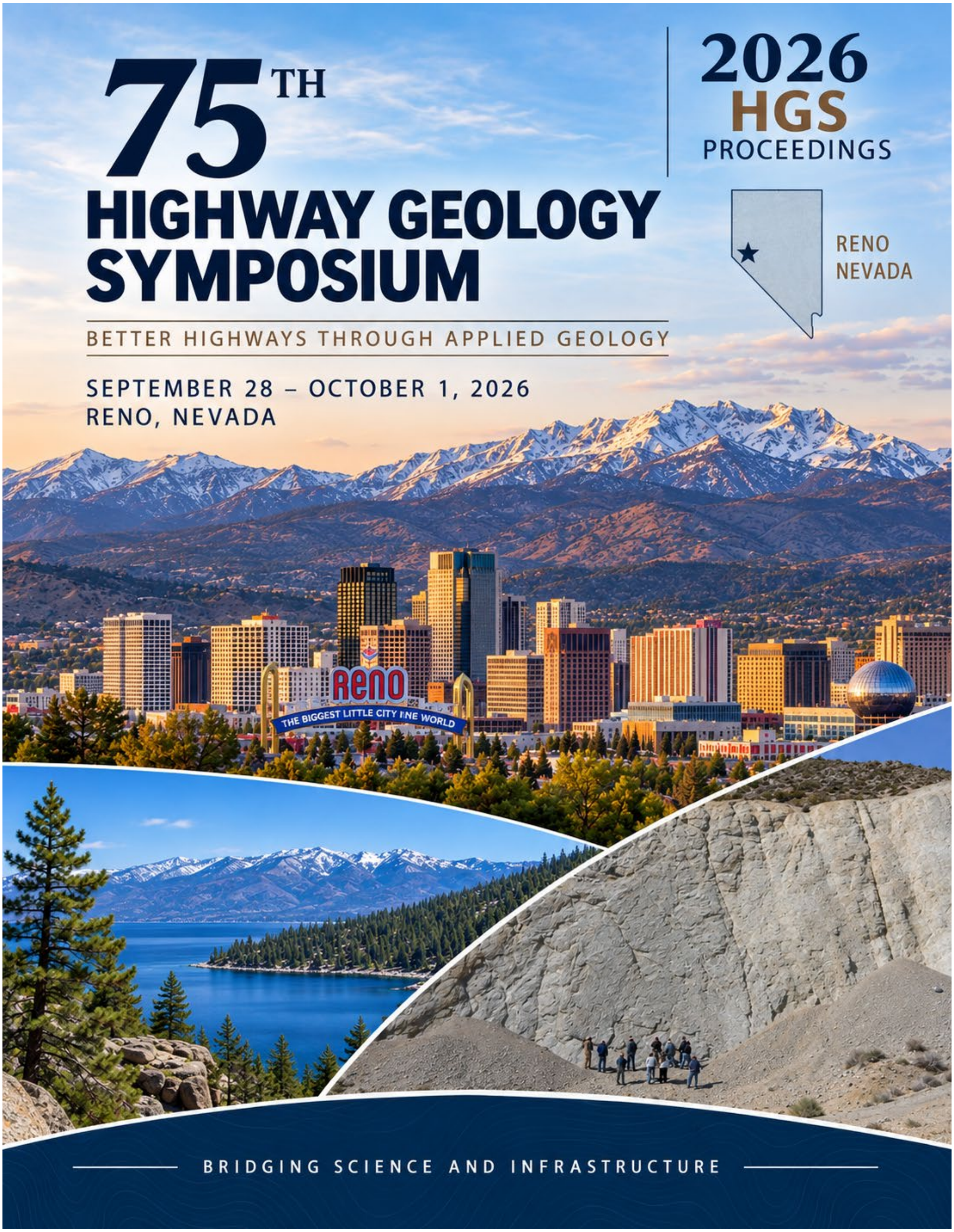
75TH
HIGHWAY GEOLOGY SYMPOSIUM
BETTER HIGHWAYS THROUGH APPLIED GEOLOGY
SEPTEMBER 28 – OCTOBER 1, 2026
RENO, NEVADA
2026
HGS
PROCEEDINGS
RENO
NEVADA
Reno
BRIDGING SCIENCE AND INFRASTRUCTURE

ABOUT THE COVER

Reno and the Sierra Nevada
The central image highlights Reno, Nevada, host city of the 75th Highway Geology Symposium, set against the eastern front of the Sierra Nevada. The setting reflects the close relationship between geology, topography, transportation, and the growth of communities throughout northern Nevada.

Lake Tahoe and the Sierra Nevada
Lake Tahoe represents one of the region's most recognizable landscapes. The Tahoe Basin and surrounding Sierra Nevada reflect a complex geologic history shaped by faulting, uplift, volcanism, and glaciation. The landscape provides a dramatic regional setting for transportation corridors that must contend with steep terrain, rock slopes, seismic hazards, snow, and other geologic constraints.

Genoa Fault
The lower right photograph shows an exposure associated with the Genoa Fault, one of the major active faults along the eastern front of the Carson Range. The exposure provides a striking illustration of the active tectonic setting of western Nevada and the importance of understanding faulting and seismic hazards in the planning and design of transportation infrastructure.

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75^{th} Highway Geology Symposium

September 28- October 1, 2026
Whitney Peak Hotel
Reno, NV

Grateful Acknowledgments

The Highway Geology Symposium National Steering Committee would like to acknowledge and extend a sincere appreciation for their efforts to make the 75^{th} HGS a success.

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Delaney Event Management

Welcome to the 75^{th} Highway Geology Symposium

On behalf of the Local Steering Committee, it is our great pleasure to welcome you to the 75^{th} Highway Geology Symposium in Reno, Nevada.

This year's symposium represents an important milestone in more than one way. Not only are we celebrating the 75^{th} gathering of the Highway Geology Symposium, but this is also the first time the symposium has been hosted in Reno. We are proud to welcome you to Northern Nevada, a region where geology has played an important role in shaping our transportation systems, communities, and infrastructure.

We are also pleased to introduce a stronger seismic component to this year's symposium. Nevada and the surrounding western states provide an ideal setting for expanding the discussion of how earthquakes and seismic hazards affect transportation infrastructure. By incorporating seismic topics into the technical program, we hope to broaden the exchange between engineering geology, geotechnical engineering, earthquake engineering, and transportation professionals while remaining true to the practical focus that has defined the Highway Geology Symposium for many years.

Our Local Steering Committee has worked diligently to develop a program that combines technical presentations, field experiences, professional exchange, and opportunities to reconnect with longtime colleagues and build new relationships. We hope the symposium provides an environment where practical experience and new ideas come together, leading to discussions and collaborations that continue well beyond our time in Reno.

We also encourage you to enjoy Reno and the surrounding region while you are here. From the unique geology and landscapes of Northern Nevada to the nearby Sierra Nevada and Lake Tahoe, this area provides an especially fitting setting for the Highway Geology Symposium.

Organizing an event of this scale requires the efforts of many people. We extend our sincere appreciation to the members of the Local Steering Committee, symposium leadership, speakers, sponsors, exhibitors, volunteers, and everyone who contributed their time and expertise to making this event possible.

Most importantly, thank you for joining us and for being part of the 75th Highway Geology Symposium. Your participation, knowledge, and professional engagement are what have sustained this symposium for 75 gatherings and will carry its legacy forward.

Welcome to Reno. We hope you have a productive, enjoyable, and memorable symposium.

Gary Norris and Sherif Elfass

75 Years of Impact: The Highway Geology Symposium

This year we celebrate the 75th gathering of the Highway Geology Symposium. Seventy-five gatherings over 77 years is no small accomplishment. Since that first meeting in Richmond in 1950, there have been wars and more wars, 13 presidents, two new states, trips to the moon, a global pandemic, and an extraordinary expansion of technology. In our own professions, we have gone from slide rules to artificial intelligence, surveying transits to satellite imagery, and blueprints to digital point clouds. Plate tectonics itself would not become broadly accepted until well after the first Symposium. The changes have been staggering.

Yet, for all that has changed, the basic idea behind HGS has changed remarkably little. The stated purpose of that first gathering was “to foster the exchange of ideas between highway engineers and geologists on problems relating to highway construction.” The early proceedings make clear that this exchange was intended to be practical, informal and personal. A 1956 foreword emphasized practical subjects over involved scientific treatises, diversity over a central theme, and considerable latitude for the local sponsors. Those principles remain recognizable today.

Perhaps even more important is the personal interaction that has always been at the heart of the Symposium. The 1956 program arrangements observed that a one-day technical program left too little time for the personal contacts and acquaintanceships that frequently form the most profitable part of a meeting. Their solution was a social gathering the evening before the program. That same spirit has endured through banquets, field trips, informal conversations and friendships that have crossed agencies, disciplines, states and generations. The field trip, now central to HGS, takes us to places many of us might otherwise never visit and lets us stand together at an outcrop, a landslide, a bridge or a rock cut and learn from one another.

That ethos was tested during the COVID-19 pandemic. Rather than simply substitute a virtual meeting for the gathering, HGS accepted a hiatus. In doing so, it affirmed something our predecessors understood early: HGS is more than a collection of papers. The face-to-face exchange is part of the event itself. In an era of remote work and artificial intelligence, that may become more important, not less.

The resiliency of HGS also owes much to its deliberately simple structure. There is no large central organization. There are bylaws, officers and a National Steering Committee, but each year considerable responsibility and flexibility pass to a local host committee. That balance has allowed the Symposium to adapt without losing its character. Technical tools and practices have evolved continuously - controlled blasting, rock reinforcement, remote sensing, numerical modeling, LiDAR, point clouds and much more - while the emphasis on practical solutions and open exchange has remained.

We benefit today from the foresight and leadership of the many people who preceded us, beginning with the chair of the 1st HGS, W. T. Parrott from the VA Department of Highways, A.

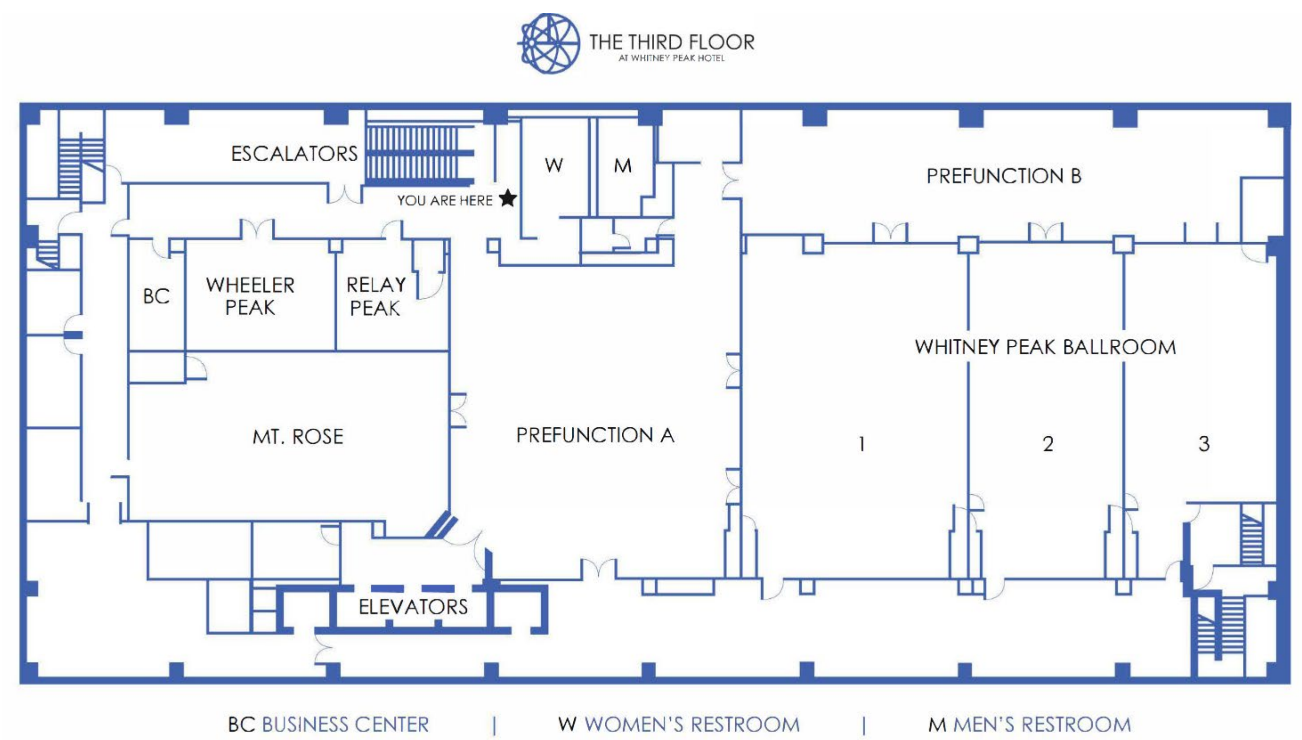
C. Dodson from the NC State Highway and Public Works Commission for the 7th HGS, and continuing through generations of organizers, authors, speakers, field-trip leaders and attendees. The proceedings they left behind are a remarkable record of both the development of highway geology and the people who made that development possible.

Seventy-five gatherings later, better highways are one result. Just as important are the relationships, shared experience and willingness to learn from one another that have sustained the Symposium. Technology will continue to change. The geology will continue to challenge us. It is the spirit behind HGS that has kept it going, and it is that spirit we carry forward.

