

2010 ANNUAL REPORT

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



Editor
Sandra Boatwright

INE Publications
University of Alaska Fairbanks
PO Box 755910
Fairbanks, Alaska 99775-5910

(907) 474-7209
sboatwright@alaska.edu
www.uaf.edu/ine/

This publication is a result of
funding from the
US Dept. of Transportation,
award DTRT06-G-0011

About the cover: see photo
credits.

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. This theme also takes into account the needs of such agencies as the Alaska Department of Transportation & Public Facilities, the Alaska Railroad Commission, the Alaska oil and gas industry, and the broader Alaska transportation community. Research at the university’s three main campuses (University of Alaska Fairbanks, University of Alaska Anchorage, and University of Alaska Southeast) fills a national need; AUTC is the only center with a specific, primary focus on transportation in cold regions.

AUTC’s theme and efforts apply to all modes of transportation. Alaska depends on multi-modal transportation for part of its economic growth. For example, the state depends on a mix of highway, air, marine, rail, and pipeline to meet its transportation needs. Alaska faces unique challenges, including population density that varies widely across the state; long distances between communities (often with no interconnecting roads) and high dependence on aviation and marine transportation; a diversity of geographic features, along with complicating factors such as permafrost and extremely cold temperatures; and high transportation costs. Pipelines for oil (and, in the future, other fuel sources) dramatically impact the economy of Alaska and the economic well-being and security of the nation. However, because the pipelines traverse arctic and subarctic terrain, the challenges of planning, designing, constructing, and maintaining pipelines are unique.

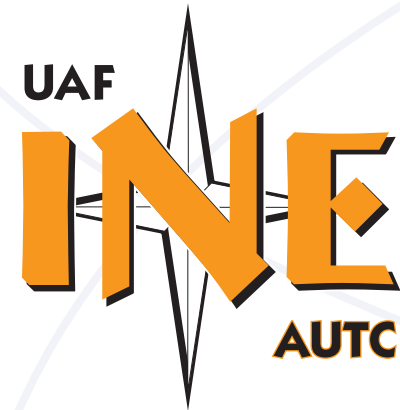
Alaska’s Congressman Don Young recently stated, “Living in a climate where the weather has such a large impact on the condition of our roadways and infrastructure, it is especially important for us to study how we can improve on what is already being done. A focus of this should be better ways to pave our roadways and keep them intact.” Young and AUTC are in agreement that improvements in cold regions transportation engineering must be a key aspect of the AUTC.

The center also 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 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 multi-modal issues facing Alaska and the nation’s transportation community.

***AN ANNUAL REPORT OF RESEARCH, EDUCATION,
AND TECHNOLOGY TRANSFER ACTIVITIES FOR 2010***

Table of Contents

Message from Billy Connor, Director	2
Organization	3
AUTC Governing Board	4
AUTC Faculty & Staff	5
Newly Funded Research	6
Ongoing Research	16
Completed Research	32
Products, Technologies, and Other Research Impacts	38
AUTC Student of the Year	40
Students in AUTC Research	41
AUTC Outreach	42
Resources, Funding, and Expenditures	44
Photo Credits	46



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



It's hard to believe **we have completed four years of our UTC grant.** The first two years AUTC focused on getting the program up and running. That meant hiring staff, upgrading lab space, putting together requests for proposals, and finding the all-important graduate students.

During this period, the AUTC Governing Board gave us sound advice about direction, potential funding sources, and feedback on projects. One suggestion was that the students give project updates.

As we grew, our partnership with the Alaska Department of Transportation and Public Facilities also grew. Our project selection process is becoming integrated with ADOT&PF. Our staff has developed personal relationships with ADOT&PF staff. AUTC has become a source of knowledge and expertise for ADOT&PF. In partnership with ADOT&PF, the engineering community, UAF College of Engineering and Mines, and AUTC, a Construction Management Graduate Certificate Program has been established. ADOT&PF is the largest participant in this program.

Our partnerships continue to grow. The Alaska Railroad, the Denali Commission, and the Matanuska-Susitna and Fairbanks North Star boroughs are good examples within Alaska. We have partnered with the Region X consortium to share ideas, coordinate activities, and co-fund common projects. We have partnered with the Western Transportation Institute, UC Davis and the University of Nevada, Las Vegas, to form a Dust Institute. Our industry partners include Peak Civil Industries, Tencate, Midwest Industries, and others in the research of common topics. We treasure each of these partnerships, not for the funding they bring, but for the opportunities they afford.

In the last four years, AUTC has grown from an unknown organization to a leader in several areas, including dust management, soil stabilization using synthetic fibers and fluids, use of herbicides in cold regions, and soil-structure

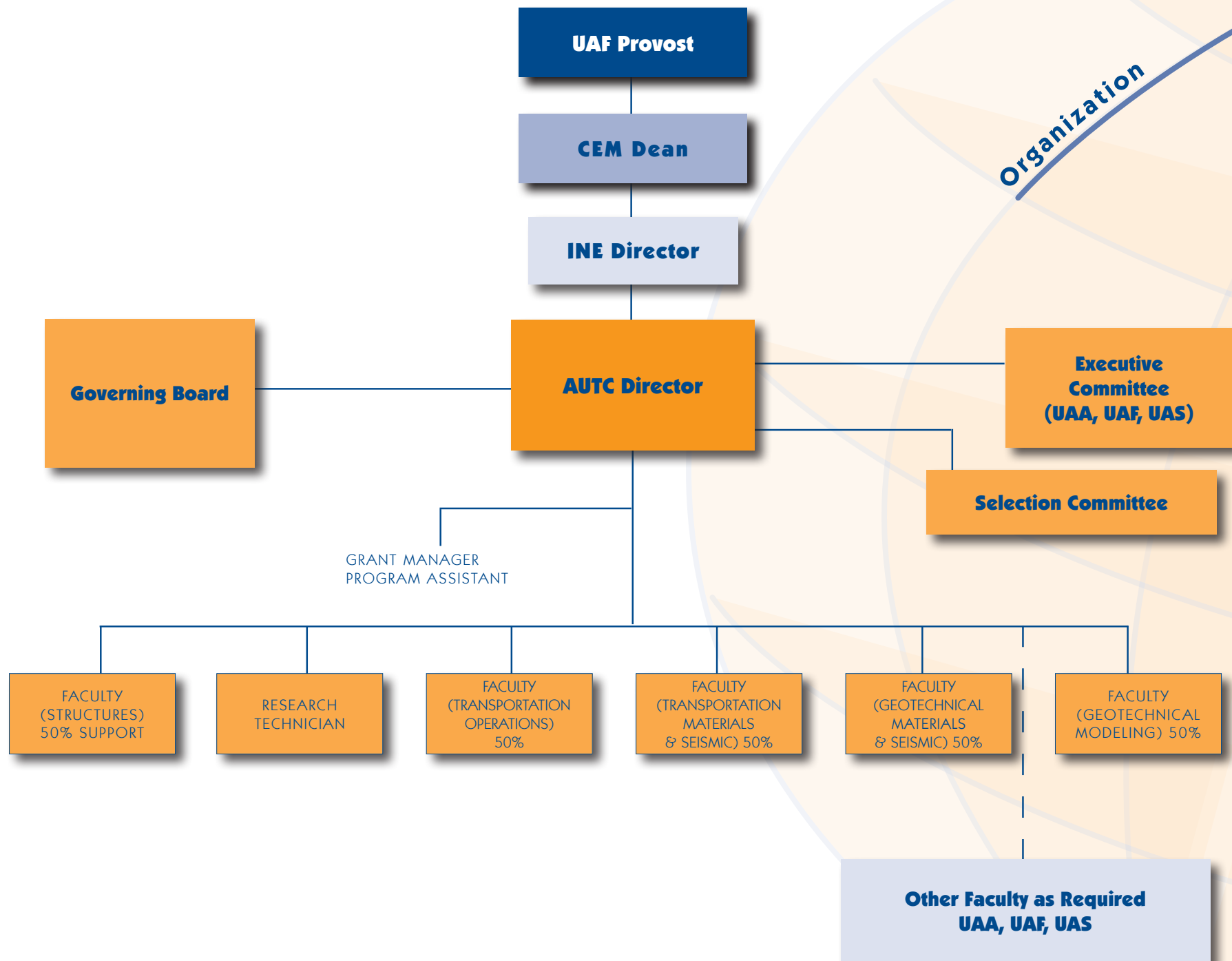
seismic interaction in frozen soils. We've also strengthened our expertise in transportation materials including asphalt, concrete, steel, and granular materials in cold regions.

