GRL Engineers, Inc. tests piles on major bridge in Ecuador

Driven piles save $12 million on $32.5 million drilled shaft proposal

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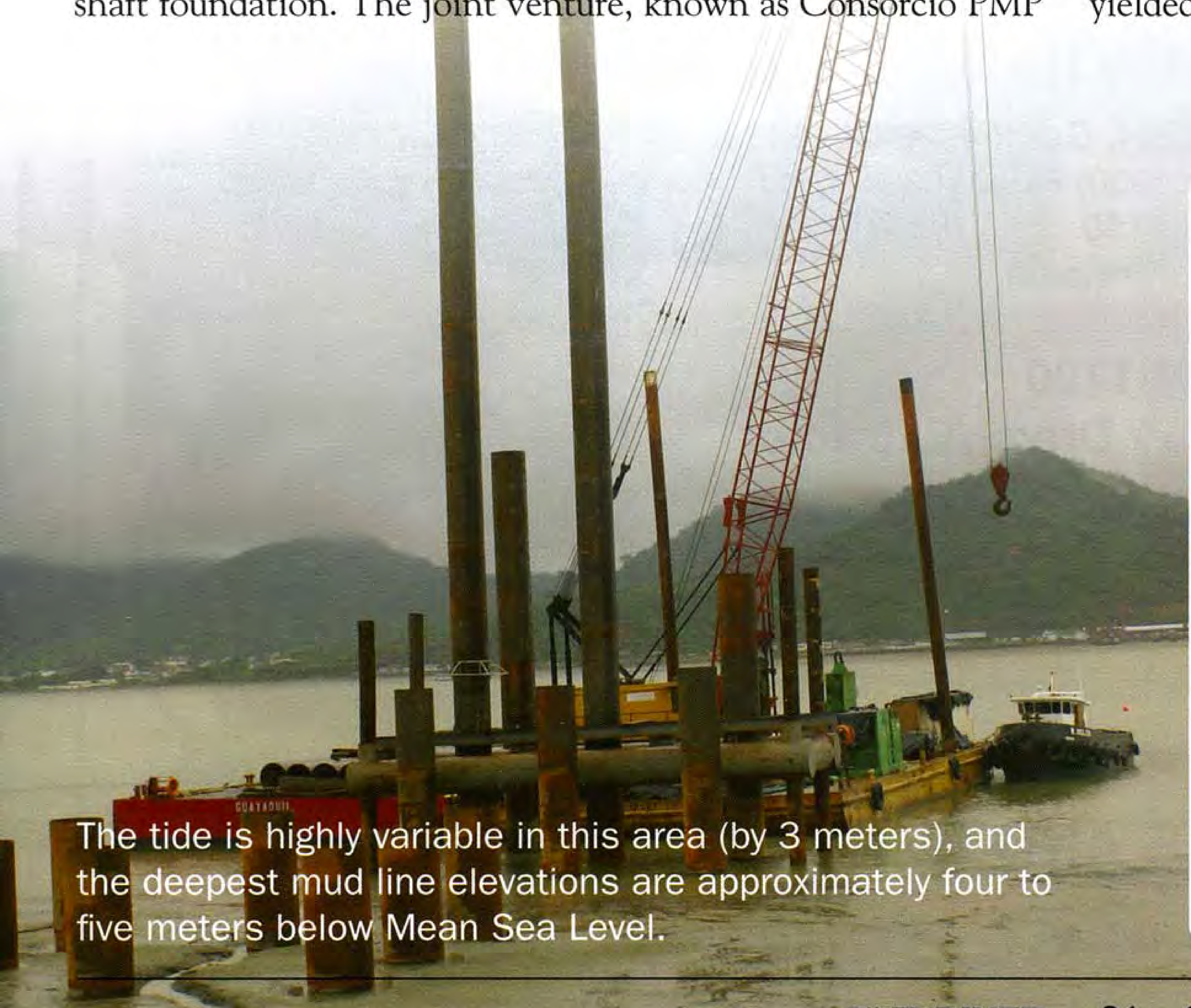
In December 2009, the final driven pile was installed at Puente Bahia-San Vicente, poised to become the longest bridge in Ecuador. The two-kilometer long bridge is located in the Manabi province of Ecuador. Its main purpose is to connect the cities of Bahia de Caraquez and San Vicente, where the river Chone flows into the Pacific Ocean. This region was hard hit by a 7.3 earthquake in August 1998, which brought complete devastation to the city. The city of Bahia has recently become a tourist location where people from around the country and overseas come to enjoy the great weather and beaches.