75th Highway Geology Symposium

September 28- October 1, 2026
Whitney Peak Hotel
Reno, NV

Whitney Peak Hotel, The Third Floor



75th Highway Geology Symposium

Schedule at a Glance

	Monday, September 28, 2026	Location
9:00 AM - 5:00 PM	Exhibitor Move-in & Setup	Prefunction A
9:00 AM - 6:00 PM	Registration Open	Prefunction A
10:00 AM - 5:00 PM	Offsite Sessions (Pre-Registration Required)	University of Nevada, Reno - Transportation departs from Hotel
10:00 AM - 11:30 AM	Shear-Wave Surveying	
1:00 PM - 2:30 PM	Slope Stabilization Based on Soil-Pile Interaction	
3:00 PM - 4:30 PM	Improving Infrastructure Resilience Through Experimental Seismic Engineering	
5:00 PM - 6:30 PM	HGS National Steering Committee Meeting	Whitney Peak 1
6:00 PM - 8:00 PM	Icebreaker Reception ***Sponsored by GeoStabilization International***	Prefunction AB
	Tuesday, September 29, 2026	**Location**
7:00 AM - 8:00 AM	Breakfast	Boundary Peak
7:00 AM - 4:30 PM	Registration Open	Prefunction A
7:00 AM - 4:30 PM	Exhibits Open	Prefunction A
8:00 AM - 9:30 AM	Welcome to Nevada!	Whitney Peak Ballroom
9:00 AM - 4:00 PM	Guest Trip to Virginia City (Pre-Registration Required)	Offsite
9:30 AM - 10:00 AM	Morning Break - ***Sponsored by DOWL***	Prefunction AB
10:00 AM - 12:00 PM	Technical Session 1: Young Authors	Whitney Peak Ballroom
12:00 PM - 1:00 PM	Lunch	Boundary Peak
1:00 - 2:20 PM	Technical Session 2: Young Authors and Others	Whitney Peak Ballroom
2:20 PM - 2:50 PM	Afternoon Break - ***Sponsored by GFT***	Prefunction AB
2:50 PM - 4:10 PM	Technical Session 3	Whitney Peak Ballroom

	Wednesday, September 30, 2026	Location
7:00 AM - 8:00 AM	Breakfast	Boundary Peak
7:00 AM - 4:00 PM	Registration	Prefunction AB
7:00 AM - 5:00 PM	Exhibits open	Prefunction AB
8:00 AM - 10:00 AM	Technical Session 4A	Whitney Peak Ballroom
8:00 AM - 10:00 AM	Technical Session 4B	Boundary Peak
10:00 AM - 10:30 AM	Morning Break ***Sponsored by Hager-Richter Geoscience, Inc.***	Prefunction AB
10:30 AM - 11:50 PM	Technical Session 5A	Whitney Peak Ballroom
10:30 AM - 11:50 PM	Technical Session 5B	Boundary Peak
11:50 PM - 1:00 PM	Lunch	Boundary Peak
1:00 PM - 2:20 PM	Technical Session 6	Whitney Peak Ballroom
2:20 PM - 2:50 PM	Afternoon Break - ***Sponsored by Fragmentation***	Prefunction AB

	Efficiency Services, Inc./KESCO, Inc.	
2:50 PM - 4:00 PM	Technical Session 7	Whitney Peak Ballroom
3:00 PM	Exhibitor Tear-down	Prefunction AB
3:30 PM - 4:00 PM	Field Trip preview	Whitney Peak Ballroom
6:00 PM - 7:00 PM	Banquet social	Prefunction AB
7:00 PM - 10:00 PM	HGS Banquet & Awards ***Sponsored by GeoStabilization International***	Whitney Peak Ballroom

	Thursday, October 1, 2026	**Location**
6:30 AM - 7:00 AM	Grab & Go breakfast	Whitney Peak Ballroom
7:00 AM	HGS Field Trip Departs **Transportation sponsored by Maccaferri, Inc.** **Snacks/soft drinks sponsored by Ameritech Slope Constructors** **Adult Beverages sponsored by Scarptec**	Offsite
12:00 PM	Lunch-***Sponsored by Geobrugg***	Genoa Golf Club
6:00 PM	Return to Whitney Peak	Hotel Lobby

Highway Geology Symposium History Organization, and Function

Inaugural Meeting and Beginnings

Established to foster a better understanding and closer cooperation between geologists and civil engineers in the highway industry, the Highway Geology Symposium (HGS) was organized and held its first meeting on March 14, 1950, in Richmond Virginia. Attending the inaugural meeting were representatives from state highway departments (as referred to at that time) from Georgia, South Carolina, North Carolina, Virginia, Kentucky, West Virginia, Maryland, and Pennsylvania. In addition, a number of federal agencies and universities were represented. A total of nine technical papers were presented. W.T. Parrott, an engineering geologist with the Virginia Department of Highways, chaired the first meeting. It was Mr. Parrott who originated the Highway Geology Symposium. It was at the 1956 meeting that future HGS leader, A.C. Dodson, began his active role in participating in the Symposium. Mr. Dodson was the Chief Geologist for the North Carolina State Highway and Public Works Commission, which sponsored the 7th HGS meeting.

Organization

Unlike most groups and organizations that meet on a regular basis, the Highway Geology Symposium has no central headquarters, no annual dues and no formal membership requirements. The governing body of the Symposium is the National Steering Committee composed of approximately 20 – 25 geologist and geotechnical engineers from state and federal agencies, colleges and universities, as well as private service companies and consulting firms throughout the country. Steering committee members are elected for three-year terms, with their elections and re-elections being determined principally by their interests and participation in and contribution to the Symposium. The officers include a chairman, vice chairman, secretary, and treasurer. all of whom are elected for a two-year term. Officers, except for the treasurer, may only succeed themselves for one additional term. A number of three-member standing committees conduct the affairs of the organization. The lack of rigid requirements, routing and relatively relaxed overall functioning of the organization is what attracts many participants. The symposia are generally run for 3 days, with 2 days for technical papers and a full day field trip. The Symposium is often preceded with a special session or workshop and an opens with an evening Ice-Breaker. Occasionally, an optional workshop or field trip may follow the Symposium

Symposium Locations

Since the initial meeting, 73 annual (2 years missed for COVID) Symposiums have been held in 36 different states. Between 1950 and 1962, the meetings were east of the Mississippi River, with Virginia, West Virginia, Ohio, Maryland, North Carolina, Pennsylvania, Georgia, Florida, Tennessee, and Nevada serving as host state. In 1962, the symposium moved west for the first time to Phoenix, Arizona where the 13th annual HGS meeting was held. Since then, it has alternated, for the most part, back and forth from the east to the west.

1st	1950	Richmond, VA	39th	1988	Park City, UT
2nd	1951	Richmond, VA	40th	1989	Birmingham, AL
3rd	1952	Lexington, KY	41st	1990	Albuquerque, NM
4th	1953	Charleston, WV	42nd	1991	Albany, NY
5th	1954	Columbus, OH	43rd	1992	Fayetteville, AR
6th	1955	Baltimore, MD	44th	1993	Tampa, FL
7th	1956	Raleigh, NC	45th	1994	Portland, OR
8th	1957	State College, PA	46th	1995	Charleston, WV
9th	1958	Charlottesville, VA	47th	1996	Cody, WY
10th	1959	Atlanta, GA	48th	1997	Knoxville, TN
11th	1960	Tallahassee, FL	49th	1998	Prescott, AZ
12th	1961	Knoxville, TN	50th	1999	Roanoke, VA
13th	1962	Phoenix, AX	51st	2000	Seattle, WA
14th	1963	College Station, TX	52nd	2001	Cumberland, MD
15th	1964	Rolla, MO	53rd	2002	San Luis Obispo, CA
16th	1965	Lexington, KY	54th	2003	Burlington, VT
17th	1966	Ames, IA	55th	2004	Kansas City, MO
18th	1967	Lafayette, IN	56th	2005	Wilmington, DE
19th	1968	Morgantown, WV	57th	2006	Breckinridge, CO

20th	1969	Urbana, IL	58th	2007	Pocono Manor, PA
21st	1970	Lawrence, KS	59th	2008	Santa Fe, NM
22nd	1971	Norman, OK	60th	2009	Buffalo, NY
23rd	1972	Old Point Comfort, VA	61st	2010	Oklahoma City, OK
24th	1973	Sheridan, Wy	62nd	2011	Lexington, KY
25th	1974	Raleigh, NC	63rd	2012	Redding, CA
26th	1975	Coeur d'Alene, ID	64th	2013	North Conway, NH
27th	1976	Orlando, FL	65th	2014	Laramie, WY
28th	1977	Rapid City, SD	66th	2015	Sturbridge, MA
29th	1978	Annapolis, MD	67th	2016	Colorado Springs, CO
30th	1979	Portland, OR	68th	2017	Marietta, GA
31st	1980	Austin, TX	69th	2018	Portland, ME
32nd	1981	Gatlinburg, TN	70th	2019	Portland, OR
33rd	1982	Vail, Co	71st	2022	Asheville, NC
34th	1983	Stone Mountain, GA	72nd	2023	Tacoma, WA
35th	1984	San Jose, CA	73rd	2024	Lawrence, KS
36th	1985	Clarksville, TN	74th	2025	Morgantown, WV
37th	1986	Helena, MT	75th	2026	Reno, NV
38th	1987	Pittsburgh, PA			

Symposium Format

The symposia are scheduled for three days, with two days of technical papers and a full day for the field trip. The Symposium is often preceded with a special session and/or workshops and opens with evening Ice-Breaker, followed by two days of technical presentations and a full day field trip.

Highway Geology Symposium Field Trip

The field trip is the focus of the meeting. In most cases, the trips cover approximately 150 to 200 miles, with stops visiting geological, geotechnical, and cultural points of interests in the host state or nearby.

Some highlights of past Symposium field trips: In Wyoming (1973), the group viewed landslides in the Big Horn Mountains; Florida’s trip (1976) included a tour of Cape Canaveral and the NASA space installation; the Idaho and South Dakota trips dealt principally with mining activities; North Carolina provided stops at a quarry site, a dam construction site, and a nuclear generation site; in Maryland (1978), the group visited the Chesapeake Bay hydraulic model and the Goddard Space Center. The Oregon trip included visits to the Columbia River Gorge and Mount Hood; the Central mine region was visited in Texas.

The Tennessee meeting in 1981 provided stops at several repaired landslide in Appalachia regions of East Tennessee. In Utah (1988) the field trip visited sites in Provo Canyon and stopped at the famous Thistle Landslide. In New Mexico (1990), the emphasis was on rockfall treatments in the Rio Grande River canyon and included a stop at the Brugg Wire Rope headquarters in Santa Fe. Mount St, Helens was visited by the field trip in 1994 when the meeting was in Portland, Oregon.


New River Gorge Bridge

1995 the West Virginia meeting took us to the New River Gorge Bridge that has a deck elevation of 876 feet above the water, and at the time, was the longest single arch span in the world. In Cody Wyoming, the 1996 field trip visited the Chief Joseph Scenic Highway and the Beartooth Uplift in northwest Wyoming. In 1997 the meeting in Tennessee visited the newly constructed future I-26 highway in the Blue Ridge of East Tennessee.

The Arizona meeting in 1998 visited the Oak Creek Canyon near Sedona and a mining ghost town at Jerome, Arizona. The Virginia meeting in 1999 visited the “Smart Road”Project that was under construction. This was a joint research project of the Virginia Department of Transportation and Virginia Tech University. The Seattle Washington meeting in 2000 visited an ancient lahar in the Mount Rainier area. A highlight of the Maryland symposium in 2001 was visiting the Sideling Hill road cut for I-68, which beautifully exposes a tightly folded syncline, common in the Valley and Ridge physiographic province of the Appalachians. The California field trip in 2002 provided a field demonstration of the effectiveness of rock netting against rock falls along the Pacific Coast Highway. The Kansas City meeting in 2004 visited the Hunt Subtropolis which is said to be the “world’s largest underground business complex”. It was created through the mining of limestone by way of the room and pillar method. The Rocky Point Quarry provided an opportunity to search for fossils at the North Carolina meeting in 2005. The group also visited the US-17 Wilmington Bypass Bridge which was under construction. Among the stops at the Pennsylvania meeting were the Hickory Run Boulder Field, the No.9 Mine and Wash Shanty Museum, and the Lehigh Tunnel. The New Mexico field trip in 2008 included stops at a soil nailed wall along US-285/84 north of Santa Fe and a road cut through the Bandelier Tuff on highway 502 near Los Alamos where rockfall mesh was used to protect against rockfalls. The New York field trip in 2009 included the Niagara Falls Gorge and the Devil's Hole Trail.

In Oklahoma (2010) the trip saw the complex geology of the Arbuckle Mountains in the southern part of the state along with stops at Tucker's Tower and Turner Falls. In the bluegrass state of Kentucky (2011) the trip included stops at Camp Nelson, the site of the oldest exposed rocks in Kentucky, near the Lexington and Kentucky River Fault Zones.

Sidling Hill Syncline

Additional stops at the Darby Dan Farm and the Woodford Reserve Distillery illustrated how the local geology has played such a large part in the success of breeding prized thoroughbred horses and made Kentucky the "Birthplace of Bourbon". In Redding, California, the 2012 field trip included stops at the Whiskeytown Lake, which is one in a series of lakes that provide water and power to northern California. Additional stops included Rocky Point, a roadway construction site containing Naturally Occurring Asbestos (NOA), and Oregon Mountain where the geology and high rainfall amounts have caused Hwy 299 to experience local and global instabilities since first constructed in 1920.

The 2013 field trip in New Hampshire highlighted the topography and geologic remnants left by the Pleistocene glaciation that fully retreated approximately 12,000 years ago. The field trip included stops at various overlooks of glacially carved valleys and ranges; the Old Man of the Mountain Memorial Plaza, which is a tribute to the famous cantilevered rock mass in the Franconia Notch that collapsed on May 3, 2003; the lacustrine deposits and features of the Glacial Lake Ammonoosuc; views of the Presidential Range; bridges damaged during Tropical Storm Irene in August 2011; and the Willey Slide, located in the Crawford Notch where all members of the Willey family were buried by a landslide in 1826. The 2014 (Wyoming) field trip presented a breathtaking tour of the geology and history of southeast Wyoming, ascending from the high plains surrounding Laramie at 7000 feet to the Medicine Bow Mountains along the Snowy Range Scenic Byway. Visible along the way were a Precambrian shear zone, and glacial deposits and features. From the glacially carved Mirror Lake and the Snowy Range Ski Area, the path wound east to the Laramie Mountains and the Vedauwoo Recreational Area, a popular rock climbing and hiking area. The 2015 field trip in Sturbridge, Massachusetts, focused on the Connecticut Valley, a Mesozoic rift basin that signaled the breakup of Pangea, and the Berkshires, which represents the collision and amalgamation of an island arc system with the North American Laurentian margin.

The field trip in Colorado (2016) was an urban setting along the western edge of Colorado Springs and around Manitou Springs. Stops included the Pikeview Quarry, Garden of the Gods Visitor Center, and several other locations where rockfall and debris flow mitigation, post-flooding highway embankment repair, and a nonconformity in the rock records that spans 1.3 billion years were observed.

Garden of the Gods

Penobscot Narrows Bridge

The Georgia (2017) field trip provided an opportunity to view the geology of northern Georgia. Stops included the Bellwood Quarry, which, at one time was run by the City of Atlanta and served as a prison labor camp. Upon completion of a tunnel to connect the quarry to two water treatment plants and three pump stations, It will serve as a 2.4 billion-gallon water storage facility for the City of Atlanta. Additional stops included the Buzzi Unicem Cement Plant to get a close up view of the Clairmont Melange, The Cooper Furnace near the Allatoona Dam, and the New Riverside Ochre-Emerson Barite mine.

The 2018 field trip of the Portland, Maine Symposium presented a good overview of the geology of coastal Maine. Field trip stops included the Sherman Salt Marsh near Newcastle which was recently restored to its natural state after the dam that carried US Highway 1 washed out during a 2005 storm, the site of the 1996 landslide near Rockland Harbor that consumed several homes, and the rock slope remediation project at the Penobscot Narrows Bridge near Prospect Maine. A lobster lunch along the shore of Penobscot Bay was one of several highlights of the field trip.

The 2019 field trip in Portland, Oregon travelled the Columbia River Gorge west. Starting at the Crown Point Vista House and Portland Women's Forum State Scenic Viewpoint above the gorge to learn about the river highway. Descending into the gorge, we stopped at scenic Multnomah Falls and Benson Bridge, and saw flexible rockfall fence installed to protect the lodge and historic Columbia River Highway. Other stops included lunch at Cascade Locks, Bonneville Landslide and rockfall areas along the highway. There was no symposium in 2020 and 2021 due to Covid-19 restrictions.