Indeed, we've come a long way; but our journey has just begun. **As we look forward, new challenges present themselves.** Climate change and the potential for increased marine traffic in arctic seas provide research opportunities in both arctic marine structures and homeland security. Coastal erosion threatens transportation infrastructure along Alaska's western and northern coastlines. Warming temperatures are beginning to melt permafrost under our roadways, railways, airports, and bridges. Changes in precipitation challenge our drainage structures.

Renewed interest in working in the arctic regions puts AUTC in an excellent position to provide education, outreach, and research in these areas. In the case of arctic marine transportation, this means increasing our expertise. In the case of permafrost, we will develop training materials and manuals of best practice to address warming temperatures. The focus on dust, marginal materials, the environment, and seismic response will continue. However, these are rapidly moving into the implementation phases.

After four years, we are excited about the challenges of the next 10 years.

A handwritten signature in black ink that reads "Billy Connor". The signature is written in a cursive, flowing style.



**AUTC's
Governing Board
provides direction in
understanding Alaska's
transportation needs.**



AMIT ARMSTRONG

Technology Deployment Engineer
Western Federal Lands
Highway Division
Federal Highway Administration
(FHWA), Washington, DC



RICK KESSLER

General Manager
Chenega Logistics



BRUCE CARR

Director, Strategic Planning
Executive Office
Alaska Railroad



CAPTAIN BOB PAWLOWSKI

Legislative Liaison
Denali Commission



MICHAEL DOWNING

Senior Project Manager
HDR Alaska, Inc.



JEFF OTTESEN

Director, Statewide Planning
Alaska Department of Transportation
& Public Facilities



GARY GUSTAFSON

Manager, Environmental, Regulatory
& Land, Alaska Gas Resources
BP Exploration (Alaska), Inc.



LANCE WILBER

Assistant Commissioner
Central Region
Alaska Department of Transportation
& Public Facilities

Our 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 about our board members, visit: <http://ine.uaf.edu/autc/>.

At its 2010 annual meeting, board members updated AUTC's Strategic Road Map, to put more emphasis on the impact of climate, workforce development, and sustainability of transportation.



MING LEE

Research Faculty, UAF
Civil Engineer, computer
technologies in transportation



SANDRA BOATWRIGHT

Proposals & Publications Manager
Certified Research Administrator,
Editing and public relations



JUANYU LIU

Research Faculty, UAF
Civil Engineer, pavement
materials and related topics



JILL DEWEY-DAVIDSON

Program Assistant
Coordination of program activities
and documentation



XIONG ZHANG

Research Faculty, UAF
Geotechnical Engineer,
modeling soil behavior under
dynamic loading



KATHY PETERSEN

Grant Manager
Certified Research Administrator,
Monitoring and management of
research funding



ZHAOHUI YANG

Research Faculty, UAA
Civil Engineer, structural
engineering and soil
interactions



GARY TYNDALL

Lab Manager
Research support, lab operations
and safety



ROBERT J. LANG

AUTC Acting Associate Director
University of Alaska Anchorage
afrijl@uaa.alaska.edu



J. LEROY HULSEY

AUTC Associate Director
University of Alaska Fairbanks
jlhulsey@alaska.edu



SONIA NAGORSKI

AUTC Associate Director
University of Alaska Southeast
sonia.nagorski@uas.alaska.edu

AUTC
Faculty and Staff
perform research, offer
training, and support
researchers all over
Alaska.

AUTC
Funded
19 New
Projects
in 2010 for
an estimated
\$3.73 million

Automatic Electrical De-icing System using Emerging Carbon Nanofiber Paper: A Pilot Field Testing

(PI Zhaohui Yang, UAA)

Snow and ice on pavement and bridge decks are a persistent problem, particularly in Anchorage, where black ice (a thin, nearly transparent layer of ice with a slick surface) often forms on coastal highways and bridge decks spanning open water. Black ice is difficult for motorists to recognize and causes many accidents.

Typical de-icing/anti-icing strategies include chemical and thermal approaches. Salting is one of the most commonly used. While salting is cheap and effective, it pollutes the environment and corrodes reinforcing steel bars in concrete, damaging bridges. Calcium chloride, magnesium chloride, and potassium acetate have been used, but high cost is only one drawback of these chemicals. Thermal anti-icing approaches tend to be difficult and expensive to install and maintain. Alaska and other cold regions need an environment-friendly, anti-corrosive, and cost-effective de-icing technology.



Left: During sidewalk construction, the project team places the prototype heating panel above a concrete base. From left to right, clockwise: Dr. Gangbing Song (University of Houston), Qiang Li, Ting Yang, and Xiaoyu Zhang (all UAA graduate students). Right: The heating panel is covered by another layer of poured concrete.

This project will develop and test an innovative de-icing technology based on emerging nanomaterials. A multi-disciplinary team (an electrical engineer, a mechanical engineer, and a civil engineer) will design an electrical de-icing system using carbon nanofiber paper; conduct large-scale outdoor experiments to collect performance data; assess system reliability and cost-effectiveness; and provide recommendations on using such systems in Alaska.

