In the overnight hours between February 12 and 13, 2020, a large landslide occurred on SR-53 (US-231) in Morgan County, Alabama approximately 1.7 miles south of the Lacey’s Spring Community located south of the city of Huntsville. The slide completely severed the 4-lane divided highway which is a major commuting route between Huntsville and several communities south of the city. A detour route around the closed section of highway was quickly established; however, this detour added 30 minutes to an hour for daily commutes of people who lived in the area but worked in Huntsville. The routes available for detour were all two-lane state highways and county roads not designed for the volume of traffic funneled to the detour. Every extra month of use strained the detour roads as well as caused significant disruptions to the small communities along the route. Significant pressure was placed on the Alabama Department of Transportation (ALDOT) from the impacted communities to quickly solve the problem and reopen the road.

The location of the slide is where US-231 hugs the side of Brindlee Mountain. The grade increases as traffic travels south from the Tennessee River valley north of Lacey’s Spring until the top of the ridgeline is accessed by a cut in the upper bedrock strata at the top of the ridge. The roadway was built as a side hill cut/fill cross-section, with the southbound (SB) lanes downslope of the northbound (NB) lanes. The SB lanes were constructed in the late 1940s. The NB lanes were added in the early 1970s.

Technical Affiliate member, Dan Brown and Associates, PC (DBA), was called by ALDOT on February 14, 2020 to evaluate the causes of the landslide and design a repair solution to reopen the road as quickly as possible. All four ALDOT drill crews were immediately mobilized to the site to begin drilling exploratory borings and install slope inclinometer casings for monitoring slide movements. ALDOT maintenance crews and a grading contractor performed pavement removal and other work to aid the investigation. The Department of Civil Engineering at Auburn University was also engaged to perform geophysical testing in conjunction with an existing research project for ALDOT. Robert Thompson, P.E., D.GE and Sam Sternberg, P.E., D.GE were DBA’s “boots on the ground” for the initial week of drilling, observing the soil and rock core samples, walking the site extensively with
ALDOT personnel, and meeting with ALDOT personnel on site to begin brainstorming solutions while the exploration continued.

For the first three weeks after the slide occurred, DBA, along with ALDOT’s Geotechnical Section, Roadway Design Bureau, and Bridge Bureau evaluated several options to repair the road: designing a complete rebuild of the roadway, installing retaining wall systems, and using bridges to span the slide area. Analyses were performed as data came in daily from the borings, geophysical testing, laboratory testing, and surveying (both on-ground and aerial). The primary focus for evaluating possible solutions was how quickly the road could be opened.

Based on the site geology, rebuilding the roadway as previously constructed was quickly eliminated due to concerns of embankment stability. Several retaining wall options were considered, centered around various configurations of anchored soldier pile walls. At the request of DBA and ALDOT, the ADSC assembled an advisory panel of Contractor Members to provide input on cost and constructability of the most feasible wall options. While several feasible wall options were found, these were ultimately rejected due to risks associated with the anchor installation and the impact on time of construction.

ALDOT selected spanning the slide area with bridges built along the existing roadway alignments. The bridges would be designed to withstand future movements of the slope subsequent to removal of the existing roadway embankments to reduce loading on the slope. The location and length of the bridges were selected based on an estimation of the limits of the slide. The limits were estimated by visual observations of surface cracks and lateral soil movements, surveyed locations of surface cracks, inclinometer data, and evaluation of the terrain. The design drawings of the existing roadways, LIDAR data obtained by ALDOT, and the geophysical data obtained by Auburn University were also evaluated to assist in locating the slide limits with respect to the existing terrain as well as the cut/fill transitions of the existing roadway embankments.

At the request of DBA and ALDOT, the ADSC assembled an advisory panel of Contractor Members to provide input.

The location and length of the bridges were selected based on an estimation of the limits of the slide.

The two bridges, one Northbound and one Southbound, are each about 947 ft in length and composed of seven spans of 135-ft long AASHTO BT-72 concrete girders with a concrete deck. A highly compressed design schedule was completed for the bridge contract to be
Experience the Progress.

Liebherr deep foundation machinery

- High availability and long service-life due to robust equipment technology
- Low emission and high efficiency thanks to intelligent drive systems
- Operating comfort through innovative control concept
- Matching working tools ensure excellent productivity
- Optimized construction processes thanks to comprehensive consultation

Liebherr USA Co.
MCCtec Division
Crawler Cranes and
Foundation Equipment
7075 Bennington Street
Houston, TX 77028-5812
Phone: +1 713 636 4050
foundation.equipment.usa@liebherr.com
facebook.com/LiebherrConstruction
www.liebherr.com
awarded about 3 months after the slide occurred. An incentive/disincentive construction contract was used to accelerate completion of the bridge. Removal of the existing roadway embankments occurred during bridge design to accelerate the schedule and have the site ready for the Contractor upon award of the bridge contract.

