Outstanding Infrastructure Project Honorable Mention—
SR-89A Banjo Bill Rock Containment

The Banjo Bill Rock Containment project is a slope stabilization project within Oak Creek Canyon, on State Route (SR) 89A near Sedona, AZ. Contracted by the Arizona Department of Transportation (ADOT), this project was designed to stabilize a slope that had historically blocked the roadway below with rockfall and debris flow. The project involved anchored micropile earth retention structures that would create two catchment basins to contain boulders and rocks that fall from the steep canyon walls. Shotcrete played a crucial role in the structural integrity of the walls, realistically carved architectural fascia, and overall blending with the surrounding scenic viewshed, making the Banjo Bill Rock Containment Project an excellent candidate for an American Shotcrete Association (ASA) 2008 Award of Outstanding Shotcrete Project in the Infrastructure category.

The need for this slope stabilization project was evident by rockfall onto the roadway and into a United States Forest Service (USFS) campground adjacent to the project area. Since 1999, ADOT closed the roadway six times at the Banjo Bill Campground, due to rockfall by boulders of up to 6 ft (1.8 m) in diameter. Fortunately, no injuries resulted from these rockfall events. ADOT first contracted the rockfall containment project in 2004, but inclement weather and inexperience on the part of the contractor caused the project to end unfinished. The contract went to bid a second time, using a prequalification process to ensure selection of a contractor with the drilling and shotcrete experience and capability to complete the project.

To fully understand the important role shotcrete played in this project, one must appreciate the issues that faced the project team during construction. Site challenges and a deadline dependent on threatened species in the canyon added to the complexity of completing the project. The site is a boulder-strewn talus slope with a 30 to 40 degree incline to the canyon rim, 1400 ft (427 m) above the roadway. The slope needed stabilization in two areas, requiring two 30 ft (9 m) retaining walls. The roadway is aligned through two natural drainage basins, very close to the pristine Oak Creek for which the canyon is named. The roadway ran through the job site, creating a constant stream of traffic during construction. Rockfall danger from upslope was present throughout, and special fences were installed to capture rocks that may potentially fall onto the “drill benches,” the work zones needed to perform the micropile drilling and excavation associated with the construction of the retaining wall. Difficult ground conditions and slope stability would be issues throughout construction, and affect the team’s ability to blow shotcrete.

These issues were addressed through careful drilling operations monitored daily with inclinometers and daily survey readings of the slope above the project. USFS protected Mexican Spotted Owls nest in the canyon. This required a contract period of October 2007 through April 2008, the period that owls were known to be away from their Oak Creek Canyon breeding areas. This meant that all construction activity needed to occur during winter months, and the project team would have to work through any and all winter weather.

The project team worked diligently together from the project award to ensure completion in the given timeframes, with a focus on safety. The project was completed on time with no impact to the sensitive Oak Creek environment and no serious injuries occurred. Shotcrete supported the effort to complete the project on time, allowing an application that could be taken uphill, provide structural support, and could be formed to visually blend with the scenic byway status viewshed within the canyon.

Shotcrete was the optimal choice for concrete application on this job. Shotcrete would allow the team to install walls in the narrow project area, using a “top down” approach. High velocity installation creates a high-density product that is structurally sound and durable. Forming the architectural fascia and staining the shotcrete is relatively easy. For these reasons, shotcrete was used to form the cap beam of north and south retaining walls, form a is-inch thick structural facing for connecting rows of anchors to micropiles, and a is-inch thick aesthetic outer facing, carved to emulate features of the natural rock in the area.

The cap beam was shot in advance of the wall construction and anchor installation. The reinforced cap beam was designed to connect the top of piles together and connect the top row of anchors. The retaining walls were built

“top down,” which meant that the shotcrete cap beam pour would be the first shotcrete install on the job—a very important piece of the structural integrity of the finished wall. The cap beam was installed in cold temperatures, with moisture on the ground. The crew used proper air entrainment techniques and covered the fresh concrete to ensure maximum strength despite multiple freezing-and-thawing cycles during curing. Additionally, the crew decreased cap beam permeability by applying silica fume, slag cement, and fly ash in the mixture. This helped the shotcrete resist the moisture it was exposed to during critical saturation. With the cap beam in place, the crews would begin excavating downward, installing reinforced reinforcing bar for the structural shotcrete facing and drilling the anchors that would hold the slope in place.

