Ingenuity Offers a Solution to an Anomaly in a Bridge Support

CSDA Contractor Member Part of the Most Expensive Public Works Project in California History

Walkway to the congested work platform.
The San Francisco-Oakland Bay Bridge was opened for traffic on November 12, 1936. At that time, it was the largest and most expensive bridge in the world. The bridge spanned the eight miles across the bay and cost $79.5 million Great Depression dollars. The double-deck bridge was essentially made up of two spans, an eastern span and a western span, connected by the world’s largest diameter tunnel at Yerba Buena Island (YBI). Each span featured a variety of design elements that made it unlike any other bridge in the world.

On October 17, 1989, when a 250-ton section of the upper deck of the East Span collapsed during the 7.1 magnitude Loma Prieta earthquake, the entire Bay Bridge was temporarily closed for repairs. Within a month, the East Span reopened but the bridge failure raised an essential question which was how could the bridge be bolstered to withstand the next big earthquake? The answer came after an exhaustive study was made by seismic experts from around the world.
It was decided that the twin suspension bridges of the West Span near San Francisco would be retrofitted with massive amounts of steel, concrete, bolts and the application of new seismic safety technology. This phase of the project was completed in 2004.

Next, the studies concluded that rather than a retrofit, the two-mile East Span needed to be completely rebuilt. When completed in 2013, the new East Span will consist of several different sections but will appear as a single, streamlined span. At a total cost of $6.3 billion dollars, this project will be the second most expensive public works project in United States history, behind the Big Dig in Boston, and the largest in California.

The new span will feature the world’s longest Self-Anchored Suspension Span (SAS) connected to a roadway on piers (Skyway) which will gradually slope down towards the Oakland shoreline (Oakland Touchdown). The east and westbound lanes of the East Span will no longer be configured as upper and lower decks. The lanes will be parallel to each other and will provide motorists with more expansive views of the Bay area. The new span will be aligned north of the existing bridge to allow traffic to continue flowing on the existing bridge as the new span is built. The new YBI Transition Structure will connect the SAS to the YBI tunnel and will transition side-by-side traffic to the upper and lower decks of the tunnel and the West Span. When construction of the new East Span is complete and vehicles have been rerouted to it, the old span will be demolished.

The SAS will be the signature span of the new Bay Bridge. Its single steel tower will reach 525 feet above mean sea level, complementing the highest tower on the West Span. To add to its distinctiveness, the asymmetrical suspension span will have a longer forward span, east of the tower, which will provide a more gradual transition from the gently sloping Skyway. This will give the East Span a unique silhouette.

Rising 525 feet and embedded in rock, the single-tower span is designed to withstand ground motions caused by a massive earthquake.

The foundation for the massive SAS tower is called the T1 foundation. The T1 foundation consists of a steel footing box welded to steel shells surrounding 13 cast-in-drilled-hole (CIDH) concrete piles. The lower portion of the pile, which is composed of massive amounts of reinforced concrete, is anchored deep into bedrock through a method called “rock socketing.” The piles extend 196 feet below the waterline and are anchored into bedrock. The CIDH piles are comprised of two parts; the lower portion of the pile is made up of heavily reinforced concrete and placed within shafts, which are drilled into bedrock. These shafts are referred to as rock sockets as they anchor the piles deep within the bedrock. The upper portion of the pile is a permanent steel shell, about eight feet in diameter and filled with more heavily reinforced concrete. This shell is welded to the footing box. The entire steel footing box is encased in concrete to make up the tower foundation that will measure 85 feet long, 73 feet wide and 21 feet thick.

During construction of the T1 footing, one of the 13 supporting piles was found to have an anomaly approximately 130 feet down from the surface of the concrete. The California Department of Transportation (Caltrans) and KFM, the joint venture partnership of Kiewit Pacific of Vancouver, FCI Constructors Northern Division from San Jose and Manson Construction Company from Seattle derived a plan to fix this problem. It was decided to drill a 14-inch-diameter hole to a depth of 150 feet. Then a 30-foot-long steel pin, measuring 13 inches in diameter, would be inserted into this hole and placed so that it would extend 15 feet above and 15 feet below the anomaly. Then the pin would be pressure grouted into place; any voids around the pin would be filled and the hole would be sealed. Some of the larger foundation drilling companies in the area were contacted to look at the possibility...
of bringing in a hammer drill or a down-the-hole drill to quickly drill out the hole that was needed. One major problem to this proposal was access to the drill site. The hole they needed was inside an 8-foot-diameter steel pile shell, 50 feet below the water surface. The other problem was that there were vertical pieces of steel reinforcements throughout the concrete so a hammer drill wouldn’t work. These two major problems made it necessary for diamond core drilling to be used.

