Bridges over troubled water

Jennifer Shields and Mark G. Thomas examine the challenges of drilling in flowing sands in East Texas, US

Drilling beside Texas State Highway 63 bridge over the Sabine River

Flowing sand conditions are always a challenge in geotechnical investigations because sampling and in-situ testing require clean boreholes to obtain reliable data.

The term flowing sand is used when saturated sand material at the bottom of a borehole flows into the hole on tooling withdrawal, thus requiring further efforts to obtain a clean bottom. In Texas these conditions prevail in and near the floodplains of many major rivers and areas along the Gulf Coast. These challenges are compounded when the project is urgent.

For much of the state of Texas, 2015 was the wettest year on record. From the record catastrophic flood in Wimberley on May 24 to the deadly flash flood in Eagle Pass on October 9 and the 20in (51cm) of rain that fell in Corsicana from October 21 to 25, the state was inundated with rain. Flooding occurred throughout many areas of the state from late 2014 through the spring of 2016, causing considerable damage to roadways and bridges.

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In East Texas, State Highway 63 (SH 63) over the Sabine River into Louisiana and Farm to Market Road (FM) 2626 over Quicksand Creek were two such bridges damaged by the flooding. Both roads were closed to traffic due to structural damage caused by the floods, resulting in major detours for the local residents and general commerce.

D&S Engineering Labs (D&S) was contracted by the Texas Department of Transportation (TxDOT) in April 2016 to provide geotechnical drilling services to collect data for the design of remedial measures for these two bridges. D&S mobilised its 2015 Mobile B-57 truck-mounted drilling rig for both sites.

SABINE RIVER

The SH 63 bridge crosses the Sabine River about 10 miles (16km) east of Burkeville, Texas, and about 18 miles (30km) west of Leesville, Louisiana, and is a major traffic corridor in the area. This multi-span bridge is about 1,900ft (580m) in length and is located about 12 miles south of the dam at Toledo Bend reservoir.

D&S drilled six borings to depths of 90ft along the sides of the bridge on the Texas side of the Sabine River in April and May 2016. Drilling challenges at the SH 63 bridge included site access and deploying standard drilling techniques to reduce the effects of flowing sands.

Due to the flood events that occurred prior to the team's arrival, thick but erratic deposits of fine sand required use of earth-moving equipment to provide access to the drill locations. Two trips to the site were required, as the gates at Toledo Bend dam were raised to release more water after work began, causing repeated flooding in the area that required more earthwork to obtain access.

The crew was briefed before mobilising to the site to expect thick deposits of granular soils, some or all of which could possess flowing conditions. As such, the crew advanced the borings utilising 4.25in ID hollow-stem augers (HSAs) to maintain open boreholes while performing Texas cone penetrometer (TCP) testing at 5ft intervals, as required by TxDOT. The test is similar to the standard penetration test (SPT per ASTM D1586), but uses a 170lb (77kg) hammer with a 24in drop to drive a 3in-diameter hardened steel cone in 6in or 50-blow increments. In both tests it is crucial that the drill string is firmly at the bottom of the borehole before starting the test.

The geology at this site was found to consist of 30ft to 38ft of fine to medium-grained sand over shale bedrock containing weakly cemented, fine- to medium-grained sandstone seams. Groundwater seepage was observed at depths of 5ft to 20ft below site grades, with artesian flowing water encountered at depths of 60ft to 90ft.

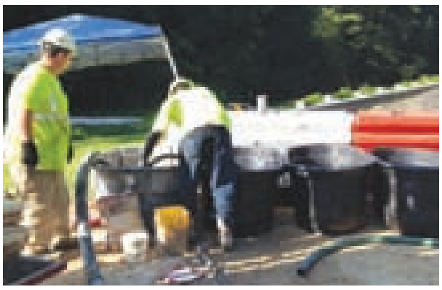
In anticipation of flowing sand conditions, standard techniques were implemented to reduce that occurrence. These included filling the HSA casing with water to the top of the drill string while the

Artesian water flow at SH 63 adjacent to the Sabine River

Access challenges at the SH 63 bridge

centre pilot assembly was withdrawn very slowly to minimise the suction effect within and minimise the resulting sand flow into the HSA string. The water level was maintained near the top of the drill string as the assembly was withdrawn.

Though generally successful, when coarser sands were encountered, sand intrusion still occurred to some degree, requiring additional trips into the borehole to flush the casing and achieve a clean bottom for testing and sampling. Once shale bedrock was encountered, the drill crew switched from HSA advancement to wash rotary drilling techniques.



D&S drillers mixing drilling mud at FM 2626 over Quicksand Creek

QUICKSAND CREEK

About 12 miles south-east of Newton, Texas, FM 2626 crosses Quicksand Creek via a single-span bridge 110ft in length. This bridge was closed to traffic after the flooding in spring 2016. Employees of the sawmill at the north end of the bridge who lived south of the creek had to either park at the south end and walk the rest of the way to the mill or take a 20-mile detour each way.

D&S crews drilled two borings to depths of 81ft to 90ft within the roadway on opposite ends of the bridge. The geology at this site was found to consist of fine- to medium-grained sand strata that became coarser below 40ft depth. The sands continued to the termination depths. Groundwater seepage was observed at depths of 15ft to 21ft, with flowing sand conditions below 25ft.

At the FM 2626 bridge over Quicksand Creek, drilling was considerably more challenging. When the drill crew encountered flowing sand conditions at about 25ft depth, techniques were quickly adjusted as noted previously for the SH 63 bridge. By 40ft depth the particle sizes of the sands were increasing.

The flowing conditions intensified, causing the materials to continue to flow into the HSAs as the tooling was removed, despite the precautions, and water circulation losses were substantial during cleanout/flushing. This required repeated washings to clean the boring down to the target test depth and production reduced greatly.

The drilling method was switched to wash rotary, using powdered bentonite mixed into the drilling circulation water to help reduce water losses and reduce the sand flow. This proved only marginally successful even at higher bentonite dosages. At 50ft depth the sands were even coarser and now contained appreciable amounts of fine gravel.

D&S then contacted Baroid Industrial Drilling Products for assistance. After describing the ground conditions and methods employed, they suggested using a borehole stabiliser additive and a pH balancer additive in conjunction with the bentonite powder. The new ingredients were acquired and drilling resumed.

This new drilling mud 'recipe' had an immediate positive effect, but large circulation losses continued. When it was clear that mixing could not keep up with drilling, D&S brought four large mixing troughs to the site, enough to mix nearly 600gal (2,728L) of drilling mud at once.

D&S continued to employ the previous techniques such as keeping the borehole full of drilling fluid while slowly withdrawing the drill string. In addition, D&S decided to slow the advancement and rotation rates to help reduce borehole disturbance.

As drilling progressed, the mud recipe was tweaked by adding more or less of the bentonite and additives until an optimal mix was found that minimised fluid losses and borehole disturbance while increasing production. With enough of this mix available to keep up with the losses, and the implementation of the other technique adjustments, D&S was able to complete the project.

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