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Foundation DRILLING

Moretrench Micropile Foundation Systems Aid in New York State Flood Mitigation

ADSC
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MC 602 drill rig with shortest mast configuration drilling Pleasantville test pile in river bed.

Moretrench Micropile Foundation Systems Aid in New York State Flood Mitigation

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With New York State suffering nine Presidentially declared disasters due to extreme weather conditions in the first three years of his office, Governor Andrew Cuomo launched his New Reality Storm Plan in 2014 to better protect New Yorkers from future events. The far-reaching plan includes The Scour Critical/Flood Prone Bridge Program which identified 104 bridges State-wide that were most at risk from repeated flooding and vulnerable to scour from the volume and velocity of water generated during extreme events. The $518M bridge upgrade/replacement program will be jointly underwritten from FEMA funding and the U.S. Department of Housing and Urban Development and administered by the New York State Department of Transportation. A range of improvements are incorporated in the program, including bridge abutment and pier upgrade, increasing waterway openings, and eliminating water-based bridge piers to reduce debris build up that can cause localized flooding.

Micropile Solution

The overall program included the $40M Region 8 Bundled Bridges Design-Build contract. Three of the six bridge upgrades included under this contract were straightforward. The remaining locations, all in Westchester County along the Saw Mill River Parkway, presented a much more complex scenario.

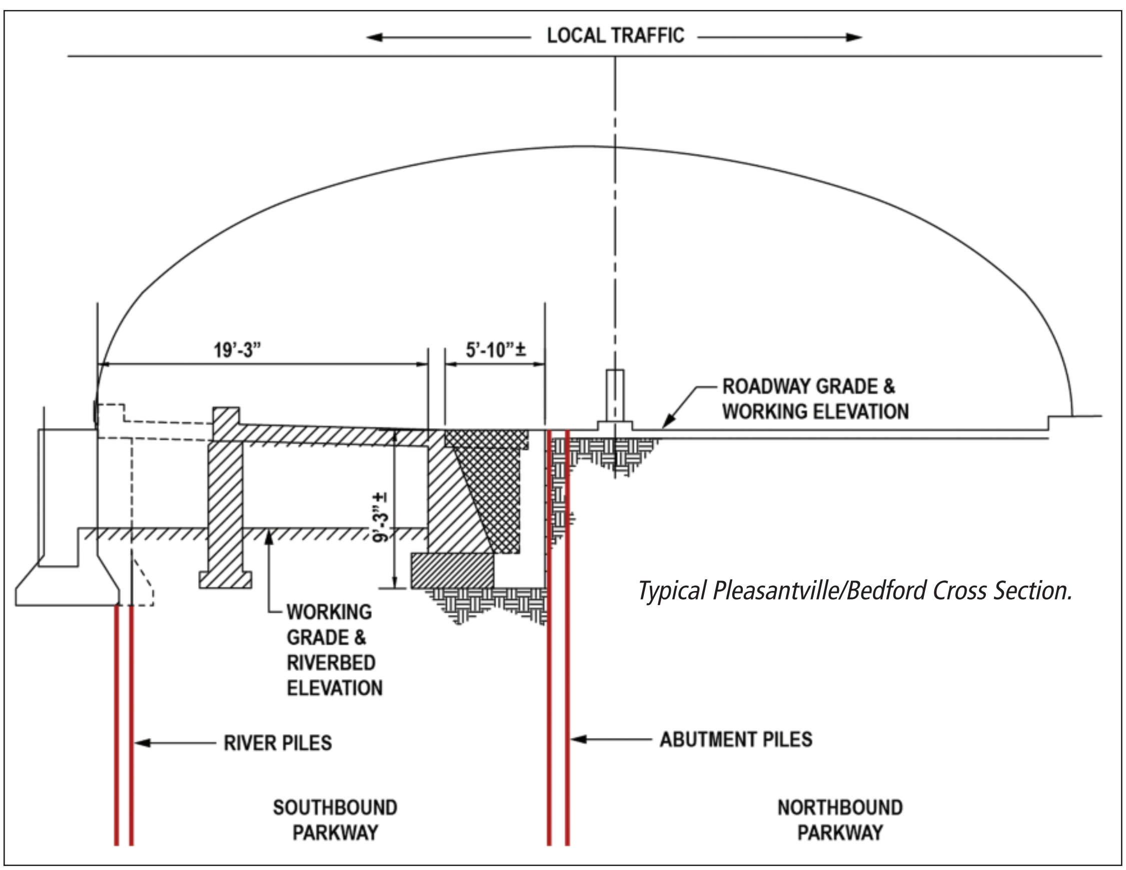
In Bedford and Pleasantville, the river parallels the Parkway for the most part but where the Parkway runs beneath historic stone arch river bridges supporting local traffic routes, a 2-lane span of the 4-lane roadbed sits atop columns founded in the water, effectively creating a bridge beneath a bridge. The remaining lanes bear on soils. At these locations, the primary objective was elimination of the water-based piers. In Mount Kisco, the bridge was slated for a full foundation and deck replacement across all four lanes.

