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ABSTRACTS

Performance of Flexible Debris Flow Barriers in Fire Burned Areas, State Route 18, San Bernardino County, CA

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Geobrugg North America, LLC

As presented at the 55th Annual Highway Geology Symposium in 2004, various flexible debris flow barriers were installed near San Bernardino, CA in the summer of 2004 in anticipation of debris flows originating from fire burned slopes. These debris flow barriers were installed in ten distinct debris flow channels upslope from and opening onto state route 18. Each of the barriers was dimensioned based on a unique dimensioning model using data provided by Caltrans including anticipated debris volumes and velocities, and a broad characterization of the expected debris flow compositions, channel geometry and barrier orientations. Each site required a unique barrier design with differing barrier heights, capacities and support infrastructure.

Construction of these barriers was completed in June, 2004. As anticipated, heavy rains in October and winter of 2004/2005 resulted in significant debris flows in all the identified channels. During the October events, all the barriers were impacted to various degrees. The barriers performed exactly as intended, and were subsequently cleaned of debris. As a result of these events, some aspects of designs were identified that could be adjusted to better facilitate cleanout maintenance and improve performance in general. In the winter of 2004/2005, the barriers were impacted again by debris during storm events. Some barriers were completely filled with debris and even somewhat overtopped, and some damage to the barriers was evident due to the greater than expected debris volumes. However, the drainage culverts immediately below the barriers remained clear and effective as intended, thus channeling water flow underneath rather than over the road. Ironically, this protected section of road was now used as a detour for other sections of road that were closed due to problems created by debris flow and rockfall; an opposite scenario from one year earlier.

The application of these barriers can be considered a complete success, performing exactly as intended. Some minor modifications to the barriers will be undertaken to prevent subsequent damage and to better facilitate maintenance.

Innovations in Shallow Landslide Repair

Al Ruckman
Soil Nail Launcher, Inc.

Shallow landslides are pervasive in certain regions and will continue to present significant problems, especially with our continuing severe storm cycles. Along with the suite of traditional solutions, we now have several new concepts for repairs including Launched Soil Nails, Launched Micropiles, GRS walls including GRS walls with negative batter, shotcrete faces and cantilevered shotcrete that can add 2-3 feet of width to the platform, and most recently, Launched Fiberglass Nails. Case Histories from recent projects in several states, Canada and New Zealand will be shown.

Triggering Mechanisms for the Garvin Landslide

Jim Nevels, PhD, P.E.
Oklahoma Department of Transportation

The Case of the Rotating RSS

Liz Smith, P.E.
Kleinfelder, Inc.

A newly constructed reinforced soil slope (1/2H:1V) had a slope stability-type failure. The failure occurred after severe rains. What caused this failure to occur? How did we design the slope to prevent future problems? The presentation will answer these questions, and will include photographs of the failure, a summary of our forensic studies, and photos of the remediation construction.

Prosonic Drilling Technique for the Geotechnical Industry

Gregory Zekoff
Prosonic Corporation

Discussion on sonic drilling techniques. Detailed information on how sonic drilling works, specialized sampling techniques, and geotechnical applications of sonic drilling.

Micropiles and the Federal Highway Administration
30 Years of Implementation

Barry D. Siel, P.E.
FHWA – Resource Center

FHWA implementation of micropiles in the highway industry dates back nearly 30 years to when a reticulated micropile (pali radice) wall was used in northern California near Mendocino to stabilize the shoulder of a roadway. Since then FHWA has used micropiles on several projects for bridge pier and abutment foundations, slope retention, and retaining wall foundations. In addition, FHWA has worked with several State Departments of Transportation in their implementation of micropiles for bridge foundations, slope stabilization and seismic retrofit.

Micropile technology was originally introduced in the United States in 1973. FHWA recognized the potential for this technology and starting in 1993, set about to establish guidelines for their use in the highway industry. This effort resulted in a four volume document, "Drilled and Grouted Micropiles, State-of-Practice Review", published in 1997. FHWA followed this with an implementation manual, "Micropile Design and Construction Guidelines" published in 2000. FHWA, through its training arm, the National Highway Institute, has recently completed an effort to develop a two-day training course. As part of the training course development the 2000 document was revised to reflect current technology and to include a chapter on Design of Micropiles for Slope Stabilization. FHWA has also supported research efforts through its research branch at Turner-Fairbanks including Seismic Behavior of Micropile Systems.