All abutments and piers have a pair of 9.5-ft diameter, permanently cased (5/8 inch wall, 60ksi) drilled shafts with 9-ft diameter, 14-ft long rock sockets drilled into limestone and shale bedrock with uniaxial compressive strengths ranging from 10 to 20 ksi. The shafts are reinforced with an 8-ft diameter (1.5-in wall, 60 ksi) steel pipe. The pair of shafts for each pier is connected by a reinforced concrete grade beam 10 ft wide by 7 ft high by 46 ft long. To connect the shafts to the grade beam, 28 No.18 Grade 75 bars are embedded 8 ft into the shaft and 6 ft in the grade beam. The permanent casing was supplied by ADSC Associate Member Nucor Steel. The reinforcement pipe was supplied by ADSC Associate Member Favor Steel and Fabricating as mentioned in the January issue of Foundation Drilling Magazine. Both the casing and the pipe came from Birmingham, Alabama.

The lateral loads generated during a potential slide event, oriented in the transverse direction of the bridge, controlled the design of the drilled shaft supported bents. Due to the time constraints, a “one-size fits all” solution was employed for the design of the foundations to expedite and simplify the design, material supply, and construction of the bridge. All of the bents and abutments were designed for the maximum loading condition and not optimized (i.e. shaft size

"Due to the time constraints, a ‘one-size fits all’ solution was employed for the design of the foundations"

Continued on page 56
reductions) for locations with lower load demands. Some of the key design (and construction) variables included:

- Depth to rock from finished grade
- Location of potential slip surfaces in the soil above rock
- Location of groundwater.
- Estimated shear strength of the soils.
- Rock uniaxial compressive strength.
- Size of the drilled shafts and the grade beam.

The maximum loading condition assumed all soil remaining above the top of rock following final site grading and acting against the substructure during a future slide event. Therefore, the final finished grade would dictate the amount of soil remaining above bedrock and thus the design lateral loading on the shafts. The structural demands during this potential event led the team to the conclusion that a conventional rebar cage would not provide sufficient reinforcement to resist the flexural demands on the shafts. The 8ft diameter, 1.5-in wall thickness steel pipe provided the necessary strength to resist the structural loads.

Room for the structural pipe to have the required embedment length into the cap was inadequate, even if shear rings were added. The solution was to use a 14-ft tall dowel cage that is located inside the top of the structural pipe and extends into the grade beam. Bar
terminators at both the top and bottom ends of the rebar allow for adequate development length of the bar within the available embedment lengths without having to bend the bars, allowing for quicker construction of the grade beams.

Design analyses included single shaft modeling, group modeling, slope stability, and calculating loads on the grade beam and shafts for a future slide event. The loads on the foundation system consist of three components: the structural loads from the bridge, lateral earth pressure on the grade beam, and lateral earth pressure on the drilled shafts. The structural loads are very small relative to the size of the rock sockets required to resist the lateral loads. The soil loads against the drilled shafts and the grade beam were calculated as the nominal passive pressure developed by the moving soil. Appropriate load factors and slope inclination factors were applied to the nominal loads, plus p-multipliers applied for each shaft.

The resistance to the lateral loads is provided entirely by the rock sockets. The elevations of the tops of the rock

Design analyses included single shaft modeling, group modeling, slope stability, and calculating loads on the grade beam and shafts for a future slide event.
sockets are set to provide rock competent to develop the required resistance. There are occasional layers of weaker shale or mudstone within the socket that were considered in the analyses. Selection of the rock socket diameter was an iterative process of evaluating different diameters of shafts, shaft groups (two or three shaft groups), and finished grade elevations. Also germane to the selection of the rock socket diameters was the anticipation of very difficult “hard rock” drilling conditions, which was founded to be true. As such, it was desirable from a constructability standpoint to keep these diameters as small as practical.

The outer permanent casing and the concrete in the annular area between the permanent casing and the inner structural pipe were not relied upon for strength nor stiffness but are relied upon to provide corrosion protection for the inner structural pipe. The permanent outer casing had one additional benefit of providing enhanced constructability of the shafts. The permanent casing cutoff of perched groundwater from the soil above rock, allowing concrete to be placed “in the dry” by ALDOT specifications. The permanent casing, with the large diameter and shallow depths of the shafts, allowed for excellent visual inspection of the sockets as well as observation of the entire concrete placement. All of these factors eliminated the need for integrity testing of the completed shafts, allowing the bridge contractor to begin forming and tying steel for the grade beams immediately after a pair of shafts was completed.
Williams Form has been a leader in anchoring technology and concrete forming systems for nearly a century. Today, we manufacture a comprehensive line of anchors, post-tensioning systems, micropile and concrete hardware. Our construction products are used in successful foundation, excavation and stabilization projects throughout North America.

