Bridge pier repair in progress

A Low Headroom Solution

An emergency bridge repair project told from the specialty geotechnical contractor's point of view as it unfolded.

Some of the most interesting projects that a geotechnical specialty contractor gets involved with begin with a phone call "out of the blue" from a potential client who has a problem — usually a very big problem. This was the case in June 2014 when A.H. Beck Foundation Company was contacted by a project team in Delaware. The I-495 bridge over the Christina River was closed on June 2, 2014, due to damage to the substructure caused by a large stockpile of fill material that was placed on very soft soils adjacent to the bridge. This stockpile caused deep soil movements so significant that they shifted the existing driven H-piles and cracked some of the reinforced concrete pile caps of the bridge. The closing of this major interstate, carrying over 90,000 vehicles per day, was causing massive traffic jams in the area and needed to be fixed as soon as possible. An emergency repair plan to get the bridge reopened was immediately initiated.

Initial Response

Once the decision was made to close the bridge, engineers from Delaware Department of Transportation (DelDOT) moved quickly to pull together a team of engineers to determine how to repair the bridge and open it back to traffic as quickly as possible. After DelDOT discussed repair alternatives with its designer, AECOM, it became clear that a contractor should also be in the room to go over all the possibilities. The contractor selected, JD Eckman, had previous experience with DelDOT and NJDOT in emergency repairs as well as large-scale construction. Upper management from JD Eckman included experienced professional engineers with a great track record on public projects — qualities that were appealing to the department. Once contacted, a representative from the contractor was in the room the next morning. All parties involved left their egos at the door in order to work together to devise a repair solution as quickly and efficiently as possible. Every idea was considered, from total replacement to full rehabilitation.

Drill rigs working at bridge site

Existing Conditions

Four of the 37 bridge piers on the 4,800 ft (1,500 m) long bridge were leaning by as much as 4%, causing lateral deformations to the superstructure of nearly 2 ft (0.6 m)

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where the bridge deck was 60 ft (18 m) above grade. The soil conditions consisted of 100 ft (30 m) of soft organic clay that was underlain by a layer of dense sand and a layer of stiff clay above the bedrock. Bedrock ranged in depth from 150 ft (46 m) to 165 ft (50 m) below the ground surface. The existing bridge was supported on 130 ft (40 m) long driven H-piles that were driven into the stiff clay but not to bedrock. The design to repair the foundations involved installing 4 ft (1.2 m) diameter fully-cased drilled shafts with full length rebar cages to bedrock.

Foundation Issues and Decision

Due to the limited available space for new foundations, as well as cost and schedule considerations, the bridge repair would have to serve as both temporary and permanent supports. The complexity of the foundation construction was further increased by the need to work in the restricted headroom below the existing superstructure. This low headroom aspect was of critical importance because it meant that the standard foundation installation equipment and procedures would not be able to be used. The project team recognized the benefits of drilled shaft foundations as the solution; however they were having trouble finding a specialty contractor who could actually install the shafts.

Demolition of the bridge would have to be considered if the much quicker and less costly repair option was not viable. Selection and construction of new foundations were particularly challenging. Since the bridge was precariously supported on the existing damaged piles, construction of a new foundation would require a delicate balance to minimize vibrations and avoid subsurface interference between old and new foundation elements. It was also recognized that the new foundations had to be robust and resistant to the geotechnical conditions that distressed the existing H-piles.

Finally, the repair was selected as the optimum choice. A key point in the decision to go with the repair option versus demolition was finding a drilled shaft contractor capable of installing the shafts with the complex job restrictions. A conference call was set-up to explain what was involved to several potential foundation contractors at the same time. It would be easier to install the shafts if they were redesigned to be located outside of the bridge deck, but that was not structurally viable.

Even though A. H. Beck was a long way away in Texas, we were contacted because of previous experience with this type of project. When the Lee Roy Selmon Freeway in Tampa, Fla., had a section of bridge piers sink several feet, A.H. Beck installed drilled shafts under the bridge deck in similar limited headroom conditions as the I-495 bridge. We felt confident we could install the shafts as designed in a timely manner.