This technology is simple to install; it includes laying CNF paper on the bottom of regular pavement and causes minimal interference in pavement or bridge deck construction and no changes in pavement mix design. Operation costs may be cheaper than available de-icing methods, and this technology will reduce corrosion damage to bridge structures, reducing maintenance costs. Last but not least, this new system may reduce pollution to the environment by minimizing use of chemical de-icers.



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

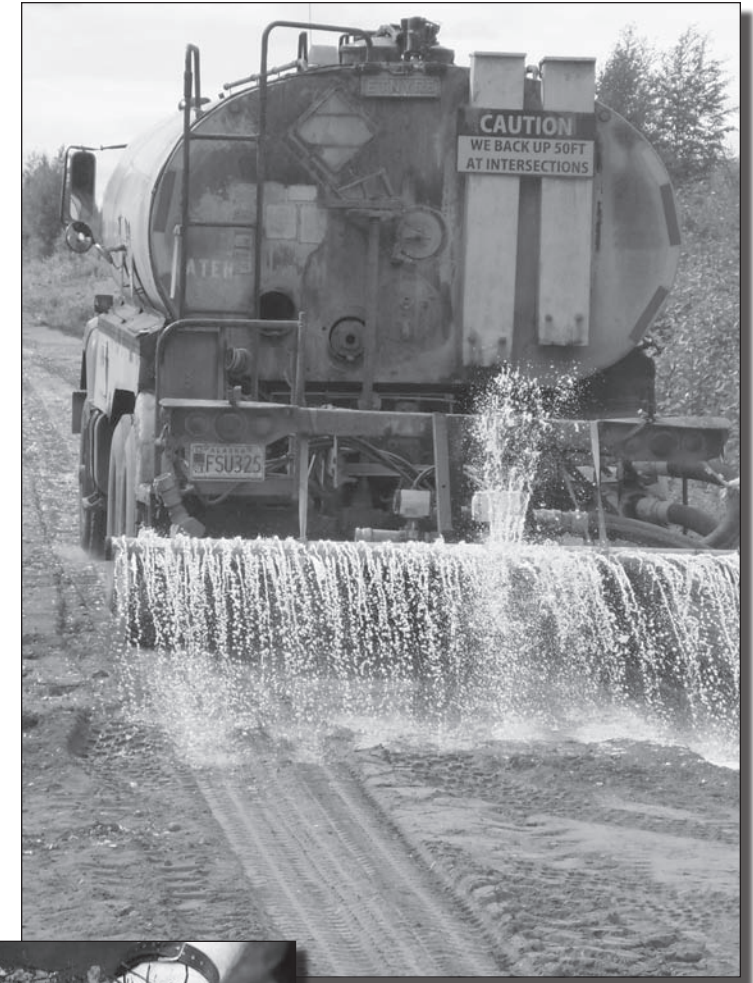
Instability of erodible slopes due to extreme climate and permafrost is a significant engineering problem for northern transportation infrastructure. Traditional stabilization techniques tend to be costly, as they require specialized skills and equipment to ensure adequate performance. The effectiveness of such methods becomes limited in cold climatic conditions. Recently, geofibers and synthetic fluids have been used to improve very loose sandy soils. This project will conduct a large-scale field investigation to study the feasibility of stabilizing erodible and thawing permafrost slopes with geofibers and synthetic fluid. This research will help minimize the problems and risks posed by thawing permafrost slopes in cold regions. The outcome of this research will be useful in ensuring a reliable, safe, and economic design.

Kwigillingok Runway Stabilization (PI Billy Connor, UAF)

The Alaska Department of Transportation and Public Facilities has sought recommendations from the Alaska University Transportation Center for the interim stabilization of Kwigillingok runway. ADOT&PF is in the early process of developing a long-term stabilization solution which will likely result in a new facility around 2015. For the interim, however, ADOT&PF has turned to AUTC for assistance in stabilizing the runway through the use of geofibers and synthetic fluid, a non-traditional technology that AUTC has been researching for the last three years.

Use of Mirafi Nylon Wicking Fabric to Help Prevent Frost Boils in the Dalton Highway Beaver Slide Area, Alaska (PIs Xiong Zhang, UAF; Michael Lilly, GW Scientific)

Many roads in Alaska, such as the Dalton Highway, experience degradation during spring thaw due to the downslope running of shallow groundwater. The water flow down the slope and pools up in the road embankments, where it freezes, causing frost boils and subsequent road damage. One good example of this damage occurred at Beaver Slide, near mile 110.5 of the Dalton Highway. The frost boils have resulted in extremely unsafe driving conditions and frequent accidents. Past repair efforts indicate conventional road construction methods do not work. The Mirafi Nylon Wicking Fabric, developed by Tencate Geosynthetics (North America), offers a potential solution. Featuring high specific surface area and high permeability, preliminary laboratory tests of MNWF indicate that it has great promise as a cost-effective means to solve the frost boil



Combining soil, geofibers, and soil-stabilizing liquids can make the poor, silty soils often found in northwestern Alaska strong enough to support roads and airfields. AUTC projects have extended the use of geofibers in Alaska transportation infrastructure.

problems on northern road systems. This proposed project aims to verify the theory, testing MNWF at Beaver Slide using moisture and temperature sensors to gather measurements for one year. Upon evaluation, researchers expect improved performance of pavement at installation sites. Data will be gathered regarding soil properties at the site; observed thermal and moisture changes and pavement performance over a one-year period; analysis of frost boil mechanisms; and evaluation of MNWF effectiveness to mitigate frost boil problems.

Research results may lead to incorporation of MNWF in the geotechnical engineering curriculum at UAF. Further, recommendations developed from the research will be useful in ensuring a reliable and economic design of roads in arctic environments.

Accelerated Degradation and Durability of Concrete in Cold Climates (Pls Pizhong Qiao, WSU; Juanyu “Jenny” Liu, UAF)

Degradation of aggregate in concrete can be caused by erosion or fracture over time. Extensive studies have been conducted on concrete mix design and composition of cementitious materials to improve the performance and durability of concrete.

This project is a collaboration between researchers at UAF and Washington State University. Project tasks include application of a promising testing protocol for long-term concrete performance characterization; evaluating damage accumulation and concrete durability at cold temperatures with damage mechanics models; developing specifications on performance criteria and service life predictions, and providing guidelines for ADOT&PF to evaluate concrete performance and safety. Study outcomes will benefit the construction and maintenance of transportation infrastructure in cold climates.

Ductility of Welded Steel Columns

(Pls Mervyn Kowalsky, NCSU; and Andrew Metzger, UAF)

This research, a joint effort between AUTC and North Carolina State University, is a continuation of an ongoing project that investigated bridge and marine structure design practices, aiming to identify improved connection design approaches to produce the necessary ductility and energy absorbing capacities required for satisfactory designs in Alaska.

