

8th Annual Technical Forum

GEOHAZARDS IN TRANSPORTATION IN THE APPALACHIAN REGION

Charleston Marriott Hotel Town Center, WV, August 5-7, 2008

TECHNICAL PROGRAM

DAY 1: August 5

5:00 p.m. to 7:00 p.m. Reception & Registration 3rd Floor - Pavilion

- **Exhibitor Set-up: Salon D**

DAY 2: August 6.

7:00 a. m. Registration Salon D

8:00 a. m. Salons A & C Welcome: Tony Szwilski (MU-CEGAS)

Opening Session: Hydrological Investigations. Chair: Kirk Beach (ODOT)

- 1. In the Age of Great Innovation, a Great Oversight: Water and its Control**
Benjamin S. Rivers, PE, Geotechnical Engineer, Federal Highway Administration
- 2. Details on How Pore Pressures are Generated in Slopes and Cause Landslides**
Richard S. Olsen, Geotechnical and Structures Laboratory (GSL) at ERDC, USCE.
- 3. Problems with Acid Rock Drainage at the Skytop Interstate-99 site in Central Pennsylvania,** *Arthur W. Rose, Dept. of Geosciences, Penn State University, PA*

10:00 a.m. COFFEE BREAK Salon D

10:30 a.m. Session 2: Site Characterization for Transportation Infrastructure.
Chair: Vanessa Bateman (TNDOT)

- 1. Using High Water Marks to Transfer Stream Gage Information through a Reach, in Natural Stream-Channel Design Studies,** *by Terence Messinger, U.S. Geological Survey West Virginia Water Science Center*
- 2. Landslide Problems on Appalachian Colluvial Slopes,** *by Richard Gray, DiGioia, Gray & Associates*
- 3. Generalized Skews for Calculating Peak Flows of Rural, Unregulated Streams in West Virginia,** *by John T. Atkins, Jr., U.S. Geological Survey West Virginia Water Science Center*
- 4. Use of Acoustic Televiewer for Exploration,** *by Pete Ingraham, Golder Associates*

12:15 p.m. LUNCH -3rd Floor Pavilion

Guest Speaker: Tom Smith, Division Administrator, WV, FHWA

1:30 p.m. (CONCURRENT SESSION) Kanawha/Blue Ridge Room
Session 3: Remote Sensing. Chair: Jane McColloch (WVGS)

- 1. Using LiDAR to Map Sinkholes in Jefferson County, WV**
by John A. Young, US Geological Survey, Leetown Science Center, Leetown, WV
- 2. Image-Object Analysis for Sinkhole Inventory,** *by Lee Stocks, WVGS.*
- 3. LiDAR for Flood Mapping, Hydraulic Modeling and Stream Restoration Design**
by Ed Watson, Hydrologist, Canaan Valley Institute, WV
- 4. LiDAR, GIS, and Multivariate Statistical Analysis to Assess Landslide Risk, Horseshoe Run Watershed, West Virginia,** *by Kory M. Konsoer, Department of Geology and Geography, West Virginia University,*

1:30 p.m. (CONCURRENT SESSION) Salons A & C
Session 4: Extreme Geotechnical Construction Chair: Steve Brewster (USCE)

- 1. Pittsburgh Light Rail Project, North Shore Connector, Tunnels and Station Shell**
by Paul Zick, P.E., North shore Contractors, Obayashi/Trumbull
- 2. Marmet Lock Replacement: Geotechnical Design and Construction Challenges**
by Sean Carter, USCE.
- 3. Hydrochemical Cause of Pavement Subsidence in the Cumberland Gap: Tunnel Kentucky & Tennessee** *by James Dinger, James Currens, Randy Paylor, R. Stephen Fisher, Kentucky Geological Survey*
- 4. Geotechnical Challenges of the Lewistown Narrows Reconstruction** *by Brent J. Basom and Daniel S. Ramer GTSTech*

3:15 p.m. COFFEE BREAK – Salon D

4:00 p.m. (CONCURRENT SESSION) Kanawha Blue Ridge Room
Session 5: River Processes & Influence on Geohazards. Chair: Scott Eaton (JMU)

- 1. Minersville Riverbank Stabilization – A Case History**
by Lisa Gatens, and Seth Lyle, U.S. Army Corps of Engineers, Huntington District
- 2. Effects of Land Use Changes and Channelization on the Stability of Streams: A Case Study from the Shawnee Hill Country of Southern Illinois**
by L. Scott Eaton, Dept. of Geology and Environmental Science, James Madison University

4:00 p.m. (CONCURRENT SESSION) Salons A & C
Session 6: Subsurface Investigation Innovations Chair: Jody Stanton (USCE)

- 1. Cone Penetrometer Testing** *by Mike Bailey, USACE-SAS*
- 2. Sonic Drilling for Geotechnical Investigation & Construction** *by Steve Bratton, Boart Longyear Environment and Infrastructure.*
- 3. Potential Concrete Growth Resulting from Adverse Reaction Between Cementing Material and Aggregates in Concrete** *by Melanie Leslie, USACE.*
- 4. Long-Term Movements of Highway Bridge Approach Embankments and Pavements** *by Tommy C. Hopkins, Kentucky Transportation Center,, University of Kentucky,*

Adjourn 5:45 p.m.

