly desired European construction method to a growing North American market. Over the years, MDCI has made a commitment

MDCI began purchasing the necessary equipment to perform this type of work approximately one year prior in efforts to bring a highly desired European construction method to a growing North American market.

to building a fleet of shoring and drilling equipment such as oscillator/rotators (as seen on the TV series Monster Machines), and large top drive drilling equipment capable of drilling the hardest rock formations. The RTG 23 and Bauer BCM 5 cutter soil mixing operation is just an example of how MDCI's goal is to be a leading innovator of the shoring and foundation industry.

The 635 Elliott project is owned by local developer Martin Selig Real Estate. The General Contractor for the project is Lease Crutcher Lewis, also of Seattle, Washington. The project consisted of a 20 foot (maximum) excavation within a 125,000 square foot site footprint. The shoring scope of this project represents only a small fraction of the primary function of the shoring wall. Designed by KPFF Engineers of Seattle, Washington, the shoring walls primary larger function entailed the prevention of contaminated

In addition to CSM challenges, drilling and permanently sealing tiebacks located below the water table proved to be a significant test as well. The results of these efforts proved much better than most critics imagined.

ground water from entering a site bordered by city streets and the Burlington Northern Santa Fe railroad line. MDCI's first CSM wall was intended to mix three

(continued on page 11)

MDCI employee unloads drill steel while installing tiebacks through the Cutter Soil Mix Wall. After tieback installation, holes were plugged with chemical cement to stop the inflow of water.

to four completely different soil types into one semi uniform, 200 psi, non-permeable cutoff wall. In addition to CSM challenges, drilling and permanently sealing tiebacks located below the water table proved to be a significant test as well. The results of these efforts proved much better than most critics imagined.

Unlike conventional slurry walls and diaphragm walls that utilize concrete, soil mixing relies on mixing the soils in situ with a cement and bentonite slurry to create a soil-cement wall. Cutter Soil Mixing technology utilizes two sets of vertically mounted cutting wheels rotating about a horizontal axis to produce rectangular panels of treated soil. By overlapping the soil mix panels, a continuous rectangular wall is constructed, as opposed to circular columns created with conventional single-axis or multiple axes deep soil mixing systems. Upon completion of an individual panel, two 18 inch wide flange beams are inserted into the wet "concrete like" soil cement material to provide structural strength to the non-permeable mix. Later, following excavation of the interior of the foundation, tieback anchors can be installed to further increase the shoring capacity of the CSM cutoff wall.

Cutter Soil Mixing technology utilizes two sets of vertically mounted cutting wheels rotating about a horizontal axis to produce rectangular panels of treated soil.

MDCI employee cleans and inspects cutter wheels after shaft installation. Continual maintenance was a major factor in the projects success.

The Elliott Avenue project is located just north of downtown Seattle at the base of Queen Anne Hill. The project design required permanent ground water cut-off to depths of up to 43 feet in mixed soil conditions. The soil consisted of 10 to 15 feet of loose sandy fill with gravel, wood debris and concrete obstructions. Underlying the fill were the original beach deposits, 3 to 20 feet in thickness, consisting of very loose to medium dense silt, silty sand, clean sands and gravels. Below the beach deposits lies a stiff to hard, glacially over-consolidated clay layer, with SPT blow counts ranging from 20 to 30 blows per foot and moderate to high plasticity, with 25 to 40 Plasticity Indices. Underlying the clays lies a very dense glacial till layer of silty sands with gravel and SPT values in excess of 50 blows per foot. The groundwater table at the site was found at a depth of 2 feet from construction grade. It was thus necessary to support the saturated loose sands and gravels with a robust earth retaining system. **Cutter Soil Mixing (CSM) was selected as the method of choice based on price and schedule relative to a concrete diaphragm wall. Another advantage is the ability to construct a permanent, high quality soil-cement wall even in the gravels and stiff plastic clays, plus its capacity to key into the glacial till, and its ability to produce a soil-cement material with a minimum strength of (200 psi) and a maximum permeability of 5 x 10-6 cm/sec as specified by Kleinfelder Associates (the project geotechnical engineer).** To provide an understanding of the permeability requirements, within the

(continued on page 12)

The encountering of existing wood piles was a common occurrence on the Elliott site. The BCM 5 cutter head made quick work of these obstructions and the resulting shavings simply floated to the top and were removed with the spoils.

need cutline

41,000 square feet of effective cutoff (below water table), only 17 gallons per minute of water was allowable through possible leaks, cracks, or normal wall perspiration. At the end of the day, the total amount of water penetrating the CSM (per discharge rates) was less than 4 gallons per minute.