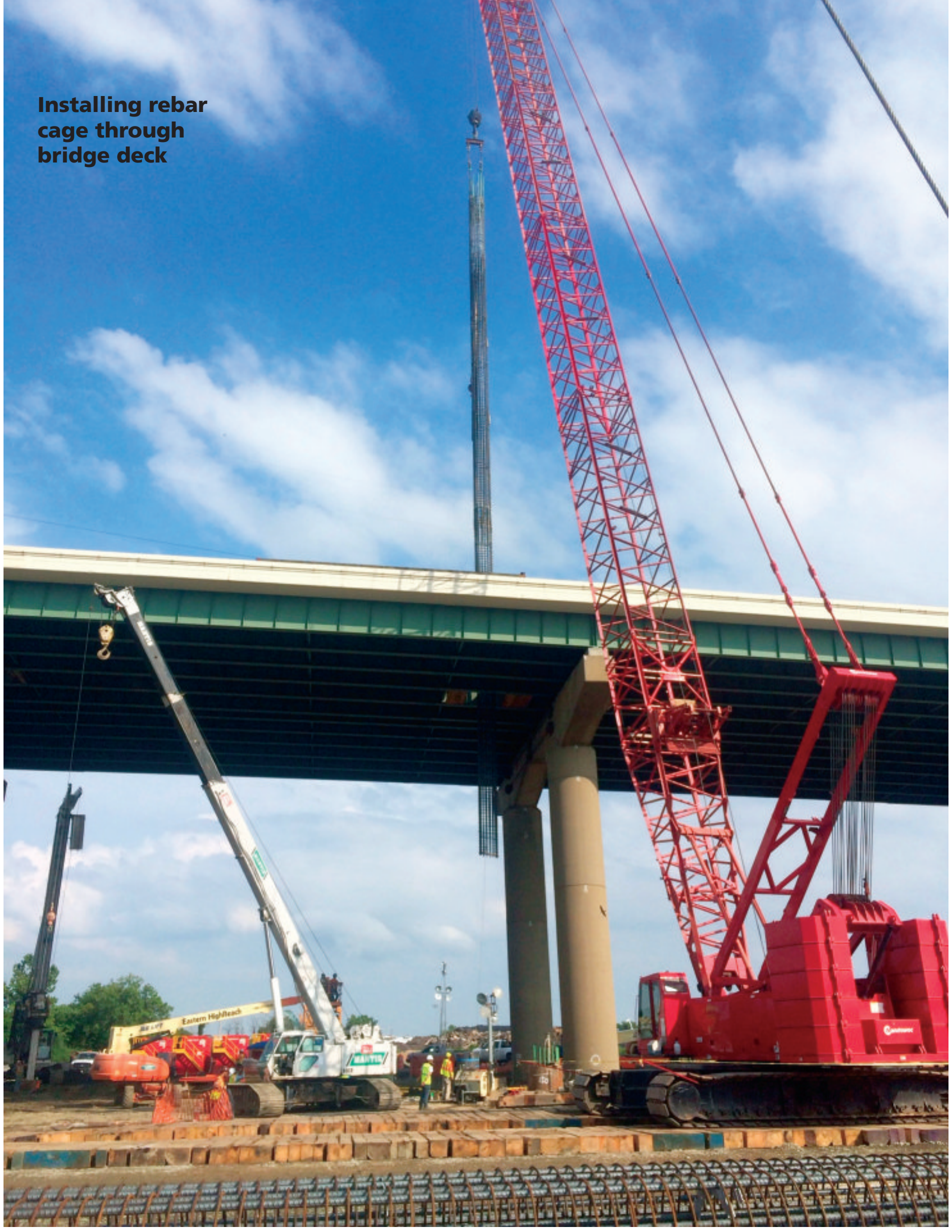
Mobilization

Within a week of that conference call, A.H. Beck mobilized three drill rigs to the site to begin work. Normally moving this much equipment across the country would take weeks just to obtain all the required trucking permits through numerous states to arrive at the project site in Delaware. The drill rigs came from Texas, Florida and New York. Additional equipment to perform the job was also shipped from South Carolina, Arkansas and Mississippi. However, due to the emergency nature of this work, each of the state DOTs waived the formal permitting to allow the equipment to get to the site as soon as possible.

