THE VIRGINIA WAR MEMORIAL EXPANSION PROJECT

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Considered to be one of the nation's premier state memorials honoring military veterans, the Virginia War Memorial is situated on a five-acre bluff overlooking the James River and downtown Richmond, Virginia. Dedicated in 1956, it serves as a shrine to the nearly 12,000 Virginians who have given their lives serving in the U.S. Armed Forces during World War II, Korean War, Vietnam War, Desert Storm, Desert Shield and the Global War on Terror.

Interest in the memorial and its programs has increased over 500% in recent years, and today it attracts more than 70,000 visitors annually. To better serve these guests, a $26 million expansion project is underway that will add 26,500 sq. ft. in educational facilities, administrative office space, a lecture hall, parking deck and a second shrine that expands the recognition of veterans of the Global War on Terror. KBS of Richmond serves as the project's general contractor, Robert Silman Associates of Washington, D.C. provided structural engineering, and ADSC Contractor Member Subsurface Construction Company (SCC) of Raleigh, North Carolina was selected as the geotechnical construction partner charged with shoring the site, which is adjacent to the historic stone and glass structure.

THE VIRGINIA WAR MEMORIAL.

SITE ASSESSMENT AND INITIAL CONCEPT

The jobsite was bounded by the existing structure on the west side, 2nd street on the east side, and property lines and utilities on the north and south sides, requiring shoring on all sides for the excavation. The lower level of the new parking deck was 20 to 36 ft. below existing site grades. The project structural drawings required a Design-Build temporary sheeting and shoring system using sheet piling and anchors along the streets and property lines. To support the existing museum and reduce lateral earth pressure on the new parking garage foundation wall a Design-Build permanent secant pile wall was specified. Movement tolerances of the existing building were limited to 1⁄2 inch vertical settlement and 1⁄4 inch horizontal movement during excavation and shoring wall construction.

The site is approximately 800 feet north of the James River, which presented some difficult drilling conditions. The geotechnical report indicated that approximately 15 to 30 ft. of fill would be encountered during the excavation and shoring installation, followed by alluvial clays typically seen in the Richmond area. The fill was highly erratic with soil types ranging from sands to clays to cobbles and debris with very soft to stiff consistency. Bedrock was very deep and not an issue with regard to shoring installation. In addition, borings indicated that groundwater was present at the bottom of the excavation. Several utilities and associated structures were present along the shoring line that had to be considered for shoring system feasibility.

CONSIDERING ALTERNATIVE SOLUTIONS

SCC provided budgeting services to the general contractor several times prior to final bid. Preliminary budgets assumed soldier piles with wood lagging and tie-back anchors. However, conventional soldier pile installation would adversely impact the cost and schedule due to collapsing ground and the presence of groundwater. In the end, SCC performed further analysis and proposed value engineered temporary shoring solutions while providing the required secant pile wall system.

For the temporary shoring, a hybrid system of pipe piles with wood lagging and conventional shotcrete soil nail walls was installed along the northern perimeter of the site where several utility lines were present. This hybrid system allowed for cantilevering the upper 5 to 8 ft. of the excavation. Installation of drilled nails started approximately 8 to 10 ft. below existing grade and utility elevations.

Along the eastern and southern perimeters, sloping was utilized to lower the top of the shoring below the utility elevations, where the SCC driven soil nail wall system was installed.

For the secant pile wall, SCC also proposed a value-engineered permanent drilled soldier pile wall with anchors and a shotcrete face as a cost and schedule-reducing alternative. However, the project design team opted to proceed with the specified secant pile wall.

COMMUNICATION AS A CRITICAL SUCCESS FACTOR

Because the secant pile wall is a slower construction process in comparison to the soil nail walls proposed for the remainder of the site, early and frequent education and communication with the project team were critical. Early in the preconstruction phase, SCC met with the team to present work bench plans for secant pile equipment as well as durations for the secant pile wall installation so that all parties could proceed efficiently. Due to the small footprint and geometry of the site compared to the depth of the excavation, no other excavation or shoring work could take place once the secant pile drilling elevation was reached. Early communication allowed the client to schedule subcontractors to perform other work and avoid unnecessary downtime. This close coordination and accurate scheduling fostered a positive relationship across the entire project team.

INSTALLATION

DRILLING UNDERWAY FOR SECANT PILES.

DRILLING UNDERWAY FOR SOIL NAILS.

SOIL NAIL WALLS

The hybrid pipe pile and conventional shotcrete soil nail wall had an overall retained height of approximately 35 ft. A primary challenge with design and installation was coordinating the location of soil nails (+/-45 ft. long) to miss existing utilities and soil nails on the opposing side of an outside corner. SCC was concerned that despite engineering the nails to miss, slight drilling deviations would inevitably cause damage to previously installed nails. To mitigate this risk, significant effort was spent on the layout of each soil nail while continuously monitoring during drilling to ensure the original alignment was maintained. In addition, the shotcrete facing was not applied until all drilling within the zone of opposing nails was complete for each lift.

VIEW OF COMPLETED SOIL NAIL WALL.