After 30 years of Micropile research, training and implementation, many State DOTs still consider micropiles an emerging technology. Through efforts by FHWA such as the new NHI micropile training course and activities by the International Society for Micropiles, it is hoped that will begin to be perceived as not an experimental or emerging technology but a mainstream practice and part of our regular bag of tools we use to address geotechnical challenges in transportation engineering.

An Experimental Study on the Effect of Lateral Cyclic on Pile Foundation with Particular Reference to Disturbance Produced at Ground Surface

Dr. Sudip Basak
Bengal Engineering & Science University

Offshore structures, namely, oil drilling platforms, jetties, Quay & Harbour structures, tension leg platforms, etc. are supported on pile foundations. Besides usual load from super-structure (dead load, live load, etc.), these piles are subjected to continuous lateral cyclic loading due to ocean waves. The quasi-static nature of such loading induces progressive alteration in the bearing capacity and head displacement of the foundation. This may sometimes lead to disastrous consequences.

In order to study the effect of lateral cyclic loading on the soil-pile interactive performance, a new apparatus has been designed and fabricated. This apparatus is based on motor-gear arrangement associated with other mechanical components. By means of this multi-purpose test set-up, horizontal sinusoidal loading can be imparted on model piles at various frequencies and amplitudes under stress-controlled mode or displacement-controlled mode. After completion of specified number of cycles at a specified frequency with a specified amplitude, the piles are tested under purely static condition to find out their post-cyclic capacities.

It has been observed that for cohesive soil, a progressive deterioration in the ultimate pile capacity takes place. This degradation is mainly due to development of irrecoverable plastic deformation of soil surrounding the piles producing formation of holes around soil surface along the direction of application of cyclic load. The depth upto which these holes are observed to extend below ground surface is about 10-15 % of embedded pile length. Heaves are as well observed in the vicinity of these holes. Also, a pair of cracks are observed on soil surface adjacent to the piles normal to the direction of cyclic load, specifically whenever the amplitude is excessive.

For cohesionless soil, on the other hand, progressive stiffening of the surrounding soil leading to gradual improvement in the ultimate pile capacity has been observed. Application of lateral cyclic load on piles induces repetitive strains in the soil surrounding the piles due to which the soil particles are realigned and redistributed in a more compacted manner. Such compaction forms a basin-like depression of ground surface around the pile. Thus, the ultimate pile capacity is improved.

For cohesive soil, the ultimate pile capacity decreases with number of cycles and increases with frequency asymptotically. The capacity decreases with amplitude but not asymptotically. For cohesionless soil, on the other hand, the ultimate pile capacity is observed to increase with number of cycle, frequency and amplitude. However, no definite pattern can be concluded.

Embankment Support with Rammed Aggregate Piers: Case Histories

Ken Hovelkamp
Geopier Foundation Company

Transportation related embankments supporting settlement sensitive structures can present challenges related to settlement control, settlement duration, and global stability. Rammed Aggregate Piers (RAPs) have been utilized to reinforce unsuitable soils prior to embankment fills while providing increased rates of settlement and total settlement control.

Two project case histories will be reviewed where RAPs were applied; bridge approach embankments and abutments for a temporary bridge over Highway 509 outside Grants, New Mexico, and the support of a large box culvert along Highway 191 near Neola, Iowa. Each case history will focus on the design challenges associated with specific site conditions and the methods used to apply a RAP system to address settlement control.

Data will be presented from soil investigations, load testing, instrumentation, and settlement monitoring. Discussion of the design methods and settlement results will be used to identify site conditions where RAPs can be applied as an alternative to other construction methods. Technical literature will be provided to guide engineers through calculations related to total settlement control and rate of settlement utilizing a RAP application.

Continuous Flight Auger Piles on Highway Bridge Foundations

Rachel Ruperto
Texas Department of Transportation

The Texas Department of Transportation has recently installed continuous flight auger piles on two state bridges as part of the second phase of research evaluating the use of augercast piles on highway bridge projects. This presentation will give an overview of the design, construction, and load testing methods used in Phase 2 of the research.