DAY 3:

7:30 am Registration

8:00 a.m. Salons A & C

Session 7: Modeling and Simulation

Chair: Jim Fisher (WVDOT)

- 1. Landslide Mapping and Research at the Kentucky Geological Survey,**
Matthew M. Crawford and William M. Andrews Jr, Geologic Mapping Section, Kentucky Geological Survey
- 2. Soil Modeling & Slope Design using PSS Slope,** *by Mohamed A. Ashour Ph. D., PE WVU Tech, Joe Carte PE WVDOT, Larry Douglas PG WVDOT.*
- 3. 3D Laser Scanning for Modeling/Monitoring Geohazards** *by Tom Rayburn, E.L. Robinson*

10:00 am COFFEE BREAK - Salon D

10:30 a.m. Salons A & C

Session 8: Seismic Hazard, Risk Assessment & Transportation Infrastructure Management

Chair: Wael Zatar (MU)

- 1. Ground Deformation in New Madrid Seismic Zone Great Earthquakes: Past and Future,** *Roy Van Arsdale, Dept. of Earth Sciences, University of Memphis, Memphis, TN*
- 2. Liquefaction Under Embankment Dams: Back-of-the-Envelope Predictions of Deformation,** *Alan F. Rauch, PhD, PE, Stantec Consulting*
- 3. Seismic Hazard and Risk Assessments for Bridges and Highways in Kentucky”,**
Zhenming Wang, Issam E. Harik, Edward W. Woolery
- 4. Risk Management in Geotechnical Decision Making”,** *Benjamin S. Rivers, PE, Geotechnical Engineer, Federal Highway Administration*

12:30 p.m. Closing Remarks

Forum Presentations: The Powerpoint presentations, in pdf format, of this and previous forums can be found on the Marshall University-CEGAS website:

<http://www.marshall.edu/cegas/geohazards/>

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 (For information contact Barbara Roberts-RTI).

GEOHAZARDS IN TRANSPORTATION IN THE APPALACHIAN REGION

ABSTRACTS

DAY 2

Opening Session: Hydrological Investigations. Chair: Kirk Beach (ODOT)

In the Age of Great Innovation, a Great Oversight: Water and its Control

Benjamin S. Rivers, PE, Geotechnical Engineer, Federal Highway Administration

The geotechnical and engineering geology disciplines have seen many high-tech advances within the transportation arena over the last few decades. Infrastructure emphases on accelerated construction, and designs for extreme loading conditions and mega-projects have spurred the development of many impressive and exciting technologies, including a multitude of ground improvement methods, large diameter foundation elements, and specialized geo-products. With the spotlight on the flashy and extraordinary improvements, our simple, less impressive yet fundamental principles and techniques have been left in the shadows. Chief among the fundamental concepts are the influences of water and its necessary control. This presentation reviews the tremendous influence groundwater can have on our slopes – directly impacting our infrastructure – and highlights the fundamentals of groundwater investigations, analysis and control. Information on the new and pertinent NHI course on Slope Maintenance and Slide restoration is also provided.

Details on How Pore Pressures are Generated in Slopes and Cause Landslides

Richard S. Olsen, Geotechnical and Structures Laboratory (GSL) at ERDC, USCE.

(Abstract not received)

Problems with Acid Rock Drainage at the Skytop Interstate-99 site in Central Pennsylvania

Arthur W. Rose, Dept. of Geosciences, Penn State University, University Park, PA, awr1@psu.edu

Planning in the late 1990's led to a proposed route for Interstate-99 crossing Bald Eagle Ridge just west of State College. A variety of environmental challenges were mounted, concerning weather conditions, endangered bats, wetlands and other topics. Possible pyrite and acid rock drainage were mentioned with little attention, and a clause in the US Highway bill in 1998 precluded further challenges. In 2002-3, a major cut through Bald Eagle Ridge disclosed numerous veins of pyrite with minor Zn-Pb sulfides. The pyritic rock averaged about 5% pyrite through 600 feet of the major cut. The broken pyritic rock was disposed in two major piles and about 10 other sites, including a 0.5-mile "Bifurcation-Buttress" zone constructed to eliminate landsliding into another cut on the west slope of the mountain. Large amounts of lime as layers were added to the broken rock.

In late 2003, reddish water was observed seeping out of several of the rock piles. The water had pH <3, and contained hundreds of mg/L Fe and Al, thousands of mg/L SO₄, and elevated amounts of As, Zn, Cd and other heavy metals. Construction on the section was halted and methods of eliminating the acid rock drainage were investigated. Later investigations show that the lime layers were ineffective because they were impermeable and acted as aquiclides in the rock piles. Injection of Bauxsol (an alkaline waste product from aluminum refining) was attempted but was unsuccessful. Proposed movement of the piles about 80 miles to a repository of alkaline coal ash was rejected because of local opposition to the transport and placement. Other types of alkaline injection were investigated but not followed up. The final solution was moving most of the rock to a lined landfill and mixing with a large amount of lime. Immovable zones including the rock faces and the Bifurcation-Buttress zone were covered with clay, plastic sheets and cellular mats filled with gravel. Cost of the remediation is approximately \$80 million. The highway is scheduled to open by the end of 2008.

10:30 a.m. Session 2: Site Characterization for Transportation Infrastructure.

Chair: Vanessa Bateman (TNDOT)

Using High Water Marks to Transfer Stream Gage Information through a Reach, in Natural Stream-Channel Design Studies

Terence Messinger, U.S. Geological Survey West Virginia Water Science Center

Many USGS stream gages are located at bridges or in otherwise degraded reaches that are uncharacteristic of natural channels. Identifying bankfull features and making appropriate channel-geometry measurements in these locations are problematic. This presentation will discuss a procedure for using near-bankfull, high-water-mark profiles to transfer gage information away from the bridge or degraded reach. This approach, which allows peak discharge to be known throughout the reach, enables the investigator to work in a selected reach with a desired stability, stream type, or more reliably identifiable bankfull features. Disadvantages include increased expense and complicated logistics and scheduling.