In 2022, we got back together again in Asheville, North Carolina. The field trip took us through Ordovician (500 my) to Precambrian (1.2 by) migmatized ortho and paragneisses, metamorphosed intrusives, thrust faults and contacts representing three orogenies and complex sequences of basement and terranes. We crossed the Brevard Fault zone several times, which is a structure that has been studied and interpreted for 100 years. Various attempts to define the structure have been made, especially in the pre-plate tectonic era. It has been theorized that these structures were as high, or higher than the Rockies at formation. 200 million years of rifted erosion leave us with an exposed look at deep orogenic roots of multiple thrust events. Precipitation in the areas is between 60-100” per year. There are deep ancient colluvial deposits, complex mineralization and weathering profiles, and non- linear/planar discontinuities. We traveled over I-26 and the Blue Ridge Escarpment where the highway is being widened. Stops included the I-26 Old Howard Gap Slide Area, the US 74 Gerton Slide, a shallow landslide barrier on I-40 W, and the Buckner Gap Cut.

The 2023 Field trip in Tacoma, Washington traveled to Mt Rainer where HGS goers were able to take various hikes around the park. Additional highlights included driving down into the Ohop Valley outwash channel, a drive by of Alder Lake, a drive along Copper Creek Forest Road 59, a view of Nisqually Glacier from Nisqually River and a final stop at Ricksecker Point.

The Lawrence Kansas (2024) symposium field trip took us to the Tallgrass Prairie National Preserve, lunch on the Dakota Formation sandstone bluff at Coronado Heights, and saw the unique differential weathering of the Dakota Formation at Mushroom Rock State Park.

Mushroom Rock State Park

The 74th HGS field trip took us into the mountains of West Virginia. Morning stops showcased the complex folding and geology of the Valley and Ridge physiographic province along recently a recently completed section of US-48 (Appalachian Highway System Corridor H). We then head down the South Branch of the Potomac River to Seneca Rocks, a 1000’ vertical outcrop of Silurian Tuscarora sandstone. After lunch at Blackwater Falls State Park, we accessed a new and yet unopened section of corridor H, with a stop looking at the Cheat River bridge consisting of 9 spans, one of which will be longest steel plate girder span in the U.S. The last stop examined the challenges of highway construction through massive (and moving) slump blocks of the Devonian Foreknobs Formation.

Seneca Rocks

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		Jody Kuhne	828-779-9482	jodykuhne@gmail.com
2023	Washington	Marc Fish	360-709-5898	fishm@wsdot.wa.gov
2024	Kansas	Kyle Halverson	785-600-8165	Kyle.halverson@ks.dot
2025	West Virginia	Ken Ashton	304-594-2331	ashton@wvgs.wvnet.edu
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2027	Pennsylvania	Sarah McInnes	724-272-7532	smcinnes@pa.gov
		Chris Ruppen	724-272-7532	christopher.ruppen@gsi.us

Emeritus Members of the Steering Committee

A number of past members of the national steering committee have been granted Emeritus status. These individuals, usually retired, resigned from the HGS Steering Committee, or are deceased, have made significant contributions to the Highway Geology Symposium. A total of 46 people have been granted Emeritus status by the Steering Committee.

R.F. Baker
John Baldwin
David Bingham
Vernon Bump
Virgil E. Burgat
Robert G. Charboneau
Hugh Chase
Jim Coffin
Dick Cross
Jeff Dean
A.C. Dodson
John Duffy
Walter F. Fredricksen
Brandy Gilmore
Russell Glass
Robert Goddard
Joseph Gutierrez
Mike Hager
Rich Humphries
Peter Ingraham
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David L. Royster
Bill Sherman
Willard L. Sitz
Mitchell Smith
Jim Stroud
Steve Sweeney
Sam Thornton
Berke Thompson
Mike Vierling
Burrell Whitlow
W.A. "Bill" Wisner
Earl Wright
Ed J. Zeigler

Medallion Award

The Medallion Award was instituted in 1969 to recognize individuals who have made significant contributions to the Highway Geology Symposium over many years. The award is a 3.5” medallion mounted on a walnut shield and appropriately inscribed. The Medallion Award is presented during the banquet at the annual symposium.

Medallion Award recipient	Year		Medallion Award recipient	Year
Hugh Chase	1970		Russell Glass	1998
Tom Parrott	1970		Harry Ludowise	2000
Paul Price	1970		Bob Henthorne	2004
K. B. Woods	1970		Michael Hagar	2005
R. J. Edmonson	1972		Joseph A. Fischer	2007
C. S. Mullin	1974		Ken Ashton	2008
A. C. Dodson	1975		David Martin	2008
Burrell Whitlow	1978		Richard Cross	2009
Bill Sherman	1980		Mike Vierling	2009
Virgil Burgat	1981		John Szturo	2009
Henry Mathis	1982		Jeff Dean	2012
David Royster	1982		Chris Ruppen	2012
Terry West	1983		Eric Rorem	2014
Dave Bingham	1984		John Pilipchuk	2015
Vernon Bump	1986		Pete Ingraham	2016
C. W. “Bill” Lovell	1989		Richard Lane	2017
Joseph A. Gutierrez	1990		Steve Sweeney	2018
Willard McCasland	1990		John Duffy	2018
W. A. “Bill” Wisner	1991		Krystle Pelham	2018
David Mitchell	1993		Vanessa Bateman	2019
Harry Moore	1996		Marc Fish	2023
Earl Wright	1997		Victoria Porto	2025

Young Author Award

The Highway Geology Symposium has always encouraged participation of young professionals knowing that they are the future of the organization. To recognize and promote participation of young professionals, an annual National Young Author Competition was established in 2014. To qualify, participants may be up to 35 years old or younger, must be the principal author, and the sole presenter of the paper at the Symposium. Papers are reviewed and judged based on technical presentation of the paper (including geology), Originality of the Work, Applicability of the Work to Others and Paper Layout. One recipient is selected each year to receive the coveted Young Author Award, consisting of a plaque and cash prize to be presented at the annual Symposium banquet.

Young Author Award winners:

2014 - **Simon Boone**, “Performance of Flexible Debris Flow Barriers in a Narrow Canyon”

2015 - **Cory Rinehart**, “High Quality H20: Utilizing Horizontal Drains for Landslide Stabilization”

2016 - **Todd Hansen**, “Geologic Exploration for Ground Classification: Widening of the I-70 Veterans Memorial Tunnels”

2017 - **James Arthurs**, “Construction of Transportation Infrastructure in Weathered Volcanic Ash Soils”

2018 - **Brian Felber**, “Geotechnical Challenges for Bridge Foundations & Roadway Embankment Design in Peats and Deep Glacial Lake Deposits”

2019 - **Anya Brose**, “The Assessment and Remediation of Wabasha St. Rock Fall”

2022 - **Christopher Mayer** “Using Geophysics to Evaluate the Results of a Grouting Program in Karstic Geology

2023 - **Cody Chaussee**, “Bolt Creek Fire: Post-Wildfire Debris Flow Risk Assessment and Barrier Design on US 2, Near Grotto, WA

2024 - **Katelyn Card**, “Post Wildfire Effects on Geotechnical Assets”.

2025- **Christina Comuso**, “Rockfall Mitigation and Slope Stability Solutions for Interstate 78 in Bethlehem, New Jersey”

75th Highway Geology Symposium Field Trip

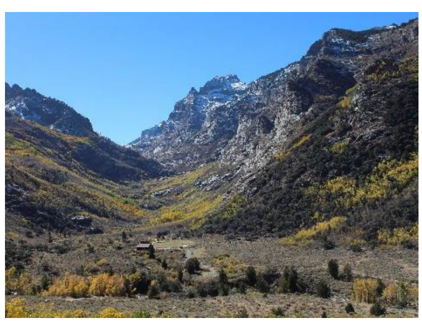
October 1, 2026

Departing the Whitney Peak Hotel at the Reno Arch at 7:30 AM, and returning at 6:00 PM, The 75th HGS Field Trip will be an all-day extravaganza covering globally notable interactions between key highways and both the urban and rural geological environments. In HGS tradition, the buses will be fully provisioned thanks to generous sponsors, and we will enjoy a lunch at an exclusive country club. Among the features we will view, with history and descriptions by local experts:

- An Interstate viaduct over an operating casino
- A fuel tank farm in active cleanup
- A gravel pit filled by a flood 30 years ago that is now a public beach and marina
- An urban basin with soft sediments amplifying and extending earthquake shaking
- The world's longest concrete cathedral arch bridge span
- A huge landslide that ripped across a highway in 1983
- The western margin of the expanding Basin and Range
- The interplay between Pluvial lakes and <1 Ma volcanics
- An inverted water-supply siphon built in 1873 with a drop of 1,870 ft
- Granite bodies on the footwall and on the hanging wall of normal faults
- One of the world's top 10 most spectacular earthquake fault scarps
- North America's largest, 2nd deepest, and most blue alpine lake, Tahoe
- Sources and deposits of titanic Pluvial jökulhlaups
- A lakeside bike trail constructed with zero sediment input to the lake
- An alluvial fan cut by dozens of fault traces
- An Interstate bridge built directly over a 100 MW geothermal field

Photographer: Kyle House

Photographer: Josiah Hassler



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The 2026 Highway Geology Symposium extends a huge "Thank You" to the sponsors for their contributions.
The Symposium wouldn't be possible without their generous support!

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Field Trip Lunch- Thursday

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GeoStabilization International
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www.geostabilization.com

Wednesday Banquet and Awards

GeoStabilization International is a geohazard mitigation firm operating throughout the USA and Canada. We specialize in emergency landslide repairs, rockfall mitigation, and grouting using design/build and design/build/warranty contracting.

Maccaferri, Inc.
Mike Koutsourais
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Phone: 301-641-8072
www.maccaferri.com/us

Field Trip Transportation - Thursday

Established in 1879, Maccaferri operates in more than 130 companies worldwide and has become a global technical reference in the research, design and implementation of innovative solutions within civil, geotechnical and environmental engineering. The company operates within numerous market sectors including infrastructure, mining, river control and environmental protection. In addition to geohazard mitigations, solutions offered to these markets include soil reinforcement, hydraulic works, ground stabilization, retaining structures and erosion protection. Maccaferri does not simply supply products but works in partnership with clients, offering technical expertise to deliver versatile, cost-effective and environmentally friendly solutions.

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Ameritech Slope Constructors

Field Trip Snacks -Thursday

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BGC Engineering is a globally recognized consulting firm specializing in geotechnical, environmental, and applied earth sciences. Established in 1990, BGC delivers innovative and sustainable solutions for complex engineering and environmental challenges worldwide. Our dedicated team of over 900 professionals—engineers, geoscientists, technicians, software professionals and corporate support staff—provides comprehensive investigation, design, and construction review services across more than 20 offices in North and South America, Australia, Europe, and the Caribbean. We combine technical excellence with a deep understanding of our clients' needs to provide tailored solutions across various industries including mining, pipelines, transportation, energy, and community sectors. BGC operates as one team with a focus on connection between our people, sectors, disciplines, and offices across the globe to provide clients with innovative, common-sense solutions partnered with exceptional service.

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BoreDM is the modern geotechnical and geoenvironmental data management platform. Manage borehole logs, lab data, and subsurface reports.

DOWL

Tuesday AM Break

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DOWL is a multidisciplinary consulting firm with more than 60 years of experience delivering civil engineering and related services throughout the western United States. With offices in Alaska, Arizona, Montana, Nevada, Oregon, Washington, and Wyoming, DOWL provides comprehensive in-house expertise in public involvement, planning and permitting, geoscience, environmental services, civil and structural engineering, landscape architecture, surveying, hydrology, GIS, transportation and airfield engineering, construction administration, and inspection services. A cornerstone of DOWL's capabilities is its geotechnical and geoscience expertise, supported by a dedicated team of geotechnical professionals and technical staff. DOWL's geotechnical engineers and geologists deliver a thorough understanding of subsurface conditions, including geohazards, soil, rock, and groundwater, providing the foundation for safe, reliable, and cost-effective project delivery. Their experience spans a wide range of infrastructure projects, including roads, bridges, utilities, dams, rockfall mitigation, and construction inspection services in both remote and urban environments. Backed by advanced training, local knowledge, strong client relationships, and proven project delivery experience, DOWL provides high-quality geotechnical evaluations, materials testing, and engineering solutions that help clients successfully address complex project challenges.

Fragmentation Efficiency Services, Inc. /KESCO, Inc.

Wednesday PM Break

Daniel Conn
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Phone: 724-548-2811
www.fesconsult.com

Designing precise, innovative, and safe explosive engineering solutions that address complex geological environments.

GFT

Tuesday PM Break

Amy Meadows
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Phone: 717-886-5367
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Hager-Richter Geoscience, Inc.

Wednesday AM Break

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Geophysics for the Engineering Community

HAGER-RICHTER GEOSCIENCE, INC. (HRGS) is an established small business that specializes in surface and borehole geophysics services for engineering and environmental applications. The firm has been in business since 1984, has grown to be one of the largest full service geophysical specialty firms in the eastern United States, and has earned a national reputation for quality geophysical services. HRGS has fully staffed and equipped offices in Derry, New Hampshire and Fords, New Jersey, and satellite offices in Nashville, Tennessee and Ashland, Oregon allowing rapid response to projects anywhere in the United States.

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Founded in 1978, Lumos & Associates is a multidisciplinary engineering and consulting firm headquartered in Reno, Nevada. They provide comprehensive civil and structural engineering, surveying and mapping, geotechnical services, and construction management to communities across the Western United States.

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Field Trip Beverages - Thursday

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The Delve Underground Geohazards Group includes a team of highly skilled engineering geologists and geotechnical engineers that specialize in the characterization and mitigation of a wide variety or geological hazards. Our teams of geoprofessionals are well versed in evaluating complex hazards impacting civil facilities including highways, pipelines, hydropower facilities, dams, and civil structures.

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Highway Geology Symposium 2026, Mini-Sessions

Reno, NV - September 28

Location: Auditorium, Earthquake Engineering Laboratory, University of Nevada, Reno. Transportation is provided to and from the hotel before, between, and after sessions. Continental breakfast and breakout coffee service will be provided, generously sponsored by Terēan.

Program	Time
Transportation from the hotel	9:30 am
Continental breakfast	9:45 am
Session 1 — Terēan Shear-Wave Surveying	10:00 – 11:30 am
Lunch (not provided)	11:30 am – 1:00 pm
Transportation from the hotel	12:30 pm
Session 2 — Slope Stabilization Based on Soil-Pile Interaction	1:00 – 2:30 pm
Transportation from the hotel	2:30 pm
Break	2:30 – 3:00 pm
Session 3 — Advancing Infrastructure Resilience Through Research and Testing	3:00 – 4:30 pm
Transportation to the hotel	4:45 pm

Session 1: Terēan Shear-Wave Surveying

Prof. John Louie & Alison Starr • 40 min classroom demo + 45 min outdoor demo

Terēan® ReMi solutions help engineers and geologists measure ASCE 7-22 Site Class, find depth to bedrock, map liquefaction potential, image faults, and locate voids. Terēan's Chief Scientist and Lead Geophysicist will demonstrate VsSurf ReMi® software with client case histories, then move outdoors for a live ēDAQ™ data-acquisition demo determining site class in under 30 minutes.

Session 2: Slope Stabilization Based on Soil-Pile Interaction

Prof. Mohamed Ashour • 45 min seminar + 45 min software demo

An examination of driven piles as a technique for stabilizing active slopes and embankments, covering shallow and deep failure surfaces and the transition between plastic-flow and intermediate soil-pile interaction modes. A hands-on demonstration of Dr. Ashour's design software (developed for WVDOT and ALDOT) follows the seminar; trial copies will be available.

