6th Annual Technical Forum

GEOHAZARDS IN TRANSPORTATION IN THE APPALACHIAN REGION

Hyatt Regency Hotel, Lexington, Kentucky: August 2-3, 2006

PROGRAM

DAY 1

8:00 a.m. Registration

9:45 a.m. Regency West & Center. Welcome: Tony Szwilski (CEGAS)

10:00 A.M. Opening Session: Mapping Utilizing GIS & GPS. Chair: John Kiefer (KGS)

1. **Cataloging Geotechnical Project Information on the Web.**
   by William Broyles (KTC)
2. **Accessing Geotechnical Information for Geotechnical Studies in Kentucky.**
   by Matt Crawford (KGS)
3. **Karst potential and Development Indices: Tools for mapping Karst Hazard Regions Using. GIS,** by Randy Paylor, James Currens, Mathew Crawford (KGS)
4. **Using Digital Technology to Collect, Manage, Interpret and Deliver Geologic Mapping Data in Kentucky,** by W. Andrews, Jr., S. Martin, R. Counts, M. Crawford, G. Weisenfluh (KGS)

12:00 n LUNCH: Speaker Jim Cobb, Director of Kentucky Geological Survey.

1:00 p.m Regency West. (CONCURRENT SESSION with Regency Center)
Session 1: Geotechnical Databases. Chair: Kirk Beach (ODOT)

1. **Development of an XML Schema for Geo-data** by Marc Hoit (University of Florida)
2. **How DIGGS May Benefit Geotechnical Data Collection and Use Efforts.**
   by Scot. D. Weaver (Earthsoft)
3. **Practical Considerations in Working with Data Interchange Standards**
   by S. Caronna (gINT Software)
4. **Resource and Asset Management through Web-Enabled GIS Database System.**
   by Robert Liang (University of Akron); Gene Geiger; Kirk Beach (ODOT).

1:00 p.m. Regency Center. (CONCURRENT SESSION with Regency West)
Session 2: Water Issues. Chair: Hugh Bevans (USGS)

1. **Avoiding Geohazards in the Mid-Atlantic Highlands by Using 'Natural Stream' Principles.**
   by Steve Kite (WVU), Neal Carte (DOH), William Harman (Buck Eng.), Donald Gray (WVU).
2. **Debris Flow Hazards in Western North Carolina – Some Geological, Meteorlogic and Hydrologic Survey** by Richard Wooten, R. Latham, A. Witt (NCGS)
3. **U.S. Geological Survey Field Investigations of Bridge Scour.**
   by Dave Mueller, Stephen T. Benedict (USGS)
4. **Stream Gages: An Essential Tool for Avoiding Transportation Hazards.**
   by Doug Kirk (WVDOH)

3:00 p.m. Coffee Break

3:30 p.m. Regency West & Center.

Session 3: Landslides: Prediction, Prevention and Remediation Chair: Vanessa Bateman (TDOT)

1. **A Sinkhole Induced Landslide Along SR 111, Dunlap Tennessee: A Case Study** by V. Bateman, Len Oliver (TDOT)
2. **Slope Stability Along the North Carolina Section of the Blue Ridge Parkway.** by Rebecca Latham, R. Wooten (NCGS)
3. **Innovations in Landslide and Erosion Repair** by Bob Barrett (Soil Nail Launcher)
4. **Characterization and Remediation of a Creeping Slope** by Todd Swackhamer (McMahon & Mann); Donald McMahon; James Zimmerman (NS Corp)

Adjourn 5:30 p.m.

DAY 2

7:30 am Registration

8:00 a.m. Regency West (CONCURRENT SESSION with Regency Center)

Session 4: Rock Reinforcement & Anchoring Chair: Steve Brewster (USACE)

1. **Changes in the Post-Tensioning Institutes New (4th Edition 2004) "Recommendations for Prestressed Rock and Soil Anchors"** by Michael McCray (USACE)
2. **Engineering Geology Challenges During Design and Construction of the Marmet Lock Project** by Michael Nield (USACE)
3. **WV 2 Follansbee to Weirton Road: Evaluation of Rockfall Protection Measures and Design of Landslide Correction Measures** by Robert L. Dodson (HDR)
4. **Hurricane Related Landslide Repair on the Blue Ridge Parkway** by Don W. Dotson (AMEC); Chris Ramsey (Richard Geottle, Inc)

8:00 a.m. Regency Center (CONCURRENT SESSION with Regency West)

Session 5: Risk & Reliability Assessment Chair: Jody Stanton (USACE)

1. **Engineering Risk and Reliability: Application to Civil Works Infrastructure.** by Robert Patev (USACE)
2. **That Slope Shouldn't Have Failed** by Pete Nix (DLZ)
3. **Managing Risk and Reliability of an Inventory of Large and, Potentially Dangerous Civil Works Projects** by Jeffrey Schaefer, Andy Harkness (USACE)

10:00 am Coffee Break

10:30 am. Regency West & Center

Session 6: Site Characterization: Over Karst & AML Chair: Bert Buchanan (FHWA)

1. **Replacement of Rt. 33 Bridges in Active sinkhole Environment** by Silas Nichols (FHWA)
2. **An Overview of Geophysics Use in Transportation Projects, and Geophysical Choices Specifically for Karst and Mine Investigations** by Rick Hoover (SAIC)
3. **The Maple Ridge Wind Farm Access road Design Over Unstable Soils on the Tug Hill Plateau** by Martin Derby (Malcolm Pirnie); Patrick O'Rourke (Contech)
4. **Geophysical Manual: A Practical Engineering Solution for Highway Related Problems**. by Khamis Haramy (FHWA); Kanaan Hanna
5. **Delineation of Karst Groundwater Basins Along the Proposed I-66 Corridor, Pulaski County** by James C. Currens, Randall Paylor (KGS

12:30 pm Closing Remarks

Note: PDH's (Professional Development Hours) will be granted for this conference. However you must register both (2) days in order to receive the credit.