Landslide Problems on Appalachian Colluvial Slopes

Richard Gray, DiGioia, Gray & Associates, LLC, 570 Beatty Road, Monroeville, PA 15146, Phone: (412) 372-4500, Cell: (724) 787-5518, www.dgaengineers.us

The Appalachian Plateau with its steep hillsides, thick soil cover, and precipitation of 900 – 1200 mm per year, with the greatest amounts occurring in late winter and early spring, has long been recognized as an area of major landslide severity. Existing and past climatic conditions have resulted in substantial mechanical and chemical weathering which produces a residual or colluvial soil mantle over almost the entire rock surface.

Except locally where sandstone may be abundant the predominance of fine-grained rock (shale and claystone) in the geologic section results in soils being silty clay or clayey silt with rock fragments. Residual soils are characteristic of the flat upland surfaces with colluvial soils formed on slopes.

Colluvial soils tend to be 1.5-9 m thick on slopes and generally increase in thickness (to a maximum of about 30m) near the toe of slopes. Colluvial soils are generally stiff to hard and individual samples have relatively high shear strengths. However, creep or sliding processes (or both) during slope formation has generally reduced the shear strength along movement surfaces to residual or near residual values. Movement surfaces may occur at several levels within the colluvial mass but there is always a movement surface at the soil-rock interface.

Residual (large displacement) shear strength is generally less than half its peak (small displacement) strength at a given effective normal strength. The peak strength of colluvium derived from claystone is commonly characterized by cohesion intercepts of 1-5 psi and friction angles of 20-25°, while the residual strength is usually characterized by negligible cohesion and friction angles of 8-16°. Since the relatively thin, low strength zones in colluvium are not readily apparent in conventional borings, geotechnical engineers need to remember how the colluvium was formed and anticipate low shear strengths.

Generalized Skews for Calculating Peak Flows of Rural, Unregulated Streams in West Virginia

Dr. John T. Atkins, Jr., U.S. Geological Survey West Virginia Water Science Center

The Log Pearson Type III Distribution is fitted to series of peak flows and used to calculate flood recurrences. Generalized skew is used in calculating the magnitude and frequency of floods. A generalized skew map for the United States has been published in Bulletin 17B by the Interagency Advisory Committee on Water Data. However, Bulletin 17B recommends investigating possible improvement of generalized skews by analyzing local streamflow data. The U.S. Geological Survey, in cooperation with the West Virginia Department of Transportation, Division of Highways, investigated development of generalized skews for West Virginia.

Generalized skews were determined from analysis of 147 streamflow-gaging stations in or near West Virginia. The analysis followed guidelines described in Bulletin 17B and considered contouring, averaging, and regression of station skews. The best method was determined as that with the smallest mean-square error (MSE). The contouring of station skews, with a mean square error of 0.2174, was found to be the best method for determining generalized skews for West Virginia and is a significant improvement over the map presented in Bulletin 17B (MSE = 0.3025).

Use of Acoustic Televiwer for Exploration, by *Pete Ingraham, P.E., Golder Associate*

Design of rock cuts, tunnels and other underground openings in rock where limited exposures or outcrops of bedrock exist has commonly necessitated oriented coring to provide joint, bedding, foliation and discontinuity data to support design. Contracting drilling services required for oriented coring except in the mining industry have become difficult to secure because there is limited demand for the service and small local contract drilling companies are reluctant to invest in the tools needed to provide the service if it is seldom required. Improvements in optical televiwer (OTV) and acoustic televiwer (ATV) methods, and PC technology over the past decade have produced highly mobile, powerful tools for rapidly collecting geologic data, verifying the quality of data in the field and developing highly visual and readily understandable borehole logs. Oriented coring technique accuracy and application of OTV/ATV logging methods are discussed as are several transportation and mining projects where OTV/ATV logging in lieu of oriented coring has been completed. Sample OTV/ATV logs are also presented.

1:30 p.m. (CONCURRENT SESSION) Kanawha/Blue Ridge Room

Session 3: Remote Sensing.

Chair: Jane McColloch (WVGS)

Using LiDAR to Map Sinkholes in Jefferson County, West Virginia

John A. Young, Biogeographer, US Geological Survey, Leetown Science Center, Leetown, West Virginia, 25430, Tel: 304-724-4469, email: jyoung@usgs.gov

LiDAR (Light Detection and Ranging) is an aircraft mounted remote sensing technology that uses pulses of laser light to very precisely map land surfaces in three dimensions (horizontal and vertical). In a test of capabilities, we used LiDAR to find small surface depressions to augment a study of water resources surrounding the USGS Leetown Science Center in Leetown, WV. LiDAR data were collected by an aerial services vendor for the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) over Jefferson County, West Virginia in April 2005. As part of a cooperative agreement between the USGS and the NRCS, the USGS conducted a quality control study to provide an independent source of validation for the data collection. The USGS found that the overall error in the data was less than 0.09 meters (3.5inches) vertically, well within the requested accuracy requirements.

Using a geographic information system (GIS), the LiDAR laser pulses returned to the aircraft sensor were converted to hundreds of thousands of mapped points representing a grid of elevation postings at approximately 1-meter spacing. These data were further processed to remove laser pulses returned from treetops and buildings for a “bare earth” surface model. Because of the enormity of the mapped laser points collected, data were broken into rectangular tiles representing 1/16th of a standard 7.5-minute USGS quadrangle for processing. These tiles were then merged to create a seamless 2-meter resolution Digital Elevation Model (DEM) encompassing the drainage area surrounding the Center. This digitally produced map was then used to identify depressions, sinkholes, and the surface expression of geologic structure, such as faults and folds in the Leetown area.