Innovative Casing Installation

One of the most difficult aspects of the project was the installation of the permanently-cased drilled shafts to 165 ft (50 m) with full-length rebar cages beneath the bridge deck. This required custom equipment capable of quickly drilling 4 ft (1.2 m) diameter drilled shafts to bedrock while working beneath the 60 ft (18 m) overhead clearance. Drilling from the bridge deck was not possible due to the heavy loads that would be applied to the already leaning bridge supports. Conventional methods of "telescoping" casings to the required 165 ft (50 m) depth would have taken too long. Due to the concern about vibrating or driving casing causing additional movements or cracking, the casings were started using an oscillator. However, this was a very slow process and the project team quickly recognized that other options needed to be considered to meet the schedule. In an effort to increase the casing installation speed, a unique casing installation process was developed in a collaborative effort by the project team. It consisted of an oscillator, vibratory hammer and drilling with slurry to both safely and quickly advance the permanent steel casing segments to bedrock. Extensive vibration monitoring was performed during this process to ensure that the vibration levels were below the magnitudes that would cause additional damage.

Casing sections beneath bridge



Installing rebar cage through bridge deck

Installing the Rebar Cage

Another major issue was how to install the rebar cages. The initial plan was to splice the cages together in sections over the open hole. This was problematic due to both the time it would take and the constructability of having to couple many bars together over an open hole. During a meeting onsite with the project team we suggested that the cages could be installed in one piece, however it would require cutting a temporary hole in the bridge deck and positioning the shafts between the bridge beams. While this was initially considered a somewhat radical idea, as the project team discussed it in more detail it became apparent that there was actually no reason why we couldn't do it. The task would require that same collaborative effort between the designers and contractors that was used for the casing installation portion of the project. A 250 ton (227 tonne) capacity crawler crane with 300 ft (90 m) of boom was required to pick the 30,000 lb (130 kN) rebar cage above the bridge deck. The rebar cages were all set full length in a single piece with no splices through a temporary opening in the bridge deck cut exactly above each shaft.

This project included the first use of self-consolidating concrete (SCC) in drilled shafts for DelDOT. Because the shafts were advanced with slurry, a special mix design was required to allow the concrete to effectively flow through the rebar and eliminate the potential for defects. All of the shafts were installed with crosshole sonic logging (CSL) tubes for integrity testing after completion. Based on our experience with both SCC and CSL on large slurry drilled shafts the project team agreed to use a special mix design.

Ahead of Schedule

The project actually had two phases: a temporary and a permanent repair with both founded on new drilled shafts extending to bedrock. The drilled shaft installation work continued 24 hours per day, 7 days per week with up to 3 rigs working until completion. This work schedule, combined with the innovative casing and rebar cage installation techniques developed during the course of the project resulted in the bridge being

Rebar cage with CSL tubes

reopened more than one month ahead of schedule. Supported on temporary towers, the southbound lanes were opened on July 31, 2014, and the northbound lanes were opened on August 23, 2014. The original schedule had shown a tentative reopening of the southbound lanes by Labor Day. The permanent repairs of the bridge were completed in March 2015.

The Future

The future of foundations for large-scale emergency repair projects rests on the ability of diverse project teams to effectively work together. In this case, the project team was able to quickly respond to the various challenges thanks to the collaborative effort from designers, contractors, and assistance from other states. Solutions to complex deep foundation projects with tight schedules can be achieved if everyone on the team trusts one another and keeps an open mind. This type of project starts with a simple phone call and in the end can be called a great accomplishment.

The project was a success thanks to the entire project team consisting of DelDOT, the FHWA, the design team at AECOM, the general contractor J.D. Eckman, R.E. Pierson Construction Company and A.H. Beck Foundation Company.

2014 Project Timeline

- June 2: Bridge closed
- June 2: Soil stockpile removal begins (24-hour-a-day operation)
- June 3: DelDOT meeting with AECOM to discuss alternatives
- June 4: Project team meeting (DelDOT Bridge, DelDOT Construction, AECOM, FHWA, JD Eckman, HNTB)
- June 5: Initial foundation design scope for repairs set; project team starts looking for potential drilled shaft contractors.
- June 10: Soil stockpile removal completed
- June 10: Conference call with A.H. Beck, proposal received the same day
- June 11: A.H. Beck authorized to proceed, mobilization begins the same day
- June 13: Drilled shaft installation begins (24-hour-a day-operation)
- June 15: Vibratory hammer for casing installation approved
- June 21: First cage installed
- July 16: Drilled shaft installation complete
- July 29: Southbound grade beams, shoring and re-leveling complete
- July 31: Southbound bridge re-opened
- August 20: Northbound grade beams, shoring and re-leveling complete
- August 23: Northbound bridge re-opened
- March 2015: Permanent bridge repairs complete

Bridge reopened to traffic