

Alaska University Transportation Center 2012 Annual Report

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**The Alaska University
Transportation Center (AUTC)**

theme, *“Transportation Safety,
Security, and Innovation in
Cold Regions,”* was selected to
complement the mission and
direction of the University of
Alaska—to inspire learning and to
advance and disseminate knowledge
through teaching, research, and
public service, emphasizing the
North and its diverse peoples.

This theme also takes into account
the needs of such stakeholder
groups as the Alaska Department of
Transportation & Public Facilities,
the Alaska Railroad Commission, the
oil and gas industry, and the broader
transportation community that
extends across the nation. Research
at the University of Alaska fills a
national need; AUTC is the only
center with a specific, primary focus
on transportation in cold regions.

AUTC directs its efforts to all
modes of transportation. Like many
northern regions, Alaska depends
on multimodal transportation for
part of its economic growth. A mix
of highway, air, marine, rail, and
pipeline infrastructure makes it

possible to meet the need for goods
and transportation for its people.

Northern regions face special
challenges, including varying
population density; long distances
between communities (often with
no interconnecting roads), and high
dependence on aviation and marine
transportation. Diverse geographic
features, along with complicating
factors such as unstable soils and
extremely cold temperatures lead to
high transportation costs. Pipelines
for oil and other fuels dramatically
impact the economic well-being and
security of the nation. When such
infrastructure traverses arctic and
subarctic terrains, the challenges of
planning, designing, constructing,
and maintaining pipelines are
unique.

According to Alaska Congressman
Don Young, “Living in a climate
where the weather has such a large
impact on the condition of our
roadways and infrastructure, it is
especially important for us to study
how we can improve on what is
already being done. A focus of this
should be better ways to pave our
roadways and keep them intact.”

Improvements in cold regions
transportation engineering and
dissemination of our innovative
research to the national forum are
AUTC’s primary goals.

The Center addresses issues
related to those identified in the
Highway Research and Technology
report (a joint publication
released by the Federal Highway
Administration, the American
Association of State Highway and
Transportation Officials, and the
Transportation Research Board)
as key research and technology
themes, including but certainly not
limited to investigating the impact
of climate change on permafrost,
reducing construction and
maintenance costs of transportation
infrastructure, improving air quality
during the winter months, and other
measures that address multimodal
issues facing Alaska and the nation’s
transportation community.



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Alaska University Transportation Center
Safety, security, and innovation in cold regions.



DIRECTOR'S STATEMENT

During the last five years, the funding landscape for transportation research has change significantly. Looking to the future, we can expect even more changes. Last year the UTC program called for a reorganization of all existing centers, and 20 specialized centers competed for 10 remaining awards. As a consequence, AUTC partnered with the University of Washington, Washington State University, Oregon State University, and the University of Idaho to form *PacTrans*, a consortium that successfully competed to be one of 10 new regional centers. This relationship is blending the expertise of the member universities to better serve the Northwest.

Through the past couple of years, we at AUTC recognized changing funding trends and that we must adapt to those changes. If you have been reading my Director's Statement in our newsletters and earlier annual reports, you know

that I have been promoting efforts to sell the value of transportation research and improve our relationships with existing and new partners. Some of you have heard me say "Chase the money and you will be poor. Seek meaningful relationships and you will be rich." These ideals represent the core values of AUTC. This is why we seek to provide the best value to those we work for, be they funding agencies, local partners, or the research community.

To ensure we meet these ideals with every project, we have adopted new requirements for our Project Investigators.

Every project begins with a kick-off meeting usually held online. At this meeting the PI reviews the proposal, including its schedule, scope, and budget. The peer review team is given the opportunity to discuss the project and offer possible changes if needed. We find the dialogue at these meetings to be quite engaging. However, the greatest benefit to the meeting is that all understand the project goals and deliverables, and the process for accomplishing these.

Semi-annual web meetings are held at which the PI presents his or her progress and findings. The peer panel then has the opportunity to discuss those findings and ask for course corrections in the research to ensure the results are meaningful. These meetings have been so successful that many of the PI's and peer panels have opted to have web meetings much more often than AUTC requires.

Lastly, once the draft final report has been completed and distributed for comment, a final web meeting is held during which the PI presents a summary of the report to the peer review panel. The panel has the opportunity to question the PI and to offer suggested changes to the report. Final comments are due within two weeks of the web meeting. As a result of these new processes, delivery of the final report has been reduced by months and the quality of the work has improved.

These three simple requirements have had an amazing impact on the relationships between the principle investigators and those we work for.

How does this help us adapt to a changing funding landscape? Simple: If we make those we work for happy, then they will come back. We find that by engaging the stakeholders regularly, they feel they "own" the project and they have an impact on the outcome. We have found oral presentations and discussions are far more effective than written project status reports. Finally, we find that by including people on the peer review panel who have local, regional, and national perspectives, we achieve a balance between national goals and regional needs.

University of Alaska Provost

College of Engineering & Mines Dean

Institute of Northern Engineering Director

Governing Board

Defines research needs from industry and consumer perspectives

AUTC Director

Laboratory Manager
Grant Manager
Program Assistant
Communication Specialist

Executive Committee (UAA, UAF, UAS)

Clarifies research directions and evaluates potential projects

Other Organizations & Partnerships

Share resources and expertise, contribute to active projects

Contributing Faculty

Provide research and expertise in
Structures
Transportation Operations
Transportation Materials and Seismic Studies
Geotechnical Materials, Seismic Studies
and Modeling

Rick Kessler
General Manager
Chenega Logistics



Lance Wilber, Director
Public Transportation
City of Anchorage



Jeff Ottesen
Director, Statewide Planning
Alaska Department of
Transportation
& Public Facilities



Bruce Carr, Director,
Strategic Planning
Executive Office
Alaska Railroad Corp.



AUTC Governing Board members represent both transportation technology users and those who must manage infrastructure at national, state, and local levels. All transportation modes are represented in this dynamic group.

To learn more visit ine.uaf.edu/autc.

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Legislative Liaison
Denali Commission



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Technology Deployment Engineer
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Land, Alaska Gas Resources
BP Exploration (Alaska), Inc.



AUTC GOVERNING BOARD and STAFF

AUTC faculty and staff perform research, offer training, disseminate results, and support a network of researchers all over the USA

Each of the University of Alaska campuses hosts an associate director, who works to engage faculty and local partners in that region of Alaska



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STUDENTS OF THE YEAR

AUTC

invites nominations for its Student of the Year (SOY) award each year. Based on a combination of technical merit, research, academic performance, professionalism, and leadership, the award has become a hallmark of engineering students immersed in AUTC's research community.

In addition to recognition, recipients receive a \$1,000 scholarship and a trip to the annual Transportation Research Board meeting, where they are formally recognized at the CUTC annual Student of the Year banquet.

Student of the Year award winners frequently continue their professional and academic growth through employment in engineering positions with major firms, meaningful work in Alaska DOT&PF, involvement in advanced research programs, and further education. Although this interest in continued professional and educational development is a trait of SOY students, it is also typical of many students in the College of Engineering and Mines at UAF, who find employment with AUTC's partners or return for graduate degrees.

Here is a snapshot of our past SOY award winners and other CEM students and what they are doing today.

Photo of Rodney Collins by T. Paris, UAF. All other photos courtesy AUTC.



**Travis Eckhoff,
2012 Student of
the Year**

Eckhoff came to UAF's M.S. program in Environmental Engineering after receiving a B.S. in Civil Engineering from the University of New Hampshire. His thesis, titled "Determining Dust Palliative Longevity on Gravel Roads and Runways," is rooted in AUTC's dust-reduction research project led by David Barnes. Eckhoff, who joined this project in 2009, has been critical in helping researchers overcome environmental and field-based measurement challenges. He helped the team develop a one-of-a-kind instrumentation and methodology for measuring dust-control palliative performance: a portable monitoring device known as the "DUSTM," which is mounted to the back of an ATV. He helped deploy the instrument and conduct sampling activities in rural and remote areas across the state. This work is helping address important public health and cost-management issues for Alaska's rural communities. Eckhoff is one of many students who have played a considerable role in AUTC's work.

Where he is today: Eckhoff will complete his Master's degree this year. He continues to spearhead a significant portion of the

fieldwork, data collection, and logistics for David Barnes' statewide rural dust-reduction and palliatives research program. This past summer, he maintained an extensive travel schedule at remote communities throughout Alaska, managing logistics and deploying the DUSTM in many different field environments. Rural testing locations included Central, Circle, Kotzebue, Shungnak, Buckland, Noatak, Noorvik, Kaltag, Summit, Kantishna, Tetlin, Eagle, Hughes, Coldfoot, Kotlik, Golovin, White Mountain, Whales, and St. Michael. His final thesis will be based on data stemming from this work.



**Rodney Collins,
2011 Student of the Year**

Collins entered UAF's M.S. program in Civil Engineering with a B.S. degree from UAF in Civil Engineering. He has been an active research assistant in AUTC projects using geofibers and synthetic fluids to stabilize marginal soils. He helped publish two papers on a Fairbanks silt-stabilization study that employed these methods to strengthen unstable soil. He was also involved

WHERE THEY ARE TODAY?

in publications on shearing tests using Ottawa sand and road stabilization. Like other AUTC student researchers, Collins worked throughout Alaska, including stints in Emmonak, Unalakleet, Kaktovik, and Kwigillingok. These projects in soil stabilization are a major area of research for AUTC, helping Alaska DOT&PF and other stakeholders gain new tools and knowledge to help mitigate slope instability. In remote areas, these tools help prevent inflated construction and operations costs, and give local governments with limited budgets a cost-effective method to extend the useful life of unpaved roads.

Where he is today: This year Collins was accepted into a doctoral program in geotechnical engineering at the University of Oklahoma, which also awarded him an Alumni Fellowship. He has begun studies and research in a program on geotechnical and geoenvironmental engineering as well as geomechanics, and is already working on two projects, both dealing with soil stability. In one project involving in-situ testing of unsaturated soils, Collins' team is setting up weather stations throughout Oklahoma and installing moisture probes at various depths to observe how water infiltration affects soil stability. In the second project, Collins is working on chemical stabilization of clay soils using acids and other soil stability methods. He is also finishing a soil-stabilization project report from work at AUTC.



Eva Stephani, 2010 Student of the Year

Stephani joined UAF's M.S. program in Civil and Environmental Engineering after earning a B.S. degree in Geological Engineering from Laval University in Quebec. As early as 2006, Stephani began working on AUTC research projects, including identification of potential road test-section sites in Alaska and Yukon as well as geotechnical characterizations of permafrost core samples. During her work on the Alaska Highway Preservation project, she helped incorporate geographic information systems (GIS) technology to capture database information used to create 3D modeling. She won numerous awards for her work, and published several technical reports, including one as second author (an AUTC final report for the Alaska Highway Preservation research project). She produced eight international scientific conference and symposium papers as first author.

Where she is today: Stephani is working as an Engineer at Golder Associates, based in Quebec.

Golder is a global engineering consulting firm that provides design and construction services in earth, environment, and related areas of energy. The firm serves a range of clients in the transportation, power, manufacturing, mining, gas, and oil sectors. Stephani continues her activity in the international permafrost research community. She coauthored a conference paper, titled "Permafrost Degradation and Settlement under Lakes in Yedoma Environment," that was presented at the Tenth International Conference on Permafrost held at Salekhard, Russia, in June 2012. Continuing her connections to AUTC, she contributes to papers with Yuri Shur and Mikhail Kanevskiy, AUTC researchers, and Daniel Fortier, past AUTC researcher, at Laval University.



Duane Davis, 2009 Student of the Year

Davis was a student in both the Civil and Mechanical Engineering B.S. programs. After completing a B.S. in Mechanical Engineering, he completed a M.S. in Civil Engineering. Davis brought with him two decades of professional

experience in infrastructure and construction work in the North Slope oil fields and other remote locations across the state, and in both field and lab testing work. His undergraduate research and lab work contributed to AUTC's research on stabilizing marginal soils with geofibers and synthetic fluids. His graduate research studied the effects of seasonal frost depth on the dynamic response of laterally loaded deep foundations. He pursued broad research interests significant to Alaska, applied Mechanical and Civil Engineering concepts to his work, and studied materials performance in the Arctic to solve cold region engineering problems. Davis believed that nontraditional engineering methods could be found to provide more cost-effective solutions to some of Alaska's unique engineering challenges.

Where he is today: Duane Davis is working as a highway designer with Alaska DOT&PF's Northern Region Design and Engineering section, and is based in Fairbanks. He is currently working on a variety of roadway projects that include culvert and bridge replacements scattered throughout the Northern Region. Two notable projects on which he is working include replacement bridges on the Old Elliott Highway at Livengood Creek and on the Tok Cutoff at the Tok River. He continues to explore innovative, cost-effective solutions to solve engineering challenges on Alaska's roadway system.



**Will
Rhodes,
2008
Student
of the Year**

Rhodes began pursuing his graduate degree in Environmental Engineering at UAF after completing a B.S. in UAF's Geology program. As a student, Rhodes was involved in a research project of great value to both Alaska DOT&PF and the Alaska Railroad Corporation (ARC). In an effort to improve decision-making about herbicide use and develop best practices for applying herbicides in Alaska, Rhodes' work examined the attenuation rates of herbicides used in combination with mechanical brush cutting for vegetation control. He helped researchers sample soil collected over a year from field sites in Delta Junction and Valdez. The project was a partnership between AUTC, Alaska DOT&PF, ARC, U.S. Department of Agriculture, and the Salcha-Delta Soil and Water Conservation District. The results helped ARC develop effective, low-cost methods for managing vegetation growth. Rhodes' involvement with logistics and project organization facilitated a study that advanced the knowledge available to

decision makers in Alaska government and local transportation stakeholders.

Where he is today: Rhodes works for Oasis Environmental, Alaska's largest private environmental services provider. For over 17 years, the company has worked to resolve complex issues in remote and inhospitable arctic environments throughout Alaska, serving partnerships with clients in government, gas, oil, and mining. Oasis was recently acquired by Environmental Resources Management, a global provider of environmental, health, safety, risk, and social consulting services for business and government clients.



**Wilhelm
Muench,
2007 Student
of the Year**

Muench entered the Structural Engineering graduate program after receiving his B.S. degree in Civil Engineering at UAF. During this time, he became involved with an AUTC project, led by J. Leroy Hulsey, testing state-of-the-art bridge decking materials proposed to replace surfaces on the Yukon River Bridge. Muench added a significant innovation to the project when he developed a traction testing machine known as the "Muench Machine" to collect data on how a smooth tire performs on a variety of bridge decking samples. He also helped researchers

compile a literature review on tire chain damage, measurements of surface traction, and material performance.

Where he is today: While completing his thesis on the tire damage study, Muench has been involved in both teaching and research activities with AUTC and the College of Engineering and Mines at UAF. He continues as an adjunct instructor, teaching surveying and mechanics courses. He has also been an advisor for the famed UAF steel bridge competition team, which most recently took eighth place in the national competition at Clemson, South Carolina. In his research work, Muench is assisting as a member of the research team on Hulsey's project, using innovative instrumentation for structural monitoring on Alaska's Chulitna River Bridge. Outside of this research, Muench has worked professionally, including a stint conducting quality-assurance work for Doyon Utilities in Alaska.



In addition to students who achieve the SOY award, many other students who graduate from engineering programs with UAF and UAA find employment with AUTC's partners, most notably Alaska DOT&PF, the Center's most robust partnership. AUTC's work with Alaska DOT&PF extends well beyond its research, into workforce development and long-term cross-pollination of expertise, knowledge, and relationships. Much of this connection includes students.

Jonathan Hutchinson, a student who completed both a B.S. and an M.S. degree, was hired by Alaska DOT&PF. Hutchinson just completed his first year on the job as an Engineering Assistant in the Aviation Design section at the Department's Northern Region offices.

Hutchinson received a B.S. in Civil Engineering from UAF in 2009, focusing his course work on geotechnical and structural engineering. He participated in the annual ice arch construction and the steel bridge team competition—both engineering traditions at UAF. As an undergraduate, he was involved in several transportation-related research projects at UAF involving hydrology and water-sampling work along the Steese Highway and a silt sample collection for a frozen silt anchor study. He also participated in a summer internship with Alaska DOT&PF's Central Region.

As Hutchinson neared graduation with a B.S. degree, Dr. Andrew Metzger, AUTC researcher and Assistant Professor of Civil and Environmental Engineering, approached him about joining ongoing research on maritime structures by pursuing an M.S. degree.

Hutchinson entered the program and began summer work on an AUTC project examining the dynamic responses of pile-guided float structures. He subsequently joined another of Metzger's AUTC projects, this one examining the loading environment of state ferry and marine landing structures in Washington and in Juneau. Hutchinson earned an M.S. degree, and his graduate study fieldwork satisfied one year of work experience toward the Project Engineer certification requirements.

The pace at Hutchinson's job in the Northern Region Aviation Design section is varied. His work is relatively calm in the winter, as he begins setting up contracts, pushing out designs, and planning for multiple summer projects. The pace picks up in the summer, as he arranges fieldwork and travel, coordinates projects, and keeps up with mapping, design, and contracting duties. He cites organizational skills as a key asset in this work, since he manages many contracts. Among his favorite job perks are the extensive field duties entailed in flying to remote locations and villages to meet with local residents and the interesting experiences that come with this aspect of his work. While well prepared for his job by the rigor and workload of UAF's engineering program, Hutchinson has found that writing and communication skills are particularly important for his work on a daily basis.

Below: Graduate student Jonathan Hutchinson installs instrumentation as part of a project on loading environment of state ferry and marine landing structures in Washington and in Juneau.

PARTNERSHIPS

Partnerships are a defining characteristic of AUTC's work, allowing the center to deliver versatile, interdisciplinary research on multimodal transportation topics. Partnerships allow AUTC to leverage the most effective balance of expertise, methodology, and knowledge for its stakeholders. In the past year, AUTC has seen positive developments both in its generally broad project partnerships, including a new regional university consortium, and its more specific interest areas of maritime and rural transportation and asset management.

AUTC helped form a Regional University Transportation Center (UTC) partnership with the University of Washington, Washington State University, Oregon State University, and the University of Idaho, establishing **PacTrans, the Pacific Northwest Transportation Consortium, which won a U.S. DOT RITA Regional UTC funding competition**. This partnership will leverage a national field of expertise and experience in transportation, infrastructure, and climate issues specific to the continental, and Pacific Northwest as well as the Arctic. Shipping and maritime transportation, icing, cold-weather infrastructure protection, and seismic design are all areas of overlapping interests and knowledge shared by this partnership.

Private Sector Partners

Alaska Railroad Corporation
Geo-Watersheds Scientific (GW Scientific)
Kansas Structural Composites Inc. (KSCI)
Midwest Industrial Supply Inc.
Soilworks
TenCate Geosynthetics
TransCanada Corporation

In the area of maritime transportation, AUTC is seeing a growing need for research and partnerships to address emerging knowledge gaps. In the past year, AUTC established a **Marine North Research Program to address engineering constraints, environmental impacts, and technological needs pertaining to maritime infrastructure development in Alaska's arctic waters**. Increased marine transportation activity in the Chukchi and Beaufort Seas raises the need for onshore support through infrastructure and technology. Through this new program AUTC will extend partnerships with a variety of UAF research institutions that have well-developed expertise in arctic research, such as the Geophysical Institute and the International Arctic Research Center.