LiDAR data were analyzed to assess potential locations of sinkholes by using GIS surface modeling functions to identify small-scale concavities in the 2-meter DEM. We compared identified surface features to aerial photography and visited possible sinkhole sites in the field. Ninety-four small surface depressions were mapped in the Leetown Science Center watershed, of which 35 were positively

identified as sinkholes, 14 as other types of depressions, and 8 as other than a sinkhole. The nature of 39 mapped depressions could not be confirmed in the field due to a lack of property access. The 2-m DEM also provided the elevation data for the upper layer of a ground-water flow model developed for the Leetown area, and was sufficiently more accurate than existing 30 or 10 m DEMs typically available for most areas of the country. This method shows great promise as a tool for sinkhole mapping and applications for fracture-trace and lineament analysis are equally as promising. We are continuing to develop methodologies for sinkhole identification and we are exploring partnerships with soil scientists and geologists for collaborative analysis.

Image-Object Analysis for Sinkhole Inventory

Lee Stocks, Geologist, West Virginia Geological Survey, 1 Mont Chateau Road, Morgantown, WV 26508, Tel: (304) 594-2331, lstocks@geosrv.wvnet.edu

Opequon Creek flows through a karst watershed 60 miles from Washington, D.C. and has experienced increasing urban growth over the last 20 years that has resulted in the emergence of sinkholes, due to water table draw down. As karst watersheds, those typified by caves, sinkholes, and sinking streams are increasingly urbanized there exists a need for evolution of inexpensive and readily-accessible methods to evaluate human-environment impacts, such as sinkhole development. Traditional sinkhole inventory involves time consuming field methods and/or interpretative grid-counts of aerial photography and topographic maps.

This research develops an object-oriented image analysis of aerial photography for multi-temporal classification of land use/land cover and sinkholes based on shape and spectral reflectance. Multi-resolution segmentation is used to extract image-objects at modifiable scales, while a nearest neighbor classifier algorithm is trained using sample image objects to classify images and generate membership statistics. Categorization, classification, and extraction of these features in a digital medium offers enormous potential for watershed assessment, management, and potential hazard mitigation.

LiDAR for Flood Mapping, Hydraulic Modeling and Stream Restoration Design

Ed Watson, Hydrologist, Canaan Valley Institute, PO Box 673, Davis, WV 26260, Tel: 304-463-4739, ed.watson@canaanvi.org

LiDAR is becoming a common tool for hydraulic modeling, floodplain mapping and management, and stream restoration design. It is an airborne, active sensor terrain mapping technology which can yield high precision digital terrain models. The Canaan Valley Institute (CVI) is a non-profit organization based in Thomas, WV. CVI has used LiDAR for floodplain mapping in Gilmer and Preston counties, WV, and hydraulic modeling and stream restoration design in Tucker County, WV and Harrisonburg, VA. LiDAR has provided updated topographic data to re-delineate detailed flood boundaries (AE zones) and conduct limited detail study of approximate study areas (A zones) to assign base flood elevations. LiDAR has also provided the opportunity to refine hydraulic analysis by adding cross sections to a model at will, to model a broad range of flood values and scenarios, and to design ecologic and hydrologic solutions without repeated visits to the site and costly conventional topographic surveying. Cut and fill volumes can easily be determined, and design scenarios adjusted to make construction more economical and effective.

LiDAR, GIS, and Multivariate Statistical Analysis to Assess Landslide Risk, Horseshoe Run Watershed, West Virginia

Kory M. Konsoer, Department of Geology and Geography, West Virginia University, 330 Brooks Hall, P.O. Box 6300, Morgantown, WV 26506-6300, Tel: 304-293-5603, Email: kkonsoer@mix.wvu.edu

Current stream restoration practices focus on stabilizing banks, transporting sediment, and creating aquatic habitats. However, only channel morphology data are collected prior to typical restoration project designs. A more thorough approach to assessing restoration projects incorporates the geomorphology of the contributing hillslopes within the watershed. For this project, a landslide risk assessment was conducted for Horseshoe Run watershed in West Virginia using LiDAR data, GIS, and multivariate statistical analysis to provide the restoration projects with information concerning the geomorphology of the hillslopes and identify areas of greater risk for slope failure. A landslide inventory map was created using field observations and remote mapping on a LiDAR-derived shaded relief map within ArcGIS 9.2. Landslides were classified as planar slides, rotational slumps, debris flows, debris fans, debris slides, or active slopes. Eight variables were determined for all landslides: elevation, slope angle, slope aspect, distance from roads, distance from streams, plan curvature, profile curvature, and bedrock geology. Similar data on the same eight variables also were collected for a random sample of unfailed slopes, and both data sets were used for discriminant analyses using Minitab 13.30. A first discriminant analysis of all failed and unfailed slopes was 75.8% accurate in predicting failures and non-failed slopes, suggesting a significant difference between the two populations. A second discriminant analysis was 76.3% accurate in determining differences between classifications of slope movements. The discriminant analyses results were used to create a landslide susceptibility map for Horseshoe Run watershed, classifying the hillslopes as low, medium, or high risk for failure. Areas classified as high risk areas were further analyzed to determine whether they were contributing to the channel instability of Horseshoe Run. The landslide susceptibility map also provided a means to evaluate the locations of the stream restoration projects based on sediment supply.

1:30 p. m. (CONCURRENT SESSION) Salons A & C

Session 4: Extreme Geotechnical Construction Chair: Steve Brewster (USCE)

Pittsburgh Light Rail Project, North Shore Connector, Tunnels and Station Shell

by Paul Zick, P.E., North shore Contractors, Obayashi/Trumbull

The Port Authority of Allegheny County North Shore Connector (NSC) Project involves TBM excavation of twin 2240 lf precast segment lined light rail tunnels through soil and rock under the Allegheny River and a downtown narrow city street. Along the tunnel alignment are a historic building on shallow foundations, modern buildings on deep foundations, and one building constructed directly over the alignment. The project also includes construction of twin 1200 lf cut and cover concrete box tunnels and an underground station. This paper provides an overview of general site conditions, current project status and construction challenges for Contracts 003 Tunnels and 006 North Shore Station.

