Nicholson Pin Piles on Interstate 78 Structure Dig In

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The I-78 dual highway crosses the Delaware River between Pennsylvania and New Jersey (Warren Co.) on new seven span, multigirder bridges. Generally bridge foundations on the Pennsylvania side incorporated driven H piles whereas the river piers and the New Jersey piers were foreseen as founded on solid rock. This proved to be valid except for pier E-6 on the eastbound structure.

Excavation for the footing to the planned elevation had revealed that rock was nonexistent. Further excavation to an elevation 15-20′ below revealed only random rock thicknesses of several feet and a highly irregular bedrock surface. The excavation was filled with lean mix concrete and the foundation design reconsidered.

Various options reviewed included:

—enlarged spread footings
—H piles in predrilled holes
—elimination of the pier
—relocation of the pier
—deep bored piling.

Only the last option proved feasible and two alternates were considered:

—6 large diameter (36″) caissons each of working load 360 tons
—24 minipiles each of nominal working load 100 tons (allowing a 11% redundancy, reflecting the highly variable rock conditions).

The owner decided on the latter option on grounds of cost, program time and the ability to demonstrate the effectiveness of the system by a test pile installed in advance.

A further technical advantage was the action of minipiles in transferring load by skin friction as opposed to end bearing: the impossibility of pile failure by "punching through" into any soft underbed immediately under founding level was therefore eliminated.

Site and Ground Conditions

The bedrock was a Cambro-Ordovician dolomitic limestone referred to locally as the Allentown Limestone. It proved to be moderately/highly fissured, cherty, and very susceptible to karstic weathering. Major clay filled beds were intersected even over 100′ below the surface e.g. 50′ soft brown silty clay below 106′ at Pile 24. Dipping 55° to the southeast, the rock mass proved highly variable laterally and vertically. The "solid" bedrock surface, as revealed in site investigation holes, and by the subsequent pile drilling is shown in *Figure 10.*

Design

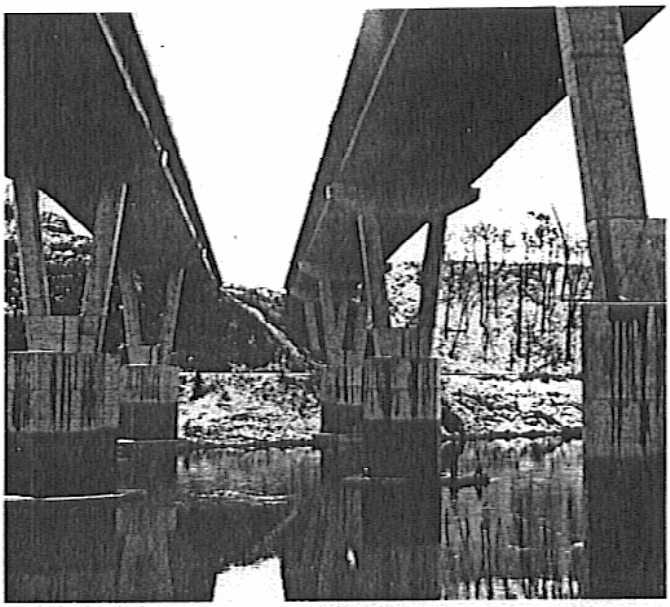
The owner's design regulations permitted:

—maximum average rock/grout bond at working load (100 tons) of 50 psi.
—maximum allowable reinforcement steel stress ("fa") at working load equivalent to 45% fc.

These factors led to the selection of:

—a load transfer zone, 8½″ diameter and 15′ long in competent rock.
—the use of a 55 ksi low alloy steel pipe of o. d. 7″ and wall thickness 0.408″ as pile reinforcement.

Recognizing that the rock was likely to be very variable,



I-78 Dual Highway Bridge Pier E-6 supported by Nicholson Pin Piles. Pier E-6 is right bridge in background crossing Delaware River into New Jersey.

Diesel Hydraulic Track Drills for Nicholson Pin Pile Installation I-78 Bridge, Warren County, NJ between New Jersey and Pennsylvania.

provision was made to allow the 15′ bond zone to not necessarily be continuous, in most piles subject to the following restrictions:

—the lower part of the zone to contain at least 10′ of continuous sound rock
—soft interbeds to be less than 3′ thick
—a zone of acceptable load bearing rock to be at least 5′ thick
—regrouting and redrilling of interbeds within the overall bond zone to be undertaken

Piles 1, 6, 17, 18, 19, 23 and 24 were required to have a continuous 15′ bond zone.

Construction

The sequence of installation was as follows:

- install 10.75″ o.d. casing through the backfill and socket into the concrete of the cap.
- drill with 10″ down-the-hole hammer through the concrete footing.
- install 9.625″ casing through the less competent upper horizons (normally 30–45′). Survey linearity and grout in place.
- drill 8.5″ hole (by hammer or rotary) to ensure minimum of 15′ bond zone as described above.
- flush hole and install 7″ o.d. reinforcing pipe. Survey for verticality (not more than 2% deviation allowable).
- tremie grout hole pile and pressure to 50 psi.

Verification of each pile alignment was made through the use of an "R" Single Shot Direction Survey Instrument, manufactured by Eastman-Whipstock. Each pile was surveyed at top, bottom and mid depth. The results indicated that every pile fell within the criterion, with most being within 1% deviation.

