

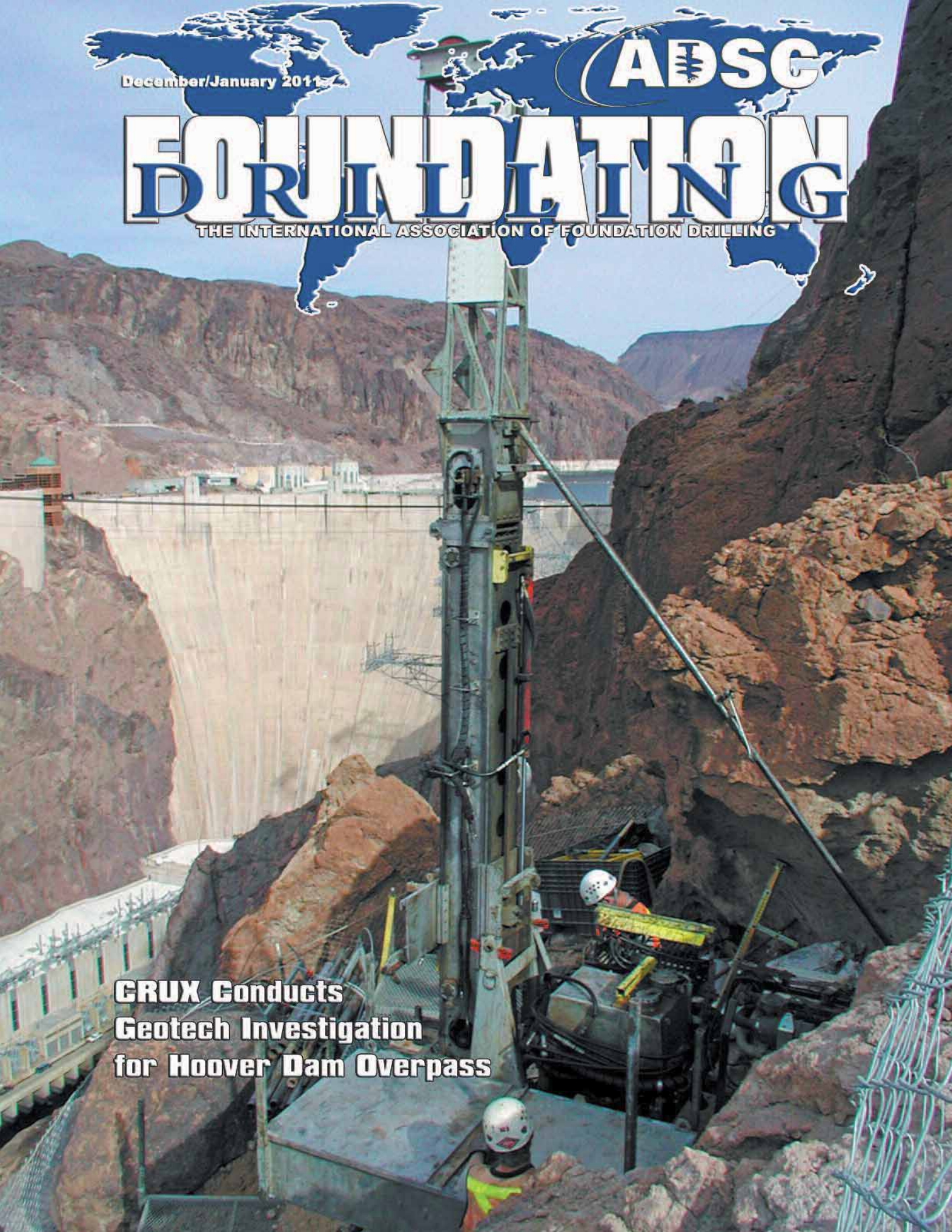
December/January 2011

ADSC

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**GRUX Conducts
Geotech Investigation
for Hoover Dam Overpass**



The Crux of the Design: A Look at the Geotechnical Investigation of the Hoover Dam Bridge Project

by Lizzy Aldridge, Technical Writer



The Crux crews are using a Goodman Jack attached to a drill rod to test the strength of the rock at the Arizona abutment site.

