FEATURE STORY

DRILLED SHAFTS PROVIDING THE SOLID SUPPORT NEEDED FOR THE HOUSTON SHIP CHANNEL BRIDGE

ARTIST RENDERING OF SHIP CHANNEL BRIDGE (COURTESY FIGG BRIDGE ENGINEERS INC.)

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Due to the projected growth in the Houston region Harris County and the Harris County Toll Road Authority (HCTRA) is replacing the existing box girder Ship Channel Bridge with a new cable stayed bridge. The overall program cost is $962 million. Currently about 60,000 vehicles a day cross the single span bridge with two lanes in each direction and no shoulders. Officials expect that number to swell to 158,000 vehicles by 2035. The new Ship Channel Bridge will be twin spans with four lanes in each direction and full shoulder lanes on each side. The goal for the Sam Houston Tollway is to have four main lanes in each direction along its entire system and this new bridge would tie into that design.

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The 1,320 ft long main span of the bridge will be supported on two massive 514 ft tall towers. The towers are being built on land out of the ship channel to both reduce the environmental impact and enable future channel widening. The current bridge span is only 750 ft long and both main support towers are in the water adjacent to the navigation channel. The navigation channel vertical clearance will be 175 ft matching the Fred Hartman (SH 146) bridge located approximately 5 miles downstream.

The bridge design will also reduce the grades of the approaches, increase visibility for drivers and allow for an increased posted speed limit. Due to their size cable stayed bridges each have a unique design and become part of the skyline in the area, similar to the suspension bridges used in the past like the Brooklyn Bridge and Golden Gate Bridge. Even though this is the largest single project ever constructed by the county, no taxpayer dollars will be used to fund the project.

GROUP OF DRILLED SHAFTS BEING INSTALLED FOR THE SOUTH TOWER

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The cable stayed bridge design was chosen because it is the most cost-effective option for a span this long. Similar to the new cable stayed design for the Harbor Bridge project in Corpus Christi, the most cost-effective deep foundation system to support the massive tower loads in the Gulf Coast soils are groups of large diameter drilled shafts.

> ***"In 1932, A.H. Beck modified his steam shovels to be capable of drilling the round excavations used in Simpson's new drilled shaft designs and the drilled shaft industry as we know it today was begun."***

CURRENT BECK DRILL RIG AT SHIP CHANNEL BRIDGE SITE

The deep foundations consist of groups of 8-ft diameter drilled shafts extending to a depth of 275 ft below adjacent working grade. There are 48 shafts used to support the south tower and 49 shafts under the north tower. Both towers connect to the drilled shafts through a 18-ft thick reinforced concrete mat (or cap) roughly the size of three basketball courts in plan view. The drilled shafts are 246 ft long from the bottom of the pile cap.

The general contractor for the project is Ship Channel Constructors, a joint venture between Indiana-based Traylor Brothers and San Antonio-based Zachry Group. The designer of the bridge is Figg Bridge Engineers, Inc. with HNTB acting as the program construction manager for HCTRA. The geotechnical consultant on the project is Fugro, Inc. with additional geotechnical review provided by Cibor, Inc.

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A.H. BECK'S ORIGINAL 1932 STEAM POWERED DRILLED SHAFT RIG

Long time ADSC Contractor Member A.H. Beck Foundation Company (Beck) was selected to install the drilled shafts for both the previous test shaft phase and the current production shafts for this project. Texas-based Beck has been a leading figure in the advancement of foundation drilling technology since the industry's earliest beginnings. In the 1920's, August Henry Beck, Sr. purchased two steam shovels and entered the excavation business using money he earned working at the San Antonio city quarry. At this same time San Antonio-based structural engineer Willard Simpson, one of the first structural engineering consultants in the US, developed a design for the first reinforced concrete drilled shafts. However, the only equipment available to drill the holes at that time was mule powered water well drilling mechanisms. In 1932, A.H. Beck modified his steam shovels to be capable of drilling the round excavations used in Simpson's new drilled shaft designs and the drilled shaft industry as we know it today was begun.

Since then three more generations of the Beck family have continued to develop new equipment and drilling techniques. Drilling with slurry to keep the holes open first took place in San Antonio in 1948. Beck was drilling though sand below the water table and shafts kept caving in. After a month's delay they tried mixing clay with water and that allowed them to complete the shafts. Over the decades each innovation has contributed to the amazing technologies that now allow for the installation of these 8-ft diameter drilled shafts. A.H "Buddy" Beck, Jr. was a charter member of the Texas Drilled Shaft Contractors Association, later to become the ADSC. August H. "Gus" Beck III (company Chairman) was a member of ADSC's Board of Directors in the 1980's and 1990's. August H. Beck IV, P.E. (company President) is now currently serving on ADSC's Board of Directors.

