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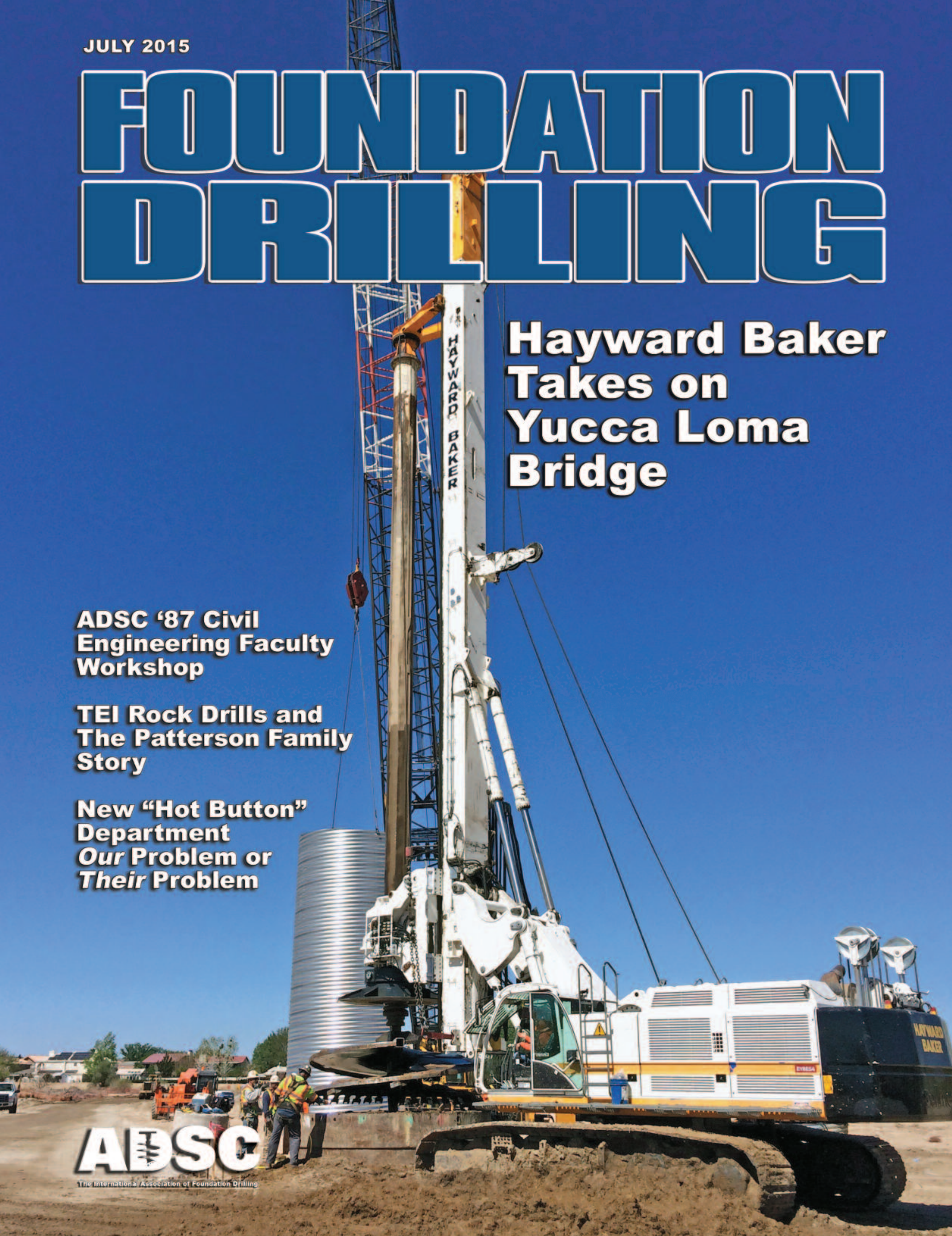
FOUNDATION DRILLING



Hayward Baker Takes on Yucca Loma Bridge

ADSC '87 Civil Engineering Faculty Workshop

TEI Rock Drills and The Patterson Family Story

New "Hot Button" Department *Our* Problem or *Their* Problem

ADSC
The International Association of Foundation Drilling

Cover Feature

Hayward Baker Inc. Takes on Yucca Loma Bridge

By Rick Walsh, P.E., GE, Business Development Manager, Hayward Baker Inc.