City/County/Borough Partners

Anchorage Metropolitan Area Transportation Solutions (AMATS)
City of Fairbanks
Fairbanks Metropolitan Area Transportation System (FMATS)
Fairbanks North Star Borough
Ted Stevens Anchorage International Airport

In the area of rural transportation needs, partnerships with several dust palliative producers have become central to ongoing work on dust reduction. David Barnes and a team of researchers have continued their work in rural communities across Alaska testing the comparative effectiveness of different palliatives, thanks in part to samples provided by commercial producers. In the area of soil stabilization, private sector partners are helping facilitate valuable research, using geofibers and chemical fluids to strengthen unstable soils. As 85% of Alaska's communities lack road access and state-managed airport costs exceed \$40 million, this research is helping reduce the cost-prohibitive need for gravel imports, a vital benefit to the limited budgets of rural communities. By enabling AUTC's research into technologies that offer cost-effective tools for rural governments, private sector and local partners are proving invaluable to this work.

DRIVE RESEARCH

State/Provincial Partners

Alaska Department of Environmental Conservation
Alaska Department of Transportation and Public Facilities
Alaska Marine Highway System
California Department of Transportation
Idaho Transportation Department
Minnesota Department of Transportation
Montana Department of Transportation
Ohio Department of Transportation
Oregon Department of Transportation
Washington State Department of Transportation
Yukon Highways Public Works

Federal Partners

American Association of State Highway and Transportation Officials (AASHTO)
Federal Highway Administration (FHWA)
National Oceanic and Atmospheric Administration (NOAA)
Transport Canada
U.S. Department of Agriculture
U.S. Department of Transportation

University Partners

Alaska Tribal Technical Assistance Program
Chico State University
Montana State University
Nanjing University of Science and Technology
North Carolina State University
Oklahoma Transportation Center
Oregon State University
Texas A&M University
University of Alaska Anchorage
Université de Montréal
University of Idaho
University of Oklahoma
University of Washington
Washington State University]

Asset management is a centerpiece of AUTC's topically diverse program. The center's partnership with Alaska DOT&PF is perhaps its most robust, one that has helped support numerous state projects focused on transportation asset management, as outlined in the TAM section of this report. From intelligent transportation system integration to life cycle cost analysis, these projects are versatile in both topic and application. Beyond their diversity, these projects illustrate the degree to which a state agency/university research partnership can help develop and apply an organization-wide asset management program. As TAM moves toward implementation across Alaska DOT&PF, the department has an able and willing partner.

Education and workforce development remain integral to AUTC's partnerships. As then Alaska DOT&PF Commissioner Marc Luiken noted in his April address to UAF engineering students (see the Outreach Section), Alaska's push to encourage graduating engineering students to enter the transportation workforce has never been stronger. AUTC's researchers support this effort, maintaining active teaching schedules at UAF and UAA, in addition to their involvement in Alaska engineering traditions like Tau Beta Pi, the steel bridge competition, and annual ice arch construction. At the project level, many undergraduate, graduate, and doctoral students currently work on AUTC research.

AUTC maintains many partnerships on individual research projects as well as broader, multiproject programs of inquiry. Above is a current list of AUTC partnerships in both the private and public sectors.

OUTREACH

AUTC has maintained a steady level of outreach to many different stakeholders. In addition

to academic presentations and conferences organized and attended by researchers, staff, and partners, AUTC has reached out through trainings, collaborative public events, career and workforce development, and technical presentations on topics of emerging interest to government and the private sector from rural Alaska to Washington, D.C.

AUTC's partners at the Alaska DOT&PF Research, Development, and Technology Transfer Division continue administering statewide trainings under the Federal Highway Administration (FHWA) Local Technical Assistance Program (LTAP). The goal of this work is to enable local governments to improve bridges and roads by offering information,

Participation in Alaska's Local Technical Assistance Program

Year	Participants
2011	212
2010	126
2009	149
2008	132
2007	211

Above: 2011 was a record year, with 212 members of Alaska local government agencies attending Alaska DOT&PF's LTAP training programs.

technology, and technical assistance. Nationwide, the program utilizes a network of 58 centers to conduct an average of 5,000 sessions to over 150,000 participants annually. It provides access to training and expertise that might not otherwise be available and facilitates a cost-savings partnership for local stakeholders. The FHWA estimates that local transportation agencies save \$8 for every \$1 spent because of LTAP information and training. As a workforce development mechanism, the program gives Alaska contractors, consultants, government officials, and professionals training on multiple technical and management topics.

This past year, Alaska DOT&PF saw a record 212 attendees at LTAP sessions held in communities across the state, including Juneau, Anchorage, Fairbanks, Nome, Kenai, Yakutat, Petersburg, Ketchikan, Tazlina, Skagway, and Haines, as well as sessions offered online. Trainings were attended by road commissioners, borough and local government engineers and managers, consultants, and others connected to FHWA-funded roadwork.

Courses covered topics such as construction and maintenance; the environment; communications; business, public administration, and quality; highway safety; geotechnical considerations; pavement and materials; intelligent transportation systems; asset



Angela Parsons, AUTC Partner and Research Engineer with Alaska DOT&PF, discusses pavement preservation with an Anchorage TV Reporter at the 2011 Alaska Asphalt Pavement Summit in Anchorage. (Photo Courtesy: AUTC)

management; structures; and planning. Course instructors included Alaska DOT&PF personnel, University of Alaska faculty, and contracted experts in specific fields.

This often custom-tailored training curriculum helps provide a critical state- and local-level knowledge base. Alaska's absence of county governments makes boroughs, municipalities, and tribal corporations more actively involved as managers of road construction and maintenance compared with other states. Oftentimes these organizations lack cost-effective, convenient access to training curriculum.

Another product of AUTC's partnership with Alaska DOT&PF occurred in October, when the two groups cosponsored the **2011 Alaska Asphalt Pavement Summit** in Anchorage. Nearly 300 transportation professionals from around

the world attended the summit to collaborate on innovative, cost-saving solutions to the pavement preservation issues that challenge Alaska and other cold regions.

The two-day event was the only forum of its kind where state and international specialists addressed ways to make pavement last longer and cost less in regions of extreme cold. A variety of factors made Alaska an ideal location for addressing pavement preservation from a cost-reduction perspective:

- » The State of Alaska spends up to \$140 million a year on surface maintenance. This figure does not include the costs that local municipalities like Anchorage spend on road upkeep (source: Alaska DOT&PF).
- » Alaskans drive up to 4.9 billion miles per year, and the average Alaskan drives 7,600 miles in a single year (source: FHWA).
- » For every dollar the state does not spend on fixing a paved road, each Alaskan will pay an estimated three dollars, as poor pavement brings on issues like vehicle damage and maintenance, insurance claims and higher premiums, and wasted gas from congested roads (source: AUTC).

Alaska is the only state in the United States with a combination of transportation challenges that involves permafrost, frozen ground, ice and moisture erosion, and rapid surface deterioration due to harsh climates.

Connecting many different transportation stakeholders, the event's attendees and presenters

included engineers, planners, researchers, government officials, contractors, scientists, crew bosses, private industry, and technology experts from Alaska, the Lower 48, and foreign countries that have similar cold-climate issues. Many attendees were current AUTC researchers and partners. Presentations addressed methods of making stronger warm-mix asphalt, recycled asphalt applications, the use of thermal imaging on the Seward Highway, as well as ongoing research sponsored by AUTC and Alaska DOT&PF.

AUTC Director Billy Connor has been involved in several areas of outreach work to local governments, national workforce development stakeholders, and high school students. This past year, he made three visits to the Matanuska-Susitna Borough in Palmer, Alaska, to help a variety of professionals develop road management expertise. Connor's presentation to businesses, local road service superintendents, and engineers focused on program development in the areas of road design, chip sealing, pavements, and soil stabilization.

Connor also developed and presented an address on AUTC's soil stabilization work to the Alaska Public Works Association, which includes members from city, municipal, and borough governments, as well as engineering, equipment, and contract firms. This presentation offered insight from a key area of AUTC's research that

is valuable for many different public works stakeholders.

Transport Canada is an important stakeholder in cold region transportation research. Connor and AUTC joined Transport Canada's Permafrost Working Group, where AUTC is lending its expertise on building and maintaining roads in permafrost.

At the national level, Connor led AUTC as a major cosponsor of a Council of University Transportation Centers (CUTC) workforce development conference this past April in Washington, D.C. The conference was part of a larger effort by the U.S. Department of Transportation to develop a national strategy for addressing transportation industry workforce challenges. Several of these challenges have been identified by the agency as most pressing and include the following:

- » Within ten years, 50% of the current transportation workforce will become eligible for retirement.
- » Competition from other labor sectors threatens an increasingly small workforce.
- » Changing demands in a transforming industry require new skills and abilities.*

A member of the conference program development team, Connor was in attendance as well as Amanda Holland, a division operations manager at Alaska DOT&PF. Holland, who currently manages a workforce excellence program within Alaska DOT&PF, gave a

* U.S. Dept. of Transportation, Council of University Transportation Centers, "A National Transportation Workforce Development Strategy: A Roadmap to the Future," Case Statement, March, 2010.

OUTREACH

presentation on this work. AUTC's insight into this issue stems from multiple research projects that address state-level transportation workforce development needs and a rising challenge of succession planning within Alaska DOT&PF. The conference drew individuals from many state and federal agencies who are dealing with similar challenges.

Closer to home, Connor conducted career outreach to students at North Pole High School in North Pole, Alaska. On two separate occasions, Connor spent the day giving presentations about engineering careers to classrooms of students, and helped them think about whether the profession might be a good fit for them. Connor is now working with teachers on developing a more formal version of this outreach for future classes.

AUTC Researcher Andrew Metzger, Assistant Professor of Civil and Environmental Engineering at UAF, is conducting research of interest to numerous stakeholders concerned about marine infrastructure in Alaska.

Last summer, Metzger gave an invited presentation on the challenges of and need for arctic maritime transportation infrastructure to the U.S. Senate Commerce Subcommittee on Oceans, Atmosphere, Fisheries, and Coast Guard. Alaska Senator Mark Begich, the Committee's Chair, invited Metzger to make the presentation.

In February, Metzger gave a similar presentation to colleagues of the American Society of Civil Engineers in Fairbanks. He

"Sandy Lego RC Derby" at the Annual Engineering Open House on Saturday February 25, 2012. Learning the fundamentals of soft-soil road design, kids attempt to keep their RC cars on a paper-track road built on a soft sand foundation in this simulated island. (Photo Courtesy: J. Liu)



discussed the feasibility and technical challenges of developing an arctic port in Alaska.

In June, members of the U.S. Department of Defense Alaska Command met with AUTC and other researchers at the Institute of Northern Engineering for a round of research presentations on arctic and cold-region engineering issues. Several researchers presented, including Metzger, who discussed the opportunities, needs, and challenges of developing Alaska's arctic marine infrastructure.

During this time, a noteworthy development occurred when **INE and AUTC launched the new Marine North Research Program**, which Metzger will lead. The program will focus on marine transportation in northern latitudes, and all engineering aspects surrounding it. The program will provide technical support for policy development and will address the research needs of government and private industry stakeholders, including:

- » Oil, gas, and mining industries.

- » Financial service firms.
- » Federal agencies such as the Department of Homeland Security, Department of Defense, U.S. Coast Guard, and Department of Interior.
- » State agencies like the Alaska DOT&PF, Department of Environmental Conservation, and Department of Commerce, Community, and Economic Development.

The program will leverage UAF's expertise in arctic issues like frozen ground engineering and arctic marine infrastructure, and will capitalize on collaborative relationships with the Geophysical Institute and International Arctic Research Center at UAF. The effort will expand these research capacities to potentially include planning, design, construction, and maintenance of arctic marine infrastructure.

In February, the **College of Engineering and Mines at UAF hosted its annual Engineering Week**, culminating in an open house throughout the Duckering Building.



Marc Luiken, former Commissioner of the Alaska Department of Transportation and Public Facilities, talks with students and faculty following his engineering career talk at the College of Engineering and Mines at UAF. (Photo Courtesy: AUTC)

The free event featured workshops and demonstrations from researchers, students, and staff, and was open to the public. Among the demonstrations was a workshop by **AUTC Researcher Jenny Liu**, Associate Professor of Civil and Environmental Engineering.

Liu ran a fun, interactive activity for kids called the “Sand Lego RC Derby.” Learning the fundamentals of soft-soil road design through a hands-on activity, kids raced remote control cars around a paper track that was laid atop a sand surface on a simulated island. The cars naturally experienced problems because the thin surface they raced on had an unstable foundation.

This simple concept underlies a broad range of research in AUTC in the areas of permafrost, soil stability, slope stabilization, soil liquefaction, and other topics involving sub-surface thermal and soil dynamics. Through Liu’s fun, interactive activity, relatively young children were able to learn these principles through an accessible kinetic game.

In April, the **College of Engineering and Mines and AUTC hosted a workforce development lecture by Marc Luiken, who was then Alaska Commissioner of Transportation and Public Facilities**. Given before a full house of students, researchers, faculty, and administrators from across multiple engineering disciplines, Luiken’s address highlighted opportunities in the Alaska DOT&PF, and the department’s need for engineers trained in cold-region transportation issues.

Luiken discussed Alaska’s job-growth statistics, and Alaska DOT&PF’s role as a major public employer of engineers. He outlined positive impacts on multiple engineering disciplines—mechanical, civil, environmental, electrical, petroleum, and mining—as the state expands its road system. Through an initiative known as “Roads to Resources,” the state will extend three new transportation corridors to areas where additional engineering opportunities will arise. In addition, Luiken provided several figures

that painted a promising picture for engineering students and engineers about to enter the workforce:

- » In 2010, Alaska DOT&PF had more than 700 engineering positions.
- » Between 2008 and 2018, projections show 240 engineering job openings per year.
- » A 10.3% growth rate in Alaska engineering jobs, with more than 700 new positions through 2018.

The state of Alaska is also part of a major effort to increase the number of engineering graduates from the University of Alaska system. As roughly 70% of UA engineering graduates seek employment in Alaska following graduation, support of the engineering programs at UAF and UAA are the focus of this effort. Luiken applauded a 2007 Alaska Board of Regents approval for an initiative to graduate 200 engineering students by 2014. He also noted a 2011 Regents decision that set a priority to more than double the number of annual baccalaureate graduates. He praised 2011 legislation to fund construction of engineering facilities at UAF and UAA.

Luiken’s address included a lengthy question-and-answer period, and he stayed after the lecture for conversations with students. He encouraged all in attendance to visit Alaska DOT&PF’s job and internships web page to pursue opportunities with the department.

AUTC BY THE NUMBERS

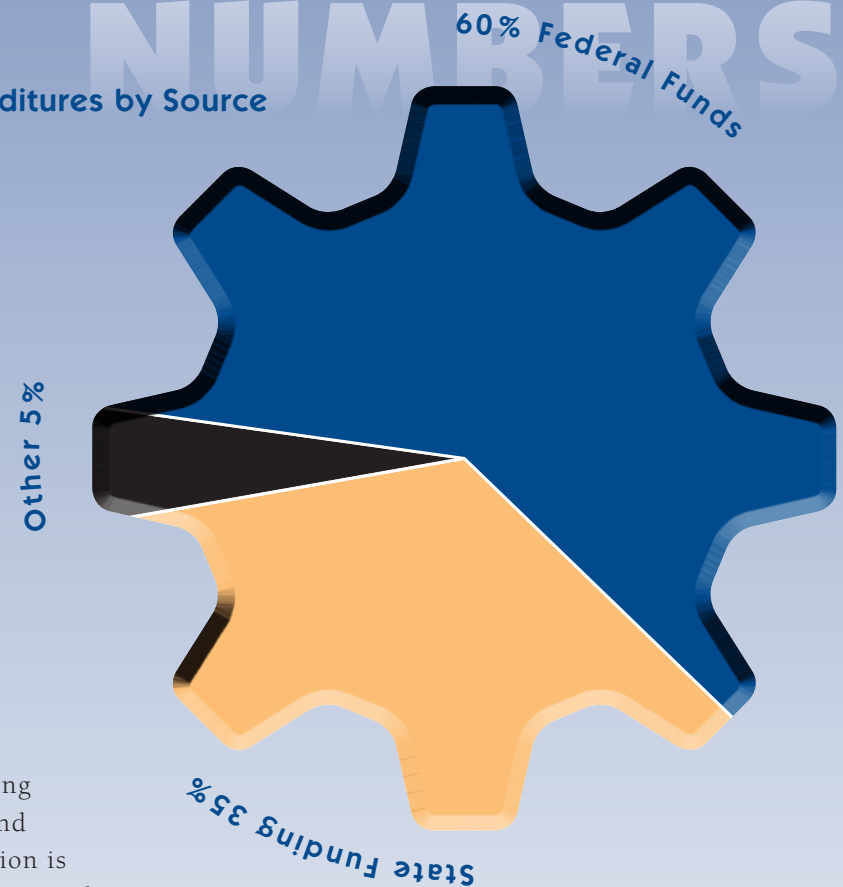
AUTC Annual Expenditures by Source

In 2012, AUTC received a total of \$3,429,063 funding from the U.S. Department of Transportation's Research and Innovative Technology Administration (RITA), plus an additional equivalent amount of matching funds. Since the beginning of RITA's University Transportation Center (UTC) program, AUTC has received over \$17 million in federal funds.

The USDOT RITA grant requires 1:1 matching of funds over the life of the grant. Although individual projects and annual budgets may vary slightly in cost share level, AUTC is on track to meet this match commitment by program end. This 1:1 commitment makes AUTC a program valued at over \$34 million from inception. Value, however, is not something we can put a number on. Research is AUTC's primary focus, representing 79% of annual funds, but the benefits from the multitude of projects and project partners is quite substantial. For example, gaining a lasting relationship with Alaska DOT&PF; this relationship will outlive many of the projects and impact State and University collaborations in the years to come.

AUTC's partnerships with Pacific Region UTCs (Region 10) and Alaska DOT&PF are also growing stronger. More and more pooled fund studies are underway, communication is stronger, and people are learning that working with a neighboring state or university can yield great outcomes.

The Private sector and industry partners are also seeing the value of AUTC. AUTC has received substantial amounts of in-kind donations, enabling more complex research projects. The leveraging of our partner organizations has already turned into future work for the AUTC. Products, time, and operational support are just a few items that AUTC has received from private sector partners.