High Capacity Driven Piles – Lessons Learned

Brian Leibich
California Department of Transportation

Managing Rock Excavation on New Mexico DOT Projects

Ron Siegel and Ed Rector
New Mexico Department of Transportation

The Economics of Current LRFD Applied to Foundations

Paul Macklin, P.E.
Yeh and Associates

Comparison between the current AASHTO LRFD foundation chapter with ASD & LFD will be offered. Presentation will intend to stimulate discussions with audience members concerning the implied factors of safety with the LRFD guideline.

Viable & Practical Stiffness Based In-Place QC Testing Of Compacted Subgrade Material

Melvin Main
Main Associates

Traditional subgrade compaction QC/QA methods do not evaluate in-place material strength or the structural uniformity of each lift as placed. Evaluating these two factors is essential if cost is to be held to a minimum while assuring the performance needed for the roadways intended function and projected life. This type of evaluation is essential if the industries trend towards modulus based mechanistic design and performance specifications for roadways is to be supported. Also, traditional methods do not provide contractors with sufficient real-time feedback so as to optimize the balance of quality and cost. A simple and precise stiffness or modulus based QC test method for subgrades is needed that will evaluate the required factors as compaction occurs at a rate greater than or equal to the rate of compaction.

Such an in-place QC test method has been developed that does not interfere with or delay the construction process. Without penetrating the ground, the method uses the stiffness of each lift to evaluate the quality of compacted subgrades. Using a control strip, lift stiffness at controlled moisture content is determined as a function of compactive effort. The resulting empirical relationship is used to establish QC stiffness targets for the subgrade. These stiffness target values are initially used to determine conventional percent compaction in real-time. Ultimately, the in-place stiffness values are used as indices of material strength, structural uniformity, projected life and design modulus. District2, Thief River Falls Construction Office, of the Minnesota Department of Transportation has specified and successfully used this QC test method on granular subgrades. Its success there has been sufficient to warrant continuing and broadening use on subgrades and bases.

Cement-Amended Roadway Bases Approach Their Potential Through A New Construction Method

Melvin Main
Main Associates

For decades, cement-amending a roadway base has been a way of employing economical local materials in place of imported, high cost aggregate. These bases have the strength and low water permeability to potentially out perform flexible aggregate bases. Unfortunately, cement-amended bases are prone to significant shrinkage cracking that concentrate and reflect traffic stress resulting in premature pavement cracking sufficient to warrant repair or rehabilitation. Consequently, cement-amended bases have seen limited use over the last twenty years. A simple and economical construction method has been developed in Europe and implemented in the United States that minimizes shrinkage cracking in these bases. The method is also practical to control. During the first two days of life, the stiffness of the base is evaluated to assure sufficient ultimate strength. At the same time, a network of micro-cracks is induced by limited vibratory rolling, lowering base stiffness by at least 40%. Stiffness is directly and quickly measured in real-time without penetrating the base or interfering with construction. The micro-cracks greatly inhibit base shrinkage cracking. The base reaches its design strength because the micro-cracks are induced early in its life. In three years of municipal use in Texas and California, this construction method has resulted in at least a 50% reduction in reflection cracking of pavements placed over cement-amended bases and a corresponding reduction in pavement maintenance cost.

Geophysical Investigation of Karst Geology

Mike Rucker and John Lommler
AMEC

Geotechnical Partnership on the I-40 Interchange Design/Build Project

Robert Meyers, New Mexico Department of Transportation
Keven Scott, Terracon

The New Mexico Department of Transportation (NMDOT) initiated a preliminary design for the reconstruction of the I40-Coors Interchange in Albuquerque, NM (a seismically active region). The estimated cost of the project was $95,000,000 for the 5 level interchange. The NMDOT made a decision to release the project for construction via a design-build (DB) delivery system, with a requirement to design and reconstruct the interchange in an 18 month time period. The project was awarded to the design-build contractor Twin Mountain Construction (TMC), with a bid price of $85,000,000. Cost savings in the DB proposal were realized by eliminating one level of the interchange, tightening the geometrics of the interchange, and eliminating some entrance and exit ramps that were in the preliminary design concept.

The DB proposal and schedule resulted in some particularly challenging impacts to the geotechnical investigations and design. The NMDOT Geotechnical Section had provided a 30% level of effort of soil borings for the interchange in the Request for Proposals (RFP) of the design build contract. The NMDOT Geotechnical Section had also required that a full scale load test be performed on any drilled shaft construction to provided efficiency for the drilled shaft design and construction. Terracon Geotechnical Consultant, a subconsultant to the DB designer Parsons Transportation, proposed Cone Penetrometer testing as the means to bring the soils exploration to 100% of the RFP requirements. The DB contractor TMC, also proposed elimination of the full scale load test as a means to accelerate the design and construction, even though this required higher factors of safety in design and greater construction costs and risks associated with drilled shaft foundations.