6th Annual Technical Forum: Geohazards in Transportation in the Appalachian Region

ABSTRACTS

DAY 1

OPENING SESSION: Mapping Utilizing GIS & GPS. Chair: John Kiefer (KGS)

Cataloging Geotechnical Project Information on the Web, William Broyles, Kentucky Transportation Cabinet

The Geotechnical Branch of the Kentucky Transportation Cabinet has compiled over 6000 engineering reports for roadways, structures, and landslides since 1973. These reports contain site maps, design drawings, core hole listings, and staff recommendations for the projects. In order to facilitate accessing these documents for conducting future studies, a Web-based system was designed to allow geotechnical staff to catalog the contents of the historical reports in a database. An Internet map service was created with custom features to assist staff in locating projects using geographic queries, storing project map footprints for geographic searching, and uploading and converting coordinate files associated with the projects. Over 2000 reports have been documented to date, and are searchable from the Web.

Accessing Geologic Information for Geotechnical Studies in Kentucky, Matt Crawford (KGS)

Geotechnical engineers and geologists routinely investigate the geological site conditions for design studies, as well as collect related information such as oil well locations, coal and mining data, water well records, seismic tests, and other environmental themes. The Kentucky Geological Survey maintains much of this information and is working cooperatively with the Transportation Cabinet to design Internet map sites where these data can be easily harvested. This geologic map information service provides access to seamless 1:24,000-scale geologic maps as well as the explanatory information found with the original published documents. The geologic units can be easily reclassified according to prevailing lithology or karst potential. Users can also overlay other site data, such as oil wells, water wells, or sinkholes, for evaluation. Databases of related information and reports are linked to the users map view. This Internet service is expected to greatly simplify the task of conducting background investigations for a geotechnical investigation.

Karst Potential and Development Indices: Tools for Mapping Karst Regions Using GIS
James Currens, Matthew Crawford, Randall Paylor (KGS)

The karst development index (KDI) evaluates the development of karst geomorphic features and bulk karst porosity. Criteria included in the KDI are epikarst development (depth to bedrock), sinkhole distribution, cave and spring distribution, and conduit density. KDI data are compiled for all areas possible, and each of the criteria is placed in a weighted scoring matrix to determine a value.

The karst potential index (KPI) evaluates the lithologic characteristics of geologic polygons that lead to karst development. Criteria selected in the KPI are bedding thickness, grain size, percentage of calcite in carbonate rock, and percent insolubles. The KPI criteria are also weighted in a scoring matrix to determine a value.

The two measures have been designed and calibrated for specific use in Kentucky. The KDI data have been collected and geologic unit polygons identified that have adequate data for scoring. The KPI compilation is complete. The two scores have been correlated to determine if the KPI is a predictor of the KDI. Classifications of karst areas as “mature” versus “immature” and differentiating those classifications with respect to land-use planning and engineering have always been subjective. The measures developed here are intended to form a basis for ranking karst potential and development, anticipate karst geologic hazards, and mitigate the impact of human activity on karst aquifers.

Using Digital Technology to Collect, Manage, Interpret and Deliver Geological Mapping Data in Kentucky
William Andrews, Steven Martin, Ronald Counts, Matthew Crawford, Gerald Weisenfluh (KGS)

Despite a long heritage of geological mapping at the Kentucky Geological Survey, changing societal needs and priorities continue to necessitate new mapping in Kentucky, especially of unconsolidated deposits and soils. Since 2003, KGS personnel have mapped Quaternary deposits near the Ohio River valley in Western Kentucky to assist with geotechnical/construction planning, seismic hazard assessment, water supply studies, and land-use planning. A new project focuses on landslide susceptibility in Eastern Kentucky to support economic development. The mapping efforts use traditional geological mapping of unconsolidated sediments and landforms. The KGS is making extensive use of digital technology to collect, process, store, and deliver the new mapping data. A subproject is integrating data from the Kentucky Transportation Cabinet to allow quantified geotechnical characterization of geologic map units. The new geologic maps are being produced in digital format, which provides flexibility and enables web delivery of data and products and facilitates rapid production of derivative maps.

SESSION 1: Geotechnical Databases — Chair: Kirk Beach (ODOT)

Development of an International XML Schema for Geo-data, Marc Hoit, University of Florida

The transportation pooled fund study (TPF 5(111)) is charged with the development of an international XML based schema that defines the transfer of data required by Geotechnical and Geoenvironmental engineers for analysis, design and maintenance. The ultimate goal is to create a standard that allows data to be transferred between and within agencies in order to support asset management. This effort is being sponsored by 12 State DOTs, FHWA, US EPA, US Army Corps of Engineers, UK Highways, and the US Geological Survey

The current program is a collaborative effort and merger of three existing standards: University of Florida, Department of Civil Engineering's (UF) pile schema, Association of Geotechnical and Geoenvironmental Specialists in the United Kingdom's (AGS) geotechnical and Geoenvironmental schema and Consortium of Organizations for Strong-Motion Observation Systems' (COSMOS) geophysical schema.

The first version of the schema will include all the data (e.g., borehole data, lab test data, basic geoenvironmental data) currently covered by the three organizations. The pooled fund study will also assess additional data standards for asset inventory systems like karsts, rock falls, landslides, complete geoenvironmental parameters and other data (e.g., geophysics). The study will also develop a management structure to maintain and enhance this developing international standard.

The presentation will provide details on the progress and format of the schema. The first release is expected in September 06.