Introduction

Additional infrastructure is needed to facilitate the daily commutes of the ever-expanding population of the high desert above Riverside and Los Angeles counties. Along with the affordability of the relatively remote real estate came commuting hours each way to work. Surface streets in many of these communities became heavily congested especially during the typical morning and evening rush hours. The Yucca Loma Bridge project in Apple Valley, California is part of the infrastructure improvement needed to relieve the congestion and to more effectively allow the population to access the interstate system.

The Yucca Loma Bridge project includes the construction of a 13-span bridge over the Mojave River. This bridge is approximately 1,600 feet from end to end. ADSC Contractor Member Hayward Baker Inc. was retained to construct the Cast-In-Drilled-Hole (CIDH) pile foundation. The abutments of the bridge are supported on each end by 6 each 72-inch-diameter CIDH foundation piles and each of the 12 piers for the bridge are supported on 4 each, 120-inch-diameter CIDH piles. The working elevation for the piers was 20 feet above the drilled shaft cut-off elevation resulting in total drilling depths for the shafts of 115 feet. In addition to the CIDH piles for the support of the bridge 16-inch-diameter CIDH foundation piles were completed for support of the soundwalls on the project.

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As far as drilled shaft quality control goes this one had it all: Osterberg Cells (O-Cells), Mini Shaft Inspection Device (Mini SID), Gamma-Gamma Non-Destructive testing techniques, and SoniCaliper.

Placement of reinforcing steel for 120-inch-diameter shaft with O-Cell visible.

Regional Topography and Geotechnical Site Conditions

The project site traverses young alluvial valley deposits of the fan type in an area of relatively low relief across the Mojave River. The deposits consist of mixtures of silt, clay, sand, pebbles, gravel, and boulders, and are unconsolidated to moderately consolidated and interbedded.

Evidence of faulting is apparent in fairly close proximity to the project site and while seismic loading factored in the structural design of the bridge structure the faulting did not directly impact the construction at the site.

The geotechnical investigation borings encountered loose to medium dense well-graded sands in the upper 15 to 55 feet of the soil profile. Many of the borings encountered a relatively thin (2 to 5 feet in thickness) lean clay lens at depths of approximately 30 to 50 feet below the existing ground surface elevation. The borings subsequently encountered dense to very dense, poorly to well-graded sands and silty sands with coarse to fine gravel which continued to the 100 foot depths explored. Groundwater elevations were measured to occur at a depth from the existing ground surface elevation of approximately 20 to 25 feet.

Quality Control on Project… Hayward Baker had it all. Osterberg Cells, Mini Shaft Inspection Device, Gamma-Gamma Non-Destructive Testing and SoniCaliper.

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A 120-inch-diameter shaft location being cored for placement of column reinforcing steel.

Drilled Shaft Construction

Two primary construction methodologies were used for the construction of the three sizes of drilled shaft foundations. The soundwall drilled shafts were located at a higher elevation than in the river bottom where the bridge drilled shafts were constructed. These relatively shallow 16-inch-diameter soundwall shafts did not encounter the ground water and were, therefore, constructed with open hole, dry techniques. The construction methodology for these shafts was to drill the shafts to tip elevation, place the reinforcing cage, and then place concrete with the use of a hopper and elephant trunk or concrete pump hose to limit free fall of the concrete. In the occasional cases where caving/excessive raveling occurred a grout ring was placed to stabilize problem zones. After each grout ring reached initial set the shaft drilling restarted. This process can be repeated until drilled shaft tip elevation is reached. During construction at the site of the 72 and 120-inch-diameter shafts, groundwater was encountered at shallow depths of less than 10 feet across the site, much shallower than encountered during the original site exploration. The shallow groundwater conditions proved challenging in getting the work completed, but the proper selection of construction techniques made the conditions manageable.

Two primary construction methodologies were used for the construction of the three sizes of drilled shaft foundations.