In preparing its bid for the contract, General Contractor ECCO III Enterprises assembled a project team including design engineers McLaren Engineering, geotechnical engineers GeoDesign, and ADSC Contractor Member Moretrench. The team spent considerable time brainstorming the options to arrive at the optimum approach that could be accomplished under severe site constraints and within the very narrow timeframe while maintaining traffic flow. At the Bedford and Pleasantville locations, McLaren's final design called for replacement of the river-bearing pier and abutments with micropile foundations that would carry the axial loads of the proposed new roadway deck in addition to the lateral loads behind the abutment. At Mount Kisco, the design incorporated vertical and battered micropiles and driven H-piles for the proposed substructure. Moretrench performed micropile installation at all three locations, while ECCO self-performed the driven H-piles.

Significant Challenges

The project created significant technical and logistical challenges. With the river temporarily diverted, the stone arches afforded a mere nine feet of overhead clearance from working grade and less than six feet of space between the active roadway rail guards and the stone arch interior face. Even in its most compact configuration, Moretrench's MC 602 drill rig tracks and mast would allow only a couple of inches of clearance in either direction. Additional modifications, including mounting the winch on the side of the mast, were needed to access micropile locations within the tight constraints.

The subsurface conditions were complex. The profile at Bedford generally consisted of gravelly sand 10 to 20-ft. thick underlain by decomposed rock which ranged in thickness from 0 to 15-ft. Beneath this, more competent rock was encountered with depth. The bedrock varied between gneiss and mica schist, which added another element to be considered during the design and testing program. At Pleasantville, a 5 to 14-ft. thick fill layer at grade was underlain with medium dense to dense gravelly



Typical Pleasantville/Bedford Cross Section.

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Dockbuilders working the front of the MC 602 to add another section of casing.

sand. At Mount Kisco, the grade level fill was 11 to 13-ft. thick underlain with a 30 to 37-ft. thick stratum of dense glacial till (sand with silt and gravel) followed by gneiss bedrock.

The river gravels presented a drilling challenge due to the nature of the smooth rocks and the low friction between the particles. While drilling smooth gravel, the lack of friction causes the particles to roll and slide over one another, preventing efficient cutting. The drill methods therefore had to be modified to accommodate the gravels, and then altered again to handle the rock drilling. To advance through the gravel, the roller bit was equalized to the same tip as the casing and this allowed for better penetration than a typical set-up that leads the drill bit ahead of the casing by a couple of inches. Depending on the type of rock encountered, the drilling technique was applied accordingly. For instance, the weathered mica schist was mostly drilled with a roller bit in a conventional application, leading a few inches ahead of the casing to seat the casing into rock, then advanced without the casing to construct the sockets. The gneiss rock was generally more competent and required the use of an air powered down-the-hole hammer to construct the rock sockets.

Due to the fluidity inherent in a Design-Build contract, the project engineer increased the lateral loads on the piles after the project was awarded, requiring close collaboration between the project teams to implement design changes in a timely manner that would not delay the aggressive construction schedule. Adding to the technical challenges were the logistics of working multiple shifts to maintain the construction schedule and the need to completely clear the work area after the night shift in time for the morning commuter traffic. In the most critical work period, one rig was working in the river bed during the day and two rigs were working simultaneously on the roadway during the night traffic closure.

Micropile Design

The design intent at Bedford and Mount Kisco was to case the micropiles through the soil and decomposed rock and bond them within the poor to fair quality bedrock. At the Pleasantville location, rock was not anticipated within the pile depth, therefore a bond zone in the dense till was utilized for the design. At Bedford and Pleasantville, the abutment micropiles were re-

Dockbuilder signaling the driller to line up the 3-in. long threaded joint during drilling of gravels within the tight constraints and slippery work surface associated with the river-bearing piles.

quired in the roadway to support the earth and roadway loading, and the river bearing piles were required to support the column loading of the proposed Parkway bridge. The primary challenge was to design the abutment piles to carry fairly high lateral loads generated by the earth pressures of the soil and roadway surcharge behind the existing abutment while utilizing the smallest pile diameter feasible due to the aforementioned tight site constraints. To accomplish this, the project team was able to keep the maximum pile diameter to 12.75-in. and utilized an inner pipe inside that casing which consisted of either a 9.625-in. or a 7-in. diameter casing to increase the section modulus of the pile. A combined stress analysis was also used to ensure that the pile would perform properly under simultaneous loading. In addition to the inner casing, a center bar was installed in all micropiles to reinforce the uncased bond zone. The river-bearing piles were more straightforward from a design standpoint. Given that their primary loading was axial, these did not require an inner casing.