Practical Considerations in Working with Data Interchange Standards
S. Caronna, gINT Software, Windsor, California

With the upcoming DIGGS data interchange standard, many questions arise regarding, communicating data through the standard and database design. In dealing with interchange standards, all too often the tendency is to try to mimic the interchange format as closely as possible. This approach can lead to improper work specifications, awkward data entry procedures, difficulty in data validation, and reduced querying capabilities. This paper explores some of the major considerations in dealing with DIGGS so as to achieve the maximum benefit to the user while still maintaining the ability to read and write interchange files.

Resource and Asset Management through Web-Enabled GIS Database System
Robert Y. Liang, University of Akron; Gene Geiger, and Kirk Beach (ODOT)

Landslides or slope/embankment failures along highways present potential safety and operational hazards. Road closures or detours due to landslides can adversely impact the regional economy. With finite financial resources available to Ohio Department of Transportation (ODOT), it is imperative that a decision making tool be developed to enable ODOT to effectively manage the landslide hazards impacting highways in Ohio. The Office of Geotechnical Engineering (OGE) has initiated a research effort to develop an innovative web-enabled database, built upon GIS platform, for real-time managing of spatial and temporal data associated with landslides along Ohio's highways. A landslide hazard rating system has been developed to provide a means to numerically score and rate the relative hazard or risk level of each site. This system will be complemented by a web application for generation of planning level cost estimates for remediation. Together, these applications will provide ODOT with powerful tools to manage geologic hazards across the state. The presentation gives an overview of the features of the system. A real-time run of the system for a particular geospatial data category is used to illustrate the advantages of using such a system for resource and asset management.

SESSION 2: Water Issues — Chair: Hugh Bevans (USGS)

Avoiding Geohazards in the Mid-Atlantic Highlands by Using "Natural Stream" Principles

J. Steven Kite, West Virginia University; Neal Carte WVDH; William A. Harman, Buck Engineering, NC; Donald D. Gray, West Virginia University.

Rivers and Streams in the Mid-Atlantic Highlands present many transportation hazards that can be reduced through appropriate design using long-established principles of fluvial geomorphology. Commonly labeled "Natural Stream Design," this approach is more accurately described as application of basic concepts in hydraulic geometry and sediment transport with the goal of maintaining channels and floodplains in equilibrium with upstream watersheds and adjacent land uses. Although ecological and aesthetic benefits are highly desirable outcomes, best design practices also lead to reduced risk and lowered maintenance costs.

The nature of regional hazards varies greatly with topography and stream type. Debris flows and debris floods are infrequent, but represent the greatest risk to life in rugged mountainous areas. Extreme flooding is a serious risk on almost all streams, but moderately frequent flows that barely fill stream banks actually determine the channel and floodplain configuration upon which flooding occurs. Stable stream channels require a hydraulic geometry sufficient to transport sediments under moderately frequent (1-3 year) flows and water conveyance to accommodate high magnitude (100-200 year) floods. Many popular flood mitigation tactics, such as channel dredging or widening, actually exacerbate flood risk. Similarly, structural approaches that are not in harmony with the local fluvial geomorphology are, at best, ephemeral solutions or, at worst, risk amplifiers.

Debris Flow Hazards in Western North Carolina – Some Geologic, Meteorlogic, and Hydrologic Aspects

Richard M. Wooten, Rebecca S. Latham, Anne C. Witt, North Carolina Geological Survey

Heavy rainfall from tropical storms that periodically track over western North Carolina (WNC) has triggered numerous damaging debris flows. The North Carolina Geological Survey maps these and other slope movements as part of a statewide geologic hazards program. Sinkholes, abandoned mines, and coastal hazards are also mapped in a GIS environment.

Heavy rainfall from the remnants of Hurricanes Frances and Ivan in September 2004 triggered at least 130 slope movements that caused five deaths, destroyed 27 homes, and disrupted transportation corridors across the region. Tropical storms in close sequence also tracked over WNC in 1916 and 1940 setting off hundreds of damaging debris flows. Rainfall measurements from storm events that trigger debris flows help constrain recharge values used in GIS-based debris flow susceptibility models.

Calculated velocity and discharge estimates for debris flows provide insights into their destructive power, and a basis for designing mitigation measures. Peak velocity-discharge values for the fatal, 2.25 mile-long, 2004 Peeks Creek debris flow are 33.3 mi/hr and 45,000 ft^3/sec respectively. The 50mi/hr dam failure torrent and debris flow from the 1916 failure of the Lake Toxaway Dam resulted in a peak outflow of about 299,000 ft^3/sec that transported boulders up sixty feet long.

Envelope Curves for Assessing Scour in South Carolina, David S. Mueller and Stephen T. Benedict (USGS)

In the late 1980's, bridge scour caused the catastrophic failures of the Schoharie Creek Bridge in New York State and the Hatchie River Bridge in Tennessee, resulting in the loss of life. Since these tragic events, much research has been conducted to advance the understanding of bridge-scour processes and to develop scour-prediction techniques. Bridge-scour research has included small-scale laboratory investigations, which provide a controlled environment to assess variables that affect scour, as well as field investigations that provide understanding of the range and trend of scour under field conditions. The U.S. Geological Survey has had a prominent role in bridge-scour field investigations including data collection at the national and state level, development and deployment of bridge-scour monitoring equipment, assessment of laboratory derived scour-prediction equations using field data, and the development of regional equations and envelope curves to help assess the potential for scour. Because of the poor performance of many of the laboratory derived scour-prediction equations, recent focus has been given to the development of bridge-scour envelope curves that display the range and trend of the upper bound of field data resulting from floods. Although much research has been accomplished since the late 1980's, there is still need for continued bridge-scour research in the laboratory as well as the field.