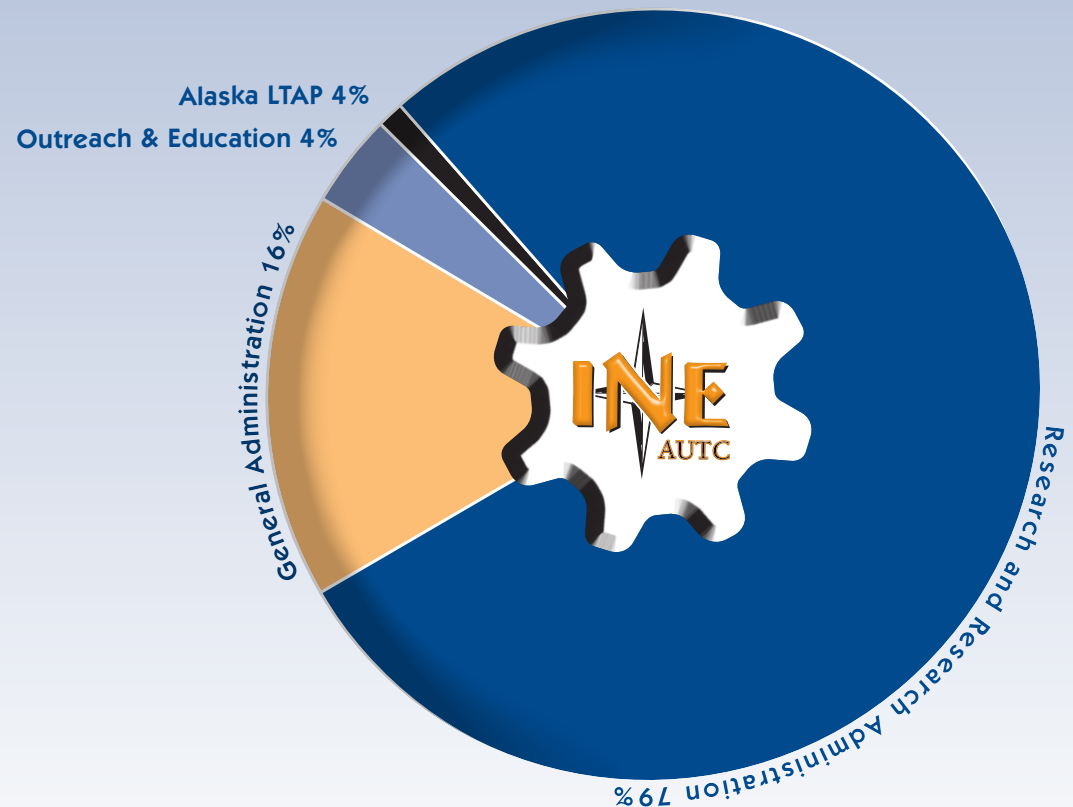
Funding Year	Federal Funds	Other Funds
2012	60%	40%
2011	57%	43%
2010	66%	34%
2009	55%	45%
2008	39%	61%
2007	44%	56%

Being the farthest north national UTC, AUTC has advantages to working with other international agencies and universities that have the same cold weather conditions and problems. International collaborations build awareness of AUTC's unique expertise and allow the Center to access world-class partners. Researchers also have more opportunities to share unique laboratory facilities, cutting-edge software and technology, and other research tools.

An important component of our work that is not fully captured in our expenditure statistics is the scope of our outreach and technology transfer activities. The majority of our public interface, workforce development, and specialized training is funded at the project level as part of each individual project's deliverable. Because of the value we place on implementation, most dissemination and outreach activities are linked to individual projects and funded through direct project and research funds. AUTC's budget statistics for outreach and education reflect only funds dedicated to support for Alaska LTAP, conferences, support for the UA Construction Certification program, and other similar endeavors.

This outreach and education tangibly enhances AUTC's work outcomes. By transferring knowledge from our researchers into the hands of community transportation managers, state engineers, geologists and other specialists, these activities enhance the applied value of our work in ways that numbers do not reflect. These efforts also boost the return on investment for our federal, private, and state level funders.

AUTC Annual Expenditures by Type



AUTC Metrics

Funded Faculty	46
Funded Students	84
Funded Staff/Research Temporary/Other	54
Funded Research Projects	104
Patents Pending	1
Applications to Market	2



A major portion of AUTC's current project portfolio includes programs aimed at enhancing transportation asset management (TAM).

Generally speaking, TAM applies economic management principles honed in the private sector to public transportation. Emphasizing “business and engineering practices for resource allocation and utilization,” TAM enables “better decision making based upon quality information and well-defined objectives,” according to the American Association of State and Highway Transportation Officials’ subcommittee on Asset Management.

Within Alaska DOT&PF, multiple research, data integration, and management programs are currently underway to help broaden the department’s TAM implementation. The Alaska DOT&PF Commissioner identified asset management as the second of six key initiatives the department will target in its new strategic plan. AUTC is supporting these program initiatives through multiple projects to provide a critical knowledge base outside of the U.S. Department of Transportation.

AUTC’s research projects in this area enhance TAM implementation at both the project and organizational level. From developing a framework for managing Alaska’s Geotechnical Assets to enabling the City of Anchorage to monitor real-time traffic and navigation monitoring, AUTC is facilitating organization-level asset management. At the program and project level, topics like pavement preservation, life cycle cost analysis, and rural runway

inspection have become the focus of efforts to develop software, interactive databases, working guides, and intensive trainings for Alaska DOT&PF personnel.

In each of these projects, AUTC is helping advance transportation expertise and technology in the context of specific asset management challenges presented by state partners—from technology integration and knowledge base growth to workforce development.

Ongoing TAM Projects

Geotechnical Asset Management (AUTC #510016) Andrew Metzger, University of Alaska Fairbanks (UAF)

Geotechnical assets—things like rock and soil slopes, shore protection, embankments, retaining walls, material sites, bridge foundations, tieback anchors and more—literally touch or affect every other physical asset owned by the Alaska DOT&PF. Because of this strong interconnection, effective management of geotechnical assets is necessary to maintain the level of transportation safety and service required by Alaska DOT&PF to serve the state’s wide variety of users.

This project is developing a framework for addressing challenges related to geotechnical asset management (GAM) that can be

implemented with other asset management systems.

Overcoming the several salient challenges GAM brings is integral to any comprehensive management approach. Unpredictable service life, financial accounting complexities, and difficulties with maintenance performance are among the proven obstacles to managing geotechnical assets within most infrastructure organizations, including those in Alaska. Researchers are producing a program “road map” for transportation-related GAM in Alaska. This draft program framework will include specific planning recommendations for implementing GAM across the range of geotechnical assets owned by Alaska DOT&PF.

So far the research team has completed the necessary contracting and agency interface needed to support this broad statewide effort. Now that discussions and feedback sessions with key regional leadership within Alaska DOT&PF have taken place, the team is moving forward with its next phase of research.

Information Gathering Infrastructure: Toward Intelligent Transportation (AUTC #510018) Jeffrey Miller, University of Alaska Anchorage (UAA)

Alaska DOT&PF has made strides in recent years towards a more “intelligent” transportation infrastructure, primarily in the Anchorage metropolitan area. Much of this work has overcome costly limitations to data collection and examination. Such research is often

AUTC researcher Jeff Miller, Associate Professor of Computer Systems Engineering at UAA, has helped Alaska DOT&PF and the Municipality of Anchorage develop a multi-faceted intelligent transportation system platform for the city. (Photo Courtesy: J. Miller)

Opposite: Andrew Metzger leader of AUTC’s new Marine North Research Program. (Photo Courtesy: A. Metzger)

constrained by a lack of real-time data analysis and typically relies upon privately owned cellular communication towers to relay necessary but costly data.

This project is developing multifaceted data collection infrastructure for state and municipal stakeholders. The research team has created and employed independent communication towers to transmit data through a Vehicle-to-Infrastructure (V2I) network, allowing for real-time, city-wide data analysis minus the costs of commercial tower use. Alaska DOT&PF now has a volume of vehicle information available in real time. Never before in Alaska has this information been exposed through a web interface, with data transmitting live over a novel V2I architecture that can operate in perpetuity.

Another innovation in this research in the use of vehicle On Board Diagnostics (OBD) ports to gather data from the vehicle’s computer system to transmit over the V2I network. Hosted at



UAA, the database server utilizes customized components designed with structural, modal, and dynamic finite element analysis techniques. Manufactured and fabricated in the UAA machine shop and design studio facilities, the system, along with its manufacturing and assembly drawings, are becoming available for AUTC’s partners at Alaska DOT&PF.

The OBD system’s benefits will be made available to a variety of other agencies as well. Researchers are designing a protocol through which other agencies and public institutions may access the server. The protocol will have specific guidelines on data retrieval, information collection requests, and specifications on scalable interface design to support future applications and projects. Including such information as revolutions per minute (RPM), fuel consumption, acceleration/deceleration rates, engine/cabin/

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outside temperature, tire pressure, and tire rotation, this data will be useful for numerous other public entities, researchers, and planners.

In recent months, the research team has begun integrating another innovative component to the study by creating a robotic test bed for simulations using 1:24 scale radio-controlled cars. After receiving routers and hardware, the team is now building an entire simulator while simultaneously developing a video camera that acts as a GPS satellite for future simulations. The next phase of work includes the purchase of system servers and integration of the overall simulation system. The team is preparing a conference paper on its work for an upcoming international conference in Anchorage.

Knowledge Transfer Needs and Methods (AUTC #510009) Robert Perkins (UAF)

While many TAM resources are technical, human resources are also a factor of asset management. An emerging challenge for Alaska DOT&PF is knowledge transfer, as nearly a third of its workforce will soon become eligible to retire. This dilemma elevates the importance of passing knowledge from more experienced employees to newer hires, and gives AUTC an opportunity to address a key workforce need for its state partners.

This project will give Alaska DOT&PF tangible implementation tools to enhance the knowledge-transfer process. Focused primarily on engineering and technical

fields, the project will provide recommendations to the department addressing recruitment, retention, and succession planning. Dr. Perkins and his team are identifying barriers to knowledge transfer, such as manager reluctance, corporate culture, and history. They are also conducting focus groups with managers and professionals to determine the most effective available tools to improve the knowledge-transfer process within the department. Researchers recently interviewed over 40 Alaska DOT&PF managers and engineers, both veteran and current employees, to determine the methods by which they learned their jobs, or critical parts of it. Results of the interviews are being analyzed, and focus group meetings will soon be scheduled to determine how more efficient knowledge transfer techniques might be implemented in a project-orientated organization.



Updated Precipitation Frequency Estimation for the State of Alaska (AUTC #207119) Douglas L. Kane, Svetlana Stuefer, and Amy Tidwell (UAF)

Designing and building river and stream crossings such as bridges, culverts, buried utilities, and pipelines is a costly exercise. When designing these structures, a hydraulic engineer's goal is to evaluate and accommodate potential flood flows while minimizing construction and maintenance costs throughout the structure's service life. Central to this task is having good information on potential future rainfall, stream flows, and precipitation.

Until this project was completed, such data on waterway crossings was sparse in Alaska. In the early 1960s, distributed maps of rainfall intensity were developed for a range of durations (30 minutes to 10 days) and frequencies (1 year to 100 years) using historical precipitation data available at the time. Since then, a great need has emerged for updated precipitation maps that make use of more recent precipitation data.

In 2008, this research team partnered with the National Oceanic and

Left: Utilizing data from far-flung precipitation gauges throughout Alaska helped AUTC's "Updated Precipitation Frequency Estimation" researchers better account for the state's diverse topography and precipitation. Left: One of many remote gauges used in the study. (Photo Courtesy: S. Stuefer)

Atmospheric Administration to refashion the intensity-duration-frequency (idf) analysis for the state of Alaska using the most recent data up to 2010. Researchers have compiled data from over 1,000 stations, federal and state agency databases, and several university institutions. They used the data to format, examine, merge, and conduct preliminary idf value estimations, as well as initiating external review of spatially distributed estimates for locations across Alaska. After this extensive data integration, the team created new maps and developed a user-friendly online mapping display with point-and-click estimations and a variety of querying capabilities.

Enriching the map's utility for stakeholders across Alaska, researchers have given several conference and public presentations on their work, as well as numerous meetings with stakeholders who have already put the new data to use.

The results of this study will be available online in an electronic format in November 2012 as Volume 7 of the NOAA Atlas 14, "Precipitation-frequency atlas of the United States."

Right: One of many remote weather and precipitation gauges used for Doug Kane, Svetlana Stuefer, and Amy Tidwell's project, "Updated Precipitation Frequency Estimation for the State of Alaska." (Photo Courtesy: S. Stuefer)

Gathering Vehicular Parameters through a Vehicle-to-Infrastructure Intelligent Transportation System (AUTC #410024) Jeffrey Miller (UAA)

Intelligent Transportation Systems (ITS) combine communications technology, data, and transportation infrastructure to supply city planners and other decision makers with information on how and when traffic moves, particularly in an urban area. Potentially reducing highway accidents by 25% in rural areas and 30% on urban freeways, ITS technology can improve public safety considerably and offer millions in cost savings, according to Iowa State University research.

This project builds upon ongoing work, applying ITS technology to the urban transportation system in Anchorage, Alaska. Recent work ("Assessment of Traffic Congestion

in Anchorage Utilizing Vehicle-Tracking Devices and Intelligent Transportation System Technology," see page 19) tracked the speed, location, and direction of vehicles in Anchorage. This new study improves tracking by enhancing the data these systems use.

The current system only collects data on a vehicle's speed, location, and a unique anonymous identifier. With a system that transmits vehicle data as a text message to a central server through existing cellular telephone networks, researchers are gathering and transmitting additional information to a central server through a vehicle-to-infrastructure (V2I) network. The network collects data from a vehicle's On Board Diagnostics port. It includes engine revolutions per minute, fuel consumption, and acceleration/deceleration rates. Many vehicles will also provide data about engine temperature, interior and exterior temperatures, tire pressure and rotation, and tire slippage—a key advancement for stakeholders in the Alaska DOT&PF. Identifying tire-slippage areas allows the system to alert drivers and state maintenance response crews about dangerous locations through web interface and real-time text messages. (The project makes real-time traffic conditions available to Anchorage travelers online at www.alaskatraffic.net.)

In its recent phase, the project has created additional data-transmitting devices to expand current collection capacity. The team is developing plans to



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install and deploy devices in winter snowplows. In coming months, researchers will continue data collection, potentially including snowplow information, and test new devices in the field.

Fairbanks North Star Borough Road Upgrading Process (AUTC #309020) Billy Connor (UAF)

This project helps transportation planners in Interior Alaska's largest population center by developing a road-upgrade decision process. Using innovative technology and process design, the results will help maximize limited road budgets and increase the life cycles of priority roadways.

Roads in the city of Fairbanks, Alaska, and the greater Fairbanks North Star Borough (FNSB) serve a variety of important organizations under extreme climate and weather conditions. In addition to an international airport, two major U.S. military bases, and numerous defense installations, the road system supports extensive

commercial trucking and energy production as a conduit between southern Alaska and the North Slope oil fields. It also supports the city of Fairbanks, with its flagship state university, numerous federal agencies, the seasonal tourism industry, and a growing population. Despite these varied needs, FNSB's transportation planners are constrained by limited budgets, extreme environmental conditions, and unclear priorities.

Currently, FNSB planners lack adequate decision-making tools to prioritize road upgrades. Results of this project will help FNSB develop a rational, effective, and efficient process for scheduling road upgrades, including a decision process for either paving a given road or continuing with unbound surfaces without reconstruction. The resulting decision process will allow FNSB—or any county government nationwide—to maximize its road service area budgets.

The FNSB road system includes more than 470 miles of maintained roadways, connecting 109 local service areas. Road conditions vary among the service areas and even along individual roads. Unsurprisingly, maintaining drivability and meeting maintenance costs are the most common challenges, leading to frequent budget requests from service areas to the FNSB for surface upgrades. Without a carefully

designed process that considers the priorities, design options, and upgrade costs, FNSB cannot fully maximize its limited funding.

FNSB needs an effective systematic approach for prioritizing road upgrades. This project identifies and helps achieve long-lasting, cost-effective road improvement solutions. Its approach will include a system for examining and sampling potential upgrade sites, a simplified flexible pavement design method, a model for estimating associated costs, and a Decision Support System (DSS) based on a GIS platform. The study will address issues intrinsic to the road-upgrading process, such as dust reduction, emergency service needs, evaluation of how inadequate gravel structures will affect future paving demands, and the economics of the upgrading investment. Harnessing the latest technology to improve this process, researchers will integrate the results in the GIS-based DSS to help FNSB decision makers and engineers develop projects for effective and economical road improvement.

To date, the team has completed a trial version of a software platform which is being tested by FNSB staff. This test group will suggest alterations to the software for the final phase of development and testing.



AUTC Partner Angela Parsons, Research and Development Engineer for Alaska DOT&PF, discusses the cost-saving benefits of pavement preservation with a TV reporter at the 2011 Alaska Asphalt Pavement Summit in Anchorage. (Photo Courtesy: AUTC)



Including Life Cycle Cost Analysis in Alaska Flexible Pavement Design Software (AUTC #309023) Juanyu “Jenny” Liu (UAF)

When something you buy breaks down, it costs money to replace it. And when something you buy needs constant repair, it costs a lot to repair it. These simple concepts underlie life cycle cost analysis, which Alaska’s transportation engineers use to make decisions about the materials they purchase. It is also the focus of innovations this project is developing for Alaska’s Flexible Pavement Design software.

Life cycle cost analysis (LCCA) is a key consideration for selecting materials and techniques that optimize the service life of a pavement in terms of cost and performance. While the Alaska Flexible Pavement Design (AKFPD) software has been in use since 2004, no computerized analysis tool exists to help pavement engineers develop cost

Jenny Liu, Associate Professor of Civil and Environmental Engineering at UAF, is leading AUTC projects on life cycle cost analysis and pavement preservation, key tools for Alaska DOT&PF’s asset management programs. Left: Liu at a runway pavement project at Ted Stevens International Airport, Anchorage, AK. (Photo Courtesy: J. Liu)

analyses for a given project. Including LCCA in the AKFPD software would benefit pavement designers substantially, allowing them to routinely improve infrastructure performance while making more cost-effective use of the design effort.

This study will update the current AKFPD program and create a single software package capable of executing economic cost analyses and structural analysis functions. Upon completion, of this project, researchers will provide the updated software, a modified AKFPD manual, and case studies with complete analysis processes to help a new user navigate the software.

The project team has developed a new layout for the program. It has added new modules as well, including “equivalent single axle loads calculation” and “LCCA analysis,” and designed more user-friendly interfaces for two other modules, “Mechanistic Pavement Design” and “Excess Fines Design.” These innovations will help engineers improve the cost effectiveness of their projects by enhancing the life cycles of materials they choose.

[Model of Alaska Transportation Sector to Assess Energy Use and Impacts of Price Shocks and Climate Change Legislation \(AUTC #309002\)](#)
Virginia Fay (UAA)

Alaska’s economy is vulnerable to changes in energy prices. Alaskans have a higher dependence on energy resources and are more vulnerable to

energy price volatility than residents and businesses in most other states. According to the Energy Information Administration, Alaska consumes 40% more fuel per capita than any other state—more than triple the national average.

This project is examining how volatile energy costs impact Alaska’s economy. Key industries, fishing, mining, tourism, and transportation, as well as subsistence activities, currently depend directly on liquid fossil fuels. At the same time, Alaska’s urban service economy relies heavily upon the relatively low cost of living and doing business (compared with costs in Alaska’s rural regions) made possible by cheaper fuels.

Researchers are developing a model of Alaska’s transportation sector to see how changes in fuel prices or use may affect activities in the state. Part of a UAA Institute of Social and Economic Research (ISER) program titled “Energy in the Alaska Economy,” it examines connections between energy use, energy prices, climate policy, and economic activity. Results will inform public policy makers about how energy use and rising fuel costs impact Alaska transportation, tourism, and fisheries.