The area where the new 635 Elliott Avenue building is to be constructed is adjacent to Elliott Bay (part of the Puget Sound) and was at one time the old Elliott Bay shoreline. Over the years the site has been filled so that the current shoreline is now located 300 to 400 feet to the west of

By jobs end, and including obstruction delays, MDCI was able to shave an additional three plus weeks off the project schedule with little to no cost impacts to the owner.

the project site (Kleinfelder 2007). As such, parts of an old buried sea wall rip rap, timber piles, and other obstructions were anticipated, and actually encountered, during construction of this project.

Two hundred and forty panels with an average depth of 45 feet were to be dug in the above mentioned ground type. From the beginning, it was the hope of the project team to remove all known pile obstructions in hopes of reducing obstructions and cost impacts. The pile removal process was somewhat successful but the removal of known obstructions amounted to only one third of the project site. In the remaining locations, obstructions such as wood, concrete, and boulders were encountered in approximately 50% of the panels. To the surprise of all involved, the MDCI owned Bauer RTG-23 with BCM 5 soil mix head cut through the obstructions with relative ease. By jobs end, and including obstruction delays, MDCI was able to shave an additional three plus weeks off the project schedule with little to no cost impacts to the owner.

The project team was further aided in their efforts to provide a quality product by Bauer's onboard B-Tronic computer control and recording system. The B-Tronic touch screen computer system allows the drill operator to monitor and control the position of the cutter head to within tenths of an inch, independently control the cutter wheels, and monitor grout and hydraulic pressures. The data from each drilled panel and corresponding batch of grout was stored on memory cards which were then transferred to a laptop computer, where Bauer's B-Report software created graphical logs of each panel. These computerized installation logs were submitted to the project team on a daily basis, providing real time quality control and assurance. During panel installation, the real time data enabled the operator to make on-the-fly corrections to account for obstructions and changes in soil types. In cases where obstructions caused significant positional deviations, the Malcolm Drilling site superintendent was able to determine immediately whether re-digging the panel to achieve proper position and overlap was required. Vertical tolerances were critical on the Elliott project. Given the close proximity to the water table and the cut-off nature of the panels, should verticality be jeopardized on any of the projects 240 panels, the resulting water

These computerized installation logs were submitted to the project team on a daily basis, providing real time quality control and assurance.

inflow would render the system ineffective. Repairs for such conditions would have been very costly but fortunately the success rate of MDCI's installation never dropped below 100%.

CSM construction typically requires a large site footprint in order to erect the on site batch plant and maintain access for daily deliveries of approximately 65 tons of bulk cement, but it is also essential in regards to absorbing the fairly large indirect costs of mobilizing the various equipment pieces to the site. 635 Elliott met both of these requirements. Prior to being awarded the CSM contract, MDCI had priced a more conventional/typical secant pile wall. This option proved very expen-

(continued on page 15)

sive and given the knowledge of existing underground obstructions, the resulting delays would create schedule impacts.

The CSM option saved the 635 Elliott owner approximately 20% in comparison with a conventional secant pile wall.

The CSM option saved the 635 Elliott owner approximately 20% in comparison with a conventional secant pile wall. In addition, the CSM shoring system took less time to construct. three weeks time was shaved off the preliminary construction schedule after switching from the Secant approach. During construction, MDCI was able to trim an additional three weeks from the master schedule on account of the well coordinated efforts of the construction team.