Site conditions required that both the 72 and 120-inch-diameter drilled shafts be constructed utilizing wet shaft construction techniques. For construction of the 72-inch-diameter shafts for the abutments the first thing completed during the construction process was the installation of an oversized surface casing which consisted of 84-inch-diameter corrugated metal pipe (CMP) and for 120-inch-diameter drilled shafts the oversized casing consisted of 132-inch-diameter CMP. This CMP casing was installed to a depth of 15 feet below the drilled shaft cutoff elevation and extended above the ground surface approximately 42 inches to act as a safety barrier. The hole in which the CMP casing was installed was drilled to a diameter of 12 inches larger than the CMP diameter. The annulus between the oversized hole and the casing was backfilled with sand and cement grout. Drilling of the shafts was completed with a combination of a Soilmec* SR 100 and the Big Stan drill rig originally fabricated by Hayward Baker's sister company Anderson Manufacturing.

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Once the CMP casing was installed the drilled shaft was advanced mainly by augers, buckets and clean-out tools. The use of

Inspection of 120-inch-diameter shaft with the Mini SID.

Relocating a reinforcement cage for finishing.

Installing PVC pipes (test tubes) for Gamma-Gamma testing after shaft construction.

CETCO* polymer drilling slurry maintained shaft stability of the sandy materials below the CMP casing and counteracted the pore pressures in the soil matrix resulting from the relatively high groundwater elevation. The use of the CMP casing and CETCO polymer slurry proved very effective and Hayward Baker did not experience any caving issues during the drilled shaft construction at the site.

Continuous monitoring of the Kelly bars helped ensure shaft verticality during drilling. Project specifications allowed a verticality tolerance of 1-1/2-inch per 10 feet of drilled shaft.

As tips of the drilled shafts were reached and the bottoms of the shafts were cleaned the next step was to verify cleanliness for the go-ahead to place reinforcing steel and concrete. The polymer slurry was tested for conformance with the manufacturer's requirements and circulated and/or replaced as needed to meet the satisfaction of the engineer. A Mini Shaft Inspection Device (Mini SID) was used to verify shaft bottom cleanliness. Each time the Mini SID was used the inspection results were deemed acceptable with no additional cleaning of the shaft bottom necessary. As a result of the demonstrated success of the shaft cleaning methods utilized by Hayward Baker after the first 15 shaft inspections the Mini SID requirement was waived for the remainder of the drilled shafts.

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Preparing to lower the corrugated metal pipe into position.

Single crane picks safely placed the reinforcing steel. Multiple picking points and spreader bars minimized cage distortion and the potential for damage while moving the cage from horizontal to vertical. The cages were relatively heavy in that the reinforcement for the 120-inch-diameter shafts included 40 ea #14 bars vertically and #6 hoops that, depending on the location along the reinforcing cage, varied in spacing from 4 to 12-inches. In addition to the steel reinforcement the 120-inch-diameter shaft cages had 10 each 2-inch-diameter PVC inspection tubes for non-destructive testing to be conducted. The 72-inch-diameter cage reinforcement included 26 each 2-bar bundles of #10's vertical (52 total bars) and #6 hoops that ranged from being bundled at 6 and 8 inches on center, and also single hoops at 6 inches on center with 6 each 2-inch-diameter PVC inspection tubes.

Hayward Baker used the wet method to place the concrete in both the 72 and 120-inch-diameter shafts through a 10-inch-diameter tremie. The tremie was first lowered to approximately 6-inches from the shaft bottom. A flexible plug placed in the tremie prevented it from being filled with the slurry. Once the concrete was pumped the plug was ejected as concrete began to enter the shaft. The concrete was pumped continuously to maintain flow and give the best possible results. Pumping was continued maintaining a minimum concrete head of 10 feet above the bottom of the tremie pipe. Volume versus depth was monitored and the tremie withdrawn as pumping continued. For shafts of this size the rate of shaft filling is relatively slow. For the 120-inch-diameter shafts the maximum amount of concrete placed into a single shaft was approximately 320 cubic yards, and for the 72-inch-diameter abutment shafts approximately 100 cubic yards.