So far, the team has finalized data collection and refined its research organization process. It has also begun utilizing energy-use modeling to integrate barge freight—a significant commercial factor—into the study. In coming months, the

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project will initiate input-output modeling of the transportation sector to estimate the impacts of changes in fuel prices on Alaska's economy, conduct additional statistical analyses, and prepare final reports.

Life Cycle Cost Analysis for Alaska Bridge Components (AUTC #207083)

J. Leroy Hulsey (UAF)

Decaying infrastructure and limited renewal funds are moving our national transportation system toward crisis. Which bridges are past their service life? Which could function safely for another decade? What will it cost to replace them? The U.S. Department of Transportation has asked every state to develop a long-range plan (through 2030) for bridge replacement.

To meet this goal, Alaska must create a priority list and a plan to replace its own aging

infrastructure. The accepted design life for a bridge is 75 years, but this arbitrary number does not take into account new building techniques, seasonal stresses, or variations in frequency and size of vehicles supported, to say nothing of environmental stresses like scouring, ice damage, and earthquakes.

Bridges deteriorate in different ways, at different rates. A more accurate way to determine an existing bridge's service life is essential to the state's plan. The research team is collecting data on environmental conditions, material aging processes, repair records, and current costs. Results are contributing to a process for conducting life cycle cost analyses for highway bridges in Alaska. This project provides state planners and engineers with the tools to estimate an average cost per bridge, as well as the upper and lower bounds of maintenance and/or damage costs.

Developing Guidelines for Pavement Preservation Treatments and for Building a Pavement Preservation Program for Alaska (AUTC #410038) Gary Hicks, California Pavement Preservation Center, Juanyu "Jenny" Liu (UAF), Hannele Zubeck (UAA)

Alaska's extreme climate takes a toll on pavement. Harsh cold, repeated freezing and thawing, moisture buildup, and other environmental factors, along with commercial wear and tear, reduce roadway service life. The resulting maintenance costs continue to strain state and federal budgets. In the past, the practice has often been "repair the worst first," but this approach means that repairs are extensive and costly. Some decision-makers argue that more frequent and proactive maintenance can extend service life and reduce long-term costs. The state of Alaska has committed to



creating an active pavement preservation program, which requires development of program guidelines and solutions to road surface damage. This project—a joint venture between the California Department of Transportation (Caltrans), AUTC, and Alaska DOT&PF—will provide a basis for such guidelines.

Using field site visits and internationally-distributed surveys, researchers identified road repair methods that are more cost-effective and environmentally sound. They helped Alaska DOT&PF and local agencies find pavement preservation techniques suitable to specific environmental regions in the state.

Project findings will help the state realize considerable cost savings. Recent studies found that active pavement preservation programs can save more than 50% in maintenance costs over a road's 20-year life cycle. Proactive maintenance specifically tailored to Alaska's various climate regions should improve the condition of Alaska's roads and increase driver safety. End-users will enjoy reduced roadway noise and reduced skid occurrences.

Researchers at the California Pavement Preservation Center have developed an online database of preservation methods based

on results produced by UAA and UAF researchers. They have applied their specific expertise in Alaska's cold regions to field monitoring test sites and synthesizing the vast amount of information available internationally.

The team has prepared results that determine the best-performing techniques for Alaska and outline a process for selecting the appropriate preservation strategy for any given area and traffic scenario in Alaska. In the most recent phase of work, the research team presented results during two intensive training sessions for Alaska DOT&PF. The sessions included introductions and instruction on using the new database and pavement preservation treatment selection guide as well as a section on life cycle cost analysis.

To learn more about this project online, visit:
<https://sites.google.com/site/alaskap2/home>

Top: Ding Cheng of the California Pavement Preservation Center presents a pavement preservation strategy selection and life cycle cost analysis system for AUTC partners at Alaska DOT&PF. (Photo Courtesy: AUTC)

Bottom: Ding Cheng, California Pavement Preservation Center, instructing partners at Alaska DOT&PF on using a life cycle cost analysis system created during his work with AUTC. (Photo Courtesy: AUTC)



Opposite right: Pavement preservation has become a high priority asset management goal for Alaska DOT&PF and a major area of AUTC's partnered research with the state of Alaska. Above: Pat Kemp, Deputy Commissioner of Highways for Alaska DOT&PF discusses the value of pavement preservation at the 2011 Alaska Asphalt Pavement Summit in Anchorage. (Photo Courtesy: AUTC)

Opposite left: AUTC Partner Gary Hicks, Technical Director of the California Pavement Preservation Center, has led multiple projects on pavement preservation in Alaska. Above: Hicks presents his work on pavement preservation at the 2012 International Society of Asphalt Pavements in Nanjing, China. (Photo Courtesy: G. Hicks)



In addition to being America's most seismically active state, Alaska has climate and environmental factors that pose unique and significant threats to structural integrity.

These factors have enriched the value of AUTC's structural integrity research for both state and national stakeholders. The Center's research program on seismic bridge design, for example, has yielded insights that have helped rewrite seismic design codes in Alaska and nationally. This work led to advancements that will potentially produce millions of dollars in long-term cost savings through improved design, mitigation, failure prevention, and retrofitting. Researchers estimate that nearly one-third of the nation's 600,000 highway bridges are currently in need of repair or replacement, and revised designs will enable more cost-effective improvements.

In other areas of structural integrity research, partnering with other institutions and state agencies is helping AUTC leverage expertise, facilities, software modeling, and analytical capabilities to create an aggregate benefit for research stakeholders. From structural health monitoring and collision protection to soil liquefaction and corrosion mitigation, these partnerships are helping address a diverse portfolio of research topics for structural design experts and engineers. This work is helping stakeholders extend asset life cycles, reduce risk, and improve safety for the public and commercial customers.

Structural Integrity Ongoing Projects

Overheight Vehicle Collision Protection and Detection System for Cold Region Highway Bridges (AUTC #510024) Pizhong Qiao (WSU) and J. Leroy Hulsey (UAF)

States like Alaska and Washington are addressing a trend in which overheight commercial vehicles are colliding with bridge structures, causing damage, increasing costly maintenance, and shortening the functional life of the bridge. This research partnership, led by Dr. Pizhong Qiao of Washington State University and J. Leroy Hulsey of the University of Alaska Fairbanks, is evaluating a system of high-energy-absorbing materials and "smart" sensors customized for cold regions to address this problem.

The system uses lightweight and high-energy-absorbing honeycomb sandwich materials, also known as Impact Laminated panels (I-Lam). The research team is integrating this system with smart impact sensors and remote sensing technology to create an impact detection warning system to protect bridge girders.

Remote detection technology allows the system to deliver information from areas that are difficult to access during cold weather so that researchers can monitor the warning system online. The team is improving rapid construction and installation techniques by using lightweight honeycomb sandwich materials and modular cold climate units. They are collaborating

with counterparts at UAF, WSU, Washington State Department of Transportation (WSDOT), Alaska DOT&PF, the Ohio DOT, and the Federal Highway Administration (FHWA) to bring multiple knowledge bases to bear on the project.

In recent months, the team has completed design of an impact protection and detection system, and conducted analysis, optimal design, and correlations or validations of quality control tests. It also has succeeded in numerical modeling and analysis of the system and evaluated its energy absorption. The group is now calibrating and monitoring an installed smart detection system.

Structural Health Monitoring and Condition Assessment of the Chulitna River Bridge (AUTC #510015) J. Leroy Hulseley (UAF)

Bridge safety and performance are national transportation priorities, and remain important challenges for Alaska DOT&PF. New research on innovative structural health monitoring (SHM) technologies currently underway at UAF is helping address these challenges. This project is developing SHM protocols for maintenance and repair of bridges in cold, remote regions. Once implemented, these new technologies and processes can extend bridge service life.

Through remote monitoring and on-site evaluations, the research team is examining the Chulitna River Bridge, an 800 foot bridge in Trapper Creek, Alaska, using the structure as a case study to develop unique SHM

instrumentation and protocols for use on this and other bridges throughout Alaska. The team is installing sensor and remote monitoring equipment and coordinating extensive logistics with contractors, adjacent landowners, and Alaska DOT&PF.

The SHM system will use a variety of sensors to monitor and measure structural and environmental conditions, providing the information necessary to continuously evaluate bridge performance and safety.

The system will monitor the behavior of defects or irregularities, collecting and relaying data on the bridge's structural integrity. The data will provide reliable information to improve decision-making about timely maintenance, repair, and closure needs.

Opposite: Students install instrumentation as part of the “Structural Health Monitoring and Condition Assessment of the Chulitna River Bridge.”

Right: Students inspect supports on the Chulitna River Bridge. Photos Courtesy: M. Fisher



Structural Integrity

Improving safety performance by remotely providing more reliable information quickly on the structural health of any monitored bridge, the system will provide a new safety and management tool with monitoring capabilities that complement traditional bridge inspection methods.

A more effective SHM system can:

- » Provide structural response data for better decision-making;
- » Conform and augment visual assessment, improve inspection credibility and subsequent rating;



- » Assist transportation asset management efforts in assessing long-term bridge performance; and
- » Optimize inspection schedules, maintenance schedules, funding, and service life.

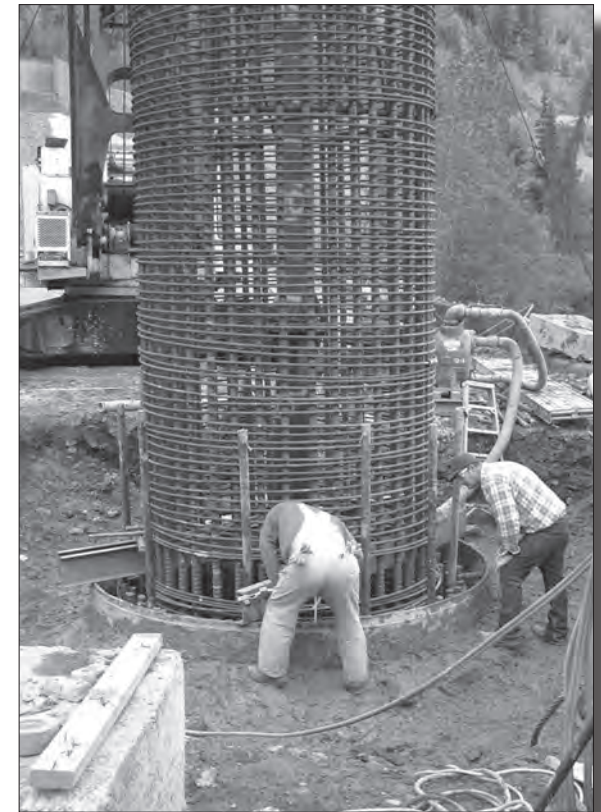
Alaska DOT&PF will use this SHM system to improve the structural conditions of certain Alaska bridges that are both regionally and nationally critical. For example, bridges such as those on the Dalton and Richardson highways serve as commercial supply routes from North Slope oil and gas resources to Interior and Southcentral Alaska, and from there to continental markets.

Identification and Laboratory Assessment of Best Practices to Protect DOT Equipment from the Corrosive Effect of Chemical Deicers (AUTC #510000) Xianming Shi, Montana State University-Bozeman (MSU), Billy Connor (UAF)

Reinforced concrete is used in many types of transportation infrastructure, but in cold-weather regions it may suffer significantly from unrecognized corrosion. Addressing AUTC's mission of maintaining cold-region transportation systems, AUTC is working with the TWI Corrosion and Sustainable Infrastructure Lab at MSU to develop a reliable, cost-effective corrosion monitoring system for existing reinforced concrete (RC) transportation structures. The resulting technology will provide a lower cost system for existing DOT RC structures in environments that have historically required more aggressive service for infrastructure and offer higher-quality

information on the material's condition. This technology will also detect corrosion initiation and propagation in RC structures at the earliest possible time, enabling condition-based maintenance strategies.

The team is pursuing four specific objectives: To improve and validate a sensor prototype for concrete-corrosion monitoring systems via benchmark lab tests; to develop quality control and sensor data interpretation algorithms; to make viable recommendations for implementing corrosion monitoring systems based on the existing Alaska DOT&PF inventory of RC



bridges; to deliver a deployable prototype sensor system, suitable for further field evaluation.

Forthcoming study results will enable more reliable assessments of life cycle performance for corrosion-affected RC structures. The project will also help minimize the impacts of corrosion on the durability, serviceability, reliability, safety, and aesthetics of reinforced concrete structures.

To date, the project has conducted probe calibration and sensor system performance evaluations, data plotting, and ongoing longevity testing, with promising preliminary results. In coming months, the team will continue sensor longevity testing and validate a sensor-embedding method, complete a lab demonstration of the pilot-scale system, and continue data and interpretation work to develop and refine the interface and algorithms.

Strain Limits for Concrete-filled Steel Tubes in AASHTO Seismic Provisions (AUTC # 510001)
Mervyn J. Kowalsky, North Carolina State University (NCSU) and Billy Connor (UAF)

Concrete-filled steel tubing is a key infrastructure component, and its integrity is a growing topic of concern for Alaska's transportation engineers. The state's

transportation infrastructure uses this type of tubing because of its strength and simple construction. However, because past research on concrete-filled tubes has dealt with tubes on a small scale and tubes without internal reinforcement, a number of important questions remain unanswered about how a particular application process will be used in Alaska.

This project addresses several problems specific to Alaska's climate:

- » The impact of reinforced steel on the behavior of the pile column;
- » The accuracy of analysis methods for predicting the force-deformation response of the pile column system;
- » The impact of the ratio of tube diameter to tube thickness (D/t ratio) upon the performance of the pile column at multiple limit states; and
- » The plastic hinge length for the below-ground hinge developed in the pile column.

To examine these problems, researchers are using a series of 10 large-scale tests on concrete-filled pile columns. They are also utilizing a finite element model capable of capturing all of the anticipated modes of failure, including local buckling of the steel tube. Using an

environmental chamber to capture the effects of low temperatures (-40°C), the NCSU team is conducting two tests on structural behavior and performance.

To date, the team has completed five tests and analyzed the subsequent data. In upcoming phases, the team will conduct six remaining tests and complete additional analyses before preparing reports and papers on the work. These results will provide construction guidance in Alaska by contributing to a concise design manual appropriate for Alaska DOT&PF use.



Opposite left: Bridge pilings are among Alaska's key infrastructure, and a growing area of focus for AUTC researchers. Here a crew works on a new bridge piling near Caribou Creek on Alaska's Seward Highway. (Photo Courtesy: Alaska DOT&PF)

Opposite right: Crew installing a bridge piling near Caribou Creek, Seward Highway, Alaska. (Photo Courtesy: Alaska DOT&PF)

Right: A bridge-railroad intersection in Interior Alaska. Alaska's frequent seismic activity makes bridge pilings a significant area of interest for AUTC's research on structural integrity. (Photo Courtesy: K. Hansen)

Structural Integrity

Ductility of Welded Steel Columns (AUTC #410001) Mervyn J. Kowalsky (NCSU) and Andrew Metzger (UAF)

Alaska is the most seismically active state in the U.S., a characteristic with detrimental implications for the state's bridge infrastructure. Bridges and the welded steel columns that support them undergo recurring strain from these seismic forces.

One of many partnerships between AUTC and North Carolina State University, this project seeks ways to strengthen bridges by improving their ability to absorb energy. Researchers are improving ductility, the ability of a structure to deform repeatedly into the inelastic range

without significant loss of strength or stiffness. This project, one of a series investigating how bridge and marine structures are designed, particularly in terms of connection between structure components, seeks to identify improved design approaches that produce the ductility and energy-absorbing capacities needed for Alaska's bridges.

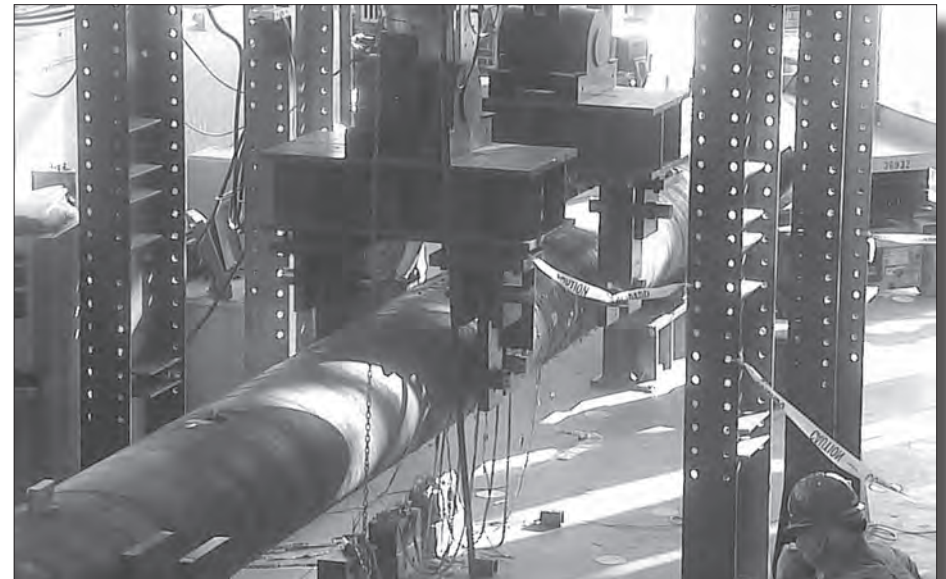
Previously, researchers identified both insufficient and improved construction methods. They found that several existing methods were inadequate, such as the current practice of fillet-welding a cap beam to a pile.

They also confirmed that a new method using a plastic hinge-relocating concept was more successful. This new approach reduced

the inelastic demands of the cap beam weld and forced the inelastic action to occur in the pile itself, displacing energy that might otherwise degrade the structure. Current research is optimizing this new design to improve energy-displacement capacity and ductility in bridge and marine structure design. The team is also investigating additional connection designs proposed by Alaska DOT&PF engineers.

In recent months, the team has conducted two seismic test experiments (grouted shear stud with axial load and truss pier connection). Upcoming research will include two new seismic tests, using a shake table, on a grouted shear stud, followed by analytical modeling and parameter studies to prepare final results and papers for publication.

Below: AUTC's partners at North Carolina State University utilize a unique seismic testing facility to conduct multiple tests on reinforced concrete and welded steel columns. Left: A bird's eye view of the testing facility. NCSU used a live, online web portal to stream real time footage of their seismic testing activities. On the right is a snapshot of a live test. (Photos courtesy: M. Kowalsky, NCSU)



The team's research is already being integrated into both state and national bridge design codes, where it will continue to improve steel bridges and marine structures. Anticipated benefits include extended bridge service life, reduced maintenance costs, and improved safety.