CSDA member Del Secco Diamond Core and Saw, Inc. from Hayward, California, was called to do the job which called for drilling a 14-inch-diameter hole, 150 feet deep and 60 feet down inside of an 8-foot-diameter steel shell. Del Secco had worked on the west approach of the bridge as well. “We were not the lowest bidder on this job,” said Michael Nunes, general manager for Del Secco. “We were given the go ahead to begin tooling up for the job after our presentation based on the fact that we had the best plan and the greatest probability of completing this hole.”

Because of the tight working conditions, 60 to 70 feet down inside an 8-foot-diameter shell, the site was considered a mineshaft. So, prior to any work being completed, Del Secco crews were trained in confined space entry as well as mineshaft safety.

The first step was to drill a 3-inch-diameter pilot hole to the desired depth of 150 feet. This was used to find the anomaly and to aid later in the retrieval of the larger 14-inch-diameter core. The 14-inch core would be drilled over the 3-inch hole using continuous tubing. Del Secco designed a bullet wedge core retrieval system that was able to go down the pilot hole and expand to grab the core and bring it up.

With the pilot hole completed, operators began drilling the 14-inch-diameter hole. With the desired depth of 150 feet and the weight of the core bit at approximately 5,000 pounds, it was apparent that one set of segments would not make the entire cut before wearing out. Del Secco designed a technique whereby a new diamond crown could be inserted into the hole without reaming the hole at any point. The hole was drilled in 12-foot passes, the core broken and then removed in about 2,000-pound increments.

Del Secco worked with Diamond Products on this project who supplied them with its M-6 drill stand. Del Secco custom fabricated the drill stand for this project, which included a foot clamp capable of grabbing the bit and holding it from going back down the drilled hole. This was attached to the Diamond Products 4-inch by 6-inch by 10-foot tall column and its M-6 carriage with 2:1 gear reduction. Diamond Products also supplied Del Secco with the low RPM hydraulic drills, as well as the bearing blocks and water blocks needed for this project.
The two operators drilling the hole had to get out of the hole each time a 4-foot section of tubing was lowered 60 feet down the 8-foot diameter caisson to the work area. To drill 12 feet took less than five hours. To remove the operators, core bit, core and continue a second 12-foot pass averaged another 12 hours, due to the confined space.

In order to move the volume of water needed to flush out a hole of this size and depth, Del Secco used four 1,000 gallon water tanks powered by four 300 psi jet pumps all directly hooked into the water block. This amount of fresh water was supplied directly from the dedicated crane supporting their operations—one of the largest cranes on the water today, the D.B. General, General Construction’s 700-ton floating crane has a 310,000 gallon fresh water tank.

The D.B. General was an instrumental part of their operations. The continuous core drill bit tubing used weighed about 125 pounds per 4-foot section. At the end of the job, they had 38 of these sections strung together and the D.B. General lifted the 150-foot-long, 5,000-pound bit in and out of the hole. The weight of the bit was so great towards the bottom of the hole that it actually impacted the segments. The crane was used at this point to help support the weight of the bit during drilling operations so that the bit didn’t just screw into the concrete like a corkscrew, never to come out again.

“All in all, we worked two 12-hour shifts around the clock on this project and it took approximately 17 days to complete, including setting up and breaking down equipment. We removed approximately 24,000 pounds of concrete core from this one hole. This project, on a difficulty scale of one to ten, was definitely a ten. Not only was this a challenging hole, but the confined space presented significant challenges,” said Nunes.

Nunes concluded, “In the past, Del Secco has drilled many small diameter holes up to and in excess of 200 feet, but nothing has even come close to the complexity of this hole. Everyone on this project was proud to be a part of the team and accomplish such a daunting task.” The operators on this job were Dave Del Secco, Joe Mantz, Bill Foland and Mike Clark with combined industry experience of more than 100 years.

The cores were piled on the work platform ready to be removed.

**COMPANY PROFILE**

Del Secco Diamond Core and Saw, Inc. has been in business for more than 20 years. They are headquartered in Hayward, California, and have a branch serving the greater Sacramento area. The company is a full-service operation and specializes in large, deep and difficult drilling projects. Del Secco has been a member of CSDA since 2004.

**RESOURCES**

General Contractor: KFM Joint Venture
Sawing and Drilling Contractor: Del Secco Diamond Core and Saw, Inc.
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