Marmet Lock Replacement: Geotechnical Design and Construction Challenges

by Sean Carter, USCE.

One of the major challenges associated with construction of the new lock chamber (2002-2008) at the Marmet Lock & Dam was the presence of saturated, soft clays. These soft clays presented problems for both the proposed 45 foot deep cut slopes associated with the lock chamber excavation and the adjacent foundation for the 120 foot tall, 3 million cubic yard disposal embankment. Two massive landslides occurred during construction of the existing lock and dam (1930's) that resulted in the death of several

workers. Extensive testing was performed on this soil including CPT and SPT borings along with undisturbed sampling, field excavation and block sampling, field vane shear, and unconfined compression testing. Laboratory testing was also performed on the obtained samples. The study concluded in recommendations for stone columns to enhance strength and drainage characteristics in combination with wick drains and instrumentation monitoring to ensure that the embankment and cut slopes would be safe during construction and that the contractor would be unrestrained in placement of fill in the disposal embankment. The next challenge for the soft, saturated clay was moisture conditioning to within 3% of optimum and at least 95% Standard Proctor density for placement in the embankment.

Hydrogeochemical Cause of Pavement Subsidence in the Cumberland Gap Tunnel, Kentucky/Tennessee

James Dinger, James Currens, Randy Paylor, R. Stephen Fisher, Kentucky Geological Survey, 228 MMRB, University of Kentucky, Lexington, KY 40506-0107, 859-257-5500/dinger@uky.edu

Brad Rister, Kentucky Transportation Center, 274 Raymond Bldg, University of Kentucky, Lexington, KY 40506-0281

On October 18, 1996, the portion U.S. Highway 25E from Middlesboro, Kentucky, to Harrogate, Tennessee, was relocated into a newly constructed tunnel beneath Cumberland Mountain to both improve transportation efficiency and safety, and to help restore Cumberland Gap to its appearance when Daniel Boone brought the first settlers to Kentucky in the mid 1770's. The tunnel is approximately 4,150 ft. long and perpendicularly pierces carbonate rocks of upper Silurian age and Mississippian age, and clastic strata of lower Pennsylvanian age. Cumberland Mountain is on the southeastern margin on the structural wedge of the Pine Mountain thrust sheet, strata are tilted approximately 40 degrees to the northwest, but there are no major faults in the tunnel.

In June, 2002, routine maintenance revealed six short, discrete sections of the highway pavement were beginning to subside in both the southbound and northbound bores. Subsequent geotechnical investigations using ground penetrating radar, limited pavement core holes and lithologic core borings, groundwater quality analyses and modeling, and excavation of 115 ft. of pavement and underlying 5 ft. of number 57 limestone roadbase aggregate demonstrate that pavement subsidence is due to dissolution of the aggregate by groundwater whose pH is generally above 7.0.

Geotechnical Challenges of the Lewistown Narrows Reconstruction by *Brent J. Basom and Daniel S. Ramer GTSTech*

The Lewistown Narrows was a heavily traveled two-lane highway conveying State Routes 0022/0322 through a narrow valley along the Juniata River in Central PA. The six-mile stretch had become a bottleneck between four-lane sections of roadway, and had been the site of numerous fatalities over the years. The Narrows had been considered for widening in the past, but the difficult terrain prohibited a safe and cost-effective solution. In the 1990's concerns over safety and traffic congestion renewed the urgency for widening the roadway, and a design team was assembled to come up with a solution.

The geologic structure of the area plays a key role in the difficulties inherent in the project. The most prominent geologic feature borders the existing roadway to the north, and consists of a marginally stable talus slope comprised of sandstone boulders weathered from the Tuscarora Formation. To the south, the project is constrained by the Juniata River and a historic canal. Design concerns included the fact that traffic had to be maintained on the roadway during construction due to the prohibitive length of potential detours, the limited accessibility for construction equipment, and the potential impact of construction on the stability of the talus.

The design of the roadway widening included several unique features to safely accommodate site constraints. Features included the extensive bifurcation of the roadway, in some cases elevating the proposed roadway over the talus to avoid cutting into the slope. "Pin piles" were used to provide additional resistance against slope failure. The design incorporated reinforced soil slopes, mechanically

stabilized earth walls -including the second largest MSE wall in the world, steel H-piles, concrete cantilever walls, a 120-foot deep rock cut, vibration monitoring, and temporary and permanent rockfall protection ditches/fences. The design utilized rock anchors to retain Tuscarora sandstone having beds dipping toward proposed roadway cuts and with clay "slip" layers and numerous springs.

The roadway construction commenced in 2004, and was completed earlier this year (2008), ahead of schedule and within budget. The construction contract was the second largest awarded in Pennsylvania Department of Transportation (PADOT) history. Some PADOT officials have called the Narrows the most complex highway segment ever constructed in Pennsylvania.

4:00 p. m. (CONCURRENT SESSION) Kanawha Blue Ridge Room

Session 5: River Processes & Influence on Geohazards. Chair: Scott Eaton (JMU)

Minersville Riverbank Stabilization – A Case History

*Lisa Gatens, E.I. and Seth Lyle, P.E., P.G., U.S. Army Corps of Engineers, Huntington District
502 Eighth Street, Huntington, West Virginia 25701*

The Corps of Engineers was requested by ODOT to stabilize a 2240 linear foot section of State Route 124 that was in active failure from top-of-bank retreat and retaining wall collapse. Reconnaissance efforts revealed that both lanes of SR 124 were being affected by the slope failure and were in need of repair. Construction began in September 2003 and was completed in September 2004, at which time, and prior to final inspection, a 300-foot section adjacent to the project was determined to also be in failure. Inactive underground coal mines, previously collapsed portals, debris, colluvium, and land slides blocked drainage and formed ponded areas upslope of SR 124 which contributed to the 300-foot failed reach. This presentation will discuss the construction, problems encountered, and lessons learned from this project.

