SPUN PIPE PILES – A TIME SAVING ALTERNATIVE TO MICROPILES

Theresa McAuliffe, PE, McFarland Johnson, Inc., 207-417-4037, tmcauliffe@mjinc.com
Thomas Kendrick, PE, McFarland Johnson, Inc., 207-869-5419, tkendrick@mjinc.com

INTRODUCTION

The Maine Department of Transportation (MaineDOT) successfully replaced the Weskeag River Bridge utilizing Accelerated Bridge Construction methods while keeping costs on par with conventional construction methods. The main challenge for the project was finding a foundation type that was suitable to both the site constraints and roadway closure window, as well as offering reduced risk. This project was only the second use of spun pipe piles by the MaineDOT. The author will discuss how spun pipe piles retain many of the advantages of micropiles, how they were the best solution for the shallow bedrock conditions and underground obstructions, how they are compatible with integral and semi-integral abutments, and how their use played into the success of the project.

BACKGROUND

Located on a tidal causeway, the existing Weskeag River Bridge was a 1930's vintage two-span reinforced concrete bridge in poor condition and in need of replacement. The existing bridge was replaced by a 95-ft long single span utilizing a Northeast Decked Bulb Tee (NEDBT) superstructure in combination with pile-supported semi-integral abutments located behind the existing stone masonry abutments. Precast decked bulb-tees, a first-time usage in Maine, were paired with contractor self-performed precasting of the substructure units, and a spun pipe pile foundation.

SITE CHALLENGES

The project had many site related challenges and only a 35-day closure to accomplish all demolition and construction of the full bridge replacement. The bridge is located on a causeway across the Weskeag River which undergoes tidal fluctuations exceeding 10-feet. In addition, there was a high likelihood that underground obstructions would be encountered due to the use of stone in the original causeway and bridge construction. The new bridge foundations were built behind and in close proximity to the existing granite block abutments which were to be retained, with the addition of vertical rock dowels, for earth retention and scour mitigation. As such, one of the design considerations was prevention of the new foundations from exerting lateral loads onto the existing abutments. Even though the existing abutments were built on bedrock, the bedrock elevation was too deep to excavate for new footing construction while also staying out of the water. The elevation of the bedrock was also too shallow for a typical driven pile foundation to achieve fixity for a jointless bridge solution. The selection of the foundation type played an integral role in the success of the project but required an unconventional solution due to these site challenges.

Figure 1 – Site Challenges at the Existing Bridge

FOUNDATION TYPE SELECTION

Constructability and accelerated construction were at the forefront of all design decisions and one key element was a foundation system that could accommodate the site conditions noted previously. The foundation needed to limit disturbance to the existing abutments, be constructed out of the water, and adaptable to shallow bedrock. There are many significant advantages to drilled foundations over driven piles such as eliminating risk associated with obstructions and causing less vibrations to nearby buildings or structures. Of the drilled foundation types, micropiles offer additional advantages such as compact equipment size and low headroom requirements.

A spun pipe pile leverages all these advantages by using the same materials and equipment as a micropile but eliminates the major disadvantage; time consuming and costly testing. This is accomplished in how capacity is achieved.

SPUN PIPE PILES

A spun pipe pile is essentially an end-bearing variation of a traditional micropile without the central steel reinforcement (*Figure 4*). Spun pipe piles are high strength (80 ksi) steel threaded pipe sections that are drilled and socketed into bedrock and filled with grout. The spun pipe pile gains axial compressive resistance through end bearing on the bedrock surface at the bottom of the casing, which requires that the casing be filled with grout to provide end bearing resistance over the entire tip area. The steel casing is the structural pile. In contrast, for a traditional micropile, the steel casings are drilled to bedrock to facilitate a second stage of drilling into bedrock and subsequently placing a central reinforcing bar and grout. A micropile achieves capacity through side friction along the bond length in the bedrock. To confirm adequate geotechnical resistance, micropiles undergo load testing which adds multiple days, and sometimes weeks, to the project schedule.

Design Considerations

The geotechnical design of spun pipe piles considers the development of axial geotechnical resistance through end bearing on bedrock in accordance with the methodology for drilled shaft tip resistance on rock and the selection of an appropriate resistance factor.