Through earlier testing, researchers not only proved what methods were inadequate (such as the current practice of fillet-welding the cap beam to the pile as well as an alternative welding methods) but also confirmed that a new method of using a plastic hinge-relocating concept was more successful. This method utilized a round steel column capital in which the top portion welded to the cap beam is thicker than the bottom thinner portion welded to the pile. The approach successfully reduced the inelastic demands of the cap beam weld, and forced the inelastic action to occur in the pile itself.

Current research includes optimizing the new design to improve displacement capacity and ductility in bridge and marine structure design, as well as investigating additional connection designs proposed by ADOT&PF engineers. The research will result in a series of design recommendations consistent with the various levels of seismicity found within Alaska. The primary benefit will be the improved design and performance of steel bridges and marine structures containing similar connections.

Effect of Load History on Performance Limit States of Bridge Columns (Pls Andrew Metzger, UAF; Utpal Dutta, UAA; Mervyn Kowalsky, NCSU)

This project investigates the impact of seismic loading history on the design of reinforced concrete bridge columns typical of those used in Alaska. Currently, structural engineers use concrete and steel strain limit states in seismic design, which have minimal experimental or theoretical basis.

The overall objective of this project is to propose strain limit states that account for regional seismic loading histories in Alaska, and to relate these proposed strain limits to displacement limits.

Project goals will be met through a combination of analytical and experimental studies. A key requirement of the experimental work is the ability to measure large strains (up to 12%). The seismic loading histories to which the test specimens will be subjected will be determined from a data set developed by researchers at the University of Alaska Anchorage. Results from both frame-type and fiber-based analyses using ground motions from the data set will guide the initial selection of specimen design variables.

A total of nine tests on essentially full-scale circular bridge columns will be performed. Given the limited number of tests, it is important to learn as much as possible from each test before designing and conducting additional

tests. These nine test units will be subjected to load histories with varying characteristics, but typical of those experienced in Alaska.

The primary benefit of this project will be a better understanding of how seismic load history influences the performance of reinforced concrete bridges in Alaska. ADOT&PF engineers will be provided 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.

Selecting Preservatives for Marine Structural Timbers in Herring Spawning Areas (PI Robert A. Perkins, UAF)

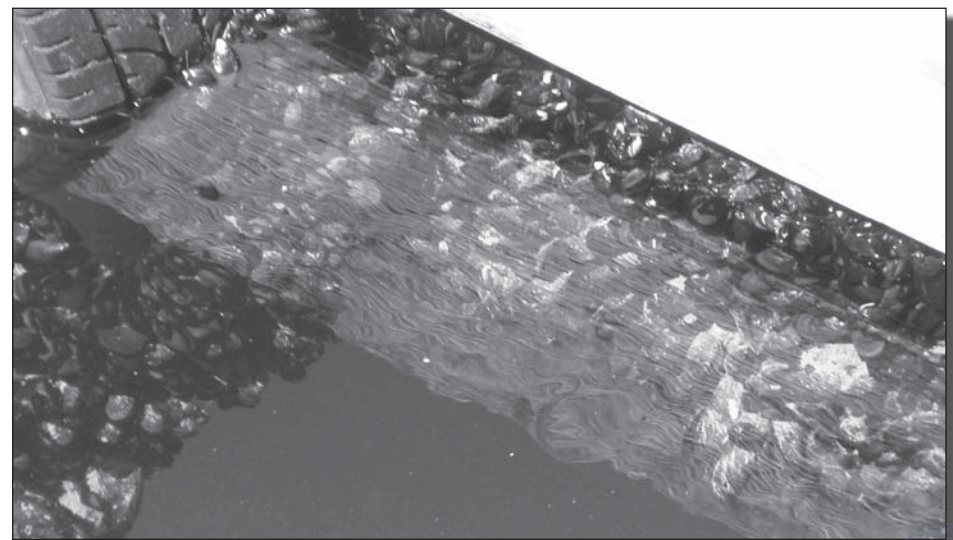
Alaska marine harbors use wood for many structures that come in contact with saltwater, including piles, floats, and docks, because it is economical to buy and maintain.

However, wood immersed in saltwater is prone to attack by marine borers, various types of marine invertebrates that can destroy a wood structure in only a few years. In Alaska marine waters there are only two wood preservatives currently recommended: ACZA (ammoniacal copper zinc arsenate) and creosote. ACZA is a water-based preservative that leaches copper into the marine environment; copper is toxic to marine invertebrates and other species. Creosote is an oil-based preservative made from coal tar; it leaches a class of hydrocarbon chemicals called polycyclic aromatic hydrocarbons into the water. Some research indicates that copper leaching from ACZA is slight after a year or so, while creosote leaches PAH at a declining rate over time, but is still measurable after many years. Field research with both preservative methods is hampered because harbors are frequently contaminated with many chemicals, so determining how the wood preservatives alone impact marine life over time is difficult.

This project will test the toxicity of marine structural materials to herring eggs under a variety of conditions common in Alaska marine waters, focusing on Southeast Alaska; it will also compare the durability of creosote-versus ACZA-treated marine timbers under comparable climatic and service conditions. This research aims to provide relevant information to ADOT&PF to improve its selection of wood structural materials in the marine environment, especially the selection of wood-preserving methods.



Two scenarios in creosote use. Top: The heavy layer of tar-like creosote on the pile is coated with wind-blown spruce needles and seeds. For modern creosote piles, Best Management Practices dictate a lighter application, with little or no surface tar. Below: Creosote members covered with mussels and algae, indicating low toxicity. With this project and others, AUTC scientists help ADOT&PF meet federal standards for environmental protection.



Testing and Screening Surfacing Materials for Alaska's Yukon River Bridge (PI J. Leroy Hulsey, UAF)

The Yukon River Bridge, also known as the E.L. Patton Bridge, carries the two-lane Dalton Highway and the trans-Alaska oil pipeline across the Yukon River at a 6% grade. It is 30 feet wide, with 6 spans; it was designed to withstand -60 degrees Fahrenheit temperatures, huge ice loads from the river, truck loads hauling supplies to the oil fields, the oil pipeline, and, in the future, a gas line.

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 also decreased, while material costs increase.

Every time the Yukon River Bridge deck is resurfaced, it costs the public millions of dollars. Further, in the past only timber was used, and the quality of this material is decreasing as the cost is increasing. It is imperative that new materials for use as a wearing surface for this bridge be identified.