Design of the drilled shaft foundations by Terracon using the CPT testing and LPC design methodology, combined with lateral forces due to the ASSHTO seismic design event, resulted in drilled shaft depths for the flyover ramps that were beyond the capability of the size and depths of the drilled shaft contractor, ATS Drilling. TMC then proposed performing a full scale Osterberg Cell (O-Cell) Load Test to see if higher shaft friction and end bearing results could be interpreted than from the CPT results. The O-Cell test was performed, but with only the result of verifying the previous shaft friction and end bearing derivations. Therefore, ATS Drilling had to mobilize additional equipment in order to construct the drilled shaft designs.

Additional challenges to the Geotechnical design and construction of the project were seen in design of a 45 foot high Mechanically Stabilized Earth (MSE) wall on the SE flyover ramp, use of hollow core self drilling soil nails for global stability of the MSE wall, design of subsurface geotextile reinforcements to eliminate MSE wall bearing pressure influence on existing concrete box culvert storm drains, design influence of MSE wall bearing pressures on stabbed H-pile foundations at bridge abutments, and temporary wall designs to handle maintenance of traffic (MOT).

All of these Geotechnical design features were accomplished with the DB contracting environment through a partnership relationship between the NMDOT Geotechnical Design Section and the Terracon Geotechnical Engineering. This partnership resulted in timely design reviews, innovation, and cooperation in all aspects of the Geotechnical Design of this complex project.

Installation of Drilled Shafts from the Contractor's Perspective

Bo Walker
ATS Drilling

The Rio Grand Rift

Gerald Lindsey
AMEC

The Rio Grande rift extends about 1000 miles from Mexico, through western Texas, New Mexico, and Colorado. Beginning about 29 million years ago, the rift began to widen along existing fractures established during previous plate tectonic episodes. The rift was part of event that created the Basin and Range faulting over six western states and most of Mexico. Initial movement on the rift created a chain of lake basins that began to be filled with sediment. As the rift continued to pull itself apart, the basins coalesced, large fault blocks foundered to great depths and mountain ranges were uplifted on its shoulders. This report covers the processes that have resulted in the present landscape of New Mexico.

The rift we know to day is defined by the course of the Rio Grande at it's axis and marked by extensive fault systems, and volcanoes as young as 3,500 years old. The spreading of the rift is still active as are the hundred or so faults that have been designated as Holocene in age. Although the return interval for large rift earthquakes are on the order of 10,000 years, the historic seismic record is very short. Recent work that has focused on the faults of Albuquerque Basin and the rift volcanoes will be discussed.

MSE Wall Rehabilitation

Abbas Bafghi
Nevada Department of Transportation

An Overview of Oklahoma DOT Geotechnical Specifications

Butch Reidenbach
Oklahoma Department of Transportation

Constructing the Tangent Pile Walls on TREX, Denver, Colorado

Mike Walden and Lonnie Terry
Anderson Drilling

T-REX is the name of the largest design build project ever constructed in the state of Colorado (estimated at 1.6 billion). When finished it will have widened approximately 19 miles of Interstate 25 through the center of Denver. The project designers used drilled shafts for many of the retaining walls. The shafts varied in diameter from 18” to 72” and lengths of 15’ to 75’. The project will include approximately 6000 to 8000 drilled shafts.

The soil conditions consisted of loose sand and gravel to a very hard clay stone / sand stone bedrock. Water was encountered through out the project site. Mudding and casing the overburden to bedrock installed shafts that needed stabilization. Anderson Drilling utilized many different types of drilling rigs (Crane rigs, Soilmec, Watson ,Spiradrill and Lowdrill) and quantities (up to 12 working at one time) to complete the scope of work. . The project is scheduled to be complete in 2006

<u>Deep Soil Improvements Alternatives for a Reinforced Earth Arch Culvert</u>

Robert Meyers, New Mexico Department of Transportations
Dave Hutchinson, Reinforced Earth Company

The New Mexico Department of Transportation (NMDOT) NM14 reconstruction between Albuquerque and Santa Fe included the bridge replacement of a 60 year old timber bridge over the San Marcos Arroyo. The NMDOT context sensitive design process required the inclusion of a Citizen's Advisory Committee (CAC) in the decision making process. The CAC desired that the NM14 San Marcos bridge replacement be an aesthetically pleasing arch culvert design consistent with the historical setting of the NM14 corridor.

