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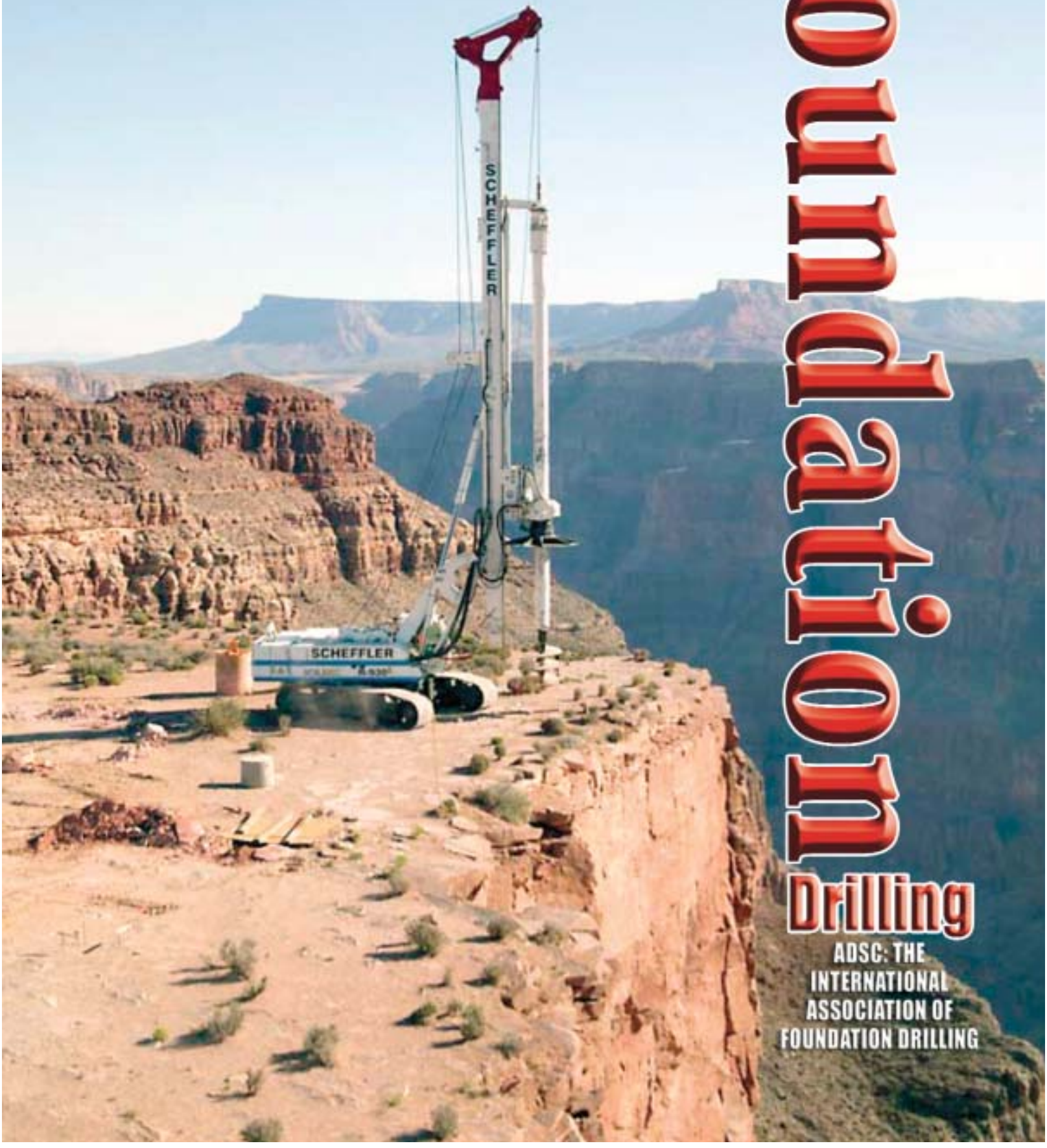
Foundation Drilling