As one of the seven modern wonders of the world, every year the Hoover Dam draws in millions of visitors from across the globe to explore the world's largest dam. As of October of 2010, the remarkable structure can be viewed atop an arched bridge set a quarter mile down river and bridge 890 feet above the Colorado River. The Mike O'Callaghan-Pat Tillman Memorial Bridge, also known as the Hoover Dam Bypass, is a stunning engineering feat, spanning the Black Canyon 1,500 feet south of the Hoover Dam. A bold design supported by a challenging geotechnical exploration project was the beginnings of what is now the largest concrete arch bridge in the Western Hemisphere.

Genesis of a New Bridge

Plans for a bypass bridge over the Hoover Dam were first seriously discussed back in the early 1980s. US 93, the highway traversing the top of the Dam, experienced high amounts of commercial truck traffic because it was the shortest roadway between two of the fastest growing cities in the US, Phoenix and Las Vegas, and also due to its designation as a North American Free Trade Agreement (NAFTA)

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route between Mexico and Canada. In addition, the Hoover Dam attracts over one million visitors a year, which added to congestion and road-way collisions. Finally in 2001, the plans for a new highway traversing atop the nearly 900 feet tall black canyon walls were put into motion.

Design and construction support services was awarded by the Central Federal Lands Highway Division of FHWA on July 12th, 2001 to the Hoover Support Team, comprised of HDR Engineering, T.Y. Lin

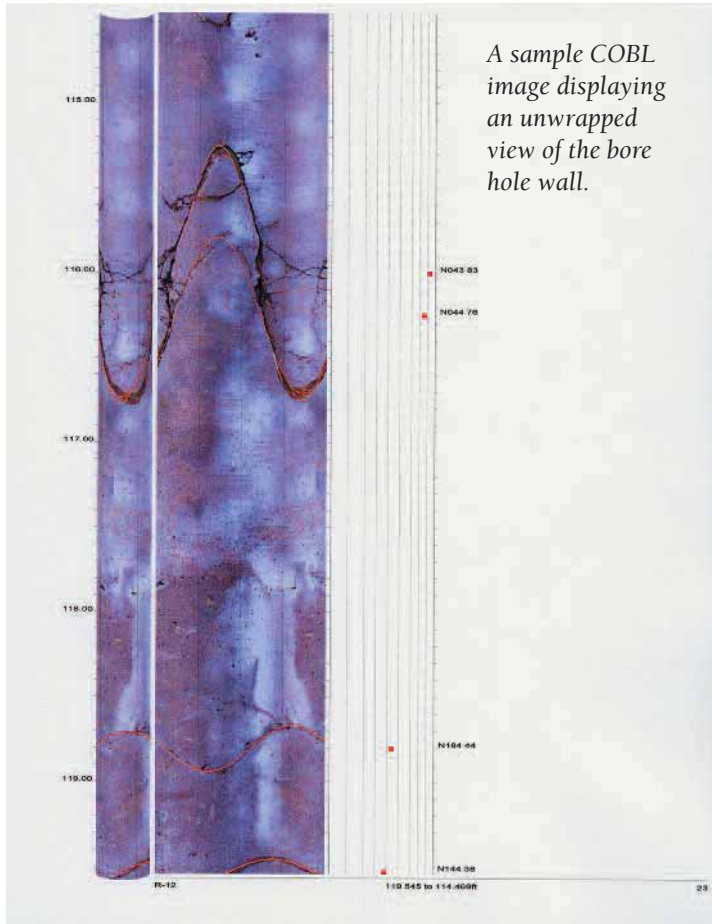
International, Sverdrup Civil, Inc. and several other supporting sub-consultants that included AMEC Earth & Environmental and ADSC Contractor Member, Crux Subsurface, Inc. The AMEC/Crux team's responsibilities for the project were to collect site data and establish

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Geotechnical investigations for the bridge began in late 2001

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A sample COBL image displaying an unwrapped view of the bore hole wall.

The geotechnical investigation confirmed that the short span was feasible, signaling final investigations of the short span locations to detail the geotechnical profile of subsurface conditions specific to the

This consisted of drilling seven boreholes up to 300 feet in depth at the alternative short- and long-span skewback locations on both sides of the canyon.

final bridge design geometry. Similar to the first phase, the final investigation included drilling, sampling and in-situ testing of an additional 22 borings at pier, abutment and skewback locations. This phase was key to obtaining information for establishing final foundation conditions and cut slope geometries for the required excavations to reach the foundation levels at each pier.