Session 3: Advancing Infrastructure Resilience Through Research and Testing

Prof. Sherif Elfass • 45 min classroom presentation + 45 min facility tour

A look at UNR's earthquake engineering program, from evolving shake-table capabilities to landmark tests on straw bale wall systems, multi-span steel girder bridges, nonstructural systems, accelerated bridge construction, and rocking-column bridges. The session also covers the nation's largest laminar soil box, used to study soil-structure interaction, liquefaction, and lateral spreading under seismic loading.

75th Highway Geology Symposium

September 28 – October 1, 2026

Reno, Nevada

TECHNICAL SESSION SCHEDULE

Tuesday, September 29			
	8:00-8:10	**Welcome, Opening Remarks & Announcements**	
	8:10 - 8:30	**Tracey Larkin Thomason, Director of Nevada DOT**	
	8:30 - 9:30	**Why Nevada Geology is So Exciting** - *Jonathan Price, Nevada State Geologist Emeritus*	
	9:30-10:00	**BREAK**	
		Technical Session 1	Page
1	10:00-10:20 Young Author	**Distributed Monitoring of Rock Slope Performance in Colorado Using Time- Lapse Photography and Vision-Language Models** - *Luke Weidner, BGC Engineering*	39
2	10:20-10:40 Young Author	**Uphill Without a Drill – HVSR as a flexible seismic method for inaccessible sites** - *Mishak Boshoff, Hager-Richter Geoscience*	40
3	10:40-11:00 Young Author	**Mapping What We Can't Touch: LiDAR-Driven Rock Structure Modeling for Safer Highways** - *Will Brandenberger, HDR Engineering, Inc.*	41
4	11:00-11:20 Young Author	**Enhanced Monitoring of High-Risk Unstable Slopes Using Remote Sensing and AI-Assisted Change Detection** - *Katelyn Card, WSDOT*	42
5	11:20-11:40 Young Author	**Bridge or Blast? Sub-title: A Look Into US19W South/ Little Creek Road Design For Repair After Hurricane Helene Damages Under Progressive Design-Build Project Delivery Method** - *Callan Swafford, HDR Engineering, Inc. of the Carolinas*	43
6	11:40-12:00 Young Author	**Integrating UAS Remote Sensing and In-Situ Instrumentation for Landslide Hazard Monitoring to Support Highway Infrastructure Resilience** - *Ashley Butterworth, Idaho State University and BGC Engineering Inc; Donna Delparte, James Mahar, Matthew Belt, Betty Brown, Idaho State University; Shawn Enright, Idaho Transportation Department*	44
	12:00-1:00	**LUNCH**	

Technical Session 2			
7	1:00-1:20 Young Author	**Design Considerations for Attenuators and Hybrid Barriers** - *Lucas Martins, Mike Koutsourais & Leticia Genelhu, Maccaferri, Inc*	45
8	1:20-1:40	**Glaciolacustrine Deposits On The SR 3002 Landslide Remediation Project** -*Jason M. Gardner, GFT*	46
9	1:40-2:00	**Emergency Landslide Response and Integrated Field-Design Approaches: US-95 MP 146.5, Idaho** - *Brittany Dayley & Malcolm Perkins, Delve Underground*	47
10	2:00-2:20	**Hidden Elements: A Context Sensitive Application of Rock Anchors for Slope Stabilizaation** - *Brian Collins, Seamus Millett, Cole Christiansen, Scott Anderson, BGC Engineering; Nicholas Farny, Western Federal Lands Highway Division*	48
2:20-2:50		**BREAK**	
Technical Session 3			
11	2:50-3:10	**The Advantages of Hybrid Barriers Over Attenuators** - *Takeshi Arita & Kiyoshi Takmori, Tokyo Rope*	49
12	3:10-3:30	**Take 2 - Rock Fall Mitigation System Replacement At Fairlee, Vermont** - *Jay R. Smerekanicz & David J. Scarpato, Scarptec, Inc; Ethan J. Thomas & Christopher W. Case , Vermont Agency of Transportation*	50
13	3:30-3:50	**Dynamic Performance Monitoring of a Rockfall Attenuator System** - *Darren Beckstrand, Rachel Hunt & Evan Beyer, Landslide Technology*	51
14	3:50-4:10	**Rockfall Wall Catchment Systems in Colorado** - *Ben Arndt, RJ Engineering and Consulting, Inc*	52

Wednesday, September 30			
Concurrent Technical Session 4A			
15	8:00-8:20	**Recent Advances in Rockfall Mitigation Technologies in Japan** - *Yoichi Nishita & Hiroshi Masuya, PROTEC ENGINEERING Co., Ltd.*	53
16	8:20-8:40	**Floyd Hill West Cut: Navigating the Investigation, Design, and Construction of a Major Rock Cut along I-70** - *Todd Schlittenhart & Melissa Boyd, Yeh and Associates, Inc.*	54
17	8:40-9:00	**From Risk Inventory To Real World Failure: Hurricane Helene Validation Of USMP Geohazard Prioritization** - *Jason A. Holland, Schnabel Engineering*	55
18	9:00-9:20	**Comprehensive Load Test Program for Steel H-Piles Driven in Intermediate Geomaterials** - Nafis Masud, Schnabel Engineering; *Kam Ng & Shaun Wulff, University of Wyoming*	56
19	9:20-9:40	**Evaluation of Drag Load and Downdrag on Axially Loaded Piles** - *Mohamed Ashour, Alabama A&M University & Aser Abbas, University of Rhode Island*	57
20	9:40-10:00	**NCDOT Measurement While Drilling (MWD) Implementation and Testing Program** - *Nick Moore, North Carolina DOT*	58

Concurrent Technical Session 4B			
21	8:00-8:20	**Advancing Geotechnical Site Characterization With 3D SPT-Seismic Testing** - *Khiem T. Tran & Bingkun Yang, University of Florida*	59
22	8:20-8:40	**Integrated Geotechnical and Geophysical Interpretation of Sterling Highway Milepost 45 to 60 Project** - *Keri Nutter & David Barrick, DOWL*	60
23	8:40-9:00	**The Chilkat Connector Feasibility Study in Southeast Alaska** - *Rachel Hunt, Paige Stuhlmuller & Benjamin A. George, Cornforth Consultants Inc. - Landslide Technology*	61
24	9:00-9:20	**Improving Williamsport Road – Overcoming Geological and Geographical Challenges in Remote Alaska** - *Kyle Brennan & Katarah Glashan, Shannon & Wilson, Inc.*	62
25	9:20-9:40	**The Famous "Billings Rims" and the Stagecoach Trail – Integrating 3D Geologic Modeling, Limit Equilibrium Slope Stability, and Discrete Element Rockfall Analyses** - *David Crotsley & Bret Watkins, HDR Engineering, Inc.*	63
26	9:40-10:00	**Groundwater Withdrawal and Potential Land Subsidence Risk at USA Parkway, Nevada** - *Erielle Cushing, Broadbent & Associates, Inc.*	64
10:00 - 10:30		**BREAK**	
Concurrent Technical Session 5A			
27	10:30-10:50	**Photomonitoring for Transportation Infrastructure in Geohazard Environments: Operational and Economic Advantages for Asset Owners** - *Tony Simmonds, Re-Monitor Inc.; Michele Gaeta, Marco Fiorio & Paolo Mazzanti, Nhazca Srl*	65
28	10:50-11:10	**ReMi® Seismic Surveys for Non-Intrusive ASCE 7-22 Compliant Site Class, Rippability, Fault Location, and Design** - *John Louie, Alison Starr & Bill Honjas, Terēan*	66
29	11:10-11:30	**Combined Geotechnical and Geophysical Data Collection for Pile Design at the Ankau Bridge in Yakutat, Alaska** - *Chloe Bjerklie & Matt Blakeslee, DOWL*	67
30	11:30-11:50	**Monitoring While Drilling Glacial Deposits** - *Bruma Souza, Weston & Sampson; Jean Benoît, University of New Hampshire*	68

Concurrent Technical Session 5B			
31	10:30-10:50	**Risk-Based Blasting Specifications for Highway Rock Excavation: Mitigating Project Risk Through Proper Specification Development** - *Anthony Konya & Juliette Oke, DetX*	69
32	10:50-11:10	**Developing a Database of Rockfall-Vehicle Impacts to Evaluate Human Vulnerability Along Transportation Routes** - *Autumn L Helfrich & Brian D. Collins,U.S. Geological Survey, Landslide Hazards Program*	70
33	11:10-11:30	**The Interrelationships of the Characteristic and Dilatant Friction Angles and Tangent Poisson's Ratio** - *Gary Norris, University of Nevada Reno*	71
34	11:30-11:50	**Developing the Triaxial Test Responses of Soil from Available Correlations and a Nonlinear Exponential Equation** - *Sherif Elfass & Gary Norris, University of Nevada, Reno; Horng-Jyh Yang (Tigra), Geo-Environmental Branch Naval Facilities Engineering Systems Command (Mid-Atlantic)*	72
11:50 - 1:00		**LUNCH**	
Technical Session 6			
35	1:00-1:20	**I-80 Mine Subsidence: Geologic Characterization and Emergency Stabilization, Wharton, New Jersey** - *Christina M. Comuso, New Jersey DOT; Matthew D. Riegel & Brian T. Felber, HNTB*	73
36	1:20-1:40	**Overview of Landslide Management Programs for Linear Pipeline Infrastructure Corridors** - *Chris Markley & Bailey Theriault, Geosyntec Consultants*	74
37	1:40-2:00	**Two Dimensional Seismic Site Response Analysis for a New Bridge in a Subduction Zone Environment** -*Zia Zafir, Kleinfelder*	75
38	2:00-2:20	**LiDAR-Based Delineation of Alluvial and High-Angle Fan Landforms for Hazard Recognition, Land Use Planning, and Transportation Corridor Resilience**-*Jonathan R. Lovekin & Amy Crandall, Co. Geological Survey*	76
2:20-2:50		**BREAK**	
Technical Session 7			
39	2:50-3:10	**A Framework for Corrosion and Asset Prioritization in Reinforced Soil Systems** *Nelson Pearson, University of Nevada, Reno*	77
40	3:10-3:30	**Applications of the Smart Rock Technology to Evaluate Rockfall Hazards** - *Bruma Souza, Weston & Sampson; Jean Benoît, University of New Hampshire; Marion Bost, Cerema*	78
	3:30-4:00	**Field Trip Preview**	

Why Nevada Geology is So Exciting

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ABSTRACT

The excitement of Nevada geology arises from a combination of the rocks and resources in them, geological hazards, environmental issues, and the geos* who live and work here. Nevada leads the country in the production of gold, barite, and lithium; is a leader in silver; and has abundant geothermal resources for producing electricity and heating buildings. Hazards include floods, landslides, avalanches, swelling clays, earthquakes, and volcanoes. Environmental issues include subsidence due to groundwater withdrawal, radon (mostly associated with granites and rhyolites), arsenic (in volcanic rocks and with gold, silver, and copper deposits), mercury (found alone and with gold and silver), endangered species (found near some mineral deposits), social concerns (encountered nearly everywhere), including those of Indigenous people, drought, concerns about CO_2 and the siting of solar- and wind-energy facilities, and disposal of nuclear waste. Geos have many opportunities to gather at meetings of the Geological Society of Nevada, Nevada Petroleum & Geothermal Society, Nevada Water Resources Association, and local chapters of the Association of Environmental & Engineering Geologists and Society for Mining, Metallurgy & Exploration, and American Institute of Professional Geologists. For the general public, the Nevada Bureau of Mines and Geology writes books and leads field trips on local geology (during Earth Science Week, the second full week in October).

*Geos is a term that includes all sorts of geologists and related folks: engineering geologists, economic geologists, geological engineers, geotechnical engineers, geotechnicians, geochemists, geophysicists, geostatisticians, geoarchaeologists, hydrogeologists, hydrologists, paleontologists, geobiologists, geodesists, and the geologically interested public.

1. Distributed Monitoring of Rock Slope Performance in Colorado Using Time-Lapse Photography and Vision-Language Models

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ABSTRACT

The proper design and maintenance of rock slopes is essential to ensure the safety of road users, but performance information for existing rock slopes is often lacking. Distributed rock slope monitoring using time-lapse single-camera photography has the potential to provide valuable information for a fraction of the cost of lidar or photogrammetry. This study presents a framework for low-cost automated rock slope monitoring using time-lapse photography and computer vision-based image analysis. Camera system hardware is assembled from off-the-shelf components (total cost approximately $370 USD per unit). The hardware is freestanding, solar-powered, and can be installed in a few minutes.

A change detection workflow is developed using a combination of alignment, structural similarity, image differencing, and deep-learning-based interpretation. We experimented with two vision-language models (GPT-5 and Qwen3) for automated rockfall identification. The models are prompted with sets of images and change masks to provide general descriptions of the changes and classify whether new rockfall is visible in the ditch.

The overall workflow is demonstrated on three rock slope sites along highways in Colorado. Results show that the image change detection successfully resolved rockfall events as small as approximately 30-40 pixels in diameter, although the vision-language models did not reliably interpret rockfalls at this scale and sometimes mischaracterized the cause of larger changes. While further work is needed to improve the reliability of automated image interpretation using VLMs, the overall framework shows promise as a low-cost method for distributed rock slope monitoring.

2. Uphill Without a Drill – HVSR as a flexible seismic method for inaccessible sites

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ABSTRACT

Highway geo-engineering investigations can occur in steep terrain and cramped urban environments. Bedrock information is often required at locations inaccessible to drill rigs. Where drilling is not feasible, geophysics can fill the data gaps. Seismic refraction, considered to be the industry standard geophysical method for determining depth and configuration of bedrock, is also subject to access limitations, as well as seismic noise constraints. Without reliable bedrock data, engineers may be forced to make decisions without critical subsurface information.

Horizontal to vertical spectral ratio (HVSR or H/V) is a seismic method which can be used to estimate bedrock depth at locations not suitable for seismic refraction or drilling. HVSR uses an ultra-portable seismograph to record ambient seismic noise. A mathematical relationship between the HVSR peak resonance frequency and bedrock depth is established for the site using measurements at locations with known bedrock depths. That relationship is then used to determine rock depths at other locations across the site. HVSR records can be acquired singly or along transects to develop bedrock profiles and/or contour plots.

Borehole data improves the precision of HVSR results, though the method still provides actionable depth estimates and clear topographic trends when boring data is scarce or absent. Bedrock depth information, based on HVSR data, facilitates geo-engineering decisions where there are gaps in critical subsurface information. In this paper we discuss three projects in which HVSR was used as the primary method or in concert with other geophysical methods to gather bedrock information.

At the first site we predicted bedrock depth in an approximately 1050-foot by 120-foot area of interest, at 42 individual stations. HVSR data were calibrated using 6 boreholes, and models of bedrock depth were generated on a station-by-station basis. Bedrock depth ranged from 90 to 120 feet with an estimated error of 6.1% ($n = 4$, $SD = 8.5\%$).