Effects of Land Use Changes and Channelization on the Stability of Streams: A case study from the Shawnee Hill Country of Southern Illinois

*L. Scott Eaton, Ph.D., Department of Geology and Environmental Science, James Madison University
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Frequently, stream restoration practices overlook 1) the importance of recent changes in sediment supply and their delayed impacts on stream channel morphology; and 2) the long term instabilities of stream channels created by channelization. A case study of these practices was studied along the eastern margin of the Ozark Plateau province in southern Illinois. Wolf Creek, a gravel-bed stream located in the Shawnee hill country, has undergone significant geomorphic changes as the result of land use practices and stream channel modifications. These past actions, which began as early as the late 1800s and ceased by the 1930s, continue to create instability in the fluvial system (e.g., channel aggradation and incision; stream avulsion). These instabilities resulted in the partial destruction of a U.S. Forest Service road and bridge in 1981. Two primary factors appear to be largely responsible for the changes in the stream channel dynamics of Wolf Creek and its tributaries. First, the basin experienced a cycle of intensive logging, farming, and subsequent erosion, followed by forest reestablishment. During the peak of soil erosion in the 1930s, the high rates of fine grained sediment delivered from the hillslopes to the channel transformed Wolf Creek from a low sinuosity channel dominated by a wide, shallow cross section; to a channel that was highly sinuous, deep, and narrow. Upon the reestablishment of forest vegetation and less intensive farming practices within the basin, the channel adjusted its morphology to transport coarser bedload derived from the local bedrock, and reverted back to a shallow, wide, and low sinuosity morphology. The second factor affecting the flow dynamics is attributed to stream channelization near the bridge crossing, which reduced the channel length of Wolf Creek by 35% and increased its channel

slope by 30%. This action increased the flow velocity, causing accelerated scouring and incising of channel bed and banks; and triggering a stream avulsion that ultimately damaged the U.S. Forest Service road and bridge. This case study of Wolf Creek illustrates the importance of documenting the history of land use changes and channel adjustments within a drainage basin prior to designing long-term stream stabilization plans for transportation corridors.

4:00 p.m. (CONCURRENT SESSION) Salons A & C

Session 6: Subsurface Investigation Innovations

Chair: Jody Stanton (USCE)

Cone Penetrometer Testing *by Mike Bailey, USACE-SAS*

Cone penetration testing (CPT) is an effective way to investigate foundation conditions in unconsolidated soils. CPT data are used for determination of a wide range of design parameters and to infer soil type. Modern CPT probes are hydraulically pushed to measure tip resistance, sidewall friction, and pore water pressure. For geophone-equipped CPT probes, the measurement of shear wave velocity enhances earthquake design capabilities. CPT is considerably faster and less expensive than traditional geotechnical drilling, sampling, and testing methods. CPT results have a high degree of precision, thus limiting data scatter commonly found with traditional drilling and sampling. A limited number of traditional geotechnical samples are typically used to calibrate CPT data to site specific conditions to ensure a high degree of accuracy.

Sonic Drilling for Geotechnical Investigation & Construction *by Steve Bratton, Boart Longyear Environment and Infrastructure. 614-402-1808. Sbratton@boartlongyear.com*

Borehole drilling plays a vital role in determining subsurface conditions to allow for design and construction of infrastructure systems. To a large extent, the drilling methods used to facilitate the implementation of investigative and remedial/construction measures have historically been based on the specific equipment possessed by the available contractors chosen to perform the work, rather than choosing a drilling method best suited to addressing overall project objectives and site specific conditions. This presentation would discuss incorporating the Sonic drilling method into the tools available to the geotechnical professional that would enhance information obtained by conventional methods, or to provide information in difficult subsurface conditions where traditional methods fail.

Information to be presented would include: a brief background on the history of Sonic; the basics of Sonic including the use of resonant energy in borehole advancement, typical drilling procedure and sample production; drill platforms available; capabilities, limitations, and geologic suitability; current and potential applications; and, project examples.

Potential Concrete Growth Resulting from Adverse Reaction Between Cementing Material and Aggregates in Concrete *by Melanie Leslie, USACE.*

By mixing a hydrated lime with a volcanic ash called pozzuolana, the Romans successfully developed a concrete and erected major structures, including the Pantheon, using this new building material. Although the Roman technology faded away with the fallen empire, concrete technology reemerged in 1756 when John Smeaton discovered how to make cement. Massive use of concrete in the mid to late twentieth century revealed some unexpectedly low strength, expanding concrete, which experienced these strength and expansion problems many years after placement. Primarily since the 1960's, researchers have identified the source of the decrease in strength and concrete growth as adverse reactions between certain aggregates and cementing materials. While this phenomenon is generically referred to as Alkali

Aggregate Reactivity (AAR), scientists divide the broader category into two differing chemical arenas: Alkali Silica (ASR) and Alkali Carbonate Reactivity (ACR). In either case AAR occurs as readily available hydroxyl radicals react with compounds or minerals found in the aggregate. Because of the severe consequences related to growing concrete, it is prudent to identify potential aggregate problems and simply avoid the aggregate source for use in the concrete. For major concrete structures such as, Kentucky Lock and Chickamauga Lock, the US Army Corps of Engineers performed extensive testing of fine and coarse aggregate sources. These structures are over 1000 feet in length and can tolerate little concrete growth. Test results from sampled quarries indicate selective quarrying will be necessary for avoid potentially reactive aggregates for these projects. While there is no known mitigation for ACR, it is possible to mitigate some of the potential problems associated with ASR. For example, the addition of a minimum 20% class f pozzolans by weight in the concrete mixture can successfully mitigate potential ASR reactions. Identification of potential concrete growth prior to construction is an essential element of the design of any major concrete structure.