For design, the structural capacity is based on the steel section alone, however, the pile stiffness considers the steel composite with the grout. Additionally, the design details specify the minimum depth to the first threaded splice to avoid a splice in the region of maximum bending stresses.

Figure 2 - Drilling of Spun Pipe Piles at Near Abutment while Precast Abutment Pieces Placed at Far Side

Figure 3 - Drilling Piles while staying out of the water

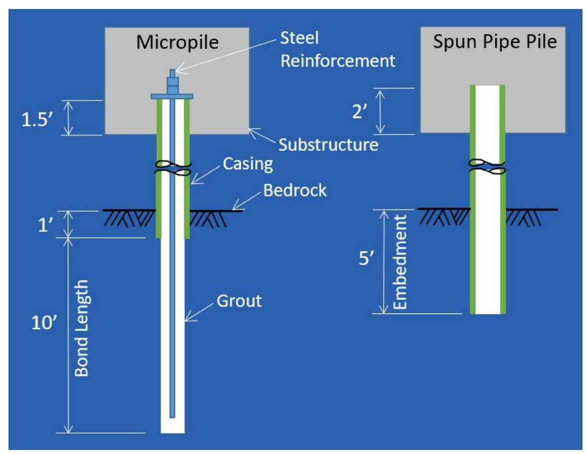

Figure 4 - Comparison of Micropiles and Spun Pipe Piles

Figure 5 - Threaded N80 Casing in 5-ft Lengths

Construction Considerations

Spun pipe piles are installed using the same methods used to install permanent micropile casing socketed into bedrock with the use of an internal bit. Each spun pipe pile tip is fitted with a sacrificial ring bit to facilitate the advancement of the pile into bedrock and to keep the bottom of the spun pipe pile and down-hole hammer locked at the same elevation. The pile and inner rods are advanced with the duplex drilling method with internal flush.

At the completion of drilling, the bedrock socket is thoroughly cleaned. The drilled holes are tremie grouted from the bottom of the bedrock socket up. Since load testing is not performed, a geotechnical engineer is onsite throughout the installation of the spun pipe piles. The geotechnical engineer observes and assess the following portions of the installation: depth to top of bedrock, embedment in the bedrock, the cleanliness of the bedrock socket, the length of pile installed, and grout volumes.

TIME-SAVING MEASURES

Multiple measures were taken on the project to reduce risk, namely in the selection of the foundation type. Encountering obstructions and performing load testing are two items that add significant risk to an ABC project during the bridge closure window. The ability to drill through obstructions, the reduction of drilling into bedrock (to develop side friction as in a traditional micropile), and the elimination of load testing through appropriate design methodologies, makes spun pipe piles an ideal candidate for ABC projects. Additionally, the number of pieces of equipment mobilized was minimized. For example, one piece of equipment was used to drill the spun pipe piles and socket them into bedrock as contrasted with drilled and socketed H-piles which typically require separate equipment to place the pile after drilling the hole with casing.

The contract specified a 35-day bridge closure. Despite a severe windstorm that caused extended power outages, the Contractor reopened the bridge after only 33 days. The installation of the twelve spun pipe piles (a total of 202 feet of drilled pile) was accomplished in 4-days working double shifts (96 hours total).

Figure 6 - Completed Bridge after 33-day Closure

CONCLUSION

Spun pipe piles are a time-saving and cost-effective foundation solution for full bridge replacements with challenging site constraints. By keeping constructability at the forefront of all design decisions and in the development of streamlining details, construction was simplified during the closure window.

One key element was a foundation system that could accommodate a jointless superstructure and the constraints of the site, including underground obstructions and relatively shallow bedrock. The drilling equipment also allowed the Contractor to stay out of the water, a significant advantage with a 10-ft daily change in water elevations from the tidal river. Unlike micropiles, spun pipe piles rely on end-bearing, negating the need for verification and proof load testing, saving critical time during the bridge closure. The project was the second use of spun pipe piles by the MaineDOT and resulted in a cost-effective foundation system compatible with ABC technologies with greatly reduced impacts to the local community, the environment and the traveling public.

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Findings and opinions expressed herein are those of the authors alone and do not necessarily reflect those of the other participants.