D.J. Scheffler Does Micropiles for Grand Canyon Skywalk



ADSC: THE INTERNATIONAL ASSOCIATION OF FOUNDATION DRILLING

The Skywalk at Eagle Point, Grand Canyon West, An Opportunity for Micropiles

by Shel Segal and
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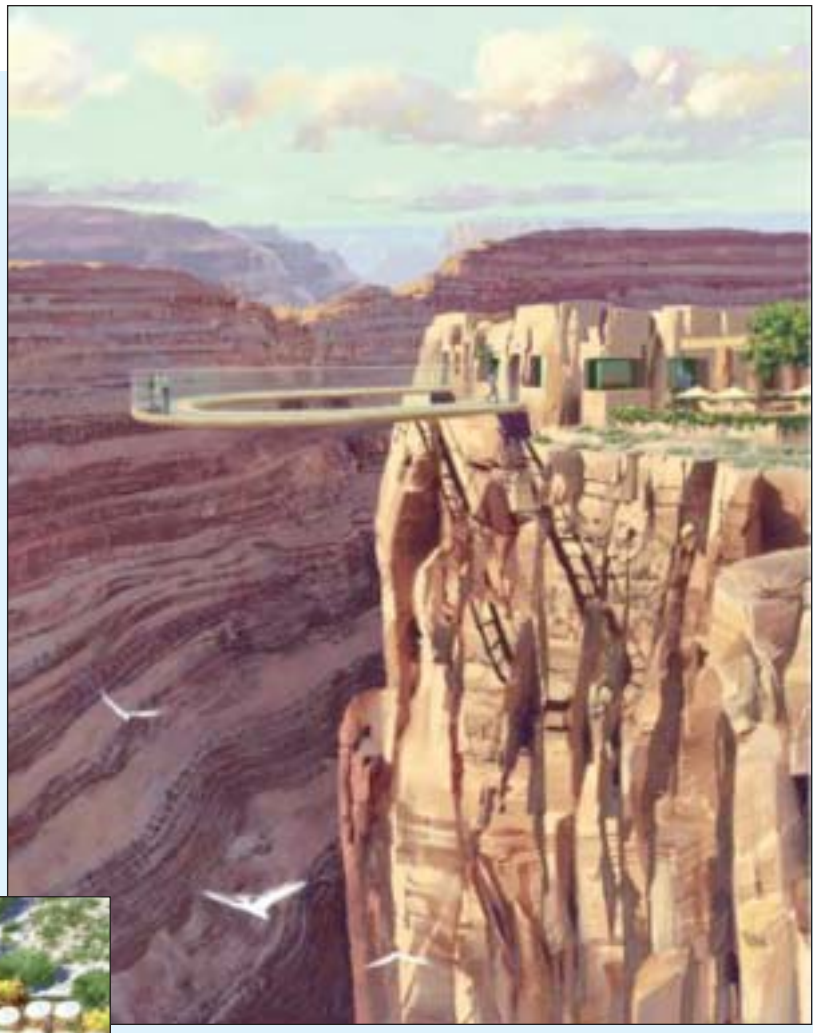
Sometimes a bold initiative requires ingenious thinking. That is what Pomona, California-based ADSC Contractor Member, D.J. Scheffler, Inc. has accomplished with its foundation drilling work on the Skywalk at Eagle Point, Grand Canyon West in Arizona. Allowing the Skywalk to support the weight of visitors, in addition to withstanding the elements, which can naturally be quite harsh at an elevation hovering around 4,000 feet, has been the primary focus of building this wonder which will one day move from being a dream to becoming a major tourist attraction. Once finished, the Skywalk will be situated off a cliff in the Hualapai Indian reservation, with nothing but 4,000 feet between them and the Colorado River.



Depicted in an artist's rendering is a bird's eye view from the canyon rim of The Skywalk at Eagle Point, Hualapai Indian Reservation, Grand Canyon West, Arizona.

Another artist's rendering of The Skywalk at Eagle Point. What a cliff hanger.

The Skywalk is a $7 million U-shaped structure that cantilevers 70 feet out over the canyon.

This will give future visitors a view once seen just by birds.

(continued on page 3)

The Skywalk is a $7 million U-shaped structure that cantilevers 70 feet out over the canyon. It was designed with a glass floor, allowing visitors to view the spectacular Grand Canyon beneath their feet. In order to ensure the long term viability of the structure under a variety of loadings, the foundation was designed to support loading equivalent to that of 72 Boeing 757 jets, while the structure was designed to withstand 100 MPH winds and survive an 8.0 magnitude earthquake centered 50 miles from the Skywalk location. In order to meet these requirements, the Skywalk design required more than one million pounds of steel beam and a massive foundation system to anchor this monumental structure in place.

D.J. Scheffler, a general engineering construction company specializing in drilled foundation systems, was invited by APCO Construction of Las Vegas to prepare a budgetary proposal for the foundation system. The foundation design at that time primarily included 30" and 36" diameter drilled shafts embedded 50' into the limestone of the canyon walls. Based on their superior qualifications and pricing structure, D.J. Scheffler was awarded the work and joined the project team, which also included Jasna Yikic of Lochsa Engineering, Mark Johnson of MRJ Architectural, and geotechnical engineer Aaron Hastings, of Arroyo Engineering Consultants, all of which are based in Las Vegas.

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View of excavated pile cap with some of the vertical micropiles installed through steel plate template.