Effect of Load History on Performance Limit States of Bridge Columns (AUTC #410002)
Mervyn J. Kowalsky (NCSU), Utpal Dutta (UAA), and Andrew Metzger (UAF)

Alaska's bridge designers have concerns over the state's history of earthquakes and other seismic activity, and the unseen effects it may have upon existing bridges and other concrete structures. This project is investigating the

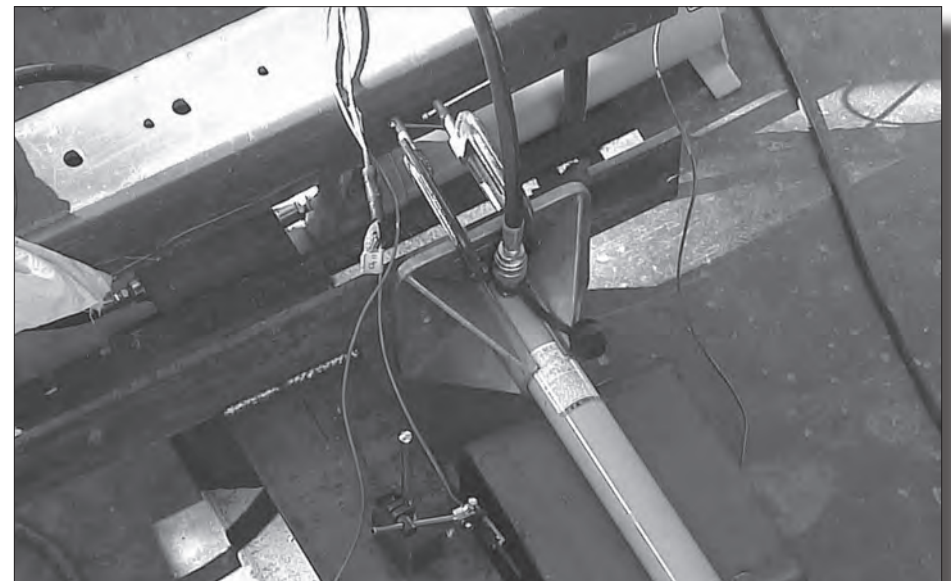
impact of seismic loading history on the design of reinforced concrete bridge columns typical of those used in Alaska.

Strain limit states are used by researchers when calculating the amount of stress that can be put upon a structure like a concrete bridge column, or a steel reinforcement beam. However, structural engineers currently use concrete and steel strain limit states that only have minimal experimental or theoretical basis. This team hopes to propose strain limit states that account for seismic loading histories specific to Alaska, and to relate these proposed strain limits to displacement limits used in testing designs for the state's bridges.

To date, the team has conducted 18 seismic tests at North Carolina State University's facilities. They have also conducted analytical work to predict bar buckling and reduce prior testing data. In the next phase of their work the team will conduct an additional ten tests before producing their final results and a set of recommendations for Alaska DOT&PF.

When complete, this research will provide Alaska DOT&PF engineers with tools to refine bridge designs, optimizing for regional seismicity and ensuring that bridges in Alaska remain safe in major earthquakes and serviceable in smaller earthquakes. This advancement will improve the reliability of bridges, decrease maintenance costs, and improve safety.

Below: Up-close views of seismic testing conducted at NCSU's facility. (Photos Courtesy: M. Kowalsky, NCSU)



Structural Integrity

Shake-table Experiments of Bridge Foundations in Liquefied Soils: An International Collaboration (AUTC #410015) Zhaohui “Joey” Yang (UAA)

Chinese and American engineers are no strangers to the lingering destruction caused by earthquakes. This project has brought together expertise from both nations to examine how earthquake-associated liquefaction threatens bridge foundations.

Soil liquefaction occurs when stress, usually caused by an earthquake or shaking, causes soil to act more like a liquid, losing stiffness and strength. A collaboration with China's University of Science and Technology, Beijing, this project is

sharing the costs of large-scale shake-table tests to investigate liquefaction-induced geotechnical engineering problems in cold regions. The valuable addition of these experiments augments AUTC's ongoing simulation project with physical testing data.

Liquefaction and associated ground failures have been common effects in major earthquakes across Alaska, causing extensive infrastructure damage.

Lateral spreading—subsurface soil shifts that often rip apart fixed infrastructure above the ground—is particularly damaging if a non-liquefiable crust rides on top of liquefied soil during an earthquake. This project is an

examination of liquefaction-induced ground failures and their consequences for highway bridge substructures and a validation of the results of earlier computer modeling.

A key area of interest is how frozen ground layers behave. The physical properties of a crust of frozen ground change drastically in winter. Stiffness and strength increase, while permeability decreases. The impact on a bridge foundation by a frozen ground crust resting on a liquefied soil layer and the loads generated during a winter earthquake are unknown.

To date, the project team has completed its testing phase, processed and analyzed the data, and begun computer model calibration and analysis. The team also has two conference papers on this work accepted and has prepared a journal article for submission. In coming months they will continue computer model analysis and submit another article for publication.

Frozen Soil Lateral Resistance for the Seismic Design of Highway Bridge Foundations (AUTC #510021) Zhaohui “Joey” Yang (UAA)

One of multiple efforts aimed at generating knowledge to improve highway bridge design for areas with frequent seismic activity, a UAA-lead project tested a fixity-depth approach and a lateral-resistance (p - y) approach in cold region seismic designs.



Left: Joey Yang and partners conducting shake table tests at China's University of Science and Technology, Beijing. (Photo Courtesy: J. Yang) Right: Joey Yang, Associate Professor of Engineering at UAA, is leading a collaborative partnership with the University of Science and Technology, Beijing, to conduct shake table experiments of bridge foundations in liquefiable soil. (Photo Courtesy: AUTC)

Although studies have been conducted on the mechanical properties of frozen soils, many of these were based on remolded, artificially frozen soil samples, which do not necessarily behave the same as soils in the field. Similarly, few stress-strain behavior studies have focused on small strains (rather than catastrophic failures), and few have made use of naturally frozen samples (as opposed to samples frozen in the lab).

Currently, Alaska DOT&PF utilizes a soil lateral-resistance approach in the seismic design of bridge pile foundations. Knowledge of lateral resistance of frozen soils, particularly seasonally frozen soils at shallow depths, can help improve pile foundation design in cold regions. This project involves laboratory experiments to examine mechanical parameters for frozen soils, particularly those used to construct the p - y curve for modeling frozen soils. Researchers are helping fill knowledge gaps by providing key information for typical Alaska soils. These soil parameters will help predict the formation and location of plastic hinges and internal loads in bridge pilings embedded in frozen soils during seismic loading.

To date, researchers have prepared and completed testing on 50 frozen soil specimens at sub-zero temperatures including -10, -7, and -2°C. The team has also completed modification of the Universal Testing Machine for unconfined compression test of frozen samples, including adopting a new data acquisition system capable of performing on-specimen strain measurements. In the next phase of research, they will continue machining frozen soil test specimens (preferably of a silty or sandy nature similar to Alaska's

soils), and will perform unconfined compression tests to address existing gaps in bridge data.

As it develops more information, this research team will hold a workshop for bridge design engineers to discuss its findings and how to apply them in the seismic design of bridges. Alaska is already incorporating this and related seismic bridge research into bridge design codes. This work has also been incorporated into the national code via the American Association of State Highway and Transportation Officials (AASHTO).

Seismic Performance of Bridge Foundations in Liquefiable Soils (AUTC #309010) Zhaohui “Joey” Yang (UAA)

What physically happens to a bridge foundation during an earthquake? And what if the bridge foundation sits on a frozen crust of ground resting upon a layer of liquefiable soil, which behaves as a liquid during an earthquake? How can engineers make bridges strong enough to withstand these natural forces? These safety issues are especially relevant to engineers in cold regions, but no seismic analysis guidelines exist to explain how frozen ground crust affects bridge foundations at a liquefiable site.

This project offers the first explanation of how bridge foundations withstand stress loads when a frozen crust is disturbed by liquefaction and lateral spreading. Researchers began this work by constructing a sophisticated model capable of simulating soil liquefaction and testing it. They used the model to simulate how a typical Alaska bridge pile foundation—one embedded

in liquefiable soils under a frozen or unfrozen crust layer—would respond to seismic activity. Preliminary results showed the bridge pile was very sensitive to crust conditions. When the crust froze, the bridge pile's internal forces changed by roughly 50%; this demonstrated a greater need for further research into this phenomenon.

Researchers are supplementing numerical simulations with an experimental component by conducting large-scale shake-table experiments with partners at China's University of Science and Technology, Beijing. Test data, including soil responses and pile internal forces, were used to validate the computer simulation results. The research team has completed model validation with shake-table test data and has validated a simplified approach based on a p - y frozen soils curve. In addition, they continue modeling activities on the non-linear behavior of piles in liquefiable soils and modeling design features such the gap between the pile and cap beam.

Outcomes are giving researchers a new understanding of how bridge foundations respond under such unusual stress, and how engineers can test structures when they design bridges in the future. Similar to Dr. Yang's other projects, this and related AUTC seismic bridge research has improved bridge design standards in Alaska, and, via the American Association of State Highway and Transportation Officials (AASHTO), in the nation.

Structural Integrity

Response of Pile-Guided Floats Subjected to Dynamic Loading (MISC2)

Andrew Metzger (UAF)

Pile-guided floats are structures that allow marine vessels to rise and fall with the tide without continuous attendance by shoreside personnel. Floats are subject to both wave action and vessel impacts. Analytically, these float-systems are somewhere between a fixed-dock and free-floating body. This makes analysis of the guide-piles, steel piles that allow the float to move up and down with the tide, challenging. An assumption of static (or constant) forces is not technically correct, because this assumption does not account for inertial forces due to lateral motion of the floating dock. Valid analysis of this system subject to dynamic (time-varying) loads is essential for safe yet economical designs.

Alaska DOT&PF is considering floating piers, already employed at a number of locations, for use at additional stops along the Alaska Marine Highway System (AMHS). However, little information is available on how to properly design the guide-piles for any given load environment. This project has developed a rational basis for estimating the dynamic response of floating pile-guided structures. Researchers created a model for two different systems that include functions representing wave action and vessel loading over time. At the project's end, AMHS and Alaska DOT&PF will have validated design charts ready to aid designers in estimating the forces guide-piles must accommodate. With the project nearly complete, the research team is looking forward

to sharing to advancing design capabilities for Alaska's marine infrastructure by sharing its results with state stakeholders.

Load Environment of Washington State Ferry and Alaska Marine Highway Landings (AUTC #309001) Andrew Metzger (UAF)

As pacific maritime trade grows, use of docking structures increases, and their performance becomes more important, from both an economic and a public safety standpoint. Hoping to improve structural design criteria and procedures, researchers designed this project to mitigate uncertainty and clarify assumptions about load demands on ferry terminal structures, specifically ferry landing structures.

For AMHS facilities, loads imposed on dolphin structures and mooring lines are a significant concern. Marine facilities that rise above the water but are not connected to shore, dolphin structures are used to extend piers, serve as ship cushions, or display information such as directions or warning lights. Mooring lines are the (often large) rope ties that connect ships to docks. The loads placed upon these structures can determine if a ship docks successfully or not, and how well it resists currents, waves, and other forces that might damage or send it adrift.

Due to a lack of information about the magnitude of these loads or how they may be determined, AMHS engineers are forced to make design assumptions. The Washington State Ferry System (WSFS) also confronts these uncertainties, specifically in the design of wing walls that accept vessels during loading/



Andrew Metzger installs instrumentation as part of the "Response of Pile-guided Floats Subjected to Dynamic Loading." (Photo Courtesy: J. Kwiatowski)

unloading of passengers and vehicles. While the structures used by AMHS and WSFS have fundamental differences, the metrics needed to determine appropriate design criteria are the same, and the instruments used to monitor these facilities are similar.

These similarities are this project's focus, one in which both Alaska DOT&PF and Washington State DOT are able to leverage research funding, allowing a much more comprehensive project than either agency could support individually. The collaboration serves shared interests in safely and efficiently operating ferry systems that run between Alaska and Washington.

The project team is developing a robust statistical sample of the metrics needed to better define vessel-impact design criteria. Data for this task was gathered by monitoring in-service facilities like the AMHS terminal at Auke Bay near Juneau, Alaska, and the WSFS Seattle terminal in Washington.

The research team has completed its field monitoring activities in Auke Bay and Seattle. The team retrieved field instrumentation in July and is currently analyzing this final season of data. Researchers are preparing manuscripts for professional journals.

Below: Low-density polyethylene membranes, coiled in stainless steel cages, and suspended at high tide, monitor the concentration of hydrocarbons in a marina equipped with creosote pilings. (Photo Courtesy: B. Perkins)



Selecting Preservatives for Marine Structural Timbers in Herring Spawning Areas (AUTC #410037) Robert A. Perkins (UAF)

Marine harbors and docking facilities are a central piece of Alaska's commerce, trade, and tourism industries. Alaska marine waters are also important thoroughways for the safe and efficient movement of people and goods to vast regions of the state that lack connected roads. Because wood is often economical to buy and maintain, Alaska harbors use it for many structures that come in contact with saltwater, including piles, floats, and docks.

However, wood immersed in salt water is prone to attack by marine borers that can destroy wood structures over the course of a few years. Only two wood preservatives are currently recommended for use in Alaska's waters, ACZA (ammoniacal copper zinc arsenate) and creosote, and both have side-effects.

A copper-leaching water-based preservative, ACZA is toxic to invertebrates and other species in the marine environment. Creosote, an oil-based preservative made from coal tar, leaches hydrocarbon chemicals into the water. While some research has been conducted on these chemicals, knowledge gaps still exist. Some research, for example, indicates that ACZA leaches copper only slightly after a year or so while creosote leaches polycyclic aromatic hydrocarbons at a declining rate over time and is still measurable after many years. Because harbors are frequently

contaminated with many other chemicals, determining how wood preservatives impact marine life independently over time is difficult.

This project is testing the toxicity of marine structural materials to herring eggs under a variety of conditions common in Alaska marine waters, focusing on Southeast Alaska. The study includes a comparison of the durability of creosote versus ACZA-treated marine timbers under similar climatic and service conditions.

This project aims to provide relevant information to Alaska DOT&PF to improve its selection of wood structural materials in the marine environment, especially the selection of wood-preserving methods. Results will help structural engineers and other marine specialists to make better-informed choices about wood preservatives that are both economical and environmentally sound. Researchers have performed toxicity tests on thousands of herring eggs and larvae using creosote-treated marine timbers, and have completed the biological and chemistry phases of this study. In upcoming months, researchers will prepare the final report and begin drafting results for publication.



Alaska DOT&PF personnel apply an experimental asphalt mix in southeast Alaska.
(Photo Courtesy: J. Liu)

AUTC's research on surface applications is providing knowledge and solutions about a widely shared concern of Alaska's transportation community: cost-effective surface preservation in harsh conditions.

Multiple modes of transportation benefit from studies in the area of surface applications. AUTC's research on deicing methods, for example, enables economical safety solutions for bridge, sidewalk, pier, runway, and roadway surfaces. Another area of research, addressing slope and soil stability, generates innovative ways to protect transportation surfaces, reducing maintenance costs and extending asset life cycles.

This surface preservation research draws on many disciplines and methodological approaches. Some projects, for example seek to improve chemical deicers through sampling and testing alternative solutions. Other efforts address better methods of testing concrete and aggregate degradation in cold climates. One AUTC team is experimenting with synthetic fluids and geofibers to stabilize soil while another is installing heated panels and carbon nanofiber paper to address icing. A major area of this work helped develop new instruments to test dust-control palliatives on rural roads and runways across Alaska.

AUTC's central aim throughout these varied projects is to advance the expertise and technology available to Alaska's transportation stakeholders. The Center is providing a critical knowledge base outside of federal transportation agencies—one that is both sensitive to and responsive to Alaska's unique transportation challenges.

Ongoing Surface Application Projects

Testing and Screening Surfacing Materials for Alaska's Yukon River Bridge (AUTC #410008)
J. Leroy Hulsey (UAF)

In one of Alaska's most important transportation corridors, a key bridge for commercial and industrial traffic needs decking replacement. This project is helping the state identify cost-effective alternative materials.

The Yukon River Bridge supports the two-lane Dalton Highway and the trans-Alaska oil Pipeline (TAPS) across the Yukon River. At a 6% grade, the bridge is 30 feet wide, more than 2200 feet long, and has six spans. It was designed to withstand -60°F temperatures, the force of huge ice loads on the river, heavy trucks hauling supplies to the oil fields, the bulk of the TAPS pipeline, and an additional natural gas line. It persists amidst

extensive use in some of the harshest conditions on the continent.

Unfortunately, changes in the timber market have made wooden decking a less viable option for Alaska DOT&PF. Over 30 years, the timber decking has been replaced several times—in 1981, 1992, 1999, and 2007. The trees that produced the original decking were massive old-growth firs, strong and close-grained. Subsequent decking has come from younger trees, which produce softer wood. As timber quality has decreased, time between replacements has decreased also, and material prices have increased.

To advance a cost-effective, performance-enhancing alternative, the research team is testing five wearing surfaces and surface treatments in both summer and winter conditions. The team has completed life cycle cost and initial capital cost analyses for each surface. The results have indicated both a financial and a safety incentive in this research. In coming months, the team will begin developing testing activities for an epoxy timber treatment alternative, and will begin low-temperature flexural tests for prequalified samples.

Understanding and Mitigating Effects of Chloride Deicer Exposure on Concrete (AUTC #510003) Xianming Shi (Montana State University-Bozeman, MSU) and Billy Connor (UAF)

While chloride deicers keep roads and runways free of ice, they often damage concrete surfaces and accelerate maintenance costs. Each year, U.S. transportation stakeholders spend more than \$2 billion to keep highways free of snow and ice, but use an additional \$5 billion to mitigate corrosion and environmental impacts caused by chloride deicers.

AUTC and the Western Transportation Institute's Corrosion & Sustainable Infrastructure Lab at Montana State University-Bozeman (MSU), are leading this effort to examine and minimize the costs of concrete damage and repairs caused by deicer exposure.

Partnering with the Oregon Department of Transportation (ODOT) and Alaska DOT&PF, project researchers are coupling laboratory testing of deicer effects on concrete with actual field exposure. This approach will help predict and reduce levels of chloride-related infrastructure damage. Through internal surveys,

Leroy Hulsey is leading a project to test and select cost-effective replacement decking for Alaska's Yukon River bridge. Pictured: Worn decking on the Yukon River Bridge. (Photo Courtesy: J.L. Hulsey)



Surface Applications

lab research, and field investigations, the team is also interfacing with these DOTs to assess the extent, effects, and possible mitigation of current chloride deicer use. When complete, this work will improve long-range infrastructure repair and replacement planning, advance the knowledge base on deicer/concrete interactions, and enhance concrete durability and sustainability.

Using multiple bridge deck samples and historical air temperature and freeze-thaw cycle data, the team has begun data assembly and preliminary analysis. They are examining and running a variety of tests on field concrete cores, including mechanical properties, absorption, air-void characteristics, staining, carbonation, and chloride penetration. The upcoming year will see continued work with other state DOTs to collect additional core samples. The team is also preparing and submitting a manuscript on the work for the 2013 annual Transportation Research Board meeting.

Develop Locally Sourced Salt Brine Additive for Anti-icing (AUTC #510006) Xianming Shi (MSU) and Juanyu “Jenny” Liu (UAF)

A research partnership between Montana and Alaska may bring considerable cost savings and safety improvements to Alaska’s roads. It may also allow certain commercial suppliers to transform a waste stream into a revenue source.