Coordination of concrete delivery is critical during pours of this size and this is usually a carefully orchestrated process with continuous communication between the site and batch plant. Rates of truck offload are coordinated with the trucks that are waiting at the site or are soon to arrive so that no breaks in the pour are experienced. In order to conduct pours of this magnitude concrete mixes are specifically formulated for many factors including slump, strength and any admixtures necessary for retarded set times. For the 120-inch-diameter shafts an 8-hour retarded mix was utilized, and a 4-hour retarded mix for the 72-inch- diameter abutment piles.

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In order to facilitate the column steel placement to the construction joint elevation the project plans presented three options. The first option included an optional construction joint approximately 15 feet below the shaft cutoff elevation. Due to the depth of cutoff below the working elevation and having this joint an additional 15 feet lower this option was not selected because of the issues associated with the shallow groundwater and trying to get a clean joint +/- 35 feet below ground surface. Cleaning of this joint would be problematic and require Mine Safety and Health Administration (MSHA) guidelines be followed with associated inspection during the process. The second option was to place a 72-inch-diameter corrugated metal pipe down the center of the shaft to an elevation of 5 feet below the base of the column reinforcement. This CMP was to be tied to the main shaft reinforcing cage. The third option was to place concrete to the cutoff elevation plus a minimum specified overpour of 2 feet and then core the center of the shaft to place the column steel. Hayward Baker chose the coring option and cored the shaft approximately 48 hours after concrete placement. Compressive strength testing indicated that the concrete had reached a strength of approximately 2,700 psi at the time of coring.

SoniCaliper Testing

The CIDH drilled shafts were advanced utilizing polymer as a shaft stabilization aid which would characterize the construction for the piles as the "wet method." Due to the utilization of polymer each of the shafts for the bridge structure was measured with the SoniCaliper prior to reinforcement and concrete placement. The SoniCaliper is utilized to measure the three-dimensional shape of the shaft including the verticality. The SoniCaliper measurement of these shafts indicated that the polymer slurry was successful in the stabilization of the drilled shaft sidewalls and that nearly all of the drilled shafts met the verticality specification. The project egineer evaluated the very few shafts that were slightly out of tolerance and found these shafts to be acceptable with only very minor remedial measures that included shaving the sides of these shafts to bring them within tolerance.

O-Cell Testing

The first two 120-inch-diameter production piles were tested with O-Cells fitted in the reinforcement cages. The O-Cell tests were specified in the original project documents with intent of verification and optimization of the CIDH design. Each of the test piles was fitted with (6) 1,400-kip capacity calibrated O-Cells for a total test capacity of 8,400 kips. The location of the O-Cells was selected during the design process to evaluate both the end bearing and side friction characteristics and capacities of the geologic materials encountered. The elevation of the load cells was about 28 feet above the tips of each of these test shafts.

The successful O-Cell load testing of the two test shafts enabled Hayward Baker to immediately proceed with production shafts based on the original design. Within days, the project structural engineer was able to utilize the test data to optimize the design and shorten the remaining 120-inch-diameter shafts by approximately 13 feet. The net savings far exceeded the cost of the O-Cell testing and allowed for additional assurance that the design assumptions originally implemented were somewhat conservative and could be optimized with site-specific testing of the geotechnical conditions.