The budgetary proposal provided by D.J. Scheffler was based on a verbally conveyed preliminary design that included numerous drilled shafts embedded into 12,000 to 18,000 PSI limestone. Based on previous drilling experience in this type of rock, it was clear to D.J. Scheffler that construction of the drilled shaft foundations would be difficult and time consuming. Adding to the difficulty was the strong desire by all parties to provide the highest level of quality control. Providing this level of quality control with a drilled shaft design was difficult due to the inherent challenges associated with the project location. In particular, the distance from the project to the nearest concrete supplier yielded strong concerns about the concrete quality given the time it would need to be in transit to the site. The long round trip time and shear volume of concrete required for the shaft foundations also carried a very high cost. In addition to these chal-

(continued on page 4)

lenges, the project was also located on Hualapai tribal land where limiting disturbance to the natural environment is of extreme importance.

After thoroughly reviewing the design of the foundation system and the project constraints, it was clear to D.J. Scheffler that the original drilled shaft foundation, while the best foundation solution in many cases, was not the optimum solution here, and would be difficult to install within budget while still maintaining the highest level of quality. "Whenever we do a project, we never want to sacrifice quality over finances," Dale Scheffler, president of D.J. Scheffler, said. "However, if we can provide an alternate solution that will save the owner money while maintaining or increasing the level of quality control, and it is the most practical way to accomplish the task, then, by all means, that is what we will do to finish the job."

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SoilMec 401 with down hole hammer drilling the perimeter of the pile cap.

SoilMec 401 drilling one of three tiebacks for the pilecap plus the template for the micropiles.

After internally analyzing several foundation systems, D.J. Scheffler proposed a much more efficient alternative foundation system to the project team, one that relied on micropiles instead of drilled shafts to achieve the required capacity. Not only did this proposal reduce the overall cost of the foundation, but it also had the advantage of eliminating the concrete quality control concerns as the

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micropiles utilized grout (six gallons of water per 94 lb bag of cement) mixed onsite in lieu of ready-mix concrete. In addition, the micropile design reduced the total volume of rock that needed to be excavated and replaced with artificial materials – very important considering that the Skywalk was not only to be installed at one of the world's greatest natural wonders, but also on tribal land, where the river is viewed as the Father and the land as the Mother. The micropile design also solved one of the other great challenges of the project – the hardness of the rock. At an average of 16,000 psi, the rock would have been extremely difficult to drill with conventional large diameter tooling, but relatively easy to drill with the down-the-hole hammers commonly used for micropile installation.

Equipment used to test the micropiles to over 500% of design adhesion.

Prior to completion of the final design, D.J. Scheffler performed a testing program to verify the assumed adhesion between the rock and grout. In June 2004, three sacrificial micropiles were installed with a 20-foot bond length and tested to 160 Kips. Additionally, a fourth was installed with a 25-foot bond length and tested to 280 Kips. None of the micropiles showed any sign of significant movement and met all creep requirements. Based on the testing program, it was determined that the adhesion values assumed for the initial design were reasonable (11.3 Kips/LF).

The final design was agreed upon after the team reviewed the sacrificial micropile test data and performed rigorous analysis of the concept with respect to wind loading. The design included the installation of four large pile caps each with up to 25 micropiles each, as well as 12 smaller pile caps that each included a single micropile.

In April 2005, prior to installation of the production micropiles, D.J. Scheffler performed a second round of verification testing, again using sacrificial micropile anchors. This testing was performed as a result of the design team's desire to test to 400% of the design adhesion load (45.4 Kips/LF or 200 psi). Two anchors, VT-1 and VT-2, were installed, both using 2-1/2" Grade 150 threadbar. VT-1 was drilled to a depth of 40-feet, with a 17-foot bond zone. VT-2 was designed to test the adhesion in the limestone near the surface, and was installed to a total depth of 21.5-feet and with a 14-foot bond zone. After allowing the grout to cure, both anchors were tested to near ultimate capacity of the threadbar. VT-1 was tested to 769.1 Kips and VT-2 was initially loaded to 633.4 Kips. Both anchors met the design criteria at these incredible loads. To further test the micropile system, D.J. Scheffler then attempted to extract VT-2 by increasing the load to 835 Kips, at which point the bond between the grout and rock finally failed. This load represented 527% of the design adhesion – well beyond the hopes of the design team. "We were very happy when the tests came back with positive results," Scheffler, said. "It validated our original premise and meant we could get to work."

In April 2005, prior to installation of the production micropiles, D.J. Scheffler performed a second round of verification testing, again using sacrificial micropile anchors.

