HP 16 and 18 pile sections used in the construction of the westbound bridge structure of I-90.

Cleveland's Innerbelt Bridge Project

Cleveland, Ohio

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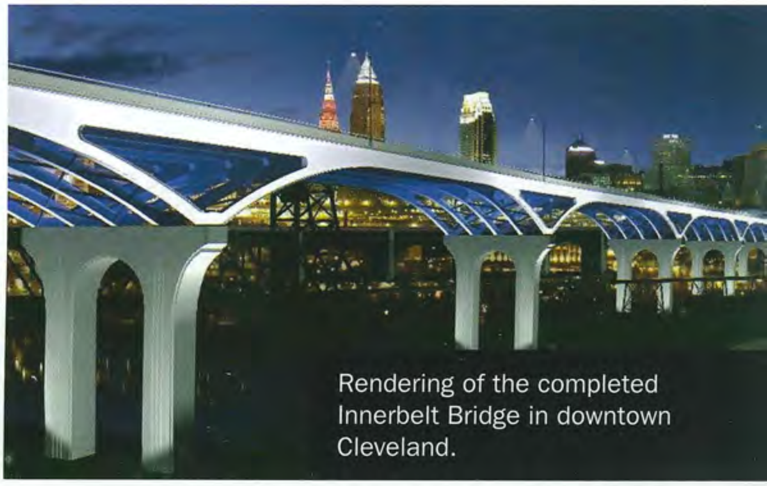
The Innerbelt Bridge is a vital link into downtown Cleveland from the western suburbs. However, the steel members of the existing 50 year old structure are aging faster than expected. In the spring of 2009, The Ohio Department of Transportation (ODOT) announced plans to construct a new westbound Innerbelt bridge. Construction of the westbound bridge structure of I-90, called the central viaduct, is ODOT's first Value-Based Design Build Project. The Value-Based process scored teams technical proposals along with price to determine the best value. The Design-Build Team of Walsh Construction (Contractor), HNTB (Designer), and HDR (Independent Quality Firm) was selected and in August of 2010, a \$287 million dollar contract was awarded to Walsh Construction. The project is the first of seven in a program totaling over \$1 billion dollars to reconstruct I-90 through downtown Cleveland.



Rendering of the completed Innerbelt Bridge in downtown Cleveland.

When it came time for foundation design choices, one of the obstacles included the need to support very high vertical and lateral loads, especially in the center 5 piers, where the superstructure extended approximately 120 ft above existing grade. Additionally, bedrock was 150 ft or more below existing grade. Drilled shaft foundations were considered, but were determined to be a very expensive option as ODOT requires that drilled shafts be socketed into bedrock. Driven piles were chosen as the solution for nearly all of the substructures. Dozens of wave equation analyses were performed by GRL Engineers, Inc. to evaluate the driveability of a wide range of pile sizes and types. Ultimately, material cost drove the decision on pile type and size. Due to the depth of the bedrock, it was determined that minimizing the number of piles and maximizing the factored load on each was the most cost effective solution.

In late 2010, Skyline Steel began distributing HP 16 and 18 pile sections, the largest being HP 18x204.

A construction worker welding the piles.

The choice to use this large section allowed for very high factored loads. In addition, the piles were fabricated using ASTM A572 Grade 60 steel, which allowed for even higher factored loads. However, with increased factored loads comes the need for larger installation equipment, i.e., the pile driving hammer and crane. To address this issue, GRL Engineers, Inc. proposed to drive the piles to refusal on bedrock with a relatively undersized hammer and perform a load test using GRL's APPLE dynamic load testing system. Dynamic testing during driving with the production pile driving hammer would provide a mobilized pile capacity, not the full geotechnical resistance. The APPLE dynamic load testing system could perform a load test to the full geotechnical resistance.

Driveability analysis indicated that the Pileco D80-23 diesel hammer proposed by Walsh Construction could drive the piles to bedrock; however, the predicted mobilized capacity at refusal was roughly 1500 kips, which was well below the required capacities. The factored loads for the main piers ranged from 1,183 to 1,917 kips. In this case, the required ultimate capacities were 1.5 times the factored design loads, as established by ODOT, or 1,775 to 2,875 kips. The APPLE load testing system would be used to prove the required capacities.

The APPLE dynamic load testing system is an 80 kip ram inside a guide frame that allows for variable drop heights up to approximately 10 ft. Wave equation analysis indicated that the APPLE could mobilize approximately 3,000 kips or more while maintaining compressive stresses below AASHTO

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recommended driving stress limit of 54 ksi.

To date, this proposed system of driving to refusal on bedrock with the production pile driving hammer and performing a load test with the APPLE dynamic load testing system has been performed at seven pier locations. The mobilized capacities from PDA testing at the end of initial driving with the Pileco D80-23 hammer ranged from approximately 1,450 to 1,900 kips. Testing with the APPLE dynamic load testing system has been performed on the same day as initial driving and up to 15 days after initial driving. The results indicated mobilized capacities ranging from approximately 2,050 to 2,850 kips. On average, the total mobilized capacity increased by approximately 900 kips when using the APPLE dynamic load testing system. At six of the seven locations, the required capacity was proven using the APPLE system. At one location, the capacity was slightly less than the required capacity, and piles were added to the footing to compensate for the lower capacity piles. In all cases, pile acceptance was based on dynamic testing results during initial driving and results from testing with the APPLE dynamic load testing system.

The ability for engineers to use very high factored loads on the large H-pile sections and minimize the number of piles provided significant cost savings and schedule advantages when compared to traditional sized H-piles. But the cost savings wouldn't have been realized if very large equipment had to be used to install the piles. The use of the APPLE load testing system to load test the piles allowed for use of smaller installation equipment while still providing the high capacities that the design required. ▽

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