Stream Gages: An Essential Tool for Avoiding Transportation Hazards, Doug Kirk (WVDO)

The West Virginia Division of Highways maintains 37,370 miles of public roads and 6,343 bridges. Our continuing program of expansion and improvements ensures that these numbers continue to increase. With catastrophic floods occurring every few years, it is essential that we have stream flow data upon which to base our maintenance program and design projects.

Data from stream gages is used in all phases of highway work, from planning and design to construction, operations and maintenance. Real-Time stream streamflow data available on the USGS website warns construction crews to seek higher ground, and advises operations and maintenance crews when to close flooded roads and bridges. Planners and designers rely heavily on historical gage data to develop safe and reliable roads and bridges. Highway engineers use several USGS publications to determine design discharges and project high-water elevations. This information is crucial in the design and construction of stream relocations, bridges, and roads located in floodplains or near rivers.

Through continued cooperation and support, USGS gage data will continue to help the West Virginia Division of Highways provide a safe and effective highway system.

SESSION 3: Landslides: Prediction, Prevention and Remediation. <u>Chair</u>:Vanessa Bateman (TDOT)

A Sinkhole Induced Landslide along SR 111, Dunlap Tennessee – A Case Study.
Vanessa Bateman and Len Oliver (TDOT)

After a heavy rain in September of 2002, a large sinkhole collapse occurred underneath a drainage ditch on a substantial cut slope along SR-111 during construction. At the same time, down-slope from the sinkhole and adjacent to the Sequatchie River, a landslide occurred in an area untouched by construction. This resulted in sediment intrusion from the landslide into the Sequatchie River. A buried cave, with a chimney located beneath the sinkhole, provided a conduit for the saturated soil and water to travel from the sinkhole through the cavities in the rock. This large amount of water and saturated soil destabilized the existing slope and was the proximate cause of the landslide. The Tennessee Department of Transportation – Geotechnical Engineering Section was called out to the site to provide emergency recommendations for repair of the landslide and sinkhole. The damaged down-slope drainage ditch had to be repaired and able to carry a large amount of water flow from the top of the slope down to the Sequatchie River. We could not divert the water to other locations. Additionally, the GES was asked to provide recommendations that would attempt to prevent further instability at the site, so that the construction project, already well behind schedule could be closed out and completed. In cooperation with the Construction Division and the contractor, Highways, Inc. we relocated and reconstructed the down-slope ditch, repaired the sinkhole and repaired the landslide. There have been no further instabilities noted at this location since the repairs were completed in 2002.

Slope Stability Along the North Carolina Section of the Blue Ridge Parkway.

Rebecca Latham, Richard M. Wooten, North Carolina Geological Survey (NCGS)

In 2000, the North Carolina Geological Survey (NCGS) began a project to produce geologic and geologic hazards inventories of the 250-mile long North Carolina portion of the Blue Ridge Parkway (BRP) and the Carl Sandburg Home National Historic Site (CSHNHS). Funded in part by the National Park Service (NPS), the project is scheduled for completion in September 2008.

The slope stability portion of the geologic hazards inventory includes developing a slope movement hazard map of the BRP corridor, a slope failure inventory, and a database with the following information: locations of slope failures and slope movement deposits (e.g. debris fans, block fields, etc.), failure dimensions, level and dates of slope failure activity, relevant rock structure information, field engineering and geologic rock and soil classifications, map units to demarcate relative potential for slope failures, and kinematic slope stability analyses. Mapping will be done at a 1:24,000- or 1:12,000-scale and will be provided to the NPS digitally in ArcGIS/ArcView™ format.

Geologic hazards mapping to date consists of fieldwork in the central (the French Broad River near Asheville, NC to Blowing Rock, NC) and southern (the southern terminus near Cherokee, NC north to the French Broad River near Asheville, NC) segments of the BRP. Data is collected at locations with past, current, or potential slope movement activity. For rock slopes, RockPack™ software is used to perform kinematic analyses and identify critical failure planes or intersections.

Types of slope failures vary from debris flows to rock fall, and rockslides. Remnants of Hurricane Frances in September 2004 triggered several embankment failures that mobilized into debris flows in the central segment. In December 2004 a past-active weathered rockslide at mile marker 401 reactivated due to freeze thaw and closed that section for over a week. In addition to concerns regarding public safety, slope failures have a negative affect on local economies that depend on tourism related to the BRP.

The first set of deliverables was provided to the NPS in June 2005. Work continues as access permits and is now focused on the southern segment. Slope stability studies along the BRP will be integrated into the NCGS landslide hazard-mapping program.

Innovations in Landslide and Erosion Repair, Bob Barrett of Soil Nail Launcher Inc.

Forty years of geotechnical research in reinforced soil retaining walls, bridge abutments, bridge piers, open bottom box culverts, landslide and rockfall mitigation. This research was performed by Colorado DOT, the US Forest Service, Federal Highway Administration and several agencies and universities. Several new tools, methods and techniques will be presented that are not as yet in standard practice. His presentation concludes with recent constructions with sawdust fills as light weight fills, GRS walls with negative batter, the Soil Nail Launcher, including Launched Nails, Launched Fiberglass Nails, Launched Micropiles, Launched Scour Micropiles and Super Nails.

Characterization and Remediation of a Creeping Slope

Donald R. McMahon, Todd W. Swackhamer (McMahon & Mann Consulting Engineers, P.C.), James Richard Zimmerman (Norfolk Southern Corporation)

This presentation describes a case history of the characterization and remediation of a creeping slope supporting active railroad tracks in a New York State Park.

Norfolk Southern Corporation (NSC) operates on a railroad track that passes through Letchworth State Park in Central New York. The track crosses over the Genesee River Gorge and runs along the ridge of a steep slope. Since NSC's acquisition of the tracks in the 1990's, the resurfacing cycles of the track along the slope were more frequent than in most areas due to the shifting trackbed. In this area there is a visible scarp crossing the tracks and extending to the crest of the slope. The hummocky terrain and distorted tree trunks downslope of the track suggested movement of the slope as the cause for the shifting trackbed.