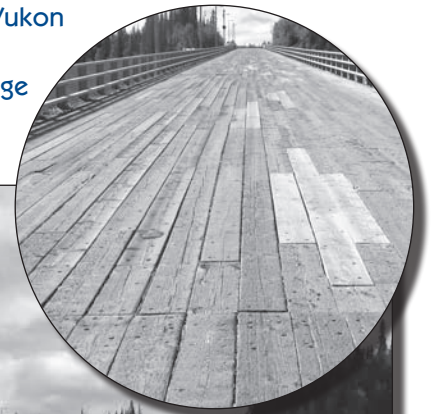
This research seeks to identify a material suitable for bridge decking that will last more than 15 years. A longer-lasting material will mean future savings to the ADOT&PF in the millions of dollars.

Developing Guidelines for Pavement Preservation Treatments and for Building a Pavement Preservation Program for Alaska (PI Gary Hicks, California Pavement Preservation Center)

This project will assist the ADOT&PF and local Alaska agencies in identifying pavement preservation treatments suitable for specific environmental regions within the state. Expected benefits of this study include cost savings (studies have shown an active pavement preservation program can offer more than 50% cost savings over a life cycle of 20 years); energy and emissions savings (pavement preservation treatments are green treatments); and satisfied users (less skid and noise).

Research results will provide the State with information on the types of preservations most suitable for Alaska; information on performance of pavement preservation treatments used in Alaska; a strategy selection guide for treatments; recommendations on building a program; and recommendations for implementing a comprehensive Asset Management program.

The E.L. Patton Bridge, also known as “the Yukon River Bridge,” which carries the Dalton Highway across the Yukon River. Close-up shows an example of the conventional wood decking used on the bridge for the last 30 years.



This project is a joint venture between Caltrans, AUTC, and ADOT&PF. The majority of the work will be performed at the California Pavement Preservation Center. UAA and UAF researchers will contribute to data analysis and to preparation of guidance materials for ADOT&PF.

Using the Micro-Deval Test to Assess Alaska Aggregates

(PI Juanyu “Jenny” Liu, UAF)

Choosing the right material is half the battle in building roads for Alaska. The extreme conditions typical to cold regions require a durable, abrasion resistant and freeze-thaw resistant aggregate. Recently the state has been wondering exactly how effective and accurate its selection methods are. Currently there is limited information regarding the Alaska Testing Method 313 (sometimes known as the Washington degradation test) used by ADOT&PF to test abrasion and degradation value.

This project will examine a new testing method, the Micro-Deval test — a wet test of how aggregates degrade when tumbling in a rotating steel drum with water and steel balls — to determine whether it can provide safe and cost-effective aggregate testing with reproducible results that correlate with field performance. The Micro-Deval test is easy, safe, and less costly to perform than traditional testing methods. It is suitable for smaller equipment, requires smaller sample quantities and uses a simple procedure.

This study will provide data and recommendations on the suitability of the Micro-Deval test as a rapid, simple, repeatable and inexpensive technique for assessing the durability of Alaska aggregates.

Characterization of Alaska Hot Mix Asphalt Mixtures

with a Simple Performance Tester (PI Juanyu “Jenny” Liu, UAF)

The current trend toward developing mechanistic flexible pavement design and the subsequent need for more reliable design procedures require more accurate characterization of hot mix asphalt properties.

This study will develop a catalog of dynamic modulus values for HMA mixtures typically used in Alaska. Researchers will investigate the correlations between simple performance test results and HMA lab performance. Results will provide practical information to ADOT&PF regarding how Alaska HMA mixtures respond to the new test procedures, and how use of Alaska HMA mixtures will affect current flexible-pavement design methods.



Engineer Jenny Liu led several projects involving testing and characterization of both hot mix and warm mix asphalt. Here ADOT&PF personnel use a hot mix asphalt during construction of a new section of pavement in Southeast Alaska. This test site will yield information on which hot mixes work best in cold regions.

Geophysical Applications for Arctic/Subarctic Transportation Planning

(PI William E. Schnabel, UAF)

Roads and bridges constructed in permafrost areas are often damaged when the thermal state of the soil changes. Characterizing soil subsurface conditions and designing for them is key to constructing a road or a bridge.

Geophysical methods such as electrical resistivity tomography and ground-penetrating radar, currently under-utilized in arctic subsurface investigations, could be powerful and relatively inexpensive tools for infrastructure planners. Current research indicates that using ERT and GPR together as part of a geophysical survey can effectively map the extent of ice wedges, ice lenses, massive ice, and talik (a layer of year-round unfrozen ground within a permafrost area).

This effort by scientists at the University of Alaska (Anchorage and Fairbanks campuses) and Laval University will describe four case studies in which geophysical surveys are implemented into subsurface investigations along road and bridge alignments being conducted by ADOT&PF. Although results will be used to 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.

The four case studies will produce initial information for a database describing geophysical properties characteristic of permafrost and talik conditions in Alaska. Thereafter, previous and new reports on the geophysical properties observed in other frozen environments in Alaska can be added to assist in interpreting future geophysical surveys.

This project will provide protocols for carrying out and interpreting arctic/subarctic geophysical surveys, as well as guidance for selecting the appropriate methods and estimating survey costs.

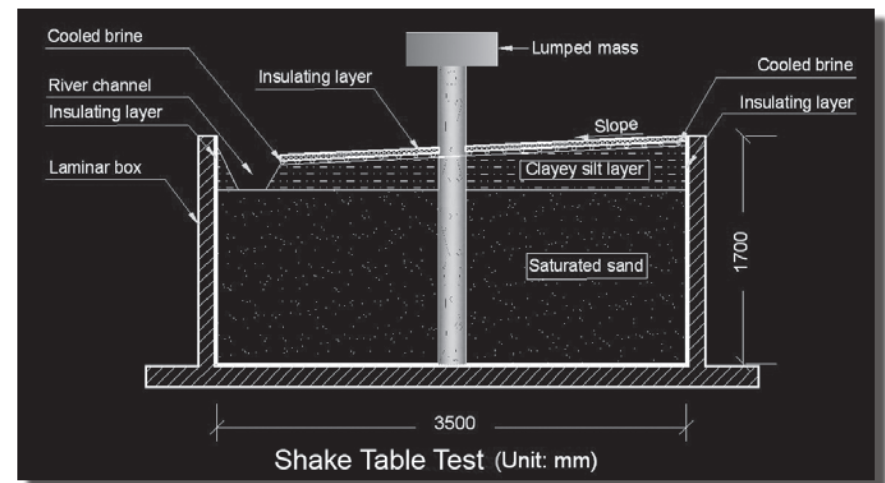
Shake Table Experiments of Bridge Foundations in Liquefied Soils: An International Collaboration (PI Zhaohui "Joey" Yang, UAA)

Liquefaction and associated ground failures have been common in major earthquakes across Alaska, causing extensive damage to infrastructures. Lateral spreading is particularly damaging if a non-liquefiable crust rides on top of liquefied soil during an earthquake.

The physical properties of frozen ground crust change drastically in winter; stiffness and strength increase, and permeability decreases. The impact on a bridge foundation by frozen ground crust resting on a liquefied soil layer and the loads generated during a winter earthquake are unknown.