Information Synthesis: Geotechnical Characterization

By the end of 2002, Crux had provided over 10,000 feet of rock core, optical televiewer logs, in-situ rock deformation, and standard penetration tests (SPT). Holes were angled from 8 to 44 degrees and up to 300 feet deep into the challenging subsurface conditions of the near-vertical canyon. Due to the remoteness of the boring locations,

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when Crux Subsurface, Inc., a geotechnical exploration and drilling contractor specializing in difficult access and logistically challenging projects, began preliminary investigations. The first significant task at this stage was to utilize information retrieved from core rock samples to determine the geotechnical evaluation of the alternative skewback locations that would support the arch along the walls of Black Canyon. This consisted of drilling seven boreholes up to 300 feet in depth at the alternative short- and long-span skewback locations on both sides of the canyon. Upon completion of this phase, it was determined that the conditions at the shorter span location were adequate to support the bridge. The short span was initially the preferred design by The Central Federal Lands Highway Division of FHWA who served as the project managers on behalf of the multiple state and federal agencies participating in the project. Short span reduced the overall cost and aesthetically it kept the arch of the bridge centered over the canyon in alignment with the Hoover Dam.



Drill rig being assembled with the aid of a helicopter at Nevada Skewback.



Drill rig is positioned on platforms for R13.

acquiring a comprehensive geological picture from specific points of interest was critical to the engineering program.

Rock core and SPT's were provided utilizing the HQ3 triple tube coring systems (HQ3 drill a 3.782" diameter hole, creating a 2.406" diameter core sample) and NQ3 triple tube for smaller Holes (3" holes, 1.75" core).

The orientation of fractures is important information because it helps provide information on rock mass conditions that is necessary to predict behavior of excavation slopes and slopes below foundations that are adjacent to steep canyon walls.

Crux Oriented Borehole Logging (COBL) is a method of optical televue logging which obtains high resolution images of the boreholes. A specialized camera is lowered into the bore holes and orients itself by a digital fluxgate magnetometer. This high resolution image in-

dicates the fracture orientations which are correlated with core samples to determine rock mass conditions. The slope and predicted rock behavior is necessary to the excavation process by establishing the optimum cut slope angles, and designing the rock bolt support system if steeper slopes are desired, which was the case in this project.

Scott Tunison, Crux Senior Project Manager and estimator, explains that the "advantage of using the OPTV system to provide detailed orientation of critical features, allowed foundation engineers to provide a design which minimizes costs associated with unanticipated geotechnical conditions during construction. Orientating core using OPTV systems also reduce overall drill time at boring locations when compared to traditional clay impregnation or scribe core orientation techniques." Dave Peterson, project geologist with AMEC also has stated "the OPTV images were invaluable in QC review of core hole data since they provide a continuous image of the boring."

In-situ rock deformation data was provided using a Goodman Jack at select locations to estimate rock mass modulus

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Another view of the helicopter and ground crew placing drill rig components at the Nevada Skewback Location.