At the second site we used a subset 31 of 56 stations positioned on boreholes to generate a linear regression model ($p = 2.2 \times 10^{-16}$, $R^2 = 0.91$, $SE = 3.63$ft) describing the relationship between bedrock depth and HVSR peak frequency. Using the regression model, we predicted bedrock depth for a subset of 52 of 301 HVSR stations at the 95% Prediction Interval and Confidence Interval levels. Bedrock depth ranged from 48 to 70 feet.

At the third site we performed a reconnaissance survey of bedrock depth and topography using transects of HVSR stations spaced approximately 70 feet apart over five transects for a total of 11,000 feet, as well as nine passive shear wave velocity transects for calibration of the HVSR data. Bedrock depth and topography were visually represented in synthetic contour plots. Bedrock depth ranged from 20 to 300 feet and errors in estimates of bedrock depth were estimated at 10% - 20%.

3. Mapping What We Can't Touch: LiDAR-Driven Rock Structure Modelling for Safer Highways

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ABSTRACT

High-resolution terrestrial and unmanned-aerial LiDAR was used on three infrastructure projects to collect supplemental rock discontinuity data where direct measurement was limited by traffic exposure, height, tunnel geometry, or rope-access constraints. This paper evaluates LiDAR-based discontinuity mapping as a supplemental field data collection method by comparing LiDAR-derived orientations and mapped structural sets with conventional hand mapping, rope-access scanline mapping, tunnel observations, and other geologic data. The case histories include the Elephant Butte Tunnel in California, the Stagecoach Trail highwalls in Montana, and the left abutment of the LaPrele Dam Replacement Project in Wyoming. The evaluation indicates that LiDAR can increase mapped coverage and reduce direct exposure to difficult or hazardous terrain; however, LiDAR measures exposed surfaces only and can be affected by line-of-sight geometry, occlusion, vegetation, resolution, weathering, and surface conditions. The LiDAR datasets were primarily used to evaluate discontinuity orientation and structural-set classification. Where sufficient exposed surface was available, mapped plane size, trace length, and apparent spacing provided additional context, but these values were reviewed as exposed-surface measurements rather than direct measurements of subsurface persistence. Reviewed datasets were used for stereonet comparison and, where supported by other observations, can inform structural surfaces in three-dimensional geologic models. The results support a combined workflow in which LiDAR is used to improve spatial coverage, field mapping is used to check geologic meaning, and three-dimensional models are used only where the structural interpretation is supported by sufficient observations.

4. Enhanced Monitoring of High-Risk Unstable Slopes Using Remote Sensing and AI-Assisted Change Detection

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ABSTRACT

Transportation agencies across mountainous regions face a growing challenge: many high- risk unstable slopes threaten highways, yet the cost to fully mitigate these hazards can exceed available funding by tens of millions of dollars. In Washington State, mitigation of several high- risk slopes and repair of damaged geotechnical assets is estimated to exceed $100 million, making immediate stabilization impractical for many sites. As a result, transportation agencies increasingly rely on enhanced monitoring programs to manage risk and detect early signs of slope instability.

To address this challenge, the Washington State Department of Transportation (WSDOT) State Geotechnical Office has initiated an expanded monitoring program focused on high-risk slopes identified through the agency's Geotechnical Asset Management Plan (GAMP). These slopes were prioritized using likelihood and consequence factors including rockfall frequency, roadway exposure, traffic volumes, and maintenance records. The monitoring program integrates remote sensing techniques including terrestrial lidar scanning, unmanned aerial systems (UAS), fixed camera monitoring, and satellite observations to collect high-resolution point clouds and imagery of slope conditions.

A key objective of this effort is evaluating automated and AI-assisted change detection techniques to process large monitoring datasets. Algorithms compare repeat lidar scans, analyze pixel-level changes in imagery, and identify potential movement or rockfall source areas indicating developing instability.

This paper presents the framework for WSDOT's enhanced monitoring program and applications of remote sensing and change detection techniques. The work explores how automated analysis can improve interpretation of monitoring data, support earlier hazard detection, and guide mitigation strategies where full stabilization is not immediately feasible.

5. Bridge or Blast?

Sub-title: A Look Into US19W South/ Little Creek Road Design For Repair After Hurricane Helene Damages Under Progressive Design-Build Project Delivery Method

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ABSTRACT

HDR Engineering, Inc. of the Carolinas (HDR) is working with Branch Civil, Inc., for NCDOT, on approximately 12 miles of roadway along US19W in Yancey County, North Carolina. The overall scope of this project is to evaluate, design, and reconstruct the US19W roadway and associated infrastructure along the alignment that was damaged during Hurricane Helene under a progressive design build (PDB) project delivery method. Little Creek Road (LCR), a 0.4-mile, secondary road off US19W, was destroyed during Helene when the Cane River scoured away the existing embankment. The road has remained closed since the storm, and the public crosses over Cane River on a temporary railcar bridge. The original design option, Option 1, was to construct a new bridge over Cane River and permanently close LCR. Due to borrow source demands across the region, obtaining sufficient material for project-wide repairs within reasonable hauling distances also became a concern. To address this concern, while still providing permanent road solutions, Design Option 2A was introduced. Design Option 2A included cutting into the hillside to produce sufficient volume of borrow material and rebuilding LCR. A phased investigation approach to support the geotechnical feasibility analysis of Option 2A was utilized. The Geotechnical investigation included eighteen borings with wireline coring, geologic mapping of readily accessible outcrops and road cuts, as well as seismic refraction surveys at the top of the ridge. Data along the existing slope face was limited due to project schedule and site accessibility. Analyses included kinematics, rockfall modeling of various rock cut scenarios, and global slope stability. Preliminary findings support that sufficient borrow, in terms of both quantity and quality, can be obtained by cutting into the slope. However, due to constructability, schedule, and rock production risk concerns, Design Option 2A has been replaced by Design Option 2B. Design Option 2B includes embankment rebuilding of LCR using engineered stabilization measures. Geotechnical recommendations are ongoing for Option 2B, and close coordination with NCDOT and the Contractor has been critical for design progression.

6. Integrating UAS Remote Sensing and In-Situ Instrumentation for Landslide Hazard Monitoring to Support Highway Infrastructure Resilience

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ABSTRACT

Highways, especially those constructed along steep terrain, are susceptible to landslide impacts, including public safety risks and economic disruptions. Early detection of potential landslides is essential for informed decision-making in highway infrastructure planning. Traditional landslide monitoring through in-situ instrumentation provides precise subsurface measurements but is spatially limited and resource-intensive. The Idaho Transportation Department, in partnership with Idaho State University, Department of Geosciences, is developing cost-effective monitoring strategies that improve spatial coverage while maintaining reliable displacement measurements. Unmanned Aerial System (UAS) surveys are a cost-effective approach to landslide hazard monitoring along transportation networks, offering repeatable high-resolution terrain models that can facilitate early detection of mass movements. This study utilized repeat UAS LiDAR and photogrammetry surveys to perform change detection along landslide-susceptible state highway US-26, which were synthesized with inclinometer measurements and bore logs to produce a comprehensive slope stability assessment. Surface displacement was quantified using the Cloud-to-Cloud Comparison (C2C) change detection method. Pairing UAS-derived products with inclinometer measurements provided a validation framework for linking surface change to subsurface movement. Bore logs further identified lithologic controls and potential slip surfaces. Repeat UAS monitoring successfully identified an unstable slope threatening a state highway, demonstrating the capability of UAS-based surveys in assessing landslide hazards along Idaho Transportation Department highway assets and reinforcing the need for continuous monitoring.

7. Design Considerations for Attenuators and Hybrid Barriers

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ABSTRACT

The capabilities of traditional rockfall barrier systems are measured according to the magnitude of their tested impact energies, and the testing and design of these systems are well established. However, as attenuators and hybrid barriers have become increasingly used in North America, their application and design are often not well understood, and no standard test and design method are available. Therefore, misapplication and a general misunderstanding of the system itself and its purpose are often the result. From terminology to design principles and system application, there is a basic need to dissect these systems and understand their purpose and limitations and how to design the various components of the system.

This paper will first discuss how to identify the application and purpose of the system based on site-specific conditions. A further discussion will be provided to explain how the various components of each system are affected by the forces acting on those components and how to design for them.

8. GLACIOLACUSTRINE DEPOSITS ON THE SR 3002 LANDSLIDE REMEDIATION PROJECT

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ABSTRACT

In mid-August 2018, a 2-day storm system dumped approximately 6-8 inches of rain on the northern tier of Pennsylvania that resulted in extreme flooding in the Region. The flooding caused erosion of roadway slopes resulting in many landslides that affected roadways owned and maintained by PennDOT, District 3-0. Two distinct landslides were identified within a ½ mile stretch of the SR 3002 roadway in southern Bradford County. The slope movement required the SR 3002 roadway to be closed to traffic in this area; however, one lane remained in service to allow local residents access to their homes.

An initial subsurface exploration program was performed in Fall 2018 at each of the 2 slide locations, and unusually thick glaciolacustrine deposits were encountered. In addition, laboratory testing was performed on representative glaciolacustrine samples to estimate the engineering properties of these soils, and the results indicated the glaciolacustrine soils exhibited extremely low peak and residual shear strength. During a site visit in June 2019, two additional landslides were observed between the original 2 landslide locations. The initial preferred remediation alternative was to realign the SR 3002 roadway to avoid the glaciolacustrine deposits and minimize risk of future landslide activity negatively impacting the SR 3002 roadway. An additional subsurface exploration program was performed for the proposed realignment and these borings also encountered thick glaciolacustrine deposits that were expected to be problematic. Based on the additional subsurface information, the preferred remediation alternative was to stay on the existing SR 3002 alignment and stabilize the 4 landslides using tangent pile walls.

9. Emergency Landslide Response and Integrated Field-Design Approaches: US- 95 MP 146.5, Idaho

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ABSTRACT

US-95 is the sole north-south corridor serving many communities in northern Idaho. In March 2025, a landslide occurred at US-95 MP 146.5 along the western slopes of the Weiser River, between the residential communities of Pine Ridge and Tamarack, Idaho, approximately 19 miles (31 km) west of the tourism hub of McCall. A portion of the northbound lane collapsed during spring snowmelt, prompting a full roadway closure and implementation of lengthy detours, resulting in significant regional economic impacts and potential constraints on emergency response.

An exploration program was initiated within approximately 48 hours of the failure and included geotechnical borings, drone reconnaissance, and detailed geologic mapping. The rapid response was enabled in part by proactive reconnaissance performed in October 2024 and by a drill crew that had already been mobilized for a previously scheduled investigation. Repair design began within one week and addressed challenges associated with an accelerated schedule, limited material availability, and steep, constrained terrain. The selected repair consisted of an anchored soldier pile retaining wall with drilled-shaft deadmen and extensive surface drainage improvements.

Construction encountered additional challenges, including large boulder obstructions, groundwater inflow, hole instability, and equipment limitations. Continuous field-based engineering geology support facilitated real-time communication with the design team regarding subsurface variability, modification to pile installation procedures, and development of alternative construction sequences. The roadway reopened to the public by April 30, 2025, 45 days after the initial failure was reported.

This case study highlights the value of flexible exploration strategies; parallel field- design coordination; and collaboration between the owner, designer, and contractor during all stages of the design and construction process in emergency highway response environments.

10. Hidden Elements: A Context Sensitive Application of Rock Anchors for Slope Stabilization

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ABSTRACT

Construction of a new bridge over the Pretty Rocks Landslide in Denali National Park required 67,000 cubic yards of excavation and a rock cut up to 160 feet tall to construct the approach to the west abutment. The rock mass and overburden were characterized through field geologic mapping of outcrops, drilling investigations with downhole televiewer logging of drill holes, laboratory testing, and geophysical surveys. Three-dimensional (3D) geologic modeling and kinematic analysis of the rock mass revealed potential rock slope failure mechanisms for the proposed cut slope orientations. The new cut is in a highly visited area along Denali Park Road that required a context-sensitive design solution to develop a natural appearance for the new cut slope. This limited possible methods of stabilization. Tensioned rock anchors, commonly known as rock bolts, were used to mitigate potential failures in the rock cut during each lift of the excavation. After the rock bolts were constructed and the grout reached design strengths, the protruding ends were cut flush with the rock surface and covered with grout matching the surrounding native rock. The rock cut was constructed without overruns in quantities or impacts to schedule and constructability, reducing geotechnical risks to the adjacent bridge and roadway. The findings demonstrate the effectiveness of a kinematic analysis and use of rock bolts as a context-sensitive solution for stabilizing new cut slopes.

11. The Advantages of Hybrid barriers over Attenuators

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ABSTRACT

In Japan, rockfall prevention measures in narrow areas that occur in steep and complex terrain are a serious challenge. Rockfall prevention measures are broadly classified as preventive measures (active method) and protective measures (passive method), with protective measures (passive method) further divided into protective fences and protective nettings. There are two types of protective nettings: attenuators, which are a construction method designed to attenuate rockfall energy within the protective netting. Hybrid barriers, on the other hand, are designed to reliably capture falling rocks, limit damage to protected objects, and safely guide them to the bottom of the protective netting.

It is generally known that protective nettings require a wide area to capture large rockfall energy (high energy).

In this study, a full-scale test was conducted using two hybrid barrier test barriers with a limited area, measuring 33 ft (10 m) in effective length and 30 ft (9 m), and 50 ft (15 m) in effective length and 30 ft (9 m) in effective height. The test test barrier was constructed by combining a buffer device with a high-strength wire netting that has high resistance to destruction. As a result, it was confirmed that both test barriers could capture a block impact energy of 1,400 kJ and 2,800 kJ, respectively, and safely guide the block simulating a falling rock to the bottom of the protective netting.

12. Take 2 – Rock Fall Mitigation System Replacement at Fairlee, Vermont

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ABSTRACT

The Palisades rock slope on Interstate 91 in Fairlee, Vermont was a highlight of the 2003 Highway Geology Symposium field trip, featuring a large, draped mesh rockfall mitigation project (197,000 ft2) constructed in 1996. The rock slope is composed of a relatively young and resistant quartz monzonite pluton (Devonian) that was later sheared by Acadian-aged thrust faulting, forming brittle structures prone to toppling failure, and is the tallest rock slope requiring mitigation in the Vermont Agency of Transportation's asset management system. Later continental glaciation "plucked" the leeward side of the pluton, forming a roche mountonnée having a very steep slope with heights approaching 400 feet above roadway grade. Long-term weathering includes joint infilling with soil/talus, ice riving, and a progressive increase in the size and frequency of rockfalls.

The draped mesh system performed well until 2020-2021, with occasional toppling angular rockfalls that tore holes in the aging mesh, but was no match for a large rockfall toppling event that occurred on February 27, 2024. The estimated 200 cubic yards of rockfall debris ripped the mesh open and spilled out onto the southbound lanes of the interstate, fortunately without injury or damage to the public.

Vermont, like much of the northeast, is experiencing more extreme weather events, such as more frequent freeze/thaw cycling that likely exacerbated conditions leading to the rock fall. As the drape system was nearing its 30th year in service and was no longer effectively preventing rockfall from reaching the roadway, the Vermont Agency of Transportation (VTrans) conducted a phased approach to mitigate the source area, address other potential risks, reopen the roadway and redesign mitigation for the entire slope. This consisted of an initial emergency mitigation phase to remove or secure additional immediate rockfall hazards in late winter/early spring 2024, followed by a temporary mitigation phase during the remainder of 2024 to address potential longer-term rockfall hazards.