This project, an outgrowth of another AUTC project, will benefit from collaboration with Professor Xianzhang Ling, an engineer at the Harbin Institute of Technology, China. Ling is interested in liquefaction-induced geotechnical engineering problems in cold regions and is willing to share the cost of two large-scale shake table tests, which makes it feasible to integrate physical testing with our ongoing simulation project.

This project aims to conduct physical experiments to gain insight into liquefaction-induced ground failures and consequences on highway bridge substructures, as well as to validate the results of computer modeling.



A shake table model of a single pipe embedded in a frozen silt layer overlying a liquefiable sand layer adjacent to a river channel. In these experiments, the loads induced on the bridge foundations by unfrozen and frozen ground crust will be measured from two shake table tests by means of strain gauges.

The knowledge gained from this project will lead to improvements in seismic design of highway bridge foundations in Alaska, as well as in other northern regions with seismic activity.

Fast Determination of Soil Behavior in the Capillary Zone Using Simple Laboratory Tests (PI Xiong Zhang, UAF; Robert L. Lytton, TAMU)

Frost heave and thaw weakening are typical problems for engineers building in northern regions. These unsaturated-soil behaviors are caused by water flowing through the capillary zone to a freezing front, where it forms ice lenses.

Although suction-controlled tests are the standard for characterizing unsaturated soils, such testing is too laborious, time-consuming, and costly for routine engineering projects. Characterizing the stress/strain behavior for only one unsaturated soil can take up to three years, and moisture content measurements are unreliable.

This research team seeks to develop a method for rapidly determining and analyzing unsaturated soil behavior through a new approach, the Modified

State Surface Approach. The MSSA can potentially reduce the time required to characterize unsaturated soils to a few weeks, as well as provide more reliable measurements and more representative soil behavior.

If successful, this research will produce a useful tool for geotechnical engineers, allowing fast, practical, and more comprehensive soil characterization for more complicated soil behavior problems.

Construction Dust Amelioration (PI Robert A. Perkins, UAF)

Dust produced on seasonal road construction sites in Alaska is both a traffic safety and environmental concern. Dust emanating from unpaved road surfaces during construction severely reduces visibility and impacts stopping sight distance, and contributes to the local burden of PM_{2.5}, small particulates that present an important environmental air quality concern. This research aims to assist ADOT&PF in developing safe, efficient techniques for short-term dust suppression.

Experts believe applying a dust-control palliative like calcium chloride, Enviroclean, Durasoil, or EK35 to the unpaved surface during road construction will solve the dust problem. This research will gather necessary information to determine when, what type, in what concentration, and how often the dust-control palliative should be applied. The amount and size of the dust particles, the time the surface is to remain unpaved, the makeup of the unpaved road surface, local environmental conditions, and the availability and cost of the dust control palliatives are factors to consider. The project is especially valuable because measurement systems used in other states involve special equipment and/or certification of observers, neither of which may be practical in Alaska with our remote locations and short construction season.

Performance of Dust Palliatives on Unpaved Roads in Rural Alaska

(PI David L. Barnes, UAF)

Over the last several years agencies in Alaska, including ADOT&PF and local governments, have been working on solutions for fugitive dust. Fugitive dust impacts health and quality of life, and increases road maintenance costs as material is lost from the road surface. One objective of this project is to assess the longevity of different palliatives applied to rural Alaska roads over two summer seasons. For this study, roads in three villages will receive palliatives



Student Travis Eckhoff drives an all-terrain vehicle outfitted with the DUSTM along a rural road near Tanana Village, Alaska. The portable UAF DUSTM can make performance testing of dust-control palliatives a standard practice.

and be monitored; in addition, researchers will treat sections of roads in North Pole and Point McKenzie, Alaska.

Data will be collected using the UAF DUSTM. The Alaska Department of Environmental Conservation requested comparisons of associated dust concentrations measurements by UAF DUSTM and by stationary monitors. Developing this correlation will determine how much of the measured fugitive dust is from a controllable emission source, and how much is from uncontrollable sources. These results will be useful to any community planning to use dust-control palliatives. From a public health and an economic standpoint, an important question is, how much of the dust arising from unpaved roads needs to be controlled to meet regulatory standards?

Assessing the Contribution of Traffic Emissions to the Mobile Vehicle Measured PM_{2.5} Concentrations by Means of WRF-CMAQ Simulations **(PI Nicole Mölders, UAF)**

Air quality in Fairbanks, Alaska, has fallen below the 24-hour National Ambient Air Quality standard for PM_{2.5} every winter since the Environmental Protection Agency set the new standard of 35 micrograms per cubic meter of air. Many people think traffic is an important contributor to the too-high PM_{2.5} concentrations.

The Fairbanks North Star Borough started measuring PM_{2.5} concentrations using instrumented vehicles in the winters of 2008/09 and 2009/10. Although these measurements represent a mixture of all potential PM_{2.5} sources, they are typically taken in places (roadways) where traffic emissions could be higher than in adjacent neighborhoods. This research will assess the traffic-emission impact on observed concentrations under various traffic and cold-weather conditions using an Alaska-optimized version of EPA's regulatory model called WRF-CMAQ.

Data from this project and the ongoing Mobile Measurement Project will be added to a GIS framework to create maps that show PM_{2.5} concentrations in Fairbanks neighborhoods under various weather conditions. These maps will be available on the web for public information on air quality.

This project will help the FNSB assess how much traffic contributes to our poor winter air quality. It will also help the borough develop good, fair, air-pollution mitigation strategies.

Gathering Vehicular Parameters through a Vehicle-to-Infrastructure Intelligent Transportation System **(PI Jeffrey Miller, UAA)**

An Intelligent Transportation System combines 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.

This project will build on the successes of an ongoing AUTC project, "Assessment of Traffic Congestion in Anchorage Utilizing Vehicle-Tracking Devices and Intelligent Transportation System Technology," which currently tracks the speed, location, and direction of vehicles in Anchorage, Alaska.

Current ITS systems collect only data on speed, location, and a unique (and anonymous) identifier. Additional data can easily be gathered and transmitted to a central server through a vehicle-to-infrastructure (V2I) architecture. The V2I architecture allows data to be transmitted as a text message from individual vehicles through the cellular network to a central server.