The thread design for the jointed micropile casing was of particular concern given the substantial lateral loads for the abutment piles. In situations where micropiles are to be used as earth retention piles, the piles would ideally be constructed using a single solid piece of casing to maximize the bending capacity of the micropile casing while keeping the pile diameter as small as possible. In this situation, that was not an option due to the low headroom constraints. Drawing on previously published technical literature as well as Moretrench's considerable experience in this particular area, the project team was able to incorporate a moment of inertia reduction in the casing at the threaded joint location to assist in supporting the lateral loading. Based on the literature findings showing that similar capacities could be generated by either a 2.5-in. or 3-in. long thread, although the failures modes would be different, the project engineer felt more comfortable with the 3-in. long thread. That design option was therefore selected.

Tension load test underway in Pleasantville river bed. Note the diverted river piping and guardrail protection.

Load Testing

Load tests were conducted in accordance with NYSDOT GCP-18 guidelines at all three locations prior to production micropile drilling. The load testing at Mount Kisco was performed on a plumb production pile loaded to 328 tons in compression and utilized the Davisson Offset Limit Acceptance Criteria. Two production reaction piles were used to lock the test beam down onto the cribbing. The results proved the 10-ft. bond length was more than sufficient and the pile performed almost entirely elastically with only 0.035-in. of net settlement.

Rather than compression testing, tension load tests were conducted at Pleasantville and Bedford, in part to reduce the testing time required and also to eliminate the need for two additional reaction anchors per test. A 2-cycle loading sequence was utilized in an attempt to take the sacrificial test piles to failure. Both test piles were instrumented with spot-weldable strain gauges to monitor load transfer throughout the pile.

At Pleasantville the test first ran up to 200% of the 53-ton design load, then an attempt was made to load the pile to failure; however, at 300% loading the cribbing towers failed prior to pile failure. The test was nonetheless successful, verifying the 20.5-ft. bond length was appropriate for soil.

At Bedford the same loading intent was utilized as at Pleasantville except that a 5-ft. bond length was designed for bedrock. During the test pile installation, the competent rock was encountered at about 80-ft. down which was 40-ft. deeper than anticipated, and was overlain by a thicker layer of decomposed/weathered rock. The test pile required two days of drilling in order to eventually "fetch up" into the competent rock. Although the project team agreed that the decomposed rock was more than sufficient to carry the loads, the decision was made to bring that

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MC 1200 rig drilling the few abutment piles with no headroom restriction.

test pile into the competent rock so that a load test could be conducted to verify the rock bond stress. The team attested that the load test results from the less competent Pleasantville soil bond zone would be a conservative underestimate of the decomposed/weathered rock bond stress at Bedford. The test was loaded in two cycles and on the second cycle failure was obtained at 290% of the design load where the load settlement curve exceeded the Davisson Offset Limit. The net result of the Bedford testing yielded two different design scenarios depending on which stratum was encountered during production. Either a soil-type bond zone was constructed 20.5-ft. in the decomposed rock or a 5-ft. bond zone was constructed in more competent rock.

Bedford / Pleasantville Production Piling

From a construction standpoint, the river piles were very challenging to install due to the arched overhead stone bridge, flowing groundwater, and limited working width alongside active traffic lanes. Although the flowing river was diverted, the groundwater table was not lowered and was at drilling grade. The drilling crews had to be aware of their surroundings and had to walk/work very carefully on the river rock. There was one occasion in particular where the drilling crews could not work since the diversion dam breached due to an excessive storm event. In addition to drilling within the physical constraints, the traffic adjacent to the river piles had to be protected from drill spoils. Plywood protection was installed onto the existing steel guardrail to provide a shield from any soil cuttings spraying onto the adjacent roadway traffic.