Long-Term Movements of Highway Bridge Approach Embankments and Pavements

By Tommy C. Hopkins, Research Engineer, Kentucky Transportation Center, Geotechnology Section, University of Kentucky, 282 Raymond Building, Lexington, KY, USA, 40506-0281
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Long-term movements of highway bridge approach embankments and pavements are described and factors that may lead to settlement of highway bridge approach pavements are discussed. Seven case histories are presented. The bridge approach sites were observed at different times during the period 1966 to 1985. At four sites, lateral movements, measured from slope inclinometers, of the approach embankments were monitored over several years. Settlements of the highway bridge approach pavements were generally monitored some three to four years after paving. One site was monitored for eight years. In all cases, the time of monitoring of the pavement settlements was sufficient to establish long-term settlement patterns. Subsurface explorations were conducted prior to and after construction.

Consolidation and triaxial tests were performed on samples obtained from the foundations and embankments of the seven sites. Estimated foundation settlements were determined from classical consolidation theory. Observed settlements (primary and secondary) of the foundations at the study sites were obtained for a length of time sufficient to establish settlement patterns over long-term time periods. Comparisons of estimated and observed foundation settlements are presented. An empirical method of estimating the rate of foundation settlement is presented. Based on triaxial shear strengths and long-term seepage measurements, long-term factors of safety of the approach embankments were calculated. An empirical method for estimating the long-term settlements (creep) of highway approach embankments is presented. This method can be used as a design procedure to mitigate and minimize creep settlement of bridge approach embankments. This method may be useful in deciding whether permanent or temporary approach pavements should be installed. With regard to the design and construction of highway bridge approach embankments and pavements, several recommendations are presented.

DAY 3:

8:00 a.m. Salons A & C

Session 7: Modeling and Simulation

Chair: Jim Fisher (WVDOT)

Landslide Mapping and Research at the Kentucky Geological Survey,

Matthew M. Crawford and William M. Andrews Jr, Geologic Mapping Section, Kentucky Geological Survey

The Kentucky Geological Survey has expanded ongoing research into landslide hazards by beginning surficial geologic mapping and developing a digital landslide inventory. Steep topography, local geology, varying thicknesses of surficial materials, and coal mining are among many geologic attributes that can contribute to high landslide susceptibility in many parts of Kentucky. Heavy precipitation, drought, or other triggers can initiate landslides in various forms, which can damage critical infrastructure, businesses, and homes. Landslides are commonly viewed as unpredictable, but knowledge of ground conditions (topography, geology, drainage) combined with well-planned construction can reduce exposure to the hazard and help reduce landslide-related losses. Landslides, large and small, are common occurrences in eastern and northern Kentucky; many go unreported. The Kentucky Transportation Cabinet has documented over 3,000 landslides and rockfalls having an impact on or threatening Kentucky highways, leading to major ongoing maintenance costs in those areas.

Surficial geologic mapping of Quaternary sediments in eastern Kentucky consists of field analysis of topography, soils data, and bedrock geology. Utilizing digital base maps and data layers enables more efficient and focused field work. Active field mapping is delineating unconsolidated materials (engineering soils); the resulting map units represent genetic origin, lithology, and, where possible, thickness. Alluvium, colluvium, and residuum are the primary surficial units in eastern Kentucky. Minor units mapped include alluvial fans, terraces, and landslides. Areas disturbed by mining, construction, or excavation are also noted and delineated. KGS is collecting the necessary data to satisfy a variety of audiences that use different classification systems for their applications. For example, lithologic descriptions are collected that satisfy users of both the USDA soil classification and the Unified Soil Classification System.

Recent surficial geologic mapping in Kentucky, as well as ongoing site studies of damaging landslides, have driven a landslide inventory for the state. Early stages of inventory include landslide data collection, field verification, and organization of a landslide database. Current and historical landslides tied with cost will be a major focus of the data collection. Sources of data come from preexisting maps, the Kentucky Transportation Cabinet, the Division of Natural Resources, and anecdotal information. Much of the inventory process will be efficient because of the Kentucky Geological Survey's online Field Data Entry Tool. Known landslide locations and current field observations, along with descriptions and pictures are able to be quickly cataloged and centralized using an online system.

3D Laser Scanning for Modeling / Monitoring Geohazards by *Tom Rayburn, E.L. Robinson*

3D-Laser Scanning provides great flexibility; it is non-contact and accurate, covering large areas quickly if necessary. Data can be loaded into 3D CAD software, allowing interaction with new structures to be explored, or linked to a Geographical Information System (GIS) so that information on asset condition can be accessed by all interested parties. In a more forensic mode, the reflectivity of measurements can be used to identify defective or repaired natural or manmade objects; finally data can be used to create fly-thru's to aid visualization of project sites.

10:30 a.m. Salons A & C

Session 8: Seismic Hazard, Risk Assessment & Transportation Infrastructure Management

Chair: Wael Zatar (MU)

Ground Deformation in New Madrid Seismic Zone Great Earthquakes: Past and Future, *by Roy Van Arsdale, Department of Earth Sciences, University of Memphis, Memphis, TN*

The New Madrid seismic zone encompassing parts of Illinois, Kentucky, Tennessee, Missouri, and Arkansas experienced at least three M 7.5+ earthquakes during the winter of 1811-1812. Some of the earthquakes were felt along the eastern seaboard of the United States. Although the magnitudes of these earthquakes are still debated, the regional ground deformation reveals very large intensities. Fault displacement and resultant earthquakes caused liquefaction, ground fissures, and lateral spreading over large areas of southeastern Missouri and eastern Arkansas, landslides along the eastern bluffs of the Mississippi River valley from northwestern Kentucky south to Memphis, Tennessee, and permanent ground warping in western Tennessee, southeastern Missouri, and eastern Arkansas. The recurrence interval of these large earthquakes is approximately 500 years and so we should expect comparable ground deformation in the future. Mapping of bedrock faults and near-surface geology, allows us to better predict the impact that future faulting and earthquakes will have on the region's landscape and transportation systems.