**WILLIAMS FORM**

**SUPPORTS YOUR TOUGH PROJECTS**

- Ground/Concrete Anchors
- Post-Tensioning Systems
- Concrete Forming Hardware

Williams Form has been a leader in anchoring technology and concrete forming systems for nearly a century. Today, we manufacture a comprehensive line of anchors, post-tensioning systems, micropile and concrete hardware. Our construction products are used in successful foundation, excavation and stabilization projects throughout North America.

**LOCATIONS:**
- Belmont, MI
- San Diego, CA
- Golden, CO
- Lithia Springs, GA
- Portland, OR
- Collegeville, PA
- Kent, WA
- London, ON

**CONNECT WITH US!**
williamsform.com  616.866.0815
About three weeks after the slide occurred, the decision to go with the bridges was made and detailed design began. Engineers with DBA, the ALDOT Bridge Bureau, and the ALDOT Roadway Design section worked in constant contact through late nights and weekends to complete the design. The designers also worked through the difficulties of the initial impacts of COVID-19 measures in Alabama with the shutdown of state offices and other businesses. Given the emergency status of the project, special consideration was allowed for select ALDOT staff to work in the office during this time. The ALDOT drill crews continued to make trips to the site up until shortly before bridge construction began to obtain additional data and to core final drilled shaft locations to allow the team to set the top of rock elevations at each shaft prior to shaft construction.

ALDOT issued an emergency contract to Reed Construction to do the site grading which began on March 9, 2020. The grading plan for the final grades and the bridge plans were developed during grading, being completed in time for the bridge contract to be awarded to Brasfield & Gorrie, Inc. (B&G) on May 8, 2020. An incentive/disincentive contract with was used to provide incentive for the contractor to open the road to traffic quickly, or at a minimum not delay past the stipulated opening date of December 1, 2020. B&G was able to open the bridges to traffic on Sept 28, 2020, 7.5 months from the occurrence of the slide and two months ahead of schedule, collecting the maximum $2,000,000 bonus.

ADSC Contractor Member A.H. Beck, Inc. was the foundation specialty contractor selected by B&G to install the drilled shafts. Beck began work at 12:01 a.m. on June 1, 2020, the first day allowed under the incentive/disincentive contract. DBA engineers along with engineers from ALDOT’s Geotechnical Section worked alongside the inspectors from Volkert, Inc., to observe the construction of the shafts. Beck completed all 32 shafts in two months, contributing to the early completion of the bridge. Tracy Brettmann, P.E., details the construction of the shafts in his article in the January issue of Foundation Drilling.

A robust instrumentation system was installed, with ShapeArray inclinometers in each shaft and in the surrounding slope, supplemented by traditional inclinometers in the slope and vibrating piezometers to monitor groundwater levels. The ShapeArray inclinometers and vibrating wire piezometers have wireless data collectors connected to data hubs that allow for remote access of the data. DBA and ALDOT will monitor the bridge foundations and surrounding slopes with the goal of measuring shaft displacement, if any occurs due to future slope movements, and characterizing the resulting load in the shafts.
YOUR DRILLING PARTNER
EXPERTS IN THE DRILLING INDUSTRY

DRILL TOOL RENTALS

- Augers
- Core Barrels
- Drill Buckets
- Clean-Out Buckets
- Over-Cutters
- Under-Reamers
- Steel Casing
- Cranes
- Concrete Pumps
- Crane-Mount Rigs
- Augercast Set-Ups
- Complete Mud Systems
- Consumables

Offering a complete line of Foundation Drilling Tools, Support Equipment and Drill Rigs for RENT.

For information, contact DAN PARKER
MOBILE (817) 205-2145
E-MAIL dparker@foundationdrilling.com

www.FoundationDrilling.com
EQUIPMENT
SALES | RENTALS | SERVICE | REPAIRS


Dan Brown & Associates feature

BECK MODEL 250
(shown with Low Clearance Kit)

- 185,000 ft-lb of Torque
- 154,000/174,000 Operating Weight
- 114" Dia. Tool Clearance (Front of Mast)
- 12 Month RPO Option (100% Applied)

CORPORATE OFFICE
9014 Green Road
Converse, TX 78109

HOUSTON
12751 South Freeway
Houston, TX 77047

FLORIDA
1710 N. 19th Street
Tampa, FL 33605

VIRGINIA
5264 Strasburg Road
Strasburg, VA 22657

9014 GREEN ROAD | CONVERSE, TEXAS 78109 | PH 210-342-5262

www.ahbeck.com
DBA is very fortunate and honored to have been trusted by ALDOT to help bring this project to completion and reopen the highway in a short amount of time. A robust design was created and built amongst the challenges of the first few months of the COVID-19 pandemic, with the bridge opened to traffic just in time to restore the normal route for commuters to Huntsville as work and school restrictions were beginning to be phased out.

“

A robust design was created and built amongst the challenges of the first few months of the COVID-19 pandemic.