Once the permanent cutoff wall was constructed, the challenge became addressing the contaminated water table which was now limited within the confines of the site. MDCI designed and submitted an elaborate combination of vacuum well points and deep sumps in efforts to drain a "bath tub" which held over four million gallons of water contaminated with both chlorinated and petroleum based hydrocarbons. The water was then transferred to a treatment system where it was stored and treated prior to discharging into the City of Seattle's storm sewer. MDCI began self performing broad scale dewatering projects in 2000 when it purchased local dewatering contractor. Anderson Dewatering. Over the course of the last 8 years, MDCI has become very involved in dewatering projects in the Northwest Region. With the presence of the contaminants, MDCI sought the experience and expertise of Clearwater Compliance Systems, Inc. of Lynwood, Washington to provide a multi-faceted, charcoal filter system to meet the stringent discharge requirements of the City of Seattle. The complexity of the system resulted in a reduction of expensive materials such as carbon and string filters which resulted in a significant savings for the project owner. In the end, the dewatering worked as planned making way for the excavation stage of the project.

The engineer inspects the final product. Amazingly, very few leaks were encountered during excavation and in the event one was encountered MDCI crews would quickly repair them.

125,000 square foot site footprint excavated up to 14' below the water table, the success of MDCI CSM shoring allows for a dry site.

In our opinion, the final benefit of CSM shoring, given the right conditions, is the elimination of lagging required to shore between piles. Conventional shoring systems require close coordination between the earthwork and shoring contractor. Typically excavations occur in lifts or cuts no greater than 6' in elevation. The earthwork contractor is essentially restricted to excavate only at a pace sustainable by the shoring contractor. On the 635 Elliott site,

(continued on page 16)

the excavation contractor was free to excavate at their own pace and schedule. The soil cement mix performs the task of lagging leaving a relatively smooth face to also act as a form for the outside of the permanent foundation wall. Given that the soil is 100% restrained, coordination issues that would typically slow the excavation process are reduced and the excavation can be performed more efficiently. Excavation depths could go from grade to the bottom of the footing in one cut. This was advantageous for the building contractor as well, as the footings are made available sooner than if conventional shoring methods were utilized.

In our opinion, the final benefit of CSM shoring given the right conditions is the elimination of lagging required to shore between piles.

The 635 Elliott Project proved to be a success for all involved. The challenges such as permeability, strength, and effects of obstructions were addressed with huge success, and the project benefited from both financial and schedule perspectives. Since the completion of the 635 Elliott project, MDCI has made further investments towards increasing its CSM capabilities. MDCI has procured a new RTG-25 Universal Piling Machine as well as an even larger BCM 10 cutter head from Bauer. With the acquisition of this new machinery, MDCI is capable of installing much larger panels as well as provides MDCI with more flexibility in regards to the numerous types of design considerations. With the influx of new equipment and the willingness of company owner John Malcolm to invest in new technology, MDCI looks forward to continuing success in this ever changing market place.■

Project Team

Owner:	Martin Selig Real Estate Jim Light, John Knickerbocker and Clyde Jones
Architect:	Ruffcorn Mott Hinthorne Stine
Structural Engineer:	KPFF Consulting Engineers Brian Robinson, P.E., S.E.
Civil Engineer:	KPFF Consulting Engineers Chris Park, P.E., C.E.
Geotechnical Engineer:	Kleinfelder Associates* David Cotton, *Principle Geotechnical Engineer* Robert Plum, *Principle Professional* Steven Flowers, *Geotechnical Engineer*
Environmental Consultant:	Entrix Inc. Robert Barrick, *Senior Consultant*
General Contractor:	Lease Crutcher Joe Neuenschwander, *Design/Build Manager* Tom Holzer, *Project Manager* Grant Howard, *Project Engineer* Jim Rose, *Project Superintendent*
Shoring Contractor:	Malcolm Drilling Co., Inc.* John Kvinsland, *Project Manager* Andy Majewski, *Project Manager* Bill Anderson, *Dewatering Manager* Wayne Broughton, *Superintendent*
Water Treatment Contractor:	Clearwater Compliance Services, Inc. John Nunn, *Estimator* Dallas Hoover, *Project Manager*

**Indicates ADSC Members*