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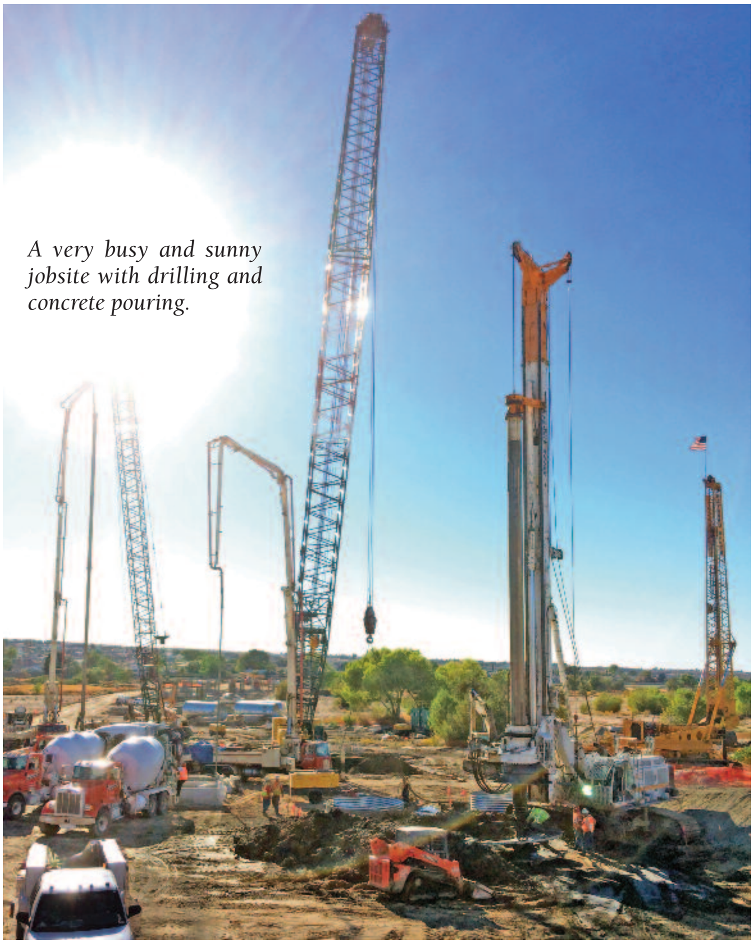

A very busy and sunny jobsite with drilling and concrete pouring.

Non-Destructive Testing

For all 72-inch and 120-inch-diameter shafts Non-Destructive Gamma-Gamma testing was conducted. This is a typical non-destructive testing method performed in California and the primary test method employed on transportation projects. The Gamma-Gamma testing is used to evaluate the density of the shaft concrete by primarily evaluating the uniformity of the concrete density readings with depth.

Gamma-Gamma testing is conducted by lowering the probe into each PVC pipe (test tube) which were previously placed with the reinforcing cage. The probe consists of a radioactive source and detector that measures density of the placed concrete. This test method is primarily used to evaluate the concrete material within a few inches around the outside of each tube. Uniformity of readings indicates material homogeneity. When readings deviate too far from the mean bulk density of the concrete it may indicate a potential problem with the concrete such as voids or soil intrusion into the concrete. Typically when the Gamma-Gamma testing indicates an issue crosshole sonic logging will be conducted to further define the potential problem area. While the Gamma-Gamma testing is conducted in each individual tube thereby testing the immediately surrounding concrete, crosshole sonic logging is conducted between the different test tubes thereby evaluating the

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Many completed shafts ready to support Yucca Loma Bridge.

concrete between any two tubes. By combining these testing techniques potential issues with concrete placed in the shafts can be defined with a good degree of precision. Once testing is completed the test tubes are filled with cement grout.

On the Yucca Loma Bridge the non-destructive testing results indicated extremely successful concrete placement. The tests found no anomalies in any of the 60 tested piles.

Of note on this project is that the specifications specifically referenced the "ADSC Standard Mitigation Plan" as found on the Caltrans website as the applicable document for mitigating anomalies encountered during the Gamma-Gamma testing. This document was developed by the Substructures Task Force that is a joint group of the West Coast Chapter of the ADSC and Caltrans. This document has been in place for a number of years and is a very valuable tool for contractors and allows for most anomalies to be mitigated in a very timely manner per this standard plan. It has been widely used in California for quite some time and is the basis for the document recently produced by the ADSC's Drilled Shaft Committee.

Site Safety

Hayward Baker worked in excess of 29,000 man hours without an injury. However, a very unusual incident did occur. The only vehicle access to the fenced in site was an unimproved dirt road. One afternoon a van sped down this road and through the site at an estimated 50-60 miles per hour with approximately 20 marked and unmarked police vehicles in hot pursuit. Fortunately, the high speed chase exited the site without striking any personnel or equipment. *This near miss should be a reminder to us all to expect the unexpected on our project sites.*

**Indicates ADSC members.*

ADSC

Project Team

Project Name:	Yucca Loma Bridge
Project Owner:	Town of Apple Valley
General Contractor:	Security Paving Company, Inc.
Soil Engineer:	Dokken Engineering
Structural Engineer:	Dokken Engineering
Foundation Contractor:	Hayward Baker Inc.*

**Indicates ADSC Members*