The soil conditions at the two main towers typically consist of 20 to 30 ft of soft clay and loose sand fill materials adjacent to the ship channel. The natural soils are primarily medium stiff to hard clays extending to the shaft tip elevations, although several dense sand layers are present in the subsurface at each tower location. The clays are generally slickensided as is typical of the Beaumont formation clays in this area. Given the highly concentrated loads for the towers placed on these soil conditions the project team selected 8-ft diameter drilled shafts for support of the main towers.

The shafts will get the majority of their capacity in skin friction in these soils with a small contribution in end bearing from the very stiff clay at the tip. A full scale field load test program was performed for the project prior to final design. This program consisted of installing and testing a full size 8-ft diameter drilled shaft at each main tower location in addition to a smaller 4-ft

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INSTALLING A TEST SHAFT WITH O-CELLS

SONICALIPER TESTING OF DRILLED SHAFTS

diameter shaft for the north approach section. The purpose of the test program was not just to check the shaft capacities as compared to the estimated capacities. It was also used to validate the quality assurance methods used in the construction of the shafts and reduce the level of uncertainty associated with the factors of safety used for the design. The load tests were performed using an Osterberg Cell (O-cell).

The test shafts for the main towers were 8-ft diameter and 225 ft long. They were tested to equivalent top load capacities in excess of 4,000 tons with a single level of O-cells. For quality assurance purposes all shafts associated with the cable stayed portion of the project will have cross-hole sonic logging performed to check integrity and concrete quality.

The project specifications listed a vertical tolerance for the shafts at 1 inch off center per 10 ft vertical (0.83%) out of plumb consistent with TxDOT specifications for drilled shafts. The verticality and shaft diameter for the test shafts and all production shafts on the project is being measured using the SoniCaliper™ tool. The SoniCaliper™ is a quality assurance tool for drilled shafts that has the ability to virtually "see" foundation excavation shapes prior to placing concrete in dry or slurry conditions. This sonar calipering technique provides results in real-time display and it creates "as-constructed" images and calculations immediately after the excavation has been profiled. This information gives the engineer and contractor confidence that the end product is manufactured according to specification. Utilizing sonar technology, the SoniCaliper™ provides a full 360-degree profile and can determine diameter, assess verticality and calculate volume.

The drilled shafts for the main towers are being installed using bentonite slurry to support the excavation below the surface casing. The shafts have full length reinforcing cages installed in three sections typically

RIGS WORKING ON FOUNDATIONS FOR BOTH TOWERS

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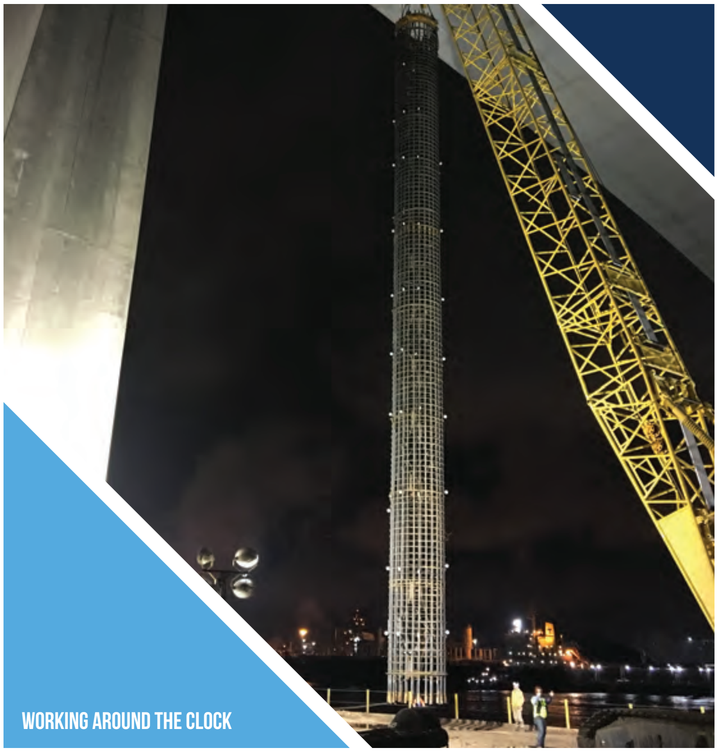
weighing around 170,000 pounds each. The shafts each require around 500 cy of concrete to be placed in one continuous pour. The shafts for both towers are being installed concurrently on a multi-shift operation around the clock. About half of the shafts are being installed beneath the existing bridge, which is being kept in service during the construction of the new bridge. Even with 150 ft of headroom to work with, this is still considered limited headroom work when installing 275 ft deep shafts.



WORKING AROUND THE CLOCK