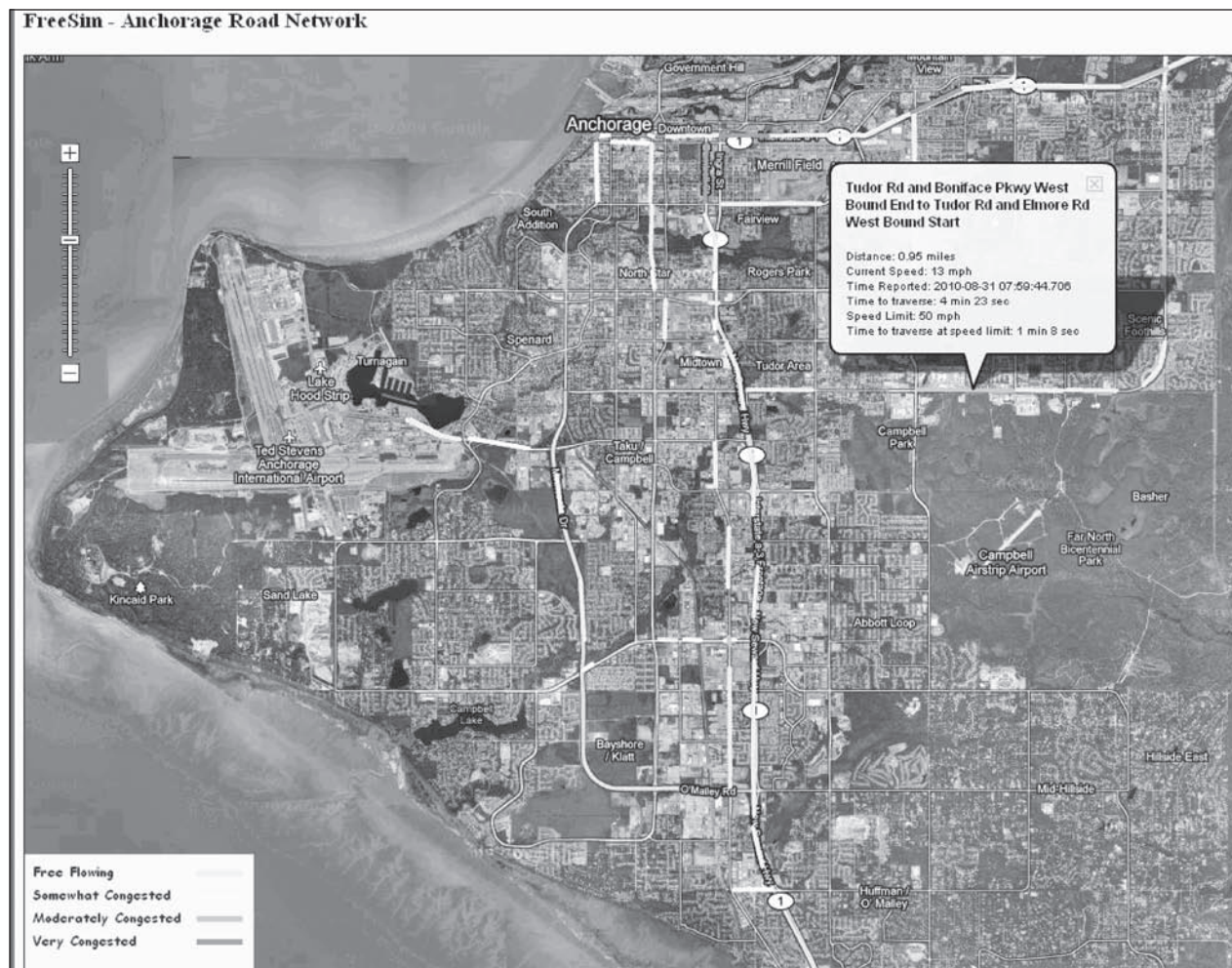
Using the On Board Diagnostics port of a vehicle will allow data from the vehicle's computer system to be gathered and transmitted over the V2I network. Although much of this data is specific to the make and model of the vehicle, there are several commonalities, including engine revolutions per minute, fuel consumption, and rate of acceleration/deceleration. Many vehicles also include engine temperature and tire slippage; others include cabin and outside temperatures, and tire pressure and rotation. For vehicles whose computer system does not report tire slippage, custom sensors will be created to identify locations where a vehicle is not able to secure traction easily.

This project will develop four applications for study:

1. It will build on the ongoing project, tracking vehicle speed, locations, and direction. As more vehicles are equipped with reporting devices, determination of congestion, speed, and travel time will improve. This data is already available via a program called FreeSim, at <http://www.alaskatraffic.net>.
2. Gathering the fuel consumption, engine temperature, and outside temperature will allow tracking of differences in air quality based on different seasons and weather patterns.
3. Tracking the effect of cold weather on engines will aid in determining ways in which to lower fuel consumption and improve operating costs for vehicles during the cold months.
4. Identifying locations where vehicles relay data on tire slippage will allow alerts to drivers through a web interface (and possibly text messages) as to the location of dangerous road conditions. A message will also be sent to public works facilities so they can decide whether or not to dispatch someone to sand the area where the slippage occurred.

Although most ITS applications assume that distributed real-time vehicular data is available, no studies make data available to other researchers in real time. This project will release data to other researchers and to the public.

The people of Anchorage and Alaska will be able to use FreeSim to determine current traffic conditions based on live, real-time data. This interface will also show the location of slippery roadways. As time goes on, more vehicles will be equipped with similar devices, along with vehicle fleets already participating in the project.



Drivers participating in the “Assessment of Traffic Congestion in Anchorage Utilizing Vehicle-Tracking Devices and Intelligent Transportation System Technology” and the “Gathering Vehicular Parameters through a Vehicle-to-Infrastructure Intelligent Transportation System” projects can log in to a web site for an up-to-date map of traffic and environmental conditions on Anchorage roads. Major roadways are color-coded to indicate levels of congestion and the amount of time it takes to travel along those roads based on real-time data from individual vehicles.

Seismic Performance of Bridge Foundations in Liquefiable Soils (PI Zhaohui “Joey” Yang, UAA)

What happens to a bridge foundation during an earthquake if it is built on a frozen crust of ground that rests on a layer of liquefiable soil (soil that changes from behaving as a solid to behaving as a liquid during an earthquake)? How large are the loads generated by the interaction of frozen crust and foundation during a winter earthquake, and how should a designer deal with them? How can engineers make bridges safe and strong enough to withstand such forces of nature?

These questions are unique to arctic areas such as Alaska, but there are no seismic analysis guidelines to account for how frozen-ground crust affects bridge foundations at a liquefiable site. This project provides the first quantitative evaluation of loads imposed on bridge foundations by a frozen crust with liquefaction and lateral spreading. Study results will improve seismic design of highway bridge foundations in areas of arctic conditions and seismic activity. Better seismic performance of Alaska’s bridges will increase transportation safety and reduce maintenance and reconstruction costs following a seismic event.