Xianming Shi from MSU’s Western Transportation Institute (WTI) and Jenny Liu (UAF AUTC) are investigating whether local agricultural or distillery by-products can replace high-cost proprietary products that enhance anti-

icing operations on Alaska roads. Counterparts at the Montana DOT have already found success with a similar effort, and Alaska hopes to realize this same potential.

Using a literature review, agency surveys, laboratory investigation, and follow-up field tests, researchers are developing and testing locally sourced salt brine additives to determine whether they are suitable for anti-icing during winter maintenance in Alaska. This determination will help improve traveler and commercial safety and mobility while reducing corrosion and environmental impacts. Results will also give Alaska DOT&PF more options for snow and ice control in its effort to provide sustainable, cost-effective winter road service. Moreover, in a time of widespread fiscal belt-tightening, this project offers more effective options in winter road maintenance, allowing Alaska DOT&PF to do more with the same budget.

Beyond reducing Alaska’s winter road maintenance costs, this research may boost local economic growth by helping build a new market for glycerol—the principal by-product of biodiesel production. This bio-based local material may be useful for dust suppression and soil stabilization as well, adding to the potential benefits of this research.

In recent work, the project team has surveyed locally available materials and conducted significant outreach with commercial producers of seafood, beer, biodiesel, and timber throughout Alaska. While developing a literature review and patent examinations, researchers will integrate new databases into the existing review

and will complete screening tests of commercial additives and several byproducts available in Alaska. This work will culminate in a statistical design experiment and full-scale testing of multiple anti-icing formulas for performance and impact.

Impact of Embedded Carbon Fiber Heating Panel on the Structural/Mechanical Performance of Roadway Pavement (AUTC #510022) Zhaohui “Joey” Yang (UAA)

Cold region roadway pavement deteriorates in the winter months, leading to many safety issues. South-central Alaska, and the city of Anchorage in particular, experience frequent icing events during winter freeze/thaw cycles. The resulting sidewalk, pavement, and bridge deck icing poses a significant hazard for travelers. An especially troublesome hazard known as “black ice” is a thin, shiny, slick layer of ice that becomes nearly invisible to drivers, pilots, and pedestrians.

This project is developing more cost-effective and sustainable deicing solutions to benefit users of many transportation modes. The research team is using carbon fiber tape (CFT) to create an environmentally friendly, anticorrosive deicing/anti-icing technology. With multimodal applications, this technology will be useful on bridge decks, roads, airport runways, street crossings, and high-use urban sidewalks.

Recently the research team ran deicing and anti-icing experiments that showed considerable cost reduction when compared to other electrical resistance heating type technologies. Researchers found that the new technology demonstrates

excellent deicing capability and has potential for application in the transportation industry. They have prepared new test concrete specimens, designed and built customized testing fixtures, and conducted experiments to monitor energy efficiency.

Continued lab and field work will address several other issues including: the impact of heating panels on pavement/bridge deck structural integrity, effects of coupled thermal and freeze-thaw cycling on pavement mechanical properties, and the impact of an electromagnetic field on steel reinforcement corrosion in bridge/pavement decks. The research team will create and test new specimens, and run comparative data analysis with past tests. Findings from the sidewalk test section and laboratory tests will be incorporated into a longer sidewalk that will be constructed on the University of Alaska Anchorage campus to evaluate the field performance of this new technology.

Automatic Electrical Deicing System using Emerging Carbon Nanofiber Paper: A Pilot Field Testing (AUTC #410014) Zhaohui Yang, UAA

This project is an investigation of carbon nanofiber to address a growing public safety risk in Alaska. Snow and ice on pavement and bridge decks are a persistent winter problem, when black ice—a thin, nearly invisible, and dangerously slick layer of ice—often covers

sections of coastal highways and bridge surfaces. A common cause of winter accidents, black ice is difficult for motorists to spot and even tougher for them to stop or slow down. All drivers in cold climates are affected by this problem.

This project is advancing an innovative option. State and municipal transportation agencies have tried various deicing strategies over the years, but many have unintended consequences for the environment and nearby structures. Salt, for example, is one of the most commonly used deicers because it is cheap and effective. Yet, it pollutes the environment and corrodes reinforcing steel bars in concrete, damaging bridges and other structures as well as vehicles. Other chemicals, like calcium chloride, magnesium chloride, and potassium acetate are costly for public agencies with limited budgets. Similarly, thermal anti-icing approaches like electric self-regulating sidewalks and roads are difficult and expensive to install and maintain. Alaska, as well as other cold regions, needs a safe solution to black ice that is both cost-effective and environmentally friendly—and one that will not corrode other structures.

Carbon nanofiber paper is composed of extremely tiny layers, similar to the way ordinary paper is made. This project is developing and testing an innovative deicing technology using electrically activated carbon nanofiber paper. It is simple to install, as engineers simply lay carbon nanofiber paper underneath regular pavement. This quick and



Anti-icing experiment facility on the University of Alaska Anchorage campus near the end of the 2011-2012 winter, in which Anchorage saw a record snowfall. (Photo Courtesy: Z. Yang)

Surface Applications

Below: a soil specimen after frost heave testing. The sample of Fairbanks silt is fitted with psychrometers (the white wires), used to measure suction changes from which we can back-calculate the unsaturated soil permeability. (Photo Courtesy: X. Zhang)



simple application minimizes interference during construction, and does not require changes in how the pavement is mixed or applied. If successful, this technology could lower operating and maintenance costs (compared to other deicing methods) by reducing corrosion damage. As the method avoids the use of chemical deicers, it may also reduce runoff pollution in local water bodies.

At a test installation on the UAA campus, use of this technology is being monitored over the long term to collect information on how the material performs under realistic conditions. The research team has installed a live camera at the site, accessible online at <http://alert.logitech.com>, where observers can watch the deicing and anti-icing experiments. With assessment of the system's reliability and cost-effectiveness, the team has completed its research and is preparing a final report and recommendations for implementing this system in Alaska.

Rapid Determination of Unsaturated Moisture Diffusivity for Soils during Frost Heave (AUTC #510017) Xiong Zhang, Gang Cheng (UAF), and Rifat Bulut, Oklahoma State University (OSU)

Frost heave and annual thaw cycles pose great risks to transportation infrastructure, raising maintenance costs and undermining transportation service and safety. Unsaturated soil mechanics and unsaturated water transmission

are key factors in understanding frost heave and thaw weakening problems typical in northern regions. Results will provide guidelines that engineers can use to reduce frost heave damage.

This project is generating practical ways for design engineers to incorporate the significant progress researchers have made in understanding unsaturated soil mechanics over the past two decades. This project—a partnership between AUTC, Alaska DOT&PF, and the Oklahoma Transportation Center (OkTC)—is developing a unified, simple and practical testing method to measure unsaturated soil moisture diffusivity coefficients. This new method will significantly reduce the time and effort needed to measure drying and wetting of unsaturated soil moisture by exposing cylindrical soil specimens to drying and wetting cycles.

The project aims to implement the most recent advances in unsaturated soil mechanics, to investigate the frost heave problem, utilizing equipment development, laboratory testing, model development, and numerical simulation. Advancing the field's understanding of unsaturated soil mechanics will reduce operations and maintenance budgets by enabling Alaska DOT&PF to more efficiently prevent and mitigate frost heave and weakening.

To date, the team has calibrated sensors and performed frost heave and validation tests. It is recalibrating sensors for use in subzero temperatures similar to those experienced in Alaska's climate and will soon conduct lab testing.

Right: Graduate student Lin Li conducts a Micro-deval test, which involves putting aggregate materials in a tumbling steel drum with water and steel balls to measure how the aggregate materials degrade. (Photo Courtesy: J. Liu)

Economic Impact of Fines in Unbound Pavement Layers (AUTC# 510012) Juanyu “Jenny” Liu (UAF)

In Alaska’s spring months, excess water underneath road pavement due to thawing weakens roads and other transportation infrastructure, causing great expense and inconvenience for private and commercial motorists. This project examines how the fines (P200) in base materials affect frost susceptibility and support for vehicular loads during the spring thaw. Realizing the variation in critical excess fines content, Liu’s team is also evaluating the financial impact of using allowable fines in the unbound pavement layers and will identify critical excess fines content (that is, threshold fines content) allowed in the typical Alaska unbound base courses. Allowing as little as 2% increase in fines could significantly reduce gravel costs for a construction project.

Expanding upon a recent UAF study, Liu is investigating the impact of fines content on resilient modulus reduction of base courses during thawing when the base course material is frozen. Testing will be conducted under different temperature gradients and with limited water access. To do this, Liu and her team will simulate a closed-water system by collecting soil specimens with different initial moisture and fines content and freezing them in the frost heave cell with no access to water. Researchers

will then test resilient moduli of soil specimens under different subfreezing temperatures and after a freeze-thaw cycle under both undrained and drained conditions. The testing will provide the data for drafting recommendations that will help Alaska DOT&PF determine the situations when designers can relax stabilized base policies and when builders might reduce costs by allowing excess fines in the base layers for highway construction.

Recently, researchers have continued laboratory performance tests and evaluated specimen heaving susceptibility. The team also has reconfigured a frost heave chamber to enable larger testing groups with more specimens. The team finalized two data processing scripts and updated an entire data set for completed specimens. In the next phase, researchers will continue lab testing on frozen and unfrozen specimens, as well as data processing.

Using the Micro-Deval Test to Assess Alaska Aggregates (AUTC #410009) Juanyu “Jenny” Liu (UAF)

Choosing the right material is half the battle in building Alaska’s roads. The extreme conditions typical to cold regions require a durable aggregate that is both abrasion-resistant and



freeze-thaw resistant. Alaska DOT&PF wants the most effective and accurate methods available to select the right aggregate to build the state’s highways.

To evaluate surface abrasion and degradation values, Alaska currently uses a testing method known as “Method 313,” or the Washington Degradation Test. This project is an examination of an alternate method that may prove safer and less costly, if its results are replicable and correlate with field performance.

The Micro-Deval test involves putting aggregate materials in a tumbling steel drum with water and steel balls to measure how the aggregate materials degrade. The test is relatively easy, safe, and less costly to perform than traditional testing methods. It is also suitable for smaller equipment, requires smaller sample quantities, and uses a simple procedure.

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Liu's team has completed and summarized their test results, including additional aggregate testing methods using sand equivalents and a hydrometer. This data will advance the state's knowledge and the eventual selection of the most effective aggregates for its needs.

Field-Evaluating Crack Sealing of Asphalt Concrete Pavements in Alaska (AUTC #510005) Juanyu "Jenny" Liu (UAF)

For years, routine sealing of cracks in asphalt concrete (AC) has cost the state of Alaska millions of dollars annually. Without new technology to eliminate the cracking, sealing and minor patching will continue to be a major expense for Alaska DOT&PF.

This project aims to find cost-effective improvements to existing crack-sealing methods. Some research suggests that it may be possible to ignore cracks entirely, under certain

circumstances, with no negative effects. Hoping to devise more economically sound approaches to road repair, Liu is working with field researchers to determine where sealing is necessary and where it is not. The team will also determine the effectiveness of several different repair treatments for major transverse cracks.

Ultimately, the research team will provide recommendations for saving a significant portion of the maintenance and operations funds now spent on crack sealing and minor patching of major transverse cracks. The research will provide Alaska DOT&PF with information that the agency can easily integrate into its Departmental Guidelines for Pavement Preservation Treatments in Alaska.

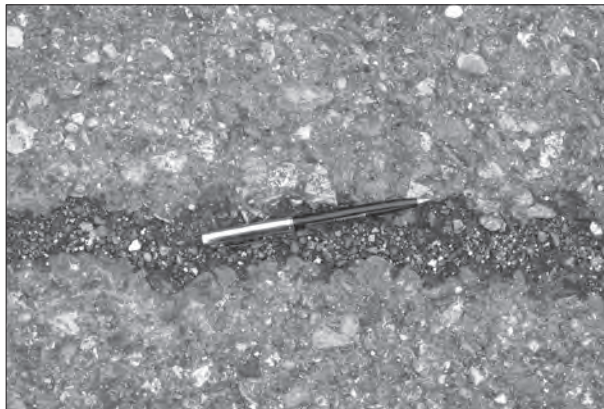
In recent work, researchers have integrated numerous articles and reports on thermal crack propagation, deterioration, numeric modeling, sealing materials and methods, and

cost-effectiveness into their ongoing literature review. This process has helped the team identify a literature gap on asphalts, base layers, soil interfaces, and computer modeling that pertains to this work. In the next phase, researchers will complete their draft literature review and finish six section evaluations and data documentation.

Accelerated Degradation and Durability of Concrete in Cold Climates (AUTC #410029) Pizhong Qiao (WSU) and Juanyu "Jenny" Liu (UAF)

Cold-weather climates degrade concrete, causing fractures and erosion. For Alaska's transportation engineers, this means more costly maintenance and risks to public safety caused by hazardous roadways and other surfaces. At the technical level, the main concern is the breakdown of aggregate materials within the concrete mix.

This year researchers drove around Alaska, collecting images that represent concrete cracking on the paved road system as part of a project on finding cost-effective improvements for common crack-sealing methods. The images below give some sense of the length and breadth of the problem. (Photo Courtesy: J. Liu)



Aggregate materials are a major component of concrete. Typically, cement mix is blended with filler such as rocks and stones of various sizes to make it more durable and cost-effective as a surface application. Cement mix is the most expensive component of concrete, so the optimal amount of aggregate makes a less expensive and more durable mix. For that reason, typical cement mixes contain as much as 60% to 80% aggregate to enhance longevity and reduce cost. Extensive studies have been conducted on concrete mix design and cement material composition to improve performance and durability. To better address aggregate degradation, researchers are looking for ways to improve how concrete aggregate is tested in cold environments.

Using damage mechanics modeling, the team is applying a promising testing protocol for long term concrete performance. It is evaluating how damage accumulates in concrete and how concrete remains durable at cold temperatures. To date, the team has performed concrete sample conditioning and Vicker identification, and developed probabilistic-based damage prediction models on concrete material degradation. After using this data for analysis and correlation, the team will prepare recommendations and specifications for long-term characterization of concrete in cold regions.

Characterization of Alaska Hot Mix Asphalt Mixtures with a Simple Performance Tester (AUTC #410020) Juanyu “Jenny” Liu (UAF)

To make pavement more durable—thus safer and more cost-effective—engineers are striving to better understand the properties of hot mix asphalt (HMA). Road builders need a mechanistic, flexible pavement design and reliable design procedures. Both require a more accurate understanding of different HMA properties.

This study is giving engineers a better idea of which HMA mixtures are more durable and suitable to Alaska’s demanding climate. The research team is developing a catalog of dynamic modulus values for mixtures typically used in Alaska. Dynamic modulus values measure the ratio of stress to strain that a material can withstand. The team is also investigating the correlations between simple performance test results and HMA lab performance for a full understanding of specific HMA properties.

Results will give Alaska DOT&PF engineers practical information on how Alaska HMA mixtures respond to the new test procedures, and how using these mixtures will effect current flexible-pavement design methods.

So far, the team has manufactured mixture specimens and coordinated testing with counterparts at the University of Tennessee to begin analyzing data. This work also entails continued data processing and analysis to compare several dynamic modulus models with experimental data.

The research team completed a literature review as well, and will move on to compiling their final results in the next phase of work.

Alaska Hot Mix Asphalt Job Mix Formula Verification (AUTC #309024) Juanyu “Jenny” Liu (UAF)

Some asphalt pavement does not last as long as it should, which means that every year, the state spends significant sums on repair and maintenance of Alaska’s paved roads. Since hot mix asphalt (HMA) is the major paving material used in Alaska, assuring its quality for cold climates is critical for contractors and Alaska DOT&PF. Ensuring that contractors in the field are working with the appropriate HMA is crucial.

This project is assessing HMA quality assurance specifications and evaluating how well contractors meet the requirements of job mix formulas (JMFs). Researchers recently field-tested a HMA formula as part of a rehabilitation and resurfacing project on the Parks Highway south of Nenana and at an Anchorage International Airport (AIA) paving project. HMA mixtures applied under four different scenarios were sampled from nine sub-lots in Nenana and four sub-lots in AIA. Included were specimens mixed and compacted using JMF in the laboratory; loose mixtures collected from windrow and either compacted in the field using a portable gyratory compactor or compacted in the laboratory; and samples retrieved from the field. Researchers obtained data from Alaska DOT&PF and contractors at each phase of lab/design, production, and new construction. Data

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included general project information, details of the materials and JMF used in the construction, and all construction test data.

Currently four tests for JMF properties are underway in the university lab, including aggregate gradation, asphalt content, mix volumetrics, and density. Researchers will investigate HMA performance to further verify the JMF and evaluate any impact of the construction process. The team recently completed ignition tests for all materials and performance tests for materials collected from the AIA paving project.

Results will help improve current mix design protocols, benefit the asphalt-paving process, and ensure the quality of HMA. Verification will enhance the long-term performance of HMA pavements and significantly reduce the state's pavement maintenance and repair budget.

Application of a Nontraditional Soil Stabilization Technology: Lab Testing of Geofibers and Synthetic Fluid (AUTC #207117) Billy Connor (UAF)

Gravel is essentially nonexistent in western Alaska. When gravel is needed for infrastructure such as a road or runway, it is imported at costs exceeding \$400 per cubic yard. These costs can be dramatically reduced if local soils can be made usable in place of imported gravel.

This project is investigating a new technique for using geofibers and a synthetic fluid to stabilize loose, sandy, and silty soils typical of western Alaska. Lab tests that measured how well these new materials might improve poor foundation soils indicate that fibers can double or triple the strength of the soil. While the addition of synthetic fluids adds some strength,

their primary function is to reduce the moisture sensitivity of fine-grained material. Further testings suggest that a two-part chemical additive can increase the strength of sands, silts and clays at a lower cost than imported gravel. This project is the basis for a field application of these new materials.

Application of a Nontraditional Soil Stabilization Technology: Use of Geofibers and Synthetic Fluid in the Field (AUTC affiliated project) Billy Connor (UAF)

In partnership with the Federal Highway Administration (FHWA), AUTC is tapping into ongoing work with soil stabilization to develop applications that can contribute to a range of transportation projects from roads to runways.

Funded by FHWA, this project utilizes AUTC's expertise to test a new soil stabilization

AUTC researchers experiment with delicate mixtures of chemical stabilizers, soil, and other materials to strengthen sub-grade soils. Left: Mixing tools used in the field. AUTC is testing chemical stabilizers to improve soil stability in remote regions. Middle: A truck applies a chemical stabilizer layer to a sub-grade surface. When AUTC researchers get the appropriate mix, unstable soils become solid like this specimen shown on the right. Researchers are challenged to get these results from Alaska's unstable sands, silts, and organic clays. (Photos Courtesy: B. Connor)



technique. Researchers performed a practical field test using geofibers and a synthetic fluid to stabilize very loose, sandy, and silty soils. These kinds of soils are common to many parts of Alaska, where transportation infrastructure faces excessive maintenance and safety challenges. Researchers based soil testing and applications at a site in the Matanuska-Susitna Borough near Horseshoe Lake, Alaska. Researchers then collaborated with FHWA to gather data from this test site as well as other active projects, and identified new test sites in the state of Washington. They aim to devise methods of strengthening soils in these regions to prevent erosion and other infrastructure damage.