The NMDOT decided to make the culvert design and construction a design-build (DB) contract delivery. A five barrel arch culvert was specified to be designed and constructed to meet the hydraulic and structural specifications of the contract. The existing approach fill and pavement section to the historic timber bridge indicated a long term settlement condition because of a 9 inch build up of the pavement section to the bridge abutments. Soils investigation and testing in the San Marcos channel by the NMDOT Geotechnical Section identified a saturated plastic clay layer. Consolidation settlement analysis indicated a 10 inch consolidation potential under the existing embankment which correlated well the observed settlement at the existing embankment approach.

Under the new profile design grade an additional embankment fill height of 16 feet would generate an additional 7 inches of settlement on the approach to the new arch culvert replacement structure. Therefore, the NMDOT Geotechnical Section evaluated settlement mitigation alternatives. Preload, lightweight fill, deep soil improvement with soil mix columns (DSM) were evaluated. The CAC was not receptive to the additional haul trucks though the rural atmosphere required to construct a preload embankment, as well as requiring that the interruptions to the traveling public be minimized. DSM technology was selected based on a comparative cost analysis. Design of the DSM soil replacement ratios, soil-cement column design strength, and geogrid bridging over the DSM was designed utilizing methodology proposed by Han (1999). Design details and specifications for the DSM were generated for the construction contract.

The construction contract was awarded to Mountain States Construction, with Reinforced Earth Company providing the design for the DB arch culvert. DSM bid prices were three times higher than estimated. Cement costs, mobilization costs, and the relatively small quantity of DSM were the primary reasons assessed for the high bid price. After consultation with the NMDOT District engineers, it was decided to eliminate the DSM and handle the settlement under maintenance forces after project completion.

The impacts to the deletion of the DSM to the RECO arch design were unexpected. The drag down forces generated on the end barrels of the arch design was excessive. In addition, RECO was expecting to utilize the DSM as a foundation treatment to allow for the construction of MSE wing walls on the DSM improved foundation soils. Therefore, RECO initiated soil improvement alternatives to allow for the MSE wingwall design bearing capacity and global stability. Over-excavation and replacement with reinforced foundation soils was proposed. Dewatering and constructability of this alternative required an alternative design be proposed. The NMDOT Geotechnical Section suggested to RECO that surplus closed end pipe piles from another project be utilized. Design and construction with this alternative successfully stabilized the MSE wall design.

Test Pile Program – Rigolets Pass Bridge; Route US 90

Chris Nickel
Louisiana Department of Transportation

The Rigolets Pass Bridge is located in Orleans Parish along route US 90 in Chalmette, Louisiana, which is northeast of New Orleans. The Rigolets Pass waterway connects Lake Pontchartrain with the Gulf of Mexico. The discussion will be on the test pile program, which will include results of static, statnamic, and dynamic testing. The test pile program involves 30" square and 66" spun-cast post-tensioned cylinder piles. Pile Set-up in these soft soils will be addressed as findings are presented. Also, the discussion will touch on some problems encountered during the pile installation process.

Pressuremeter Testing in Sand, Gravel and Cobbles

Dean Durkee
Gannett Fleming, Inc.

Shallow soil conditions within the Phoenix basin consist of alluvial deposits of fine-grained soils of low apparent cohesion underlain by fine-grained soils with minor amounts of gravel and a varying degree of cementation. Near major rivers there are coarse-grained deposits of sand, gravel and cobbles with boulders, known locally as the "SGC" that also exhibit varying amounts of apparent cohesion. The amount of apparent cohesion in these shallow soils has in the past been loosely correlated to depositional age (Holocene vs. Pleistocene epoch).

The SGS soils are particularly problematic for site characterization and development of soil parameters from laboratory and in-situ testing techniques. In particular it is difficult to determine strength and modulus parameters. Although analyses for design of drilled shafts, support of excavation, underpinning, and tunnel lining have been performed using conservative assumptions and literature values for similar soil types, difficulties with significant sloughing and ground loss in drilled shaft and tunnel construction have been well documented.