The structural shotcrete facing was installed to connect the remaining three anchor rows to the previously-drilled micropiles. The structural shotcrete was installed in three lifts, each one requiring the team to excavate further downward to facilitate anchor drilling, reinforcing bar placement, and shotcreting. This method of construction indicates that each “lift,” or row of anchors, could stand alone as structurally sound. Each anchor row tied the shotcrete facing into the micropile-stabilized hillside with bearing plates and embedded blockout pipes, with each anchor bond length founded deep in the sandstone bedrock. The shotcrete facing is heavily reinforced to act as a waler section along each anchor row alignment, and the entire facing is vertically reinforced for strength. These construction techniques allow the three components to work together to reduce potential slope shifts. By creating the retaining walls in this manner, the project team achieved slope stabilization while mitigating the outwardly moving effects of static, water, and seismic pressure. The structural shotcrete facing ties the anchors and piles together and acts as support for a is-inch thick aesthetic outer shotcrete facing.

Installing the outer facing, or architectural fascia, was one of the final stages of the project. The previous two shotcrete installations had been performed by ACI Certified Nozzleman employed by the prime contractor. The aesthetic fascia was subcontracted to a firm that specializes in “rockscaping” a sculpted shotcrete to the plans and specifications of contractor, ADOT, and the USFS. The rockscaping and staining procedure required approval from the USFS in this stage. Attention to detail was required to sculpt the shotcrete to visually blend with natural rock formations in Oak Creek Canyon. The dramatic topography of Oak Creek Canyon, combined with erratic exposure and the effects of erosion, creates a color and textural pattern that varies greatly throughout the Canyon.

The goal of the project team was to create a retaining wall system that was integrated into the viewshed of this particular area of the Canyon. The retaining walls are located on USFS land in the Coconino National Forest, across from the Banjo Bill Day Use Area, in an area designated as a Scenic Byway. This is a highly traveled tourist corridor and the project intent was to create a seamless visual aesthetic for Canyon visitors. To be considered successful, Coconino National Forest management staff approval was required. Traditional shotcrete sculpting and staining methods were used to create a small “test pane” allowing the project team to tweak the finished shotcrete product to USFS specifications.

Shotcrete methods and materials allowed this project to be extremely successful. There was little option when considering how to get structurally sound and aesthetically pleasing retaining walls installed in the narrow project area through difficult winter conditions. Strength tests well over 4000 psi (27 MPa) for each shotcrete element indicate a finished product that will safely protect the roadway from rockfall for years to come. Shotcrete clearly played the major role in this project, enabling the “top down” approach, tying all the micropiles and anchors together, and forming the complex visual component of the finished product.

Shotcrete is an application process that aided the project team in producing a high-quality product in the timeframes allotted. Shotcrete was used as a starting point for best construction practices implemented by the construction team. Shotcrete allowed each row of anchors to connect to the micropiles and the retaining wall itself, creating a retention system in which each element is linked together, reducing the possibility of failure. Shotcrete provided the final look and feel of the product, allowing ADOT to maintain the safety of the roadway corridor and create two walls that visually blend with the surrounding Oak Creek Canyon in a way that does not adversely impact the experience of visitors to the scenic byway that winds through the canyon.

Each of these elements showcases why shotcrete is a valuable and widely-used building process. Shotcrete has advantages over traditionally-placed concrete in many instances. On a project like this, where poured concrete is not an option, the true utility and versatility of the material and process is crucial. Shotcrete was used in multiple critical construction steps to produce retaining walls that met all structural integrity and aesthetic goals. The Banjo Bill Rock Containment Project demonstrates the usefulness, strength, and aesthetic adaptability of shotcrete.