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SECANT PILE WALL

For the secant pile wall, SCC teamed up with the experts at Equipment Corporation of America (ECA) to supplement its own experience with this construction method. From the initial bidding process to the wall's construction, SCC worked closely with ECA's Gordian Ulrich and Jeff Harmston to assess the appropriate drill rig and tooling needs. Casing was required due to the soft ground, presence of groundwater, and accuracy of the alignment of the piles. SCC used a Bauer BG 20 rig with 35-inch sectional casing and an earth auger for secant pile installation. The process alternated between 1-2 days of primary pile construction and 1-2 days of secondary pile construction spaced at 6 ft. on center. The construction of the secant pile wall was a success, two weeks ahead of schedule, due to pre-planning with the ECA team.

THE COMPLETED SECANT PILE WALL.

ANCHORS

Once the excavation had progressed 6 ft. below the top of the wall, a pressure grouted anchor was installed through each primary secant pile. The anchor location was designed 4 to 5 ft. below the top of the wall to reduce movement during the temporary cantilever condition. Anchor design lengths were on the order of 75 feet, extending underneath the existing museum. For anchor installation, SCC chose continuous flight augers to eliminate the need for drilling with compressed air thereby reducing the risk

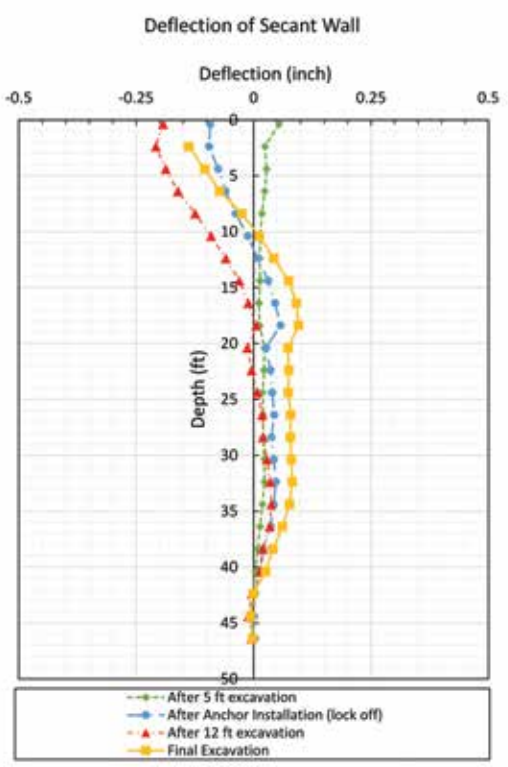
DRILLING ANCHORS THROUGH THE SECANT PILE WALL.

of damage to the existing building. The anchors were drilled through prefabricated holes in the H-piles located in secondary piles. Anchors were tested and locked off at 119 kips.

TOLERANCES AND ACTUAL MOVEMENT RESULTS

To meet the project tolerances and ensure overlap of the primary and secondary piles, Subsurface constructed a guide wall consisting of reinforced concrete on either side of a custom foam template that matched the secant pile dimensions. The secant pile tolerance for location and verticality was 3 inches and 1%, respectively. Meeting this tolerance was critical because the secant pile wall was designed to serve as the foundation wall and permanently support lateral earth pressures as well as structural loads from the adjacent museum building. In addition, a CMU wall was to be installed within inches on the inside of the secant pile wall, and a proposed drain line was to be installed on the back side with no margin for error.

SCC engineers performed a plain strain finite element (FE) analysis using various soil models to estimate the deformation behavior of the secant pile wall during excavation. The average maximum horizontal movement predicted was approximately 1⁄4 inch. Through-



GRAPH OF ACTUAL MOVEMENT MEASUREMENTS

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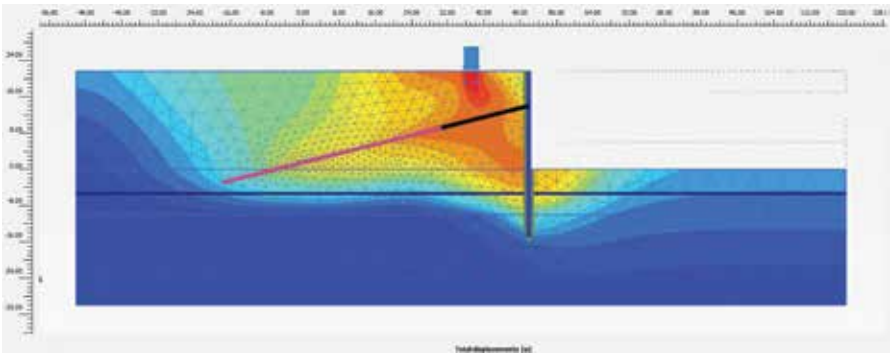
PLAXIS PREDICTION MODEL.



out the various stages of excavation, SCC calibrated the FE soil model using measured inclinometer data. The maximum horizontal movement measured was less than 1/10 inch.

PROJECT COMPLETION

Subsurface Construction Company takes the success of every project to heart, bringing their company values of honesty, creativity, excellence and efficiency to every endeavor. Through innovative thinking and continuous, transparent communication, SCC was able to deliver solutions that positively impacted the project budget and schedule. Teamwork, careful planning and open communication between the entire project team were instrumental in the ultimate success during excavation of the Virginia War Memorial Expansion project.

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"THROUGH INNOVATIVE THINKING AND CONTINUOUS, TRANSPARENT COMMUNICATION, SCC WAS ABLE TO DELIVER SOLUTIONS THAT POSITIVELY IMPACTED THE PROJECT BUDGET AND SCHEDULE."