Researchers hope to apply this work to a variety of transportation infrastructure needs. Project results will provide engineers with soil preparation strategies that make use of locally available materials, significantly reducing overall construction costs. This technology can be used for roads, highway embankments, unstable slope management, and remote airports and landing strips. In addition to providing engineers with a variety of applied research results, this project has provided valuable hands-on experience for four UAF undergraduate students—another benefit to AUTC's partnerships with federal and state counterparts.

Right: Small plastic fibers used to reinforcement and strengthen unstable soil.

Below: Crews dispense handfuls of plastic fiber used to reinforce a new layer of soil.

Lower right: Crews pile plastic fiber reinforcement before spreading them evenly over a sub-surface grade.

(Photos: Courtesy B. Connor) .



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[Attenuation of Herbicides in Subarctic Environments Across Alaska \(AUTC #207110, Seward test site; AUTC #309026, Fairbanks test site\)](#) David L. Barnes (UAF)

This partnership between AUTC, the U.S. Department of Agriculture, and the Alaska Railroad Corporation (ARC) will improve infrastructure protection for Alaska's railway.

ARC needs effective, cost-efficient methods to manage vegetation growth along rail lines. Manually removing railway brush and vegetation is costly and relatively ineffective, so researchers are testing herbicides use for vegetation removal.

AUTC researchers and USDA's Agricultural Research Service are evaluating the environmental fate (that is, what happens to a herbicide once it is distributed), attenuation, and effectiveness of several herbicides in use along Alaska's transportation corridors. Once these herbicides are applied, how long does it take for them to enter the soil? Where do they go? How long does it take for them to dissipate? How well do they repel vegetation?

Herbicides have been applied at one field site near Seward, Alaska, at the southern end of the ARC rail line. Researchers have tracked these applications over two years through a series of soil and groundwater samples to obtain site-specific attenuation data. They performed mass balance studies on the same herbicides using lysimeters installed at the Fairbanks Experiment Farm on the UAF campus.

With their research phase complete, the team has communicated results to partners at ARC and received feedback in developing the final project report over the coming year.

Results will yield a better understanding of the fate of these herbicides in Alaska's maritime subarctic zone, and lead to more cost-effective infrastructure protection.

[Longevity Analysis of Dust Control Palliatives \(AUTC #510019\)](#) David L. Barnes (UAF)

Communities and government stakeholders in rural Alaska need cost-effective methods to reduce road and airfield dust. Before applying dust-control products, however, they must consider the longevity and performance of the different commercial palliatives currently available.

This project has helped develop new instruments and methods for field-based measurements of dust-control palliative performance and longevity. Supported by Midwest Industrial Supply Inc., manufacturer of EK35—one of two palliatives tested in the study (Durosoil, is the other, manufactured by Soilworks® LLC)—Alaska DOT&PF and the research team applied and monitored these products at several airfields and roads in rural Alaska. The team is using laboratory tests as well to better understand differences in product performance. By correlating these tests with field-based measurements, researchers can predict a palliative's possible performance prior to its application, enabling cost-effective implementation.

In recent months, the research team has developed a new data analysis method, and has completed field testing at five sites throughout Alaska. It also has incorporated two new palliatives into the study to broaden the potential uses and application of the study results. Over the next year, the team will continue testing activities on unpaved roads and runways in rural locations across the state.

[Performance of Dust Palliatives on Unpaved Roads in Rural Alaska \(AUTC #410036\)](#) David L. Barnes (UAF)

This project is one of a series assessing the longevity of different palliatives applied to rural Alaska roads over two summer seasons.

Researchers continue collecting data using a custom-made dust-monitoring system (DUSTM). Created and assembled by the research team, the DUSTM is a portable dust-monitoring device that can be attached to the rear of an ATV, and is compact enough to be transported in a small airplane. It measures the amount of airborne or loftable dust that rises from an unpaved roadway (sometimes called "fugitive dust"). Researchers can use the data it yields to calculate reductions or increases in dust over time. The research team is applying and monitoring palliatives in multiple sections of Alaska roads in rural villages and towns across the state. Recent testing took place in Central, Circle, Tetlin, Eagle, and Hughes, Alaska. The team applied two new palliatives with no previous use in Alaska to a surface in Summit, a community along the Richardson Highway.

A partnership between AUTC and the Alaska Department of Environmental Conservation, this project compares associated dust concentration measurements taken by DUSTM with those collected by ADEC stationary monitors. Data correlations between the two sources will determine how much of the measured fugitive dust is from a controllable emission source and how much is from uncontrollable sources. Both for public health and cost-effectiveness considerations, researchers want to know how much fugitive dust must be suppressed to meet regulatory standards. The results will help local communities plan the use of dust-control palliatives.

The DUSTM is mounted to the back of an ATV. It is easily transported in a truck or small airplane, and measures the loftable dust levels (specifically, PM-10 by EPA standards) from unpaved surfaces. Top left: UAF graduate student Travis Eckhoff uses the DUSTM to measure dust levels on the Taylor Highway. (Photo Courtesy: D. Barnes)



Measuring the Effectiveness of Rural Dust Control Strategies (AUTC #107019) David L. Barnes (UAF)

Dusty, unpaved roads and airports affect the quality of life for many villages in cold regions, as roughly 60% of Alaska's roads are unpaved. Alaska is not alone. Of America's 4.2 million miles of roads, 1.7 million are unpaved. Dust reduces road visibility, causes respiratory ailments, and affects fruit and plant harvesting activities. In addition, loss of fine material reduces road surface quality, increasing maintenance costs as well as wear and tear on vehicles.

Extending AUTC's expertise in road dust reduction, project researchers are conducting one of several studies to improve rural dust control. Simply paving is often unworkable; costs are high, local materials are often unsuitable, and long-term maintenance may be unavailable. Possibilities for dust control abound, but which will fit best with the subsistence lifestyle practiced in rural areas, and what can the state's thinly stretched budget afford?

To help address these questions, this project is developing a dust control research map that prioritizes critical areas. Researchers are designing instrumentation and methodology to accurately monitor road dust production. These tools will be used to support Alaska DOT&PF in field-testing various dust control measures in several locations.

So far, researchers have qualitatively assessed dust control performance on unpaved runways, tested new instrumentation, and measured

palliative performance with this prototype instrument at one rural road site. In addition to adding two types of palliatives to the study, they have also developed a new data analysis method and have completed testing with the prototype instrument at five new locations throughout Alaska. With multiple effectiveness evaluations concluded, the team will collect additional data at new test sites in the coming year.

Alaska Specification for Palliative Applications on Unpaved Roads and Runways (AUTC #309015) David L. Barnes (UAF)

After limited use of dust-control palliatives in northern Alaska, State transportation professionals are looking for ways to measure the effectiveness of these applications on rural roads and runways. For the past seven years, Alaska DOT&PF has applied dust-control palliatives to rural airport runways with their only guidance coming from manufacturers, who tend to have little experience with practical use. State engineers were unable to determine whether these products met specific standards, or which were the most effective at specific locations.

This project is using an innovative dust-monitoring (DUSTM) instrument to collect data and compare the effectiveness of newly laid palliatives and older (1 to 3 years) applications. Researchers are developing performance-based specifications for applying dust-control palliatives to unpaved transportation surfaces. These specifications will enable Alaska DOT&PF to choose the best palliative for a specific community's needs.

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Researchers have developed a new methodology for comparing the variability of palliative concentrations after application at field sites between successive years. In coming months, the research team will continue developing this new data analysis to include the magnitude of palliative concentrations, which will help the project team compare palliative performance between sites. The team will also use this data to develop new dust-control strategies.

Eagle Dust Project (AUTC #MISC3) David L. Barnes (UAF)

As part of a group of projects testing dust control strategies and collecting information across Alaska's several different environments, Alaska DOT&PF applied a dust-control palliative to the surface of the Taylor Highway near Eagle, Alaska. Over the past two years, AUTC researchers have been monitoring the palliative's performance and gathering data both at the test site and, as a control, at nearby untreated sites. The final report, which is in preparation, will include detailed testing results and recommendations on palliative application strategies for roadways.



Dust Palliative Performance Measurements on Nine Rural Airports (AUTC #MISC4) David L. Barnes (UAF)

In the summer of 2009, Alaska DOT&PF began applying dust-control palliatives to nine rural airport runways across Alaska. AUTC researchers are monitoring these runways to assess the quality and durability of several palliatives. Measurements are taken with the UAF dust-monitoring device (DUSTM), a portable instrument that measures lofted dust as it rises from the rear tires of an all-terrain vehicle. Palliative performance will be assessed by comparing the measured fraction of lofted dust produced by the ATV on the treated section of the runway with the fraction produced on the untreated control section.

Researchers have taken measurements within 30 days of the first treatment on each runway and have followed up with another measurement each following year. Recommendations will help Alaska DOT&PF select the most effective product out of several and plan the most efficient application schedule for Alaska's many unpaved runways.

Previous to the DUSTM's creation, researchers had not developed a repeatable methodology for this kind of loftable dust rate monitoring. Top left: DUSTM measures dust levels on the Taylor Highway. (Photo Courtesy: D. Barnes)

The DUSTM is being used to monitor palliatives on unpaved roads and runways in over thirty remote Alaska communities. Below: A UAF graduate student uses the DUSTM on the Taylor Highway to measure dust levels. (Photo Courtesy: D. Barnes)

Construction Dust Amelioration (AUTC #RR10.03) Robert A. Perkins (UAF)

Dust produced at seasonal road construction sites is both a traffic safety and public health concern. Dust that emanates from unpaved road surfaces during construction reduces visibility for drivers, affecting safe sight and stopping distances. Dust stirred by wind or traffic contributes to the local burden of airborne particulates (also known as PM 2.5) that people breathe. Experts believe applying commercial dust-control palliatives to unpaved surfaces during construction will mitigate this problem.

This study examines a variety of factors dealing with use of dust-control palliatives and potential alternatives. The research team has tested several commercial palliatives under specific conditions to determine their ideal use. It examined several factors, including the amount and size of the dust particles, the time the surface is to remain unpaved, composition of the unpaved road surface, local environmental conditions, and palliative cost and availability.

Study results offer helpful conclusions for Alaska DOT&PF and rural communities seeking dust reduction solutions:

- » Compared with the tested palliatives, watering is a more cost-effective solution for temporary (1 to 4 weeks) dust control.
- » When applied at the specific undiluted rates outlined in the study, the tested palliatives were unsuccessful in providing the desired 7-day, 14-day, and 28-day temporary dust control at acceptable levels.

- » Limiting vehicle speed is an alternative to watering as a strategy to control construction zone dust.
- » Quantity of dust generation by a vehicle is dependent upon the vehicle's travelling speed.

The team also identified several methodological improvements for future testing, such as addressing how adding 200-250 trucks per day to construction zone traffic significantly affected the performance of dust control measures. This project is especially valuable to Alaska, because measurement systems used in other states involve special equipment and/or certification of observers, neither of which may be practical in Alaska with its remote locations and short construction season.

Permafrost & Frozen Ground

Among AUTC's key research areas, permafrost and frozen ground studies have become its most distinct specialty for state stakeholders.

Because Alaska's interior and northern regions are where permafrost shows its most destructive and costly effects on transportation infrastructure, AUTC's location provides an ideal launching point for both field and lab research. Roughly 80% of Alaska's landmass has permafrost beneath it, and the state's road system expansion plans chart courses through many of these regions.

The Center's partnership with the Alaska Department of Transportation and Public Facilities furthers the state's knowledge of the dynamics of frozen ground, and the challenges it poses to transportation engineers and planners. To date, these challenges are costly issues. With road maintenance alone, the Department estimates it spends \$11 million a year due to permafrost-related problems.

While researching a variety of these issues, AUTC's projects in frozen ground studies share a single concern: helping inform more robust designs to extend the service life of cold region transportation infrastructure. Research teams are advancing understanding of natural fluid, soil, material, and thermal dynamics to enable less expensive, longer-lasting bridges, roads, and runways. This work maximizes maintenance efforts and facilitates more cost-effective transportation budgeting to make the most of every dollar Alaska receives for transportation. AUTC's research is also frequently translated into new manuals and training, and other formal guides for Alaska DOT&PF.

Permafrost/Frozen Ground Ongoing Projects

Impact of Groundwater Flow on Permafrost Degradation and Transportation Infrastructure Stability (AUTC #510011) Margaret Darrow (UAF)

Thawing permafrost creates significant infrastructure challenges near roadway embankments, increasing life cycle costs and reducing transportation system effectiveness. Studies indicate that groundwater flow along the permafrost table will increase permafrost degradation, accelerating damage. As changing surface temperatures affect permafrost and compromise embankment stability, this research looks at the impact of groundwater and advective heat transfer on permafrost degradation below embankments. To help maintain long-term infrastructure stability in permafrost regions, this project is working to gain a better understanding of the complex interactions between groundwater, permafrost and overlying embankments.

UAF researchers Margaret Darrow and Ronald Daanen have partnered with colleagues (led by Daniel Fortier) at the Université de Montréal (UdeM) to investigate the relationship between groundwater flow, permafrost degradation, and embankment stability. Elements of the collaborative study include fieldwork at a test section on the Alaska Highway near Beaver Creek, Yukon, Canada.

There the team has installed temperature sensors, moisture probes, and piezometers, and collected soil samples later used for laboratory measurements of

Below: Margaret Darrow's thermal modeling station near the Dalton Highway. Darrow's team uses thermal modeling to better understand permafrost stability near and underneath roadway embankments. (Photo: Courtesy: M. Darrow)

Opposite: PI Darrow downloads data from the thermal modeling collection station. (Photo: Courtesy: M. Darrow)



hydraulic conductivity and unfrozen water content. These data are used to model the interaction among these complex phenomena, using coupled mathematical equations in COMSOL Multiphysics (a software package). Researchers then use this information for road embankment simulations to determine how advection contributes to the degradation of frozen ground through groundwater flow.



The results of this work will improve our understanding of groundwater flow through taliks and within warm (near 0°C) permafrost soils with high unfrozen water content, and help designers create robust embankments and more effectively mitigate groundwater flow.

Experimental Study of Various Techniques to Protect Ice-Rich Cut Slopes (AUTC #510010) Xiong Zhang (UAF)

For more than 50 years, state construction officials have wrestled with the costly problem of uncontrolled erosion, runoff, and slope failures from permafrost. The permafrost that underlies most areas of Alaska potentially adds significant development costs in the form of environmental distress, project delays, change orders, and claims that often occur during building.

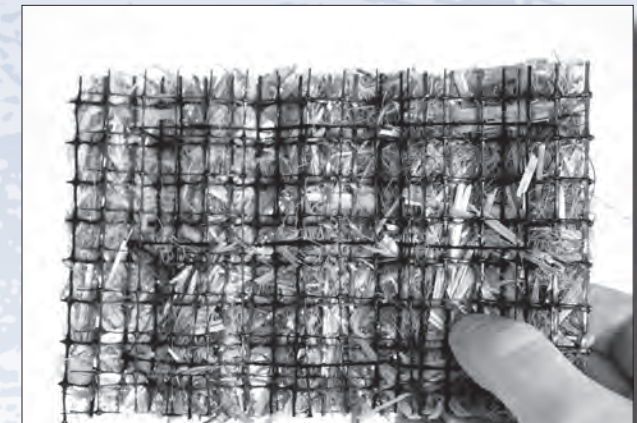
This project is a study of potential thermal erosion mitigation techniques that will better control erosion of cut faces in the first thaw season, effectively reducing the dangers and costs caused by slope failures that block or damage transportation infrastructure.

Cuts in frozen ground surfaces are often required to achieve design grades in permafrost areas. This excavation exposes ice-rich soils and destroys the existing thermal balance, which results in thawing and soil movement. While research has addressed this issue, environmentally acceptable, legal, and economically viable solutions have not yet been developed. In fact, new and strict environmental laws constrain long-accepted Alaska DOT&PF methods for dealing with ice-rich permafrost, making them either undesirable



Above: Wood chips used to cover and insulate cut slopes. Such materials reduce the amount of heat absorbed by the exposed ice-rich soil, which, as it melts, can create an unstable and erodible slope. Slowing the melting rate stabilizes the soil. (Photo Courtesy: Gillmore Construction)

Below: A coconut fiber matting sample. Researchers use this material to cover unstable ice-rich slopes; it absorbs moisture and reduces temperature fluctuations. (Photo: AUTC)



Permafrost & Frozen Ground

or completely unacceptable. This project examines several thermal erosion mitigation techniques that may prove useful to ADOT&PF.

Researchers will build several experimental test sections to monitor and evaluate the effectiveness of different mitigation techniques. In their recent phase of research, the team acquired sensor and instrumentation equipment and began coordinating testing logistics with contractors involved in the study. In the next phase of research, the team will work with ADOT&PF's construction section and contractors to begin experimental fieldwork and construction.

At the project's completion, the research team will translate their results into recommendations and guidelines for Alaska DOT&PF's design and construction staff. These will help the state properly apply the successfully tested mitigation approaches.



Supplemental Study to “Using Mirafi Nylon Wicking Fabric to Prevent Frost Boils in the Dalton Highway Beaver Slide Area, Alaska” (AUTC #510020) Xiong Zhang (UAF), Michael R. Lilly, Geo-Watersheds Scientific

Advancements in geotextile technologies are helping mitigate the damage permafrost causes to Alaska's highways. Tencate's Mirafi Nylon Wicking Fabric is becoming a prevention solution of interest for AUTC researchers, who are testing the material's ability to mitigate frost boils and subsequent road damage in the Beaver Slide area, near mile 110.5 of Alaska's Dalton Highway. Jointly funded by Alaska DOT&PF, Tencate Geosynthetics, and AUTC, this team constructed a test section in the area for fabric experiments. Preliminary results suggest the material was helpful in mitigating frost

boils, prompting the team and sponsor to extend the data collection period for a more meaningful analysis phase. The team is now compiling a final report and continuing data collection. They have also successfully submitted two conference papers on this work, and in coming months will assemble their results for review by stakeholders and sponsors.

Stabilization of Erodible and Thawing Permafrost Slopes with Geofibers and Synthetic Fluid (AUTC #410028) J. Leroy Hulsey and Xiong Zhang (UAF)

Thawing and eroding permafrost slopes create costly road maintenance issues that often persist for years. The sinking and cracks in roadways caused by changes in permafrost seem to elude most conventional mitigation methods. However, recent research in the use of synthetic fluids and geofibers is developing potentially effective solutions that can reinforce subgrade soils in pavements.

Traditional stabilization techniques are costly and require specialized skills and equipment to ensure adequate performance. They also are only marginally effective in the cold climates of Alaska and other northern regions. This project has conducted a large-scale field investigation into the use of geofibers and synthetic fluid to stabilize erodible and thawing permafrost slopes. Research is showing these methods improve very loose, sandy soils—the material often left behind after

Left: Thawing permafrost along Alaska's Dalton Highway. (Photo Courtesy: Mikhail Kanevskiy)

permafrost thaws. The outcomes of this research will help future engineering teams design safer, more robust embankments.