The construction of the bridge was considered a challenge, not due to the length of the bridge but to the conditions of its site: The tide is highly variable in this area (by 3 meters), and the deepest mud line elevations are approximately four to five meters below Mean Sea Level. This meant construction was time dependent since barges will have limited or no access to certain locations of the site during most of the day. Initially, multiple foundation designs were considered for the project. The final set of plans called for two 1.9 meter drilled shafts with a rock socket, this being the preferred foundation element used in this region. The anticipated shaft lengths were variable, but since the rock was generally encountered at depths greater than 80 meters, designs called for shaft lengths around 90 meters.

The initial accepted bid for the bridge bents, was slightly under 32.5 million dollars. After considering the difficulties and the amount of time that the foundation construction was going to take, a new design was proposed to replace the drilled shaft foundation. The joint venture, known as Consorcio PMP consisted of three companies: CIPORT, TECHNAC, and geotechnical Engineers Nylic (all national companies based in Guayaquil), proposed steel piles be driven in the forty bents of the central portion of the bridge. In addition, the joint venture proposed pre-stressed concrete piles to be driven at the six abutment elements near the city of Bahia, and three at the abutment elements in San Vicente. The main purpose of this proposal was not only to minimize costs but, more importantly, to reduce the construction time of this important bridge project. The Corps of Engineers of Ecuador, the entity overseeing the project, reviewed and accepted the design change. The final design included eight to sixteen pre-stressed concrete piles to be installed at each abutment element on land and eight or nine 1.2 meter diameter steel pipe piles over water at each individual bent. Due to the depth of the bedrock, it was also proposed that the piles be designed for friction piles which would eliminate the need to drive them into bedrock. Due to the high seismic activity of the region in which Bahia and San Vicente are located, it was proposed to dynamically instrument multiple piles in the bridge, to assure piles met the required capacities below the expected liquefiable zones. Loose sand deposits were encountered in the upper layers (sometimes close to 30 meters) followed by clayey sands and silts, which increased the challenge of pile acceptance. GRL engineers were contracted to perform test pile installations at both abutments and bents utilizing high strain dynamic pile testing (PDA) as the main tool.

Initial installations of the driven piles at the abutments yielded shorter lengths than expected, vastly exceeding the



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required loads in these locations. The estimated cost savings in both abutments was close to 3 million dollars with respect to the initial proposed estimate, in foundations alone. To start installing the steel piles in the central portion of the bridge, a test pile program was executed, which included initial drives and restrike testing of multiple piles. After completion of an initial test program, it was determined that high levels of soil setup developed after the initial pile installation. Driving criteria was developed for the piles, not for them to achieve the required ultimate capacities at the end of initial drive, but for them to gain the additional resistance from soil setup. Most of the piles were then driven to blow counts near 200 blows/meter with an ICE 205 hammer. This driving criterion helped avoid excessive blow counts, minimized driving times and time consuming and costly exchanges of hammer cushions.

After the initial test pile program was completed, estimates of pile lengths were presented by both the Joint Venture and the Corps of Engineers. The proposed average pile length was close to 50 meters, although in more critical locations piles reached lengths close to 70 meters. Pile cutoffs were as well kept to a minimum, further decreasing the installations costs. As part of the quality assurance and pile acceptance, restrike testing was proposed of at least two piles in each eight or nine-pile group. This was also essential, because skin friction piles are generally not accepted in Ecuador. The idea was not only to prove that loads were above the required values, but also to allow for a low LRFD (Load Resistance Factor Design) resistance factor, for an optimal foundation solution.

It took approximately nine months to install the bent piles over the water and two months for the installation of the abutment piles. The total pile driving time was significantly shorter than expected, which meant that sometimes pile installation had to be stopped for lack of material. The cost of the central bent portion of the project was close to 20 million dollars. Thus, compared to the initial cost proposal of 32.5 Million dollars for the central portion of the pile work, the cost savings were above 12 million dollars. This does not include the abutments, where costs savings averaged 3 million dollars. Most critical, however, was the record time in which the piles were installed under very rough site conditions. In fact, the foundation was built in less than half the time anticipated by the initial proposal, even with budget and material supply problems slowing down the construction. Another advantage of the revised design is a greater redundancy; the original design called for two shafts per bent while the driven solution provides eight to nine piles per bent.

The bridge is expected to open for public use in the fall of 2010.

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