The second phase bought more time for a third phase to develop and construct an effective, long- term rock slope mitigation design. This improved design utilized extensive scaling, rock dowels, shotcrete, drains, and both pinned and draped mesh, and was constructed in the latter half of 2025. This project highlights the challenges associated with an initial emergency response that evolved into a mitigation redesign project, constructed using fast-paced methods during highly variable New England weather conditions.

13. Dynamic Performance Monitoring of a Rockfall Attenuator System

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ABSTRACT

The Western Federal Lands Highway Division (WFLHD) commissioned an advanced dynamic instrumentation system to monitor two mid-slope rockfall attenuator systems along the Ketchum–Challis Highway corridor in central Idaho. These systems have experienced structural distress from heavy snow loads, rockfall, and avalanche impacts, resulting in bent posts, deformed base plates, broken wire ropes, and mesh panel failures. To quantify the loading mechanisms responsible and support future design optimization, WFLHD prioritized a high- resolution dynamic monitoring system capable of 20 Hz data acquisition.

Landslide Technology designed and installed the instrumentation system, equipping each attenuator's three to four posts with strandmeters on wire ropes, load cells on post anchors, and strain gauges near post bases to capture axial loads and bending strains under snow and avalanche loading. Campbell Scientific CR1000xe dataloggers and VWIRE 305 vibrating-wire analyzers enable capture of rapid load cycles from impact events. Each system is supported by 300 AmpHr of battery capacity and 800 W of solar input to sustain continuous high-frequency measurements.
Data transmits via 900 MHz radios to a base station within cellular coverage, then forwards to cloud-based platforms for near-real-time visualization of snow depth, wire rope loads, post strains, and site imagery. Threshold-exceedance rules trigger dynamic event recording in response to abrupt changes in measurements.

Landslide Technology completed installation in summer 2025, deploying a three-person SPRAT-qualified team with rope hauling systems to access the steep terrain. Monitoring is now underway, and the data collected will enable WFLHD to drive design improvements and develop more resilient rockfall and avalanche attenuation infrastructure.

14. Rockfall Wall Catchment Systems in Colorado

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ABSTRACT

For many rockfall prone sites next to roadway corridors, a typical rockfall fence or attenuator may not be practical or efficient for containing or mitigating rockfall. Additionally, rockfall fences and attenuators may require extensive repair or maintenance after repeated impacts.

In certain instances, rockfall wall containment systems have been used in Colorado where a higher impact energy system may be needed, or the roadway ditch width is limited (but wide enough to accommodate vertical faced systems). The intent is to have a more resilient rockfall system than may partially or fully restore the raveling slope to a stable angle over time and are slender enough to fit within the roadway width requirements.

This presentation illustrates multiple case histories of rockfall wall containment systems in Colorado. These systems function to absorb energy impacts, fit within the catchment shoulder of the roadway, and are designed to restore raveling rockfall prone slopes to more resilient stable angles.

15. Recent Advances in Rockfall Mitigation Technologies in Japan

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ABSTRACT

Rockfall hazards along mountainous roads have long posed significant risks to road users in Japan. Since the tragic Hida River bus accident in 1968, which was triggered by a sediment disaster, research and technological development in rockfall mitigation have progressed significantly. In addition, the collapse of a rock shed along the Echizen Coast in 1989 led to revisions in the design of approaches for rock slope failures and protective structures.

While rock sheds were historically the primary countermeasure, high-energy-absorption rockfall protection fences have increasingly been adopted because of their structural efficiency, constructability, and cost-effectiveness. Among these countermeasures, pile-supported vertical rockfall protection fences installed at the toe of slopes have become widely used in Japan, particularly in locations where installation space is limited, such as along roadways and behind residential areas.

This paper focuses on vertical rockfall protection fences installed at the toe of slopes. The study reviews the background behind their increasing adoption in Japan and examines their structural performance, including impact energy absorption capacity and deformation behavior during rockfall impact. Representative installation of case studies along highways and behind residential areas are also presented to demonstrate the effectiveness and practical applicability of these systems.

16. Floyd Hill West Cut: Navigating the Investigation, Design, and Construction of a Major Rock Cut along I-70

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ABSTRACT

The I-70 Floyd Hill project is a major expansion and realignment of an 8-mile stretch of the Interstate 70 Mountain Corridor in the foothills of the Colorado Rocky Mountains. Serving as the primary access for Coloradans and its visitors to visit the mountains, I-70 is the lifeline for commerce and tourism that support the mountain town economies. The goals of the Floyd Hill project are to improve travel time reliability, safety, and mobility by adding additional lanes, reducing steep grades, eliminating sharp curves, and addressing deficient infrastructure. The project is subdivided into three segments; East, Central, and West, to aid in the design and delivery of the overall project.

A large rock cut within the West Section of the project serves to widen and realign the highway by eliminating a tight curve, allowing increased design speeds through this segment. The rock cut, informally named the “West Cut” reaches a maximum cut height of approximately 210 feet and includes removal of over 350,000 cubic yards of highly metamorphosed gneiss. Investigation, design, and construction of the West Cut faces the challenges of working within a steep, narrow mountainous canyon, variable degrees of metamorphism, strong foliation, designing a rock cut within a curved alignment, and assessing impacts of the rock cut on a high-voltage electrical transmission tower situated at the top of the cut. Within the framework of a CM/GC contract, multiple surface and subsurface investigative techniques were utilized during the design phase to achieve the rock cut design that is now under construction.

17. From Risk Inventory to Real-World Failure: Hurricane Helene Validation of USMP Geohazard Prioritization

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ABSTRACT

The Unstable Slope Management Program (USMP) provides a systematic framework for identifying and prioritizing unstable slopes along transportation corridors. In late September 2024, Hurricane Helene produced record setting rainfall across western North Carolina, triggering multiple landslides along segments of the Blue Ridge Parkway previously inventoried under the USMP. This extreme event provided a rare opportunity to evaluate how well USMP risk ratings correlate with real world slope failures.

This presentation compares USMP inventory results with documented landslides that occurred following Hurricane Helene, focusing on eight failure sites between Mileposts 336 and 349 investigated as part of post storm geotechnical exploration efforts. USMP risk ratings, hazard classifications, and slope characteristics were evaluated alongside post hurricane field observations, subsurface exploration data, and repair documentation. Spatial comparisons were performed between pre storm high risk USMP locations and confirmed landslide occurrences.

Results indicate that several Hurricane Helene landslides occurred at or immediately adjacent to slopes previously identified as unstable or high risk within the USMP framework. Contributing factors commonly included steep terrain, adverse geologic structure, drainage conditions, and rainfall driven groundwater response. These findings demonstrate that USMP ratings provide meaningful insight into slope vulnerability during extreme precipitation events, supporting their use as a proactive risk management and prioritization tool for transportation agencies.

18. Comprehensive Load Test Program for Steel H-Piles Driven in Intermediate Geomaterials

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ABSTRACT

Full-scale static and dynamic load tests were conducted on eleven steel H-piles driven into intermediate geomaterials (IGMs) in Colorado, Iowa, Kansas, North Dkota, and Wyoming. Three static load test (SLT) systems were developed to address the construction scenarios encountered across the study sites. The first SLT system was an Independent Static Pile Load System (IndeSPLS), which was conducted on test piles (TP) 1 to TP5 driven into shale and claystone in Iowa, Kansas, and North Dakota. The second system was an Integrated Static Pile Load System (InteSPLS) designed for TP6 and TP7, which were driven into siltstone in Wyoming. The third system was an Innovative Static Pile Load System (InnoSPLS), which was designed for TP8 to TP11 driven into shale, siltstone, and claystone in Colorado. Dynamic load tests (DLTs) were conducted using Pile Driving Analyzer (PDA) with the Case Pile Wave Analysis Program (CAPWAP). This paper presents site and subsurface conditions, test pile instrumentation and protection, data collection, load distribution from SLTs, and the comparison of load test results. Six failure criteria were used to determine the ultimate failure resistances from the SLT. The ultimate resistances of TP1, TP3, TP4 and TP10 based on all failure criteria were lower than that from CAPWAP at the 24-hour restrike. For TP7 and TP6, the ultimate resistances based on the Davisson, De Beer YL, Fuller & Hoy, 10% pile size, and 1-in displacement criteria were higher than that from CAPWAP. The ultimate resistances of TP8 and TP9 based on all failure criteria were higher than those from CAPWAP. Comparison with CAPWAP showed that the agreement between static and dynamic resistance estimates varied depending on the test pile and failure criterion. The findings provide practical guidance for selecting appropriate SLT systems for driven piles in IGMs under different bridge construction conditions.

19. Evaluation of Drag Load and Downdrag on Axially Loaded Piles

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ABSTRACT

Piles installed through soil that settles after construction of the piles can develop negative skin friction along the upper part of the shaft or along its full length, that increases the axial force carried by the pile and can add to its settlement. The soil settlement may be produced by consolidation under fill or dewatering, by reconsolidation following liquefaction, or by collapse of a metastable deposit upon wetting. Common force-equilibrium procedures locate the neutral plane by balancing driving and resisting forces, treat the shaft resistance as fully mobilized, and evaluate the pile settlement separately from the force calculation. This paper presents a soil-pile model that couples the soil and pile settlement profiles with the mobilized skin friction and tip resistance in an iterative analysis. The load transfer (t-z and q-z) relationships are constructed from soil properties, pile properties, soil-pile interaction, and a single constitutive soil model rather than prescribed empirically, so the shear mobilized at each depth follows from the relative soil-pile displacement computed at that depth. For a given permanent pile-head load, the analysis returns the axial load distribution, the maximum drag load, the location of the neutral plane, the extent of the transition zone from negative to positive skin friction, the mobilized tip resistance, and the pile-head settlement. The procedure is extended to long piles in which the pile-head load and the drag load are fully resisted above the pile tip. Comparisons are presented with two full-scale field tests: one at Bangkok, where the downdrag was induced by soil consolidation settlement, and one at Nikopol, where the downdrag was triggered by the inundation of collapsible soil.

20. NCDOT Measurement While Drilling (MWD) Implementation and Testing Program

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ABSTRACT

The North Carolina Department of Transportation (NCDOT) partnered with North Carolina State University (NCSU) in 2024 to conduct a research project on the establishment of correlations between Measurement While Drilling (MWD) data and strength properties of soils in North Carolina. The project led to the procurement of an MWD console and multiple sensors which were installed by a certified technician on a CME-55 SPT track drill owned by NCDOT in December of 2024.

The general thesis of this program is to gather statistically significant datasets that include MWD data as well as SPT, CPT and soil test data within the same geologic units at the same depths and locations allowing for comparison and correlation of these datasets. To this end, NCDOT is also working with multiple consultants to install and operate MWD equipment during the initial subsurface site investigation for the Cape Fear Memorial Bridge in New Hanover County.

While the primary objective of this program is to correlate MWD data to soil strength properties, it also hopes to prove that MWD testing provides more thorough subsurface data than traditional methods alone. MWD testing offers advantages over SPT and CPT since it can be performed in material too dense for CPT testing and can record data in soils too soft for traditional undisturbed sampling techniques. MWD testing also provides a continuous data profile in SPT borings where traditional SPT alone typically leaves gaps in the logs between tests.

Current research of correlations between MWD data and strength properties of soils in eastern NC shows promise. Opportunities for further study exist in the utilization of MWD in rock coring at drilled pier locations, inclusion of SPT-seismic data collection and in the characterization of weak sedimentary deposits of the Triassic Basins in NC.

21. Advancing geotechnical site characterization with 3D SPT-seismic testing

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ABSTRACT

Recent advancements in seismic testing have led to the development of the 3D SPT-seismic method, an innovative approach that integrates seismic wave analysis with conventional standard penetration test (SPT) measurements to enable volumetric imaging around boreholes. Unlike traditional geotechnical characterization methods that rely on discrete measurements at borehole locations, this approach utilizes the seismic energy generated during routine SPT hammer blows. These impacts act as repeatable seismic sources that produce body and surface waves propagating through the surrounding ground. The resulting wavefields are recorded at the surface using a dense 2D array of geophones, capturing detailed waveform information that can be used to reconstruct subsurface properties.

The recorded seismic data are processed using 3D full-waveform inversion (3D FWI), a physics-based imaging technique that iteratively updates subsurface models until the simulated waveforms closely match the observed data. By utilizing the full waveform information, including amplitude, phase, and scattering effects, FWI provides significantly higher resolution than conventional seismic methods that rely primarily on travel-time analysis. In the 3D SPT-seismic framework, hammer blows at multiple depths along the borehole serve as vertically distributed seismic sources, enabling the inversion to illuminate the surrounding subsurface from multiple directions and improving the stability and resolution of the reconstructed models.

This paper presents a comprehensive validation of the method at three geologically complex sites in Florida. Results demonstrate that subsurface properties can be imaged at sub-meter resolution within a 3D volume extending up to approximately 18 m laterally from the borehole and to the full depth reached by SPT. Multiple voids at various depths (5 to 15 m) were detected and confirmed by SPT data. A strong correlation between the shear-wave velocity (Vs) profiles derived from FWI and measured SPT blow counts (N-values) is observed across all sites. This relationship enables reliable 3D estimation of SPT-equivalent N-values, providing continuous volumetric characterization that can significantly enhance geotechnical site investigation and foundation design.

22. Integrated Geotechnical and Geophysical Interpretation of Sterling Highway Milepost 45 to 60 Project

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ABSTRACT

The Sterling Highway Milepost 45 to 60 project consists of 15 miles of new highway cutting across the steep topography north of Cooper Landing on the Kenai Peninsula in Alaska. To date, field investigations include more than 200 test holes, 160 test pits, mapping of geological features, dozens of near-surface geophysics transects, and the collection of groundwater and inclinometer data.

The geology of the project alignment varies across the project corridor; significant portions of the corridor consist of glacial till overlying schist bedrock of the Valdez Group. The schist is generally highly fractured, with zones of steeply dipping foliation, and has a mylonitic to migmatitic texture.

DOWL and its project partner, Landslide Technology, in collaboration with the Alaska Department of Transportation & Public Facilities, investigated the section of the project where the new highway alignment intersects the existing Sterling Highway. This area is characterized by very steep topography, dense vegetation, and culturally sensitive sites, which limit access with traditional drilling equipment.

To address these investigative challenges, the project team combined test hole data with multiple geophysical methods, including seismic refraction tomography (SRT), multichannel analysis of surface waves (MASW), and electrical resistivity tomography (ERT), to estimate stratigraphic coefficient of variation, which is a parameter in Reliability Based Design (RBD). The geophysical and limited borehole data were then integrated into Leapfrog Geo®, a 3D geological modeling software, to support the interpretation of the subsurface conditions to evaluate options for steep slopes and retaining walls.

Results demonstrate that integrated geophysical and geotechnical characterization reduces stratigraphic uncertainty and improves confidence in subsurface interpretation for the design of steep cuts and retaining walls.