So far, this project has made significant strides in testing these methods. After conducting a literature review of existing erosion-loss measurement methods, the team developed a three-pronged measurement approach. It then conducted field- and laboratory-based measuring and monitoring activities and designed soil sampling methods specific to this research, leading to soil sampling and plant surveys. In upcoming research, the team will continue field observation of total slope erosion, soil and biomass sampling, lab and statistical analysis of soil and plant samples, and perform a final comparison of tested treatments.

Geophysical Applications for Arctic/Subarctic Transportation Planning (AUTC #410018) William E. Schnabel (UAF)

Permafrost poses numerous challenges to cold region road and bridge designers with Alaska DOT&PF. Bridges and roads constructed in permafrost areas are often damaged due to changes in the soil's thermal state. Engineering designs that do not adequately account for these subsurface dynamics result in flawed structures that require excessive maintenance or replacement, with risks to safety and exorbitant costs.

This project will help designers utilize improved geophysical information when constructing cold region bridges and roads. The project is assessing the use of geophysical methods such as electrical resistivity tomography (ERT) and ground-penetrating radar (GPR) for arctic subsurface

investigations. Geophysical surveys that combine these technologies can more effectively map the extent of the subsurface ice formations that undermine structural stability—formations like ice wedges, ice lenses, massive ice, and taliks (layers of year-round unfrozen ground within a permafrost area).

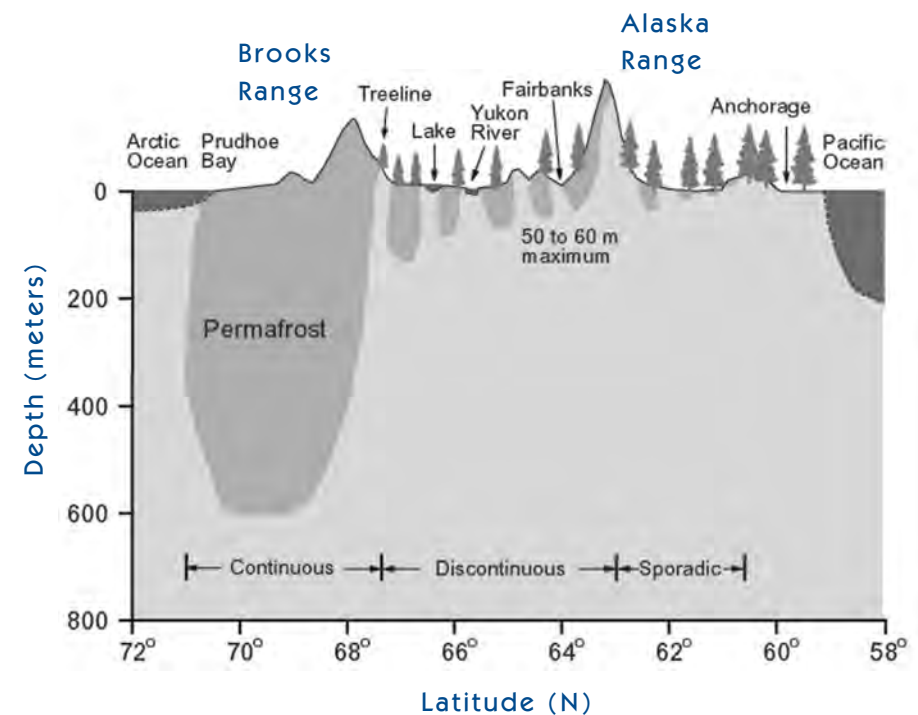
Although results will augment existing ADOT&PF projects, the team's primary goal is to provide guidance on making ERT and GRP a routine component of characterizing arctic and subarctic soils.

In addition, this study will produce initial information for a database describing geophysical properties typical of Alaska's permafrost and talik conditions. This database will allow engineers to better address the subsurface challenges that increase maintenance costs and undermine safety. It will also facilitate protocols for carrying out and interpreting arctic/subarctic geophysical surveys, as well as guidance for selecting more appropriate methods and estimating survey costs.

After conducting surveys in the Anaktuvuk basin, at the 9-Mile Dalton Highway realignment, and the UAF Agricultural and Forestry Experiment Station, the research team completed fieldwork in the Goldstream Road region north of Fairbanks.

With fieldwork complete, the team is now in the final phase of the study, conducting data analysis to compile its report for engineers at ADOT&PF.

Below: Transect of Alaska showing the frequency and depth of permafrost. (Image by Larry Hinzman, International Arctic Research Center).



Permafrost & Frozen Ground



Above: Evidence of differential settling on the Richardson Highway, just south of Fairbanks. The damage is due to the dynamics of changing permafrost. (Photo Courtesy B. Connor)

Fast Determination of Soil Behavior in the Capillary Zone Using Simple Laboratory Tests (AUTC #410025) Robert L. Lytton (TAMU) and Xiong Zhang (UAF)

Frost heave and thaw weakening are typical problems for engineers building in northern regions. Thaw weakening makes pavement and other surface structures prone to damage when water from thawing ice and snow pools under pavement and weakens the road. Frost heaving occurs when ice forms in the soil during freezing temperatures, then grows, often upward toward the freezing front. These behaviors are caused by water flowing through an area called the capillary zone to a freezing front, where it forms ice lenses that eventually wedge soil apart and cause significant infrastructure damage. To design for these subsurface dynamics, engineers must first examine and understand them.

This project is developing more cost-effective, reliable, and timely methods to examine soil strength. Researchers typically use suction-control testing to determine the strength of unsaturated soils. The standard for characterizing unsaturated soils, suction-controlled tests often take months to perform (in some cases a year), are too laborious, and too costly for routine engineering projects. Understanding stress/strain behavior for only one unsaturated soil can take up to three years, and moisture content measurements are unreliable.

This research team is developing a method for rapidly determining and analyzing unsaturated soil behavior through a new approach, the Modified State Surface Approach (MSSA). The MSSA can reduce the time required to characterize

unsaturated soils from several years to a few weeks or days. It also provides more reliable measurements and information on representative soil behavior.

Researchers have completed fabricating suction tensiometers to measure suction in saturated soils, and calibrated psychrometers for high-suction measurements. They have also developed a new method for measuring total volume changes in unsaturated soils, and performed undrained tests to characterize unsaturated soil behavior. Their next phase of research will finalize soil tests, conduct data analysis, and compile final results.

Opposite: Shallow anchors placed in frozen soil hold down large sections of steel wire mesh, typically spanning an entire slope. This keeps surface soil intact to prevent sliding. A Tecco steel mesh wiring system is anchored across this unstable slope. (Photo Courtesy: Geobrugg)

Evaluating In-Place Inclinometer Strings in Cold Regions (AUTC #309022) Margaret Darrow (UAF)

In cold regions, subsurface movements of frozen ground impact transportation infrastructure. This threatens roads, bridges, runways, railways, and other structures. This study advances our knowledge of how inclinometers—tools used to measure ground movement—perform in cold regions. Transportation designers can then more effectively use them to measure vertical and horizontal ground movement within slopes, embankments, bridges, retaining walls, and other structures.

Testing a new type of geotechnical instrumentation that incorporates Micro-Electro-Mechanical Systems (MEMS) accelerometers, this project is employing a technology first used for automotive air bags. Automated in-place MEMS inclinometer strings (AIMIS) can be directly inserted in the ground, avoiding the setbacks of manual methods. These strings are more flexible and can withstand greater ground movement. They can be installed with a remote power supply and telemetry link to provide continuous ground movement observations. By reducing field monitoring needs and providing a reusable technology, this equipment saves significantly on costs associated with older technology.

AIMIS technology has not been fully evaluated for use in cold regions. Darrow is comparing AIMIS against the existing methodology, evaluating its cold region versatility and accuracy, and testing its ease of use and recoverability for Alaska DOT&PF. She will use this fieldwork along with data analysis

to develop a set of Best Practice Guidelines for ADOT&PF.

Darrow has installed AIMIS and temperature sensors in field locations. From preliminary data analysis, she has finalized a publication entitled “Evaluating Automated MEMS-based In-place Inclinerometers in Cold Regions” for the Fifteenth International Specialty Conference on Cold Regions Engineering.

Using Shallow Anchors and an Anchored Mesh System for Cut Slope Protection in Ice-Rich Soils (AUTC #207121) Xiong Zhang (UAF)

When a sloped bank in a permafrost area is cut to make way for a road, the soil may thaw and slump or collapse, leading to a need for costly and ongoing mitigation measures. In addition, as many as six years may pass before new vegetation re-stabilizes a cut bank. While engineers can design embankments to compensate for these soil changes, there is growing concern that eroding soils may impact water quality and fish habitat. Engineers are looking for new designs that better protect the immediate environment, meet federal guidelines, and remain economically viable.

Builders have tried numerous slope stabilization strategies, some more effective or expensive than others. Some methods employ wire netting held in place by soil anchors, but little information exists on how this approach works in Alaska’s

frozen, shallow, silty soils. This project is helping Alaska DOT&PF understand how shallow anchors perform in frozen soils by designing an anchored wire mesh system to protect and stabilize ice-rich cut slopes. The research team has conducted anchor creep tests as well as numerical simulations and analyses. Their findings will be useful for other types of mitigation strategies, including highway retaining walls, and for addressing rockslide areas; both are significant issues for state transportation engineers.

So far the project has laboratory tested its data acquisition system and working with a contractor to install the test anchor system. Project personnel are also completed field drilling and extended testing activities as they prepare their final report and an accepted conference presentation on this work.



COMPLETED RESEARCH PROJECTS

Serving Future Transportation Needs: Strategies to Improve Alaska DOT&PF's Professional and Support Staff Recruitment and Retention (AUTC #309038) Robert Perkins (UAF)

Bridge Deck Runoff: Water Quality Analysis and Best Management Practice Effectiveness (AUTC #RR08.13) Robert Perkins (UAF)

Assessing Anchorage Traffic Congestion with Vehicle Tracking Devices and Intelligent Transportation System Technology (AUTC #309039) Jeffrey Miller (UAA)

Alaska Marine Highway System Analysis, Phase I (AUTC #RR07.04, #207105, #309018) Paul Metz (UAF)

LED Streetlight Performance in Interior Alaska (AUTC #RR10.01) Richard Wies (UAF)

Economical Analysis of Using Light-emitting Diode Technology for Alaska Streetlights (AUTC #207099) Hsueh-Ming Wang (UAA)

Long-range Transportation Forecasting for Greenhouse Gas Emission Estimation (AUTC #309042) Ming Lee (UAF)

Developing Ambient PM2.5 Management Strategies (AUTC #107004) Ron Johnson and Tomas Marsik (UAF)

Feasibility Study of RFID Technology for Construction Load Tracking (AUTC #RR08.12) Oliver Hedgepeth (UAA)

Feasibility of Electric Cars in Cold Regions (AUTC #RR08.05) Jing Zhang (UAF)

Unstable Slope Management Program: Background Research and Program Inception (AUTC #RR08.10)
Margaret Darrow and Scott Huang (UAF)

Converting the Fairbanks Metropolitan Area Transportation System (FMATS) Travel-demand Forecasting Model from QRS II to TransCAD (AUTC #MISC7) Ming Lee (UAF)

Performance Analysis of the Dowling Multilane Roundabouts (AUTC #RR08.08) Ming Lee (UAF)

Alaska Bridge Bent Pushover Software, Including Concrete Confinement (AUTC #107013) Michael Scott (Oregon State University)

Creosote-treated Timber in the Alaska Marine Environment (AUTC #RR08.14) Robert A. Perkins (UAF)

Evaluating the Overheight Detection System at the Eklutna River/Glenn Highway Bridge (AUTC #RR08.09) Ming Lee (UAF)

Seismic Design of Deep Bridge Pier Foundations in Frozen Ground (AUTC #107033) Sri Sritharan (Iowa State University)

Investigating Methods for Maturing Concrete in Very Cold Weather (AUTC #107052) Yongtao Dong (UAF)

Field Study to Compare the Performance of Two Designs to Prevent River Bend Erosion in Arctic Environments (AUTC #309009)
Horacio Toniolo (UAF)

Characterization of Asphalt-treated Base Course Material (AUTC #107049) Juanyu "Jenny" Liu (UAF)

Warm Mix Asphalt (AUTC #207086) Juanyu "Jenny" Liu (UAF)

Warm Mix Asphalt: Experimental Features in Highway Construction (AUTC #MISC5) Juanyu "Jenny" Liu (UAF)

Seasonally Frozen Ground Effects on the Seismic Response of Highway Bridges (AUTC #107014) J. Leroy Hulsey (UAF)

Preservation of the Alaska Highway, Phase 2 (AUTC #309035) Daniel Fortier (Laval University) and Yuri Shur (UAF)

Evaluating Liquefaction Resistance in Degrading Permafrost and Seasonally Frozen Ground (AUTC 107041) Kenan Hazirbaba (UAF)

Geological Investigations for the Dalton Highway Innovation Project as a Case Study of Ice-rich Syngenetic Permafrost (AUTC #207122) Yuri Shur and Mikhail Kanevskiy (UAF)

Impact of Fines Content on Resilient Modulus Reduction of Base Courses During Thawing (AUTC #107045) Juanyu “Jenny” Liu (UAF)

Effects of Permafrost and Seasonally Frozen Ground on the Seismic Responses of Transportation Infrastructure Sites (AUTC #107017) Zhaohui Yang (UAA)

Preservation of the Alaska Highway, Phase 1 (AUTC #107054) Daniel Fortier (UAF)

Measuring Temperature and Soil Properties for Finite Element Model Verification (AUTC #RR08.11) Margaret Darrow (UAF)

Nylon Wicking Fabrics (AUTC #RR10.02) Xiong Zhang (UAF)

Assessing the Contribution of Traffic Emissions to the Mobile Vehicle Measured PM_{2.5} Concentrations by Means of WRF-CMAQ Simulations (AUTC #410003) Nicole Molders

Climate Change Assessment for Surface Transportation in the Pacific Northwest and Alaska (AUTC #RR10.040) Ming Lee (UAF)

Smart FRP Composite Sandwich Bridge Decks in Cold Regions (AUTC #107018), Pizhong Qiao (WSU)

Bridge Structural Health Monitoring and Deterioration Detection: Synthesis of Knowledge and Technology (AUTC #309036) Yongtao Dong (UAF) and He Liu (UAA)

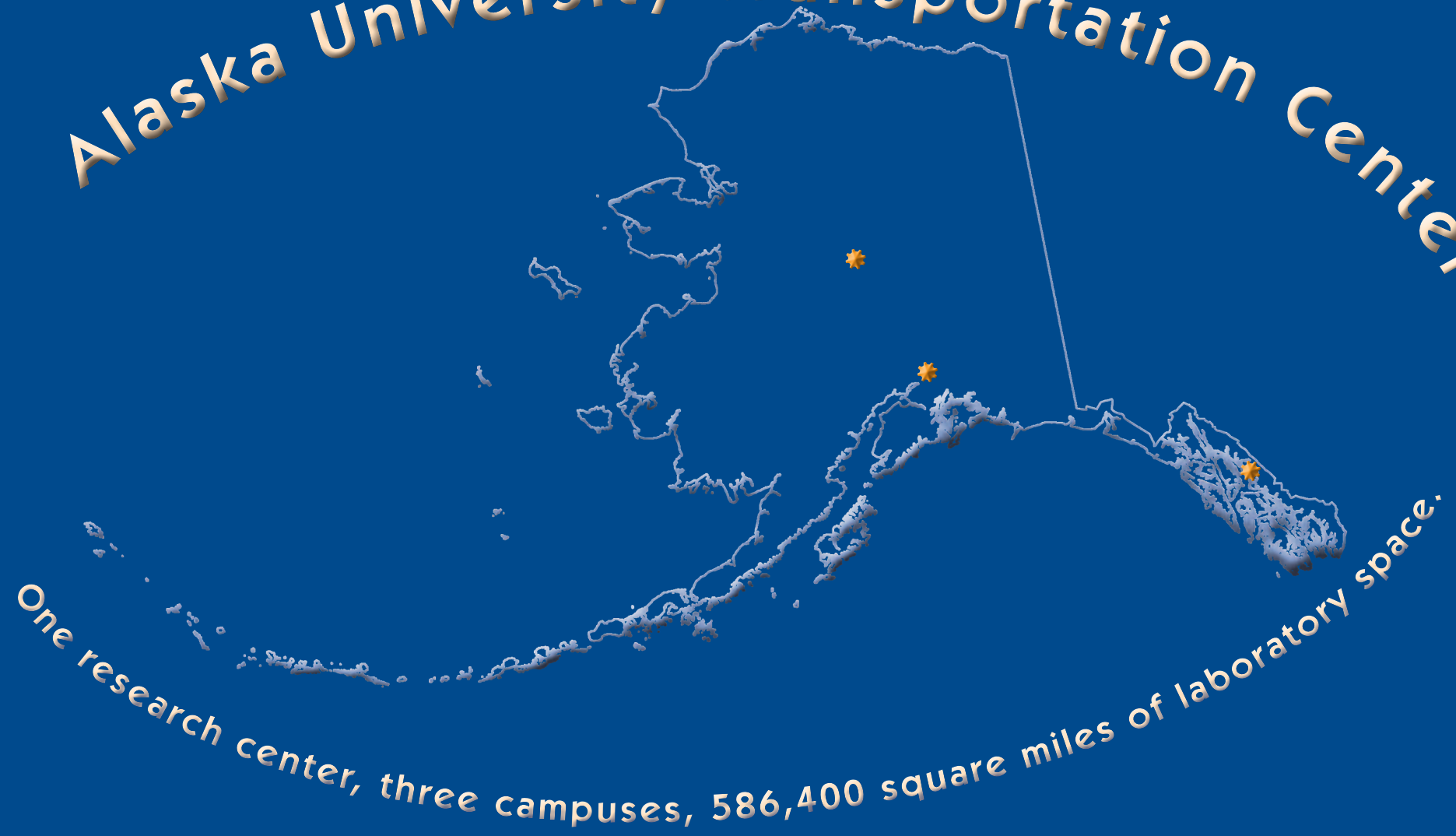
A Study of Unstable Soil Slopes in Permafrost Areas in Alaska: Case Studies used as a Training Tool (AUTC #309032) Margaret Darrow and Scott Huang (UAF)

Horseshoe Lake (FHWA funded; UAF #G-5806) Billy Connor

Impacts of Climate Variability and Change on Flood Frequency Analysis for Transportation Design (AUTC #207120), Amy Tidwell

About the front cover: Upper left: Students install instrumentation as part of the “Effects of Permafrost and Seasonally Frozen Ground on the Seismic Responses of Transportation Infrastructure Sites” project. (Photo Courtesy: Z. Yang) Lower left: AUTC student researchers collect data on the embankment of the Alaska Highway, near Beaver Creek, Yukon Territory, Canada. (Photo Courtesy: D. Fortier) Lower right: AUTC researcher Xiong Zhang (far left) and students in the Permafrost Tunnel, a natural research laboratory jointly operated by the US Army Cold Regions Research Laboratory and the University of Alaska Fairbanks Institute of Northern Engineering. (Photo Courtesy: AUTC) Top right: Graduate student Peng Li checks asphalt samples as part of the “Alaska Hot Mix Asphalt Job Mix Formula Verification” project. (Photo Courtesy: AUTC)

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