Following the secondary test program, construction started on the foundation system. This included four large pile caps that were 13.5' L x 6' W x 6' D. At the base of each pile

(continued on page 6)

This photo shows the remoteness of the area and the difficulty in bringing in equipment and concrete.

cap, 22 each 6" diameter micropiles were installed to a depth of 40'. At two of the four large pilecaps, D.J. Scheffler also installed 3 each battered micropiles. The battered micropiles were also installed to a depth of 40' at an angle of 30-degrees from horizontal. The large pile caps were excavated using conventional earthwork equipment, after line drilling the perimeter using a down-the-hole hammer mounted on a Soilmec 401* single rotary hydraulic drill rig. D.J. Scheffler then installed the micropiles in the base of each pile cap, using a template made of steel plating to ensure that the micropiles were properly positioned and installed within tolerance. The steel plate also served as a platform for the drill rig and crew while installing the micropiles in the center of the excavation. Each of the vertical micropiles had a 40' length and a working adhesion of 11.31 Kips/ft. To achieve this load, D.J. Scheffler installed 2-1/2" diameter Grade 150 threadbar in a 6" diameter hole drilled with a down-the-hole hammer and button bit.

Rick Broadrick, project superintendent for D.J. Scheffler, said he was just awestruck with the magnitude of building the Skywalk. "The bottom line is it is a unique project," Broadrick said. "You do not see many glass walkways over canyons, let alone over the Grand Canyon."

In addition to the total of 94 micropiles installed at the large pilecaps, D.J. Scheffler also utilized a 220,000 lb Soilmec 930* to drill the smaller diameter pilecaps, as the limestone would have been extremely difficult to excavate using conventional equipment. Just getting the massive Soilmec 930, one of only four in the United States at that time, to the project site proved to be a great challenge. After receiving permission to pass through the Indian reservation with the equipment, a dirt road was taken across desolate Mojave County. This took three days to get the drill to the site. However, Scheffler said the officials with the county were extremely helpful and made sure the equipment

(continued on page 7)

got to Eagle Point. We could not have done it without the help that some of the guys with Mojave County gave us," he said. "Logistically, this was pretty difficult and the mobilization required a lot of planning of its own.

Scheffler added he knew the project was off to a good start when a medicine man from the Hualapai tribe, who has since passed on, blessed the equipment and the crew.

But, with the help of a few, it became possible and we were able to begin the task that we were selected to do." Scheffler added he knew the project was off to a good start when a medicine man from the Hualapai tribe, who has since passed on, blessed the equipment and the crew.

Once the pilecaps were drilled to depth with the Soilmec 930, D.J. Scheffler installed one micropile at the base of each pilecap. These micropiles each utilized a 40' long, 6" diameter drill hole and were installed using a Davey Kent DK525* hydraulic single rotary drill rig with down-the-hole hammer system.

The construction phase of the project was a great success due to D.J. Scheffler's proposal to use micropiles in lieu of the original drilled shaft foundation system. The micropile drill rigs had little difficulty drilling through the extremely hard limestone, evidenced by the max drilling rate of 7 micropiles per day. In addition, quality control was maintained throughout the process, not only through the demanding testing programs, but also through constant observation of qualified geotechnical engineers. Reza Bionki, senior estimator for D.J. Scheffler, estimated the decision to use micropiles on this project saved the owner somewhere in the neighborhood of $500,000.

Steve Morgan, site superintendent for D.J. Scheffler, said this project was rather unusual given the elements and work area. "It was quite a challenge," Morgan said. "The site was 20 miles away from civilization, reached only by a dirt road. When you are working that close to the edge, 4,000 feet up, it really makes a difference. It can turn your stomach."

"It was a difficult job and made more difficult by the climate of the area," said Scheffler, of the winds in the area that can at times exceed 90 miles per hour. "But with a good plan in place and a solid, hard-working team, the plan was perfectly executed."

The Skywalk is scheduled to open sometime in late 2007. It will be the highest man-made structure in the world, more than twice as high as the tallest skyscraper in Taipei, Taiwan and a great addition to the eighth wonders of the world, the Grand Canyon. "This will be an incredible attraction, once it is completed," Scheffler said. "It will cater to people from all over the world, and I am glad we had a chance to be a part of it."

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Project Team

Project:	Skywalk
Owners:	David Jin and Hualapai Tribe
Foundation Contractor:	Dale Scheffler, D.J. Scheffler, Inc.
General Contractor:	APCO Construction of Las Vegas
Structural Engineer:	Jasna Yikic, Lochsa Engineering
Architect:	Mark Johnson, MRJ Architechtural
Geotechnical Engineer:	Aaron Hastings, Arroyo Engineering Consultants
Estimator:	Reza Bionki
Superintendent:	Rick Broadrick