23. The Chilkat Connector Feasibility Study in Southeast Alaska

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ABSTRACT

The Alaska Department of Transportation & Public Facilities (DOT&PF) initiated a new feasibility study focused on the west side of Lynn Canal with the goal of connecting Juneau to the Haines Highway. The proposed corridor, named the Chilkat Connector, is roughly 65 miles long, and represents one of the few remaining opportunities to provide overland access to Alaska's capital city. This feasibility study evaluated the geotechnical and geological aspects related to the long-term viability of developing a combination of new roadway, bridge structures, and associated ferry terminals that would link Juneau with northern communities and the broader highway network.

As part of this effort, a high-level geotechnical reconnaissance of the project corridor was conducted by Landslide Technology (LT) and DOWL to identify major geologic and terrain considerations that may influence corridor feasibility, construction methods, and potential costs. The reconnaissance focused on non-invasive field methods, including geologic mapping, collection of surface samples, broad evaluation of soil and rock conditions, and preliminary assessment of geologic hazards such as landslides, rockfall, glacial deposits, karst terrain, and steep coastal terrain.

After the field reconnaissance, LT created a geohazard inventory with 69 individual landslides, 19 landslide complexes, 34 debris flows, and 47 karst features within the project study area. LT also completed shallow landslide and debris flow susceptibility mapping. The results from the susceptibility mapping highlight that most of the project corridor is susceptible to shallow landslides and debris flows, common for the overstepped terrain observed along most of the corridor. Findings from this feasibility study will be used to narrow potential alignments, identify locations where more detailed surface and subsurface exploration may be needed, and highlight areas of significant engineering concern.
This paper will describe the geohazard findings for the feasibility study. It summarizes the observations and interpretations from the 2025 reconnaissance, identifies key geotechnical considerations related to geohazards along the proposed corridor, and provides baseline information that will inform subsequent engineering evaluations, environmental review, and future project development phases.

24. Improving Williamsport Road – Overcoming Geological and Geographical Challenges in Remote Alaska

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ABSTRACT

Williamsport Road, constructed in the late 1930s, traverses wild and undeveloped terrain between Iliamna Bay in Cook Inlet and Pile Bay on Lake Iliamna. The road follows a historic Native Alaskan portage route approximately 14 miles long and is owned and operated by the Alaska Department of Transportation & Public Facilities (DOT&PF). It serves as a vital route for hauling supplies and fuel to Lake Iliamna communities and is also used to haul fishing vessels of the Bristol Bay Fishery. The southern end of the road rises from extensive mud flats on Iliamna Bay and traverses up three miles over steep mountainous terrain. The mud flats present access and boat staging challenges and the road is a treacherous, single lane roadway that experiences significant rockfall, erosion, and slope instabilities which often limit road serviceability for weeks at a time. To improve resiliency of the transportation corridor, the DOT&PF is improving the roadway and adjacent facilities. This paper includes an overview of the project and a description of the challenging geologic, seismic, and geographical conditions in which it exists. It also includes a review of our data collection approaches including aerial imagery evaluation, drone-based photogrammetry and processing, hand-collected measurements, and remote-operations challenges encountered. The paper also incudes a description of our engineering analyses, additional data needs, and how the collected data will support design of road improvements in an extremely challenging environment, focusing on overcoming rock and soil slope instability and development over tidal mud flats.

25. The Famous "Billings Rims" and the Stagecoach Trail – Integrating 3D Geologic Modeling, Limit Equilibrium Slope Stability, and Discrete Element Rockfall Analyses

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Abstract

This case study presents the geotechnical and geologic design framework for the Stagecoach Trail corridor in Billings, Montana, a setting dominated by the "Billings Rims"—steep, jointed sandstone escarpments with a history of both frequent nuisance rockfall and episodic, high-magnitude block releases. Three preliminary trail alignments were advanced through a risk-informed, cost-benefit screening that explicitly accounted for differential exposure to rockfall sources, constructability within constrained benches, and long-term maintenance liabilities.

Using high resolution UAV photogrammetric data in conjunction with 3D geologic mapping, we developed a model of the site to resolve key stratigraphic contacts, persistent joint sets, and colluvium thickness variations along the slopes. The model underpinned a 3D limit-equilibrium slope stability analyses to evaluate slope stability, fill geometry, and potential rockfall catchment areas. Rockfall hazard was then characterized through 2D renderings as well as discrete element modeling utilizing ANSYS ROCKY, to evaluate the impacts of surface irregularities. Combining the use of geosynthetically stabilized earth slopes, localized rock stabilization and routing the trail to minimize exposure to pedestrians, the greenway trail will provide a critical link for Billings residents providing a safer connection from the Rims to the valley.

26. Groundwater Withdrawal and Potential Land Subsidence Risk at USA Parkway, Nevada

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ABSTRACT

Groundwater is a critical resource for the State of Nevada, the resource is utilized by public water systems, domestic, agricultural, industrial, and for energy and mineral resources. The heavy reliance on groundwater resources across the state has highlighted the issue of declining water levels in the underground aquifers. Besides the concern of losing an essential water source in an arid environment, groundwater level decline can also lead to ground surface subsidence. Ground subsidence can cause structural issues for infrastructure and roadways. These issues can include roadway settlement, bridge footing instability, and impact foundations and drainages. Evaluating previous decline in groundwater and ground subsidence studies, potential risk can be assessed for other locations across the State. USA Parkway outside of Sparks, Nevada requires industrial pumping for cooling data centers. The volume of water needed for the industrial hub has raised concern regarding over pumping of the aquifers in this region. There is historical groundwater and surface water data across the State of Nevada. Utilizing previous studies and additional groundwater monitoring, risk assessments can be made to determine if infrastructure in the area is susceptible to damage due to water level decline.

This study evaluates groundwater-level records obtained from the Nevada Division of Water Resources and reviews the hydrogeologic conditions that influence susceptibility to groundwater-induced land subsidence. Representative groundwater hydrographs indicate spatial variability in groundwater-level trends, with several monitoring wells exhibiting long-term declines while wells hydraulically connected to the Truckee River remain relatively stable. Although groundwater-level declines alone do not confirm land subsidence, the observed trends, combined with the geologic setting and continued industrial growth, indicate that portions of the basin may be susceptible to future aquifer-system compaction.

27. PhotoMonitoring for Transportation Infrastructure in Geohazard Environments: Operational and Economic Advantages for Asset Owners

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ABSTRACT

Transportation agencies in the United States require monitoring approaches that operate continuously, automatically, and safely to support decisions for high-value assets exposed to geohazards such as rockfalls, debris flows, erosion, creep, post-wildfire instability, and construction-related ground movement. This paper presents PhotoMonitoring as a scalable, contactless technology for geohazard monitoring, emphasizing its operational and economic advantages for highway and road infrastructure owners. In a typical workflow, high-resolution images acquired at user-defined intervals are transferred to a processing environment and analyzed using computer-vision algorithms for image preprocessing, co-registration, change detection, and Digital Image Correlation-based displacement analysis. The result is a high- frequency record of site evolution with full-field change and displacement maps, rather than sparse, periodic point observations alone. Compared with conventional inspection and instrumentation approaches, PhotoMonitoring can reduce field exposure, limit manual intervention, improve temporal density, and support earlier recognition of evolving deformation or detachment patterns. The workflow is illustrated through a 2025 application to an unstable rock slope along State Route 14 in Washington, where repeat UAV imagery and image-based change detection were used to assess rockfall-related change before and after a wildfire-triggered period of elevated hazard concern.

28. ReMi® Seismic Surveys for Non-Intrusive ASCE 7-22 Compliant Site Class, Rippability, Fault Location, and Design

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ABSTRACT

ASCE/SEI Standard 7-22, Chapter 20 describes new standards for determining seismic site class that encourage geophysical surveying rather than cone penetrometer or standard penetration testing. Invasive methods can fail to achieve compliance because of refusal or difficulty for intrusive methods to access sites. For non-intrusive geophysical surveying to achieve code compliance it is important for geotechnical engineers to employ geophysical survey methods effective at determining Vs30. Without Vs30 measurements, taking the default seismic site class may lead to over-design of infrastructure, inflated construction costs and extended project timelines.

Code allowance of seismic surface-wave-arrays offers engineers the opportunity to perform one geophysical survey yielding Vs30 and site class along with a more comprehensive site investigation including assessments of landslide and liquefaction potential, rippability, depth to bedrock, fault location, and even P-wave velocity and Poisson's ratio. ASCE 7-22 compliant surface-wave surveys, when acquired, processed, and interpreted with Terēan ReMi® systems and software, will provide this full range of results while saving projects cost and time. Most sites require less than one hour to complete. Many case histories at scales from 15 ft to 3000 ft (5 m to 1000 m) serve to demonstrate these rapid and comprehensive results. Simpler geophysical surveys with more comprehensive results allow engineers to more efficiently complete geotechnical assessments, speeding infrastructure improvements.

29. Combined Geotechnical and Geophysical Data Collection for Pile Design at the Ankau Bridge in Yakutat, Alaska

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ABSTRACT

The Ankau Bridge crosses the Ankau Slough in Yakutat, Alaska and provides access to recreational and culturally significant areas to the remote, coastal community. Constructed in 1961, the timber bridge has experienced significant deterioration due to the harsh tidal inlet marine environment. The bridge was recently assigned a Poor condition rating under the National Bridge Inventory during its last inspection in 2022, prompting the need for a replacement bridge. DOWL was tasked to perform a geotechnical investigation and develop pile foundation recommendations for the replacement structure.

Site conditions presented significant logistical challenges for conventional subsurface data collection within the channel along the proposed bridge alignment. The shallow depth of the Ankau Slough, strong tidal currents, and limited structural capacity of the existing bridge prevented the safe deployment of a barge for offshore drilling or drilling from the bridge deck. To address the limitations, a combined geotechnical and geophysical investigation was implemented to limit conventional borings to the abutments. Geophysical surveys consisting of seismic and electrical resistivity profiles were conducted along the shoreline and within the channel to fill the data gaps between the two abutments.

Correlation between the geophysical profiles and boring data at the abutments allowed for interpretation of subsurface conditions across the channel where direct drilling was not feasible. The combined dataset proved to be successful in providing sufficient information to support pile design and highlights the importance of adapting investigation strategies to address access limitations and complex conditions common to remote, Alaskan communities.

30. Monitoring While Drilling in Glacial Deposits

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ABSTRACT

The latest Monitoring While Drilling (MWD) systems consist of several sensors mounted on conventional drill rigs to monitor various aspects of borehole drilling, whether drilling soil overburden or bedrock as well as coring in rock. These sensors record the advance rate, rotation rate, downthrust (pressure and force), torque, water/mud flow, water/mud pressure, vibration, among other parameters as a function of depth and time. These measurements are obtained in real-time by an automated system without interfering with routine drilling operations. The New Hampshire Department of Transportation (NHDOT) recently installed and implemented an MWD system on two drill rigs to support subsurface investigations. The equipment installed to date and the test procedures were gradually adapted and improved during an extensive field campaign across 14 sites, primarily involving glacial deposits commonly encountered in the region. MWD measurements were used to evaluate changes in ground stratigraphy and bedrock cores, and were compared with field logs and results from conventional geotechnical testing, such as the Standard Penetration Test (SPT), as well as Rock Quality Designation (RQD) for bedrock coring. This paper introduces the Monitoring While Drilling system used in this experimental campaign and discusses the results and data processing from drilling at one site in Londonderry, NH. The instrumentation is particularly helpful in delineating changes in stratigraphy and serves as a useful tool to bridge geotechnical data gaps in sites where results from SPT or other conventional tests are limited or sparse. MWD technology and approaches to data assessment are increasingly being developed in the United States and have strong potential to evolve into a reliable, standardized geotechnical test. To achieve this, correlations should be evaluated across a broader range of geological materials, and drilling techniques should be assessed and optimized to promote efficient drilling. Establishing procedures that produce high-quality parameters is essential to ensure that MWD measurements reflect the ground response and support reliable data interpretation.

31. Risk-Based Blasting Specifications for Highway Rock Excavation: Mitigating Project Risk Through Proper Specification Development

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ABSTRACT

Blasting specifications for highway rock excavation are often written with the intent of minimizing risk to adjacent infrastructure, the public, and project stakeholders. However, poorly structured specifications, whether overly restrictive or insufficiently defined, can unintentionally increase project risk. Overly prescriptive requirements may prevent proper blast design, leading to inefficient excavation, schedule delays, and inconsistent performance, while vague specifications can result in inadequate documentation, poor quality control, and increased potential for disputes and claims.

This paper presents a framework for developing risk-based blasting specifications that balance safety, performance, and accountability. The approach emphasizes hybrid specifications that combine performance-based requirements with essential design controls, allowing contractors to apply sound explosive engineering principles while maintaining clear risk management standards.

Key elements include appropriate vibration and air overpressure limits based on predictive modeling, required blast design documentation, drill log verification, monitoring and reporting procedures, and clearly defined QA/QC requirements. The paper also examines common shortcomings in current specifications, such as unrealistic vibration limits, overly prescriptive geometric restrictions, and the absence of documentation standards necessary for effective oversight and risk management. By focusing on risk mitigation through well-structured specifications, owners, engineers, and contractors can improve blasting performance while reducing the likelihood of damage claims, construction delays, and contractual disputes. The resulting framework provides practical guidance for developing specifications that protect project stakeholders while enabling safe and efficient rock excavation operations.

32. Developing a Database of Rockfall-Vehicle Impacts to Evaluate Human Vulnerability Along Transportation Routes

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ABSTRACT

Rockfall poses a widespread hazard along roads below steep slopes and affects the safety of roadway users. When vehicles are impacted by falling rock, occupants may sustain major injuries or be killed. However, low- or no-consequence rockfall impacts also occur and these are particularly important when evaluating the statistical vulnerability of people in vehicles struck by falling rock. Here, we examine more than 50 case studies from publicly available data sources (e.g., published literature, news reports) that document rockfalls with a confirmed vehicle impact. Using these resources, we record detailed site conditions (e.g., sourced from a roadcut or cliff, cause), rockfall metrics (e.g., volume, fall height), and vehicle characteristics (e.g., type, occupancy, travel direction) and compile that information into a database. These data provide a mechanism to evaluate relationships between hazard and risk through testing and development of vulnerability metrics. For example, from the site-specific event rockfall geometry characteristics (block size and fall height), the calculation of the potential energy of impacting blocks can be determined and compared with reported vulnerability outcomes. Additional statistical analysis can then be used to quantify the risk to people travelling along roadways and assess the likelihood of outcomes given site and vehicle characteristics. To develop statistically rigorous relationships, additional case studies are needed to develop an expanded database. Thus, this work highlights the benefit of preserving both the source area characteristics and the resultant human vulnerability outcomes in the wake of rockfall incidents to inform future risk assessments. These data and associated analyses can be used to assist transportation and land management agencies with risk assessment and decision making along rockfall-prone transportation corridors.

33. The Interrelationships of the Characteristic and Dilatant Friction Angles and Tangent Poisson's Ratio

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ABSTRACT

The characteristic friction angle (φ_c) has been used to develop a volumetric strain (ε_v) versus axial strain (ε_1) curve that closely matches the recorded volume change curve from the drained compressive triaxial test. Such characterization is provided in the paper, "The Characteristic Friction Angle, Its Determination and Use" (Norris, 2019) from the 70th Highway Geology Symposium. It is shown here in addition that the ratio of mobilized to characteristic friction angles (φ_m/φ_c), the tangent Poisson's ratio (ν_{tan}) and the mobilized angle of dilatancy (ψ) are each sole functions of the slope ($d\varepsilon_v / d\varepsilon_1$) on the volume change curve and, therefore, they are explicitly related to each other. The variation of such relationships is demonstrated via the data of a frictionless cap and base triaxial test.