NSC engaged McMahon & Mann Consulting Engineers, P.C. (MMCE) in 2000 to explore the slope and develop a conceptual plan for its remediation. MMCE installed geotechnical instrumentation to measure the depth of the slip surface, the magnitude and velocity of movement, and ground water conditions during movement. The data showed a correlation between groundwater levels and slope movement. When the groundwater elevation rose above a certain threshold elevation, approximately 25 feet below the surrounding ground surface, the slope began to creep.

MMCE recommended permanently depressing the groundwater level in the slope below the threshold elevation. MMCE developed a conceptual plan consisting of a gravel drain and perforated drainage pipe to suppress the groundwater level below the threshold elevation. Right-of-way restrictions through the state park and the site's geometry and geology, however, precluded the use of conventional trench installation measures. As such, MMCE identified specialty contractors with equipment that could excavate a 25-foot deep trench, place a flexible perforated drainage pipe, and backfill the trench with drainage stone in a one-pass operation.

The drainage trench was installed in the autumn of 2004 and the groundwater was directed to a small creek at one end of the slope. Since installation, the tracks along the slope have required little or no maintenance due to slope movements.

DAY 2

SESSION 4: Rock Reinforcement & Anchoring. Chair: Steve Brewster (USACE)

Changes in the Post-Tensioning Institutes New (4th Edition 2004) "Recommendations for Prestressed Rock and Soil Anchors", Michael S. McCray (USGS)

Recent advances in the state-of-practice in post-tensioned anchor design and construction have been compiled and published in the Post-Tensioning Institute's (PTI) recently revised design manual "Recommendations for Prestressed Rock and Soil Anchors," 4th Edition, 2004. This presentation describes these recent revisions from the perspective of a Corps of Engineers representative member of the revision committee. The presentation includes discussion on the major changes to the Recommendations, especially as applicable to large civil works projects requiring post-tensioned anchors. Topics will include corrosion protection, manufacturing process for large-diameter bars and its impacts on anchor testing, and epoxy-coated strand creep characteristics and procedures for testing.

Engineering Geology Challenges During Design and Construction of the Marmet Lock Project
Michael Nield (USACE)

A navigational lock, having a chamber dimension of 110' x 800', is currently under construction to supplement the existing smaller and aging locks on the Kanawha River at Marmet, West Virginia. This additional lock, approach walls and temporary cofferdam are founded on a sandstone member of the Pennsylvanian aged Kanawha Formation. Rock and soil anchors were used extensively to stabilize the temporary cofferdam from overturning and sliding forces, to provide support for a temporary 45-foot tall soil retaining wall and to resist sliding forces along newly discovered weak seams within the new lockwall foundation. Geologic challenges resulted, in part, from the proximity of the new lock to the existing lock and the surrounding suburban neighborhood and to accommodate innovative lock design concepts. Challenges that occurred during the design phase of the project involve: site characterization, developing bedrock strength parameters, designing rock anchors and geotechnical design of large-diameter laterally-loaded drilled shaft foundations. Construction challenges included: specifying appropriate construction methods and sequencing, identifying deep-seated sliding failure planes that "daylight" into the adjacent excavation, revising geologic parameters and developing solutions to the discovery of adverse geologic conditions, responding to detected horizontal movement within the cofferdam foundation, implementing foundation preparation and treatment, and limiting damage and vibrations from blasting.

WV 2 Follansbee to Weirton Road: Evaluation of Rockfall Protection Measures and Design of Landslide Correction Measures, Robert L. Dodson (HDR Engineering, Inc.)

HDR Engineering, Inc. was retained by the West Virginia Department of Transportation to provide design services to upgrade two miles of WV 2 in Brooke County from 2 lanes to a divided 4 lane facility. The existing roadway was located on a narrow bench along the Ohio River between a freight railway and a steep hillside ranging in height from about 250 to 400 feet above grade. This section of roadway had a long history of rockfalls and landslides that had caused closure of the roadway on several occasions.

The widening to a 4 lane facility required a 7.5 million cubic yard cut into the hillside. An 80 to 100-foot near vertical exposure of jointed shale at existing grade and a massive 90 to 100 foot near vertical exposure of sandstone located approximately 150 to 250 feet above grade presented significant risk for maintenance of traffic during excavation activities. Based on the results of rockfall analyses, several rockfall protection measures were developed and evaluated to protect traffic during construction.

Evaluation and analyses of landslides at and below grade of WV 2 resulted in the development of recommended rehabilitation options consisting of slope regrading to improve the factor of safety to the installation of soldier pile walls.

Hurricane Related Landslide Repair on the Blue Ridge Parkway,
Don W. Dotson (AMEC), Chris Ramsey (Richard Geottle, Inc.)

Remnants of Hurricane Frances crossed western North Carolina on September 8, 2004 producing heavy rains that caused widespread landslides to the area and along portions of the Blue Ridge Parkway in Buncombe and McDowell counties. Damage was estimated at $60 million to state and federal parklands alone. The slides forced the closure of an eight-mile section of the Parkway south of Linville Falls from Milepost 317 to Milepost 325. Another slide occurred near Milepost 357. Within these areas, four slides were identified by the Federal Highway Administration – Eastern Lands Division for a design/build solution. This presentation discusses the repairs for two of the slides. The repair at Milepost 322 comprised a system consisting of micropiles, soil nails, rock anchors, and a Mechanically Stabilized Earth (MSE) wall. At Milepost 323, the repair consisted of post-tensioned rock anchors inserted through pre-cast concrete reaction blocks.