Liquefaction Under Embankment Dams: Back-of-the-Envelope Predictions of Deformation, *by Alan F. Rauch, PhD, PE, Stantec Consulting*

Using the results from thousands of parametric numerical simulations, simplified equations have been developed for predicting the deformations of embankment dams and levees when the underlying foundation soil liquefies. These tools were developed to support the U.S. Army Corps of Engineers' Portfolio Risk Analysis (PRA), which will probabilistically quantify failure risks at over 600 dam and levee projects. During major earthquakes, many of these facilities are subject to liquefaction of saturated alluvial soils beneath the embankment. Given the resources and site specific data available in the PRA process, the Corps needs simple tools for identifying projects where liquefaction-induced deformations might jeopardize the impoundment. In this study, an explicit finite difference code, capable of tracking large deformations in soil structures, was employed to model a simplified embankment cross section. The embankment height, side slopes, embankment soil strength, headwater pool level, liquefied soil thickness, and residual liquefied soil strength were parametrically varied to represent the conditions typically found in the Corps' projects. The full parametric matrix involved 20,000 numerical simulations, which were run in a batch analysis on a network of desktop computers. Many of the simulations attempted for the weaker liquefied soil strengths could not be completed, due to severe distortions and large deformations within the solution grid. The results from each analysis that converged to a stable solution were compiled into a large dataset. Using linear regression, simplified algebraic equations were then fit to the results. Equations were developed to predict (a) the loss of freeboard and (b) a characteristic displacement magnitude (defined as the 99.8th percentile displacement magnitude within the embankment cross section). The fitted equations and associated guidelines are suitable for use as screening tools to identify earth structures that warrant more detailed analysis and study for liquefaction risks.

Seismic Hazard and Risk Assessments for Bridges and Highways in Kentucky,

by Zhenming Wang¹⁾, Issam E. Harik²⁾, Edward W. Woolery³⁾ Kentucky Geological Survey, University of Kentucky, Lexington, KY 40506; 2) Department of Civil Engineering/Kentucky Transportation Center, University of Kentucky; 3) Department of Earth and Environmental Sciences, University of Kentucky.

Although causes of earthquakes in and around Kentucky are still not fully understood, and difficult to predict, these earthquakes continue to occur and will pose certain hazards and risks to the built environment. It is a challenge for seismologists and engineers to estimate seismic hazard and risk in Kentucky, as well as in the central and eastern United States, because there are very limited observations available. For example, large earthquakes of about M7.5, similar to those that occurred during 1811-1812 in the New Madrid Seismic Zone, are of great concern for the communities in western Kentucky. But, there are only a few historical observations (damage descriptions) available from the 1811-1812 earthquakes. These large earthquakes have been found to have occurred a few times in the past couple of thousand years with an average recurrence interval of 500 to 1,000 years.

The most common approach for seismic hazard and risk assessment is probabilistic seismic hazard analysis (PSHA). It has been found that PSHA is not appropriate because it is not consistent with earthquake physics and statistics, however. In this paper, we applied a new approach to assess seismic hazards and risks for engineering design and analysis of bridges and highways in Kentucky. Ground-motion parameters, such as peak ground acceleration, response spectra, and time history, associated with three earthquake scenarios, the *expected earthquakes (EE)*, *probable earthquakes (PE)*, and *maximum considered earthquakes (MCE)*, have been developed in Kentucky, based on the current scientific understanding of earthquakes. *EE* is defined as the earthquakes that could be expected to occur any time in the bridge lifetime of 75 years. *PE* is defined as the earthquakes that could be expected to occur in the next 250 years. *MCE* is defined as the maximum event considered likely in a reasonable amount of time. Three sets of maps, depicting peak ground acceleration and short period (0.2 s) and long period (1.0 s) response accelerations with 5 percent damping have been produced for the three earthquake scenarios. Associated time histories have also been developed using the composite source model from individual earthquakes that have maximum ground motion and response spectra at the county seats in each earthquake scenario. The composite source model takes into account the source effects, including directivity and asperity, and three-dimensional wave propagation. These ground motion parameters provide bases for performance-based seismic design and analysis of bridges and highways in Kentucky.

Risk Management in Geotechnical Decision Making, by Benjamin S. Rivers, PE, Geotechnical Engineer, Federal Highway Administration

Competition for resources (time, funds, personnel, etc.) is a common struggle for many public and private geotechnical service providers who are continually challenged by management to “cut costs” or “do more with less.” In addition, many transportation organizations are now embracing an Asset Management philosophy to administer monies and efforts to a practically complete yet aging and expanding highway infrastructure. Decision makers can often lose sight of the fundament of geological assessments and geotechnical engineering in transportation program and project activities. Risk management provides a framework in which geological and geotechnical considerations can be rationally compared to other program and project considerations, which will often illustrate to decision makers the gravity geologic and geotechnical involvement and resources have on the life-cycle costs of highway infrastructure assets. This presentation provides an overview of how risk management principles can be applied to transportation program and project decision making, providing more visibility to geologic and geotechnical considerations, and potentially bolstering geologic and geotechnical involvement and resources when justified.

12:30 pm Closing Remarks

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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 an 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 workings for transportation infrastructure planning.
- Identify and characterize geohazards through the resources required (information, equipment, collaboration, funding) to assess and address geohazards.