34. Developing the Triaxial Test Responses of Soil from Available Correlations and a Nonlinear Exponential Equation

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ABSTRACT

A nonlinear exponential stress-strain equation has been used to closely match the shear modulus reduction curves of Seed and Idriss (1970) for sandy soils and Vucetic and Dobry (1991) curves for clays over the strain range, 1×10^{-6} to 0.01, and the Duncan and Chang (1970) response over the moderate to large strain range (0.003 to soil failure). From the methodology to be presented here, along with cited correlations, and with a very few input parameters, the reader will be able to generate the following drained triaxial compression test responses for a cohesionless soil: the deviator stress (σ_d) versus axial strain (ε_1), the mobilized secant friction angle (φ_m) versus axial strain, the volumetric strain (ε_v) versus axial strain, the secant (ν_{sec}) and tangent (ν_{tan}) Poisson's ratios versus axial strain, the mobilized characteristic (φ_c) and dilatant friction (ψ) angles versus axial strain, and the secant Young's (E) and shear (G) modulus versus axial (ε_1) and shear (γ) strain responses, respectively, as well as the modulus ratios (E/E_i and G/G_o) versus strain. Cross plots of parameters related to axial strain can then be established as well. For the undrained behavior of saturated clay, the responses that can be generated are: the deviator stress versus axial strain, the secant Young's modulus versus axial strain, the shear modulus versus shear strain, as well as the modulus ratios (E/E_i and G/G_o) versus strain.

35. I-80 Mine Subsidence: Geologic Characterization and Emergency Stabilization, Wharton, New Jersey

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ABSTRACT

This case history examines the engineering geology and rapid site characterization efforts that guided the emergency response to a series of mine subsidence events beneath Interstate 80 at Mile Marker 34 in Wharton, New Jersey. The affected highway segment was located above the Mt. Pleasant Mine, which was mined from 1786 to 1896, and experienced three collapses within a 200-foot stretch between December 2024 and March 2025, forcing full closure of both travel directions on one of New Jersey's most heavily traveled corridors.

The project required rapid characterization of the mine geometry and assessment of risks to public safety and critical transportation operations. The subsurface evaluation integrated ground penetrating radar, microgravity, multichannel analysis of surface waves , downhole sonar, borehole televiewers, and targeted drilling, along with review of historic mine documents to delineate the mine stope and identify contributing mechanisms.

The project included the design and construction of a micropile-supported concrete slab system spanning the mine feature. A comprehensive instrumentation program, including Shape Acceleration Arrays, multipoint borehole extensometers, tiltmeters, and seismographs, provided real-time data during construction and continues to support long-term monitoring.

This case history highlights the critical role of engineering geology, geophysics, and rapid site characterization in mitigating geologic hazards that threaten major transportation infrastructure.

36. Overview of Landslide Management Programs for Linear Pipeline Infrastructure Corridors

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ABSTRACT

Landslides can pose significant risks to linear infrastructure like highways, railroads, and pipelines. To minimize the impacts of landslide hazards on infrastructure, landslides should be proactively identified, characterized, and if necessary, mitigated and monitored. This paper outlines a systematic approach to identify and manage landslide hazards in the pipeline industry, where operators may be managing thousands of landslide hazards located along tens of thousands of miles of pipeline. Where long distances of buried pipelines are constructed in areas of high landslide incidence, a landslide management program needs a consistent approach for data collection and analysis, where it is essential to identify threats early and prioritize responses based on the severity of each hazard. Once an initial landslide inventory is established and threats are assessed, a landslide management program needs to continue to evaluate and identify changing landslide conditions and associated threats that may increase or decrease over time. It is essential to recognize new and emerging identification and monitoring techniques and to use complementary technologies to balance strengths and weaknesses of each monitoring method. This paper will discuss a three-level approach for landslide assessment, detailing the processes implemented to identify and evaluate landslide threats, as well as the long-term monitoring approaches used at a system-wide scale, including the use of repeat LiDAR surveys (i.e., LiDAR Change Detection Analysis), interferometric synthetic aperture radar (InSAR) data, aerial and drone patrol/reconnaissance, and ground patrol. Case studies will be presented from the Appalachian Basin, including how the three-level assessment approach was broadly applied along approximately 164 miles of pipeline in West Virginia, and how the understanding of the threat of a specific landslide in West Virigina to pipeline integrity evolved through observations made during successive assessments over the course of 10 years.

37. Two Dimensional Seismic Site Response Analysis for a New Bridge in a Subduction Zone Environment

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ABSTRACT

Smith River Bridge replacement project involves construction of a new about 1,000 feet long four-span hunched box girder bridge with a continuous deck isolated by triple frictional pendulum (TFP) bearings. The bridge will replace an existing bridge supported by two abutments and 17 piers. The site is located in northwest California near Crescent City in an active seismic region. The seismic environment around the project area is dominated by the Cascadia Subduction Zone (CSZ). Although some shallow crustal faults are located near the bridge site, the seismic hazards for this bridge are governed by the CSZ. Based on the available subsurface information, geotechnical/geologic conditions vary significantly along the length of the bridge, ranging from shallow metamorphic bedrock north of the river, to deep alluvium consisting of saturated sand, silt, gravel and cobbles south of the river. Depth of alluvium at the south side extends to about 130 to 150 feet below the ground surface. In order to perform three-dimensional (3D) soil-structure-interaction analysis of the bridge and foundation systems, three-component time histories at 10-foot vertical intervals along the foundation length at each pier and abutment location are needed. Due to the variation in geotechnical/geologic conditions along the longitudinal direction of the bridge, a two-dimensional (2D) seismic site response analysis is required to develop three-component time histories. The 2D seismic site response analyses were performed using computer program QUAD4M. Response spectrum at the bedrock level was developed using recommended procedures by California Department of Transportation (Caltrans) and using probabilistic and deterministic seismic hazard analysis (PSHA and DSHA). Seven sets (each set containing two orthogonal horizontal and one vertical motions) of spectrally matched time histories representing subduction zone environment were developed and used in the 2D seismic site response. In addition, computer program DEEPSOIL was used to perform one-dimensional (1D) seismic site response analyses to model site response in the transverse direction of the bridge. Results of QUAD4M were calibrated against the DEEPSOIL results in the transverse direction of the bridge. This presentation will present the results of ground motion hazard analyses, deaggregation analyses, selection and spectrally matching seven sets of time histories, and results of 1D and 2D site response analysis. Results of seismic site response show significant variation in site response along the longitudinal direction which can't be captured in a 1D site response.

38. LiDAR-Based Delineation of Alluvial and High-Angle Fan Landforms for Hazard Recognition, Land-Use Planning, and Transportation Corridor Resilience

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ABSTRACT

Repeated land-use reviews in western Colorado revealed a practical hazard-recognition problem: alluvial and high-angle fan landforms were not always consistently identified, mapped, or evaluated in existing hazard and geologic information. Although these depositional landforms influence where sediment-laden floods and debris flows intersect developed areas and transportation corridors, they were commonly generalized within broader surficial map units or obscured by development and channel modification. This paper describes the development of a statewide LiDAR-based inventory designed to improve recognition of these geomorphic receiving landforms and support screening-level geologic judgment in land-use, post-wildfire, and transportation-corridor settings.

Using 1-meter digital elevation models, terrain derivatives, slope criteria, geomorphic interpretation, quality-control review, and field verification, the Colorado Geological Survey delineated more than 8,854 alluvial and high-angle fan landforms across ten Colorado counties, with five additional counties currently undergoing quality assurance and quality control (QA/QC) review for planned production. The repeatable mapping workflow emphasizes apex position, basin and channel connectivity, fan morphology, landform preservation, and a two-axis confidence framework that independently evaluates confidence in landform identification and mapped boundary extent.

The importance of these receiving landforms became especially evident following the 2020 Grizzly Creek Fire and subsequent debris-flow impacts in Glenwood Canyon, where transportation consequences were governed not only by hazardous source basins but also by the depositional settings where sediment-laden flows emerged from confined channels and intersected Interstate 70 and other infrastructure. The inventory is intended as a screening-level susceptibility and exposure dataset rather than a probability model, runout model, or site-specific design tool. By systematically identifying geomorphic receiving landforms, it provides the missing geomorphic layer between source-basin hazard assessments and corridor-scale consequences, supporting hazard recognition, transportation screening, emergency planning, geotechnical asset management, and resilience-oriented decision support.

39. A Framework for Corrosion and Asset Prioritization in Reinforced Soil Systems

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ABSTRACT

Current design practice for metallic Mechanically Stabilized Earth (MSE) walls relies on electrochemical characterization of the reinforced backfill and empirical metal-loss models to estimate the long-term durability of the reinforcement. While these methods establish the corrosion assumptions used for design, they provide limited means of verifying that buried reinforcements continue to perform as intended throughout their service life. This paper presents a practical framework for extending corrosion verification beyond construction by integrating Linear Polarization Resistance (LPR) monitoring into transportation asset management.
The framework was developed through reanalysis of the Nevada Department of Transportation Phase II statewide corrosion monitoring program, including electrochemical characterization and 177 in-service corrosion measurements collected from representative metallic MSE walls. Measured corrosion rates were normalized using the Corrosion Severity Ratio (CSR), a dimensionless index that compares observed corrosion activity to the corresponding AASHTO design corrosion model. Site-level CSR rankings were then combined with normalized electrochemical conditions to establish a practical approach for prioritizing corrosion monitoring, inspection, and maintenance activities.

The statewide results generally support the current corrosion design methodology, with most monitored reinforcements exhibiting corrosion activity consistent with the underlying design assumptions. Localized CSR exceedances were observed, particularly at sites with unfavorable electrochemical conditions; however, isolated elevated corrosion rates alone do not indicate unacceptable long-term deterioration. Rather, the principal value of corrosion monitoring lies in establishing long-term trends in reinforcement performance that validate design assumptions and provide transportation agencies with objective condition data for risk-informed, condition-based management of metallic-reinforced soil infrastructure.

40. Applications of Smart Rock Technology to Evaluate Rockfall Hazards

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ABSTRACT

Rockfall events pose a risk of irreversible damage to motorists on transportation corridors and other infrastructure in many states across the country. Rockfall hazard assessment for transportation corridors commonly relies on trajectory modeling approaches that use empirically selected input parameters, commonly based on a limited understanding of rockfall movement on different ground material types. This limitation is partly due to the difficulty of obtaining field measurements that fully capture the movement of a falling block. To help address this limitation, Smart Rock (SR) sensors have proven useful for geotechnical instrumentation of these natural hazards. The latest SRs consist of 3D-printed capsules equipped with triaxial dual accelerometers, a triaxial gyroscope, and an altimeter that measure rockfall motion from the perspective of the falling block. This paper introduces the latest sensors, discusses SR data outputs, and summarizes the main methods and applications of the Smart Rock technology over a five-year experimental research program. Data collected from more than 400 controlled and in situ tests using instrumented blocks of different mass across sites in the northeastern U.S. and France were evaluated alongside camera measurements and ground characterization methods. Results demonstrate that SR instrumentation provides new information on rockfall movement and its interaction with the ground that cannot be captured through conventional methods. Measurements from the falling rock perspective can be used to support the selection of model input parameters and provide insights to improve the accuracy of existing simulation software.


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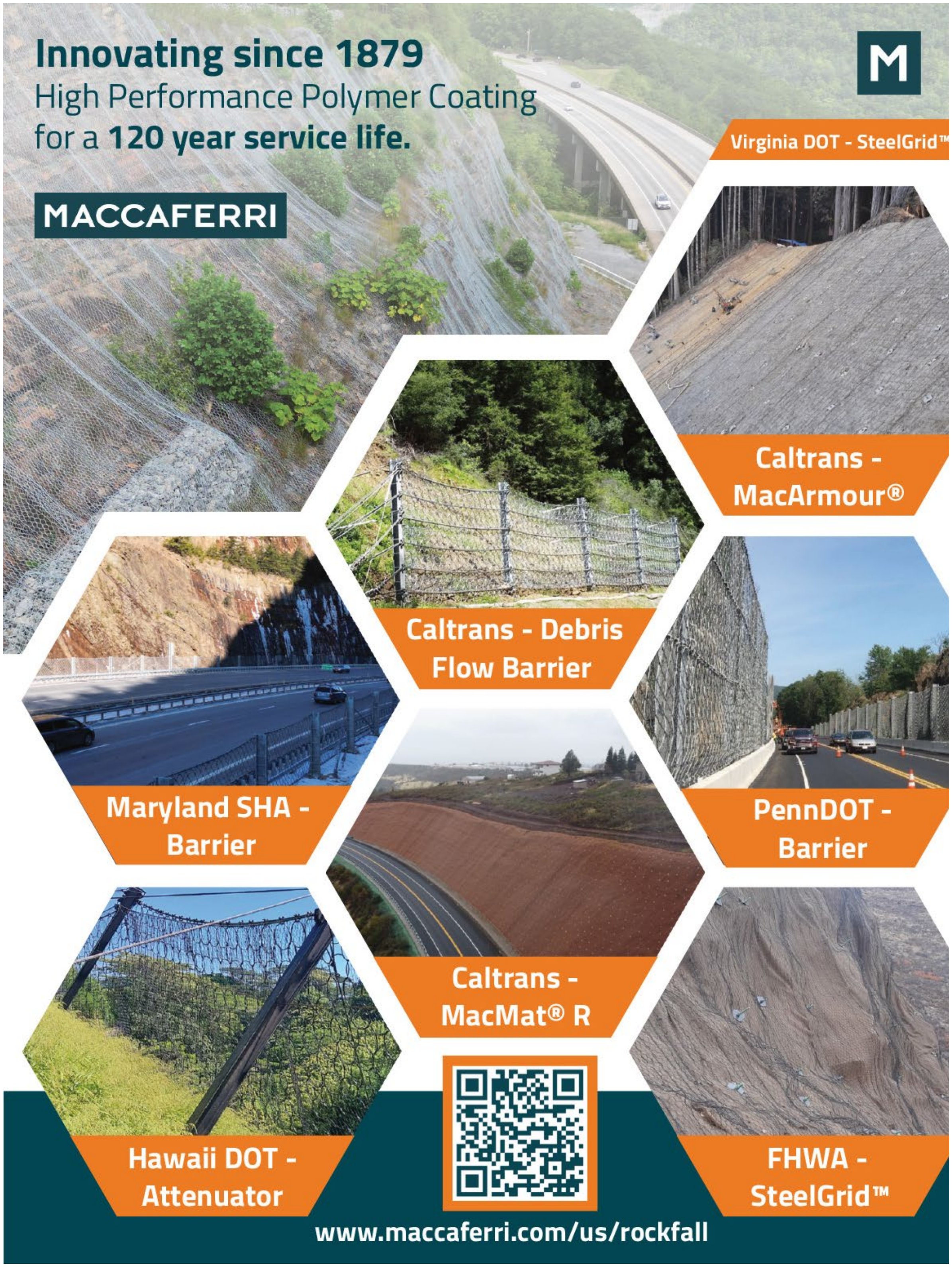
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Notes