SESSION 5: Risk & Reliability Assessment — <u>Chair</u>: Jody Stanton (USACE)

Engineering Risk and Reliability - Application to Civil Works Infrastructure
Robert C. Patev (USACE)

The presentation will provide a basic introduction to the audience on engineering risk and reliability. A discussion of practical reliability methods that can implemented in the risk analysis of infrastructure projects will be covered. Examples will highlight how the risk and reliability process is used in the major rehabilitation of USACE navigation and flood control projects. Time will be reserved at the end of the presentation for audience question and answers on engineering risk and reliability.

That Slope Shouldn't Have Failed by Pete Nix (DLZ)

In the spring of 2003, a slide occurred on an embankment slope at the I-77 and I-480, a very heavily traveled interchange near Cleveland. A period of heavy rain preceded the failure and a field reconnaissance indicated numerous seeps from the embankment slopes. A subsequent review of the available subsurface information and a subsurface exploration and instrumentation program indicated that the embankment was not constructed of fill. Originally, the 'embankment' was a high ridge flanked by shallow swales. These swales were cut deeper during construction for the new ramps. These cuts left an approximately 60 foot high ridge that was capped with fill to support the roadway.

The borings indicated that the natural soils in the ridge were saturated silts. Seepage from these silts saturated the slopes and caused the failure at point where the slope was the steepest. DLZ prepared a plan to over excavate the failed soil, install a significant drainage system, then replace the over excavated material with well-compacted fill. The slope repair was completed in 2004 and has remained stable.

Managing the Engineering Risk and Reliability of an Inventory of Large and, Potentially Dangerous Civil Works Projects, Andy Harkness, Jeffrey Schaefer (USACE)

Risk management for any organization that maintains a large portfolio of engineering works that have associated consequences to public safety and economics is a challenge. A method for ensuring that limited resources are directed toward those projects that present the greatest risks is needed. This paper outlines how the Corps of Engineers has tackled this problem in the area of Dam Safety with the assumption that this method has relevance to major transportation civil works projects. Risk analyses and assessments for dam safety will be performed at three levels (1) screening portfolio risk analysis (SPRA), (2) portfolio risk assessment (PRA), and (3) site specific risk assessment (SSRA). The purpose of having these three levels is to allocate limited funds to studies and modifications of projects where the potential for overall risk reduction appears to be greatest. To narrow the focus of this presentation it will focus on the **Screening Portfolio Risk Analysis (SPRA).** The analysis at this level is intended to identify dams that warrant detailed risk analysis. The analysis herein should rely solely on existing information and uses the following simplified risk model:

Risk = (Hazard rate) (Conditional failure probability) (Conditional breach probability) (Exposure) (Loss rate) (1)

Or $R = H\,P_f\,P_b\,X\,L$ (2)

where R is the annual risk (expected losses per year); H is the hazard rate in the form of an initiating event rate, such as a flood or an earthquake (events per year); P_f is the conditional failure probability of a feature given the initiating event (conditional failure probability per event); P_b is the conditional dam breach probability (conditional breach probability per feature failure); X is the exposure of downstream developments due to breaching of the dam and uncontrolled flooding (population or property at risk per breach); and L is the downstream loss rate of the uncontrolled flooding (lives or dollars lost per population or property at risk). The product of X L is called the consequences associated with downstream developments due to breaching of the dam and uncontrolled flooding (lives or dollars lost per breach).

SESSION 6: Site Characterization: Over Karst and AML Chair: Bert Buchanan (FHWA)

Replacement of Rt. 33 Bridges in Active Sinkhole Environment, Silas Nichols (FHWA)

In January 2004 a sinkhole formed under a pier of the three span bridge carrying northbound Pennsylvania State Route 33 traffic over Bushkill Creek in Stockertown, PA. The bridge was located in a highly active sinkhole area just downstream from limestone quarry. Attempts to fill the sinkhole and halt settlement of the pier were unsuccessful, and necessitated closing and eventual replacement of both the northbound and southbound structures. The geology includes the Epler and Jacksonburg Formations, which are intensely folded and faulted with numerous joints and fractures. Weathering of these deformed units produced a deeply developed karst topography that required an extensive subsurface exploration program for the replacement structures that included a combination of borings and geophysical methods. Rock encountered consisted of highly voided limestone and dolomite with soil filled seams, and generally low recovery. The replacement bridges consisted of single span prestressed concrete I-beam structures supported on micro-pile foundations. Sinkhole activity has remained high in and around the site, during and after construction operations.

An Overview of Geophysics Use in Transportation Projects, and Geophysical Choices Specifically for Karst and Mine Investigations, Rick Hoover (Science Applications International Corporation)

A Transportation Research Board National Academy of Sciences Synthesis Study will be reviewed. The study provides a brief summary of the North American use of geophysics for transportation projects. The presentation will then focus on the selection and use of geophysical methods for karst or mine feature investigations.

It is not unusual for a geologist or engineer to be called upon to investigate and address problems related to sinkholes in karst environment. Most professionals know that geophysics can help, but the geophysical method and parameters that may be best suited for the problem at hand are a less certain choice. Geophysical technology and standards have evolved tremendously over the last 15-years. This presentation examines geophysical standards that have been developed. A discussion of the methods that are commonly applied to karst investigations, the advantages and disadvantages of the methods, acquisition parameters, and the kinds of results to be expected will be presented. Common geophysical methods to be examined in detail include electromagnetic terrain conductivity, gravity, electrical imaging and seismic. Examples of the equipment, and resulting investigation results will be addressed.

The Maple Ridge Wind Farm Access Road Design Over Unstable Soils on the Tug Hill Plateau

Martin P. Derby (Malcolm Pirnie, Inc.), (formally with Contech Construction Products, Inc.) and
Patrick O'Rourke (Contech Construction Products, Inc.)