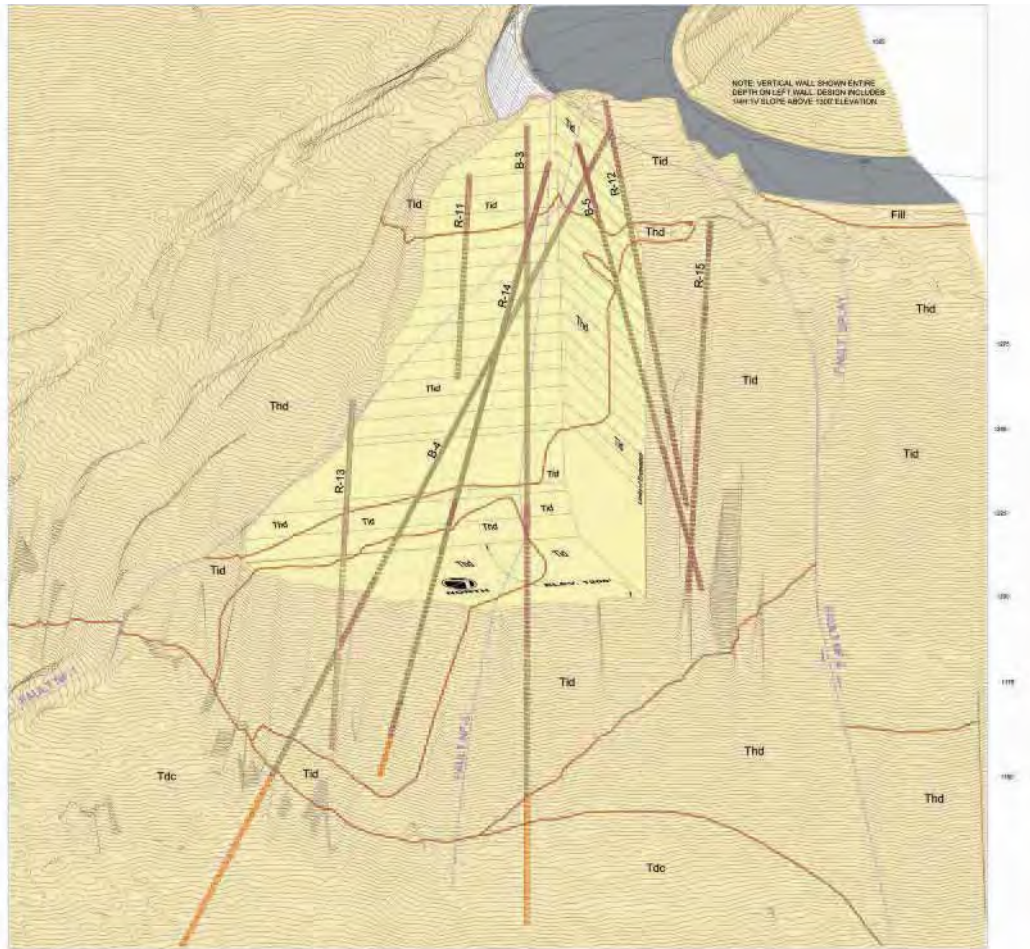
below critical foundations at the skewbacks. The tool is a borehole probe used to measure deformation of the borehole wall, as a function of applied load. The Jack is coupled to the drill rod and inserted into a 3.0 inch diameter borehole, along with its hydraulic lines and signal cable. The pistons push a curved bearing plate against the borehole wall, producing a uniform, uni-directional stress field. The applied pressure is measured with a pressure gauge, and the deformation of the rock is calibrated by two linear variable differential transformers (LVDT). The data from this in-situ testing was then considered by the geotechnical engineers to characterize rock quality and rock mass strengths.

Acquiring Data from the Edge

Crux was selected to perform the geotechnical exploration because the multifaceted access constraints and borehole requirements necessitated a contractor with the specialized equipment and techniques to complete the work. Crux's key qualifications for this project was the team's ability to employ helicopters and cranes to position their custom made drill rigs on the near vertical canyon walls. In addition, Hoover Dam's 250 kV transmission line created significant access challenges. Expert helicopter pilots had to navigate both above and below the live wires to deliver the equipment to the sites.

The drill rigs used in this investigation are compact and portable and are designed to break into small components which allows for safe helicopter transport from the yard location or to the next drill site. The componentized design of the rigs allow for delivery via truck, track, crane, helicopter, or the Crux fabricated Spyder walking excavator. Multiple platforms were used to support the drill rigs, including self-propelled track mounts for the boreholes above the canyon walls, and platforms with adjustable legs that could be set up within the canyon. Rock bolted anchors and steel rebar were installed using rock hammers and air rotary hammers by crews in advance utilizing mountaineering skills. The high capacity anchors allowed for placement of the steel platforms and the rig by either a 35-ton rough terrain crane or helicopter.

The extreme exposure of working on the steep canyon walls also required safety anchoring and fencing for fall protection. All field personnel were trained in fall protection and rigging, and wore appropriate fall protection equipment to assure personnel safety. Mike Kennedy, Crux Subsurface project manager for the project, explains "safety is always the biggest priority on any job, we always make sure our crews are set up in the safest manner possible. We will go above and beyond with customized tooling or procedures to get the job done in the safest manner possible."



Computer generated depiction of Nevada Scowback with bore hole locations and final excavations.

Geologic Findings and Final Design Recommendations

The subsurface data gathered by Crux was an essential component for developing the geotechnical design recommendations. "Crux's innovative approach using multiple investigative techniques to efficiently and cost effectively collect quality geotechnical data given the access constraints, was key to the final design of the Bridge foundations and required excavations," confirmed David E. Peterson, P.G. The exploration program confirmed that foundations would be founded on Tertiary-age volcanic and sedimentary rocks, but composed of variable quality. Massive tuff and basalt dikes dominated the site and were found to underlie most of the pier foundations. Tuff is a soft rock, variable in quality where the basalt is more consistent in hardness and rock quality. The conclusion of the geotechnical investigation was that, although two different rock qualities existed at the skewback locations, there was adequate bearing capacity to support spread-type footings for the new bridge. The bridge skewbacks were designed and constructed as spread footings on rock, with heavily reinforced concrete on a bench excavated into the canyon walls on