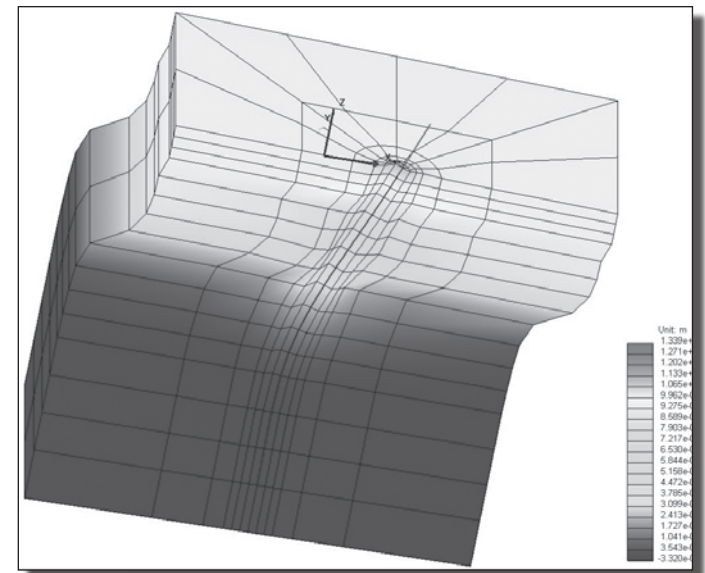
In the first year of this two-year project, a sophisticated model capable of simulating soil liquefaction has been calibrated and validated with physical testing data. This validated model has been applied to simulate the response of a bridge pile foundation typical in Alaska, embedded in liquefiable soils with an unfrozen or a frozen crust. Preliminary results show that pile performance is very sensitive to crust conditions. The internal forces of the pile (for example, bending moment and shear force) change by about 50% when the crust freezes. These results demonstrate the great need to further this research.

Numerical simulation seems insufficient in such determinations; researchers have proposed an experimental component to supplement this project. The funding request

has been approved by AUTC and ADOT&PF (see Newly Funded Projects). In the experimental component, large-scale shake-table experiments will be conducted in China in collaboration with the Harbin Institute of Technology. Test data, including soil responses and pile internal forces, will be collected to validate the computer simulation results.

This project is the study focus of UAA graduate student Qiang Li, who has contributed to all project tasks. Li is working on his Master of Science degree in civil engineering.

A modeling representation of a bridge foundation undergoing liquefaction-induced soil lateral movement caused by an earthquake. AUTC projects support safer bridge designs for cold regions.



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

The Alaska Department of Transportation & Public Facilities continually loses professional and support staff, both seasoned and young, a problem experienced by other agencies state- and nationwide. Besides losing the valuable expertise of professional and support staff, the agency loses organizational wisdom and historical knowledge of project history — often important elements in designing and constructing roads, airports, structures, and marine facilities. This project describes the best ways to improve recruitment and retention of the ADOT&PF workforce, including specific management and organizational tools to help minimize these problems. The project team includes Professor Perkins, Professor Emeritus Larry Bennett, and ADOT&PF engineer Bob McHattie; together they have over 90 years of experience dealing with management and professional issues in Alaska. All current and former employees in engineering job categories or other professional job types that directly support the engineering process were surveyed. A novel technique was used to improve survey response. First, the ADOT&PF commissioner e-mailed the agency's employees and wrote a letter to former employees, asking their cooperation. Then, the research team met with individual employees and called former employees, personally asking their cooperation. The response percentage was about 80%, which is outstanding for this type of survey. Responses to individual questions are currently being organized. Although individuals will remain anonymous, the survey results can be ordered by region and job type, to better help improve the retention process. The results are intended to help ADOT&PF secure a sufficient workforce for the future.

Bridge Deck Runoff: Water Quality Analysis and Best Management Practice Effectiveness (PI Robert Perkins, UAF)

ADOT&PF is responsible for more than 700 bridges, most of which span water bodies. Are these water bodies affected by storm water (rain and snowmelt) runoff from the bridge decks? What are the regulatory and economic constraints on the agency regarding this runoff? What actions, if any, should ADOT&PF take? These are questions addressed by this project.

Best management practices are mandated or recommended for certain bridges. Which BMP is best for each bridge is not defined in law, but requires selection by ADOT&PF after consideration of the bridge characteristics, costs and benefits of candidate BMPs, and practicalities of construction. While many practical BMPs are in place for runoff from streets and parking lots, far fewer options exist for bridges and fewer still work in Alaska's cold climate. Transportation officials in Norway, Canada, and northern U.S. states were contacted in the search for economical and practical BMPs for bridge decks. The project includes development of a database of all Alaskan bridges and their parameters relevant to storm water runoff. From those parameters, a numerical rating is being developed for each bridge. This rating, together with certain regulatory thresholds, will be used to determine if BMPs are required.

Spring converts snow and ice to meltwater at a bridge over the Chena River in Fairbanks. Such runoff can carry heavy metals and salts (from de-icing practices). This bridge is designed to direct runoff to the ends of the bridge, where it can be treated before it enters the river.

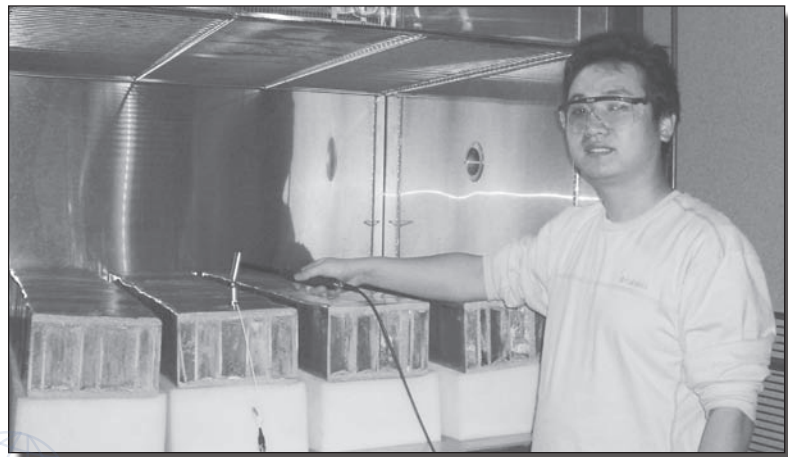


Smart FRP Composite Sandwich Bridge Decks in Cold Regions

(PI Pizhong Qiao, Washington State University)

What if every time a bridge on a lonely road got icy, it automatically notified the local DOT to begin ice-control safety measures? What if a bridge could tell someone every time an overloaded truck hit the decking, or when the trusses under it began to weaken? This project, a partnership of Washington State University, the University of Alaska Fairbanks, and Kansas Structural Composites, Inc. takes the first steps to develop, manufacture, test, and implement Smart Honeycomb Fiber-Reinforced Polymer (S-FRP) sandwich materials for transportation projects. This material integrates advanced composite materials with sensors and actuators.

So far, researchers have tested an S-FRP sandwich deck panel, evaluated several S-FRP sandwich beams in cold temperatures, and developed effective structural-health monitoring strategies. Dynamic tests of the S-FRP