The Maple Ridge Windmill Farm is located on the Tug Hill plateau in the Town of Lowville, New York. The site consists of 120 windmills, and when fully constructed will produce approximately 200MW of electricity – enough to power 59,400 homes. The Maple Ridge project ($320M) is the largest windmill project east of the Mississippi River. Approximately 23 miles of access roads were required for the windmill project.

During the initial stages of the access road construction (May 2005), the general contractor (Blattner), and the excavation contractor (Delaney) encountered unstable soil conditions. Engineers from Contech Construction Products, Inc. (Contech) were contacted to assess the soil conditions, and to provide an access road design/solution capable to withstanding 300 ton crane loadings. The original access road design included an undercut of approximately ten inches, inclusion of a geotextile, and the installation of 10 inches of 3 to 4 inch aggregate.

Contech performed an inspection on two of the completed access roads and observed several areas were the soil (primarily silt) had day-lighted at the surface (indicating the geotextile had ruptured or failed) due to rutting. Soft to medium soils were encountered with an estimated CBR of approximately 0.8 to 1.6 based on observed rutting depths of vehicle tracks.

Contech reviewed the available boring logs, and utilized the SpectraPave2 software to determine the amount of aggregate material that would be required for both the average and "worst case" CBR scenarios. The results indicated that utilizing Tensar's BX1200 geogrid, a minimum of 14 inches of Type 2 aggregate would be required for the access roads. The aggregate thickness could be increased to 22 inches where softer subgrades were encountered.

To date approximately 453,000 square yards of Tensar BX1200 have been installed.
Tensar BX geogrids were successfully used at the Maple Ridge Wind Power site to improve the bearing capacity of the soils, reduce the amount of aggregate required to stabilize the soils underlying the tower access roads, and provide ease of construction.

Geophysical Manual: "A Practical Engineering Solution for Highway Related Problems"

Khamis Haramy, (FHWA-CFLHD), Kanaan Hanna (Blackhawk GeoServices)

Applied geophysical technologies are increasingly being used by State DOTs to solve transportation-related problems. The reason is relatively straightforward. Very simply, geophysical methodologies are often the quickest and most cost-effective means of investigating a geotechnical site or highway structure. This is particularly true when "time is of the essence", when the geotechnical site is relatively large, where site conditions are highly variable, and when accessibility is a problem.

Each geophysical method has its own characteristic applications, advantages and limitations. Some of these methods are used to generate structural/lithologic images of the subsurface between boring locations. Other tools are used to log boreholes and provide information about in-situ porosity, saturation, fluid content, permeability, fracture density, lithology, lithologic contacts, etc. Some surface-based technologies work best in areas where the ground surface is dry and sandy; others work best where the surface is moist and clayey. Some borehole-based technologies work best above the water table; others work better below the water table.

In an effort to assist State DOT engineers responsible for geotechnical and/or structural investigations, the FHWA recently completed a geophysical manual entitled **"Application of Geophysical Methods to Highway Related Problems"** that describes the commonly employed geophysical methods and their principle applications in the transportation industry. The purpose of this document is to provide highway engineers with a basic knowledge of the state-of-practice for geophysical andNDE methods appropriate for solving a wide range of engineering problems during project: Planning, Construction, and Remediation/maintenance of highways

Specific headings include:

1. Bridge System – Foundation, scour, and deck stability
2. Pavement/Runway – Concrete and asphalt
3. Roadway Subsidence – Voids, sinkholes, abandoned mines, and cavities
4. Subsurface Characterization – Bedrock, fractures, lithology, utilities, storage tanks, UXO, and contaminant plumes
5. Vibration Measurements

The manual presents a summary of state-of-practice for geophysical imaging and emerging NDT technologies, appropriate for a wide range of highway construction projects. Users involved in site characterization, geotechnical investigation, design, construction, and roadway remediation effort, will find this manual useful. It is designed with a "Solution Matrix" that guides the user, without reading the entire manual, to obtain an answer during the initial design phase of a survey. For more complex problems, the matrix will direct the user to specific sections to assess the most appropriate methods, their advantages and limitations, and interpretations.

Delineation of Karst Groundwater Basins along the Proposed I-66 Corridor, Pulaski County.

James C. Currens and Randall L. Paylor (University of Kentucky, KGS)

Kentucky Transportation Cabinet is planning a segment of the I-66 corridor (project 8-59.1) in Pulaski and Laurel Counties. Pulaski County includes some of the most significant karst in Kentucky. Karst mapping can improve the design of runoff treatment structures, lower construction and maintenance costs, preserve water quality, and help protect sensitive stygobitic species.

The Kentucky Geological Survey hydrologic project area includes approximately 56 square miles. KGS conducted 45 groundwater traces and mapped an estimated 75 percent of the groundwater basins within the area. KGS also inventoried about 110 additional karst features, conducted flow measurements, surveyed one cave, and recorded descriptions of 35 springs.

Karst development is found throughout the carbonate section. West of Buck Creek significant thickness of limestone has been removed. Active conduits occur at shallow depths along valleys and are commonly perched on the Borden Formation. Larger, more integrated conduits occur east of Buck Creek, particularly in Sinking Valley. Most karst basins conform to topographic watersheds, but there are exceptions. Vertical shafts occur along the carbonate/clastic caprock contact. The no-build option is the only way to avoid all negative karst issues. Among the build options, certain sections of Alternates D and KY80 reconstruction would encounter the fewest karst geologic hazards. Because of the suspected effect of current land use, the protection of groundwater would be less critical along these same routes.