Evidence from a geotechnical investigation and from previous construction projects in the area indicates that the Holocene soils, and to a greater extent, the Pleistocene soils behave as a matrix supported material due to the minor amounts of clay present, the low degree of cementation, and low matric potential. Although the clay content is variable, at small strains (prior to sloughing and the initiation of running ground conditions) the soil behaves primarily as a continuum.

For the purpose of deformation analyses associated with design for support of excavation, underpinning, and ground improvement it is important to determine representative strength and modulus parameters. This was accomplished using pressuremeter testing in the SGC. Pressuremeter testing had been performed successfully in the fine-grained soils in the Phoenix basin. However, due to the presence of large particles, including boulders as large as two to three feet in diameter, and the generally low apparent cohesion of the soil, pressuremeter testing had not previously been performed in the SGC.

An innovative method of borehole formation that was developed to allow pressuremeter testing in the unstable and variable coarse-grained SGC deposit will be presented. In addition, the results of the testing are presented in the form of strength and modulus parameters. The results indicate that the borehole formation technique yielded successful pressuremeter tests.

Three Strategies for Small Slope Repair in Steep Mountainous Terrain

Ron Richman
California Department of Transportation

Every year, there is at least one location in California that experiences a high intensity rainfall event, commonly between January and April. For some inexplicable reason, these events typically occur on weekends and/or Holidays. Saturation of near-surface soils may result in shallow flow and slump failures of roadway embankment soils or the natural geo-materials support the roadway. Conventional state operated roadway facilities in steep mountainous terrain are also damage when concentrated surface water leaves the roadbed and flows down embankments.

The public and DOT management have come to expect the almost immediate presentation of repair strategies from the geotechnical professional. Where the failure is small, the terrain is steep, and the cost of repair is modest, the San Luis Obispo office of Caltrans Geotechnical Services commonly employs one of the following three strategies: geosynthetic reinforce embankment, cellular confinement embankment and rock embankment. Several case histories where variations of these strategies were employed are presented.

<u>Foundation Excavation and Treatment</u>
<u>Burro Creek Arch Bridge</u>
<u>Mohave County, Arizona</u>

Robert A. Cummings, P.E., President
Saguaro GeoServices, Inc.

Construction of a new steel arch bridge, crossing Burro Creek Canyon along US 93 in northwest Arizona, entailed extensive foundation excavation in vertical basalt cliffs above a sensitive riparian area. The new companion structure is designed to complement the existing two-lane, 700-ft-long steel truss arch, which it parallels, by adding two new northbound travel lanes. The existing bridge was built in the 1960s, a time when all excavated foundation rock could be released to the canyon. This could not be allowed for the new bridge, however. This and other modern constructibility, cost, and aesthetic issues played a great role in the new bridge selection and preliminary design process, begun in 2001. The foundation construction met several challenges:

- Rock fall impacts to the Burro Creek habitat below were mitigated with special blast sequencing, reduced lift heights, rock fall containment blankets, and special mucking procedures. Rock fall impacts to the adjacent bridge structure were also minimized.
- Public trail and creek users were protected from the excavation and construction activities on the cliffs above by closures and spotters.
- A collapsed lava tube structure beneath the east abutment was confirmed by core drilling and borehole camera imaging, and was corrected by a reinforced shotcrete seal at the canyon wall and the injection of over 100 cy of neat cement grout.
- A dangerous detached rock mass above the east skewback foundation was removed and the back slope was stabilized with high-strength wire mesh and tensioned rock bolts as the slope was brought down. During removal, spot blasting, a 30-ft vibro-hammer, and an excavator free-hanging from a crane accomplished removal while maintaining control and safety in the highly unstable mass.
- Unstable rock blocks above both skewback excavations were restrained with pattern and spot rock bolts.
- The west side pier was excavated in a stepped foundation, tied down with heavy rock anchors. An unexpected vertical fissure in the footing bearing area was repaired by rock bolting.
- Blasting disturbance of the new excavation surfaces were minimized with presplitting and trim blasting.
- A specially modified air-track drill was suspended in a 4-point sling, to reach loosened areas between the new and existing excavation surfaces, which were stabilized with shotcrete and rock bolts.
- A soil nail wall was built above the east side skewback to stabilize a lens of loose, unstable volcanic breccia.
- The east side deadman tieback subexcavation was successfully carried out adjoining the canyon wall without affecting the newly completed concrete bridge pier below.

Foundation excavations required approximately 10 months and were complete in March 2005. The bridge will open for traffic at the end of May 2006.

<u>Bridge Approach Settlement Research Project</u>

Lary Lenke
University of New Mexico

Construction of High Performance Flexible Pavements over Soft Subgrades

Jodi Winney, P.E. MACTEC
Orion J. Graham CONTECH

This presentation will discuss design and construction considerations of a premier race facility that hosts racing sports enthusiasts from across the country. A Motor Sports Park in Tooele County, Utah did not shy away from development when pavement subgrades proved to be less than perfect for the tight paving requirements of a high speed race track. The poor soil conditions, unique asphalt design criteria and a short timeline for construction were critical components that made the construction of this track a memorable project.

Poor strength subgrade materials were prevalent at the site resulting in questionable support characteristics, difficulty in obtaining compaction, and serious doubt about whether the strict pavement smoothness and performance specs were attainable. The design team recognized the need to provide economical alternatives to increase the apparent strength of the subgrade materials. When cement stabilization was no longer an option due to cement availability, and a complete remove and replace proved too costly, MACTEC was asked to find yet another feasible and cost effective alternative for subgrade improvement.

After looking at alternates and the construction of a test section, it was concluded that stiff, biaxially (BX) oriented geogrids would serve as an immediate, effective method for improving subgrade stability below flexible pavements. This discussion will review the design considerations, cost considerations and construction methods employed in the development of the race track at this premier racing facility.

Dilatancy in Geotechnical Engineering

Jie Zhang
New Mexico State University

Storm Induced Landslide Stabilization at SR 55/91 in Orange County, California

Mohammed Islam
California Department of Transportation

The Southern California region experienced a series of large storms and extremely heavy rainfall during the 2004/2005 winter season. This had resulted in a large number of landslides severely affecting the State Highway System. One of the large landslides occurred within an 80 to 100 feet high highway cut slope near the SR 55/91 interchange in Orange County. This landslide initially involved a small area mostly within the State right-of-way and gradually developed into a large three-landslide complex extending into private property and damaging a number of residential structures. The slope has a complex topography and is underlain by highly variable geology characterized by poorly defined geologic structures. The subsurface material, consisting of mainly stiff to hard, highly plastic clay with interbedded localized lenses of coarse-grained weathered soil, is widely known for its landslide susceptibility and as a difficult deposit to characterize for engineering analysis. This paper presents the results of a geotechnical investigation and stabilization design for this landslide.

Crosshole Sonic Logging and Tomography for Finding and Imaging Anomalies – Defect Resolution through Knowledge

Hunter Yarbrough
Olsen Engineering, Inc.

Crosshole Sonic Logging (CSL) has come into widespread use for quality assurance of the concrete placement in concrete drilled shaft foundations, particularly when they are drilled using wet-hole drilling methods due to the risk of concrete contamination. The CSL method is used to measure the speed of sound between water-filled cast-in-place access tubes. The velocity of the sound wave which travels from source to receiver in a horizontal plane determines the presence of anomalous regions (due to water or air-filled voids or soil intrusions) and therefore the quality of the concrete. When plotted against depth, a CSL velocity log quickly defines the depth and approximate lateral location of a potential defect. For added higher resolution of shaft integrity and defects, the Crosshole Tomographic (CT) velocity imaging method is used. The CT velocity method accurately and precisely defines the size, shape, severity, depth, and location of potential defects by determining the spatial velocity distribution of shaft concrete through analysis of numerous soundwave raypaths. Although the CT process is currently slower than CSL, its two-dimensional (2D) and three-dimensional (3D) imaging results go unmatched for engineering accuracy, interpretation simplicity, and visual appeal.

CSL and CT results are presented for sound and defective drilled shafts tested in research projects and real-world consulting. The methods have been successfully applied in both arenas to locate unknown and pre-existing test defects. Meaningful and valid CSL and CT data analyses and interpretation require sufficient knowledge in the history of the concrete placement, local site parameters, material properties of concrete, and the physics of the test. The CSL method has been standardized by the American Society of Testing and Materials (ASTM) and is described in ASTM D 6760. When used by an experienced professional, the CSL and CT methods are an excellent tool for determining shaft integrity and imaging potential areas of concern. Further, they eliminate the questions and concerns associated with a problematic concrete placement.