Grout was mixed in a colloidal mixer and injected by Moyno pump. A neat Type III mix of w - 0.5 was used providing 3-day crushing strengths of over 3500 psi.

Throughout construction, the very adverse geological conditions posed major drilling problems. These were resolved, at length, by repeated pregrouting and redrilling. Great care was taken to provide bond zones in accordance with the design provisions. *Figure 11* summarizes the actual total drilled lengths.

Regarding the anticipated caisson tip elevations, also shown in *Figure 11*, these would have been in all cases shorter than subsequently proved necessary to found safely the minipiles. Poor or voided rock was consistently found below these anticipated elevations, further supporting the decision to use minipiles.

Overall the total drilled length of 1920 lin. ft. corresponded with the total foreseen quantity of 1710 lin. ft. However, variations from 43′ less to 30′ more (with respect to foreseen) were recorded on individual piles highlighting the variability of the rock. Overall, a volume of grout equivalent to four times the nominal hole volume drilled, was injected, with much of this being consumed in the zone above rockhead during pregrouting operations. The level of maximum takes corresponded with ground water level.

Testing and Performance

A separate test pile, 30′ long with only 5.33′ of bond was load tested in accordance with ASTM D1143 "Quick Load Test Method" to 205 tons, using rock anchors as reaction. This particular socket length was selected as a test load, the average grout-rock and grout-steel bonds would be 304 psi and 250 psi respectively—both considered to be at or near ultimate values. An outer sleeve of p. v. c. pipe extending to the top of the rock socket ensured load transfer only in the socket. A 6″ thick wooden plug was attached to the bottom of the steel pipe to ensure no load could be transferred in end bearing.

The total settlements recorded at each successive cycle to 205 tons were 0.367″ and 0.373″ respectively. Creep of 0.011″ was recorded over 60 minutes hold at these loads. The permanent set after this operation was 0.07″.

The next day testing was continued to higher levels, but at 224 tons the material of the upper casing began to fail. Until that point, the pile was performing exactly as it had during the previous testing sequence. (Total displacement of 0.371″ at 215 tons, but 0.452″ at 224 tons.)

In addition, during installation of the reinforcing pile in the last (and deepest) pile (Nr24), a thread parted and a 130′ length of pipe fell into the 200′ deep hole. Borehole TV revealed the casing to be further ruptured 30′ above the bottom of the hole, due to its impact with the bottom. After various attempts at recovery and recoupling, it was decided to grout the pile, having previously suspended a 20′ long, 4½″ diameter 150 Ksi steel pin, with centralizers, from 62′ to 82′ below the top. The intention of this pin was to ensure effective load transfer across the upper discontinuity. A very rigorous extended load test was then executed to 170 tons. The performance of the pile proved excellent, (e.g. total displacement 0.187″ at 170 tons, 0.010″ creep in 24 hours, permanent set of 0.009″) and it was judged capable to safely perform its function in service.

The bridge is now complete and the performance of Pier 6E has proved exceptional.

PHIA Proposes New Economic

A network of economic generator-type highways has been proposed to link with the Interstate Highway System in Pennsylvania.

Citing the success of the superhighways in Pennsylvania that will be completed in their entirety next year, Robert E. Hetherington, managing director of the Pennsylvania Highway Information Association said, "now is the time to begin something new."

Speaking to executives of the Defense Transportation Association during National Transportation Week, Hetherington said the nation's 41,000 mile network of interstate roads and bridges has been a success story.

"The nation has changed dramatically since these roads were first planned in the 1950s," Hetherington said. "America has to build on these successes."

The few remaining segments of Pennsylvania's 1,300 miles of Interstate are to be completed in 1990, he said. Most of this mileage is in suburban Philadelphia and the Lehigh Valley near Allentown.

"Lifeline" Routes

Hetherington said the highway system continues to be the "lifeline for moving people and products." He explained that the major highway connectors in the Harrisburg area are a striking example as industry and trucking terminals have located adjacent to these interstate routes.

Stressing the value of roads and Pensylvania's uinque location, Hetherington said, "the state cannot rest on its laurels. We must provide for the future by laying the groundwork now."

He pointed out that a study PHIA commissioned a year ago estimated that more than 2,700 jobs are created for every $100 million spent for new highway work. "A key element of the study shows $36 million in direct benefits result from this expenditure," he pointed out.

Outlining the PHIA program, Hetherington said, the "Primary highways in the Commonwealth hold the key to our proposal." The primary system was the major road network identified by states and the federal government before the Interstate highways were authorized in 1956.

"What we have to do now is build on this system," he explained.

Pin Pile— From Page 37

We hear a great deal about the tide of "European technologies" lapping at our shores. There is no doubt that pin piling was born in Europe, but it is equally certain that it is reaching a new maturity in this country. It has grown in response to the changing face of our construction industry and has developed its own particular national identity in the process: pin piles of exceptional length and capacity are being installed. There is an intensity of activity in certain of our older eastern cities unrivaled anywhere in the world. As redevelopment of our cities and industrial centers continues, we can expect the growth of pin piling to proceed apace, and the special national "flavor" to intensify.

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