During the design stage, the selection of the 3-in. long threaded joint did not appear to have any construction impacts; this was not the case in the field. In tough drilling situations, i.e. the rounded river gravels, the extra-length thread presented quite a challenge for the drill crew. While drilling through the gravels, the drill rig's alignment could be thrown off the pile location and thus disturb the alignment with the threads. While a typical thread length is 2.5-in. in length, the 3-in. length was not as forgiv-

Moretrench's MC 1200 working beneath the Kisco bridge where more headroom was available.

ing for adding or removing sections of casing, especially when the alignment was only fractions of an inch off the mark. The result was longer drilling times and the more severe impact was stripping and/or damaging casing threads, which required entire strings of casing to be replaced in some situations.

The abutment piles were drilled from the Saw Mill Parkway roadway during night work under a Parkway closure. The majority of the piles were drilled with a low headroom rig to allow access underneath the overhead stone arch bridge, but the few piles that were outside of the overhead footprint were installed using a much larger MC 1200 drill rig to expedite the schedule and increase the production. Moving the equipment on and off the Parkway each night was well coordinated by ECCO and minimal downtime was achieved. ECCO also devised a road plate system that fit together like a puzzle along the alignment of the abutment. This allowed for controlled spoils clean-up below the roadway elevation and covered each micropile hole prior to opening the Parkway in the morning.

ECCO III driving H-piles while Moretrench's MC 1200 installs battered piles under the Kisco bridge.

Working within the confines of the Bedford stone arch bridge next to active traffic lanes.

Mount Kisco Total Replacement

Since more working room was available at Mount Kisco than the other two locations, Moretrench was able set up the drill rig with a specific length of mast to physically fit under the existing bridge, yet provide enough stroke to install 10-ft. lengths of 12.75-in. diameter casing. The drill rig had to be tracked into the excavated trench of the proposed abutment at the water table depth, with sump pumps working to control the water. The main challenge was to work with a large rig inside a narrow trench in between existing columns and an existing embankment. The design called for both plumb piles and 1H:6V battered micropiles to handle some of the abutment lateral loads, which added to the difficulty of the site logistics.

Substructure & Superstructure Construction

Bedford & Pleasantville Locations: With both southbound lanes

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ECCO III setting superstructure precast concrete slabs.

accessible during the nightly shift, ECCO completed all river pile and substructure work falling under the footprint of the southbound Parkway lanes. ECCO first established a road plating system using skid resistant plates securely anchored and recessed into the existing pavement. On a nightly basis, ECCO removed plates as necessary to allow excavation, drilling and installation of micropiles by Moretrench, construction of a reinforced concrete pile cap, completion of the proposed substructure connection to the existing retaining wall and, in general, completion of all east side substructure preparatory work necessary prior to the implementation of the full 24/7 detour superstructure phase.

The abutment pile and substructure work falling outside the footprint of the southbound SMRP lanes was constructed during daytime shifts utilizing single lane southbound closure during off-peak hours. Because the abutment side work area is outside the footprint of the southbound lanes, work progressed unencumbered by lane closure restrictions.

With all the pile supported substructure elements in place, the superstructure phase could begin. During this phase, southbound traffic was reduced to one lane and detoured onto the northbound left lane for the full 24/7 detour, which was allowed for 21 days. During this period, ECCO demolished the existing bridge, set the new superstructure precast concrete slabs, formed and poured Ultra High Performance Joints that join the slabs together, and completed all other miscellaneous roadwork including guide rail, asphalt paving, concrete approaches, and striping. Once this work was completed, traffic was restored to the original configuration ahead of schedule.

Mount Kisco Location: Once the micropiles were installed, ECCO constructed 95% of the substructure prior to the superstructure replacement stages using "bridge under bridge" construction techniques. This approach allowed ECCO to complete the proposed substructure footing and stem walls up to the new bearing pedestal elevation underneath the existing superstructure while the existing superstructure was still in place. Due to existing superstructure interference, the final back wall and approach work was completed during the subsequent stages. The superstructure replacement was performed in three stages which also included noise walls, rock blasting, widening and auxiliary lanes, asphalt paving, guide rail, curb, median barrier, detention basins, and drainage.

Overall, the Design-Build process was instrumental in completing a complicated project in an expeditious manner. ECCO worked relentlessly with all the team members to ensure ideas were shared effectively, and the results speak for themselves. The geotechnical engineer, GeoDesign, was a critical team member by providing the project engineer with assurance that the foundation design and construction was technically sound. Moretrench's superintendent is quoted as saying, "I still don't know how we did that!"

Project Team

Owner:	New York State Department of Transportation
General Contractor:	ECCO III
Design Engineer:	McLaren Engineering
Geotechnical Engineer:	GeoDesign Inc.*
Geotechnical Contractor:	Moretrench*

**Indicates ADSC Members*