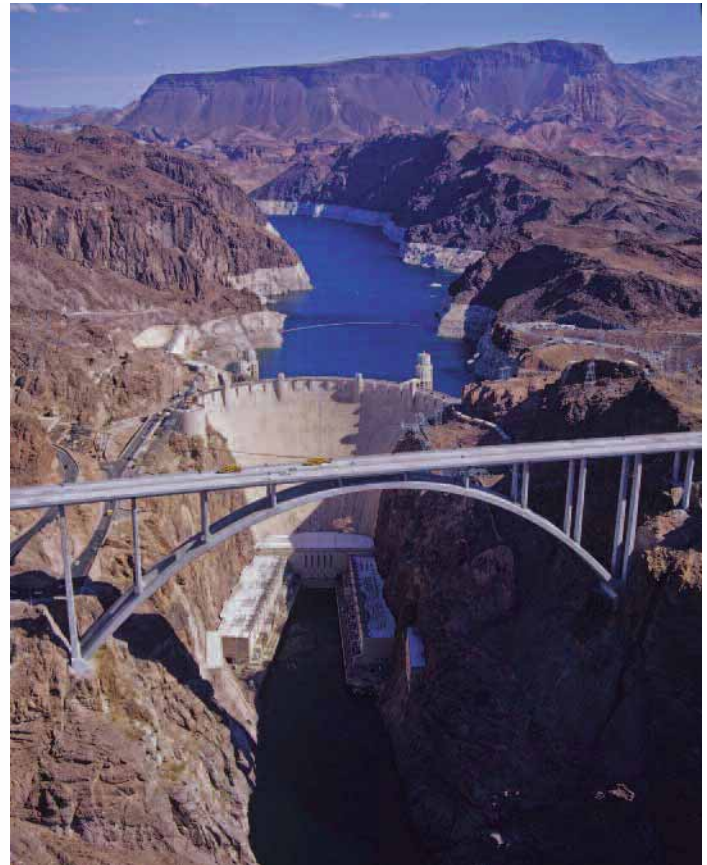
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either the tuff or basalt rock. During construction for the bridge, the excavation revealed that the geotechnical conditions very closely matched the conditions presented in the geotechnical report. Crux's participation aided in the ability to compile highly precise and accurate information during the geotechnical investigation which contributed to this successful project, without surprises in foundation conditions.

After nearly a decade and 16 million pounds of steel, 30,000 cubic yards of concrete and 2 million feet of cable later, the Hoover Dam Bypass Bridge opened officially on October 19, 2010.

This monumental project presented many challenges to the design and construction teams. Creative and innovative approaches were necessary to bring this concept to reality, and that was certainly reflected in the geotechnical investigation. A highly specialized contractor, combined with modern approaches to mapping, modeling and testing, created a clear picture of the geotechnical conditions and allowed for a design to incorporate the rock conditions at the site. Nick Salisbury, CEO of Crux Subsurface, explains how this project has nationally expanded the utilization of their unique geotechnical investigative methods. "It certainly was an honor to work on a project of this magnitude, and although we have executed hundreds of geotechnical exploration projects since the completion of the Hoover Dam Bypass project in 2002, to this day it remains a cornerstone project in Crux's resume."

The Mike O'Callaghan-Pat Tillman Memorial Bridge is now a magnificent representation of what can be accomplished when a dedicated team allows convention to be cast aside.



The project consists of 3.5 miles of new four-lane highway and a new 1,900 foot long bridge over the Colorado River, tying into the existing U.S. 93. The bridge construction was completed in October of 2010.



Project Team Box

Agencies:	HWA/Central Federal Lands Highway Division Arizona Department of Transportation Nevada Department of Transportation U.S. Bureau of Reclamation National Park Service Western Area Power Administration
Consultants:	HDR Engineering, Inc.* T.Y. Lin International Sverdrup Civil AMEC Earth & Environmental* Crux Subsurface, Inc.*
Contractor:	Crux Subsurface, Inc.* Nick Salisbury, Project Executive Mike Kennedy, Project Manager Scott Tunison, Estimator/Senior Project Manager Fred Kruger, Division Manager, COBL (division of Crux) Harold Skaar, Lead Project Pilot, Director of Flight Safety

*Indicates ADSC member firms.



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