Closing Remarks 12:30 PM

The Appalachian States Coalition for Geological Hazards in Transportation: Committee Members

Tony Szwilski, Chair

Professor and Director,
Center for Environmental, Geotechnical and Applied Sciences (CEGAS)
Marshall University
Address: Gullickson Hall 112, 18th St, 3rd Av.,
Huntington, WV 25755
Phone: (304) 696-5457; Fax: (304) 696-5454
Email: szwilski@marshall.edu

Kirk Beach, Co-Chair

Senior Geologist
Geotechnical Design Section
Ohio Department of Transportation
Address: 1600 West Broad Street, Room
Columbus, OH 43223
Phone: (614) 275-1342; Fax: (614) 275-1354
Email: kirk.beach@dot.state.oh.us

Vanessa Bateman

Tennessee Department of Transportation
Geotechnical Engineering Section
Address: 6601 Centennial Blvd.
Nashville, TN 37243-0360
Phone: (615) 350-4137
Email: vanessa.bateman@state.tn.us

Thomas M. Berg

State Geologist & Chief
Division of Geological Survey
Ohio Department of Natural Resources
Phone: (614) 265-6988; Fax: (614) 268-3669
Email: thomas.berg@dnr.state.oh.us

Hugh Bevans

District Chief
U.S. Geological Survey
11 Dunbar Street, Charleston, West Virginia 25301
Phone: (304) 347-5130 ext. 23
Fax: (304) 347-5133
email: hbevans@usgs.gov

Steve Brewster

Chief, Geology Section
US Army Corps of Engineering
Huntington District
Address: 502 8th St., Huntington, WV 25701
Phone: (304)529-5279
Email: steve.brewster@lrh01.usace.army.mil

Jim Faircloth

Sr. Project Engineer
CSX Transportation
Address: 4901 Befort Rd-J350, Jacksonville, FL 32256
Email: james_faircloth@csx.com

Jim Fisher

West Virginia Department of Transportation
Division of Highways Engineering Division
Address: Building 5, Room 650
1900 Kanawha Blvd., E., Charleston, WV 25305-0430
Phone: (304) 558-2885; Fax: (304) 558-7297
Email: jfisher@dot.state.wv.us

Tommy Hopkins

Chief Research Engineer, Head of Geotechnology
Kentucky Transportation Center
Address: University of Kentucky, 282 CE/KTC
Lexington, KY 40506-0281
Phone: (859) 257-4513; Fax: (859) 257-1815
Email: thopkins@engr.uky.edu

John D. Kiefer

Assistant State Geologist
Kentucky Geological Survey
Address: 228 Mining & Mineral Resources Building
University of Kentucky, Lexington, KY 40506-1147
Phone: (859) 257-5500; Fax: (859) 257-1147
Email: kiefer@kgs.mm.uky.edu

Jody C. Kuhne

NCDOT- Geotechnical Engineering
Asheville Area Office
Address: P.O. Box 3279
Asheville, NC 28802
Phone: (828) 298-3228
Email: jkuhne@dot.state.nc.us

Thomas Lefchik

Structural Engineer
FHWA
Address: 200 North High Street, Room 328
Columbus, OH 43215
Phone: (614) 280-6845
Email: lefchik@fhwa.dot.gov

Jane McColloch

Senior Geologist
West Virginia Geological Survey
Address: P.O. Box 879
Morgantown, WV 26507-0879
Phone: (304) 594-2331 Ext. 425; Fax: (304) 594-2575
Email: janemc@geosrv.wvnet.edu

Kerry W. Petrasic

Chief Geotechnical Engineer
PA Department of Transportaion
Bureau of Construction and Materials
Address: 1118 State Street
Harrisburg, PA 17103
Phone: (717) 787-4319; Fax: (717) 705-5750
Email: kpetrasic@state.pa.us

Thomas Smith

Division Administrator
FHWA, West Virginia Division
Address: Geary Plaza Suite 200, 700 Washington St. East
Charleston, WV 25301
Phone: (304) 347-5928; Fax: (304) 347-5103
Email: thomas.smith@fhwa.dot.gov

John Stanton

US Army Corps of Engineers, Nashville District
Geology Section
Address: P.O. Box 1070
Nashville, TN 37202
Phone: (615) 736-7906
Email: john.i.stanton@usace.army.mil

Derek H. Whitehouse, CPG

Chief Transportation Geologist
Virginia Department of Transportation
1401 E. Broad St., Richmond, VA 23219
Phone: 804-328-3170
Fax: 804-328-3136
email: Derek.Whitehouse@vdot.virginia.gov

J.R. Zimmerman

Geotechnical Engineer
Norfolk Southern Corporation
Address: 175 Spring Street, S.W.
Atlanta, GA 30303
Email: james.zimmerman@nscorp.com

GOALS

The Appalachian states are tied by common geographical and geological challenges. Multi-Model transportation in the Appalachian region is essential for economic development. The coalition includes members from West Virginia, Virginia, Kentucky, Pennsylvania, Tennessee, North Carolina, Ohio Departments of Transport, and Geological Surveys, FHWA, USGS, CSX, Norfolk Southern and USACE. This grass root organization of federal, state and private entities confront similar geological hazard prevention and remediation issues in the Appalachian region.

OVERALL GOALS:

- Address geologic hazards in the Appalachian states related to transportation, highway, river, rail and air.
- Promote the sharing of technical resources and information.
- Provide and electronic medium for the exchange of ideas, experiences, and methodologies.
- Facilitate the development of geologic hazard inventories and to assemble remediation costs.
- Identify new and innovative technologies/research applicable to transportation projects involving remediation of geologic hazards.
- Identify resources to address geohazards.

SHORT-TERM GOALS

- Initiate appropriate communication channels that will benefit the Appalachian Coalition members and other interested parties.
- Develop a regional database/Geohazard Management System that will store geohazard inventories, remediation methods and costs.
- Develop a methodology and testing protocol for site characterization over karst and abandoned mine working for transportation infrastructure planning.
- Identify and characterize geohazards through the resources required (information, equipment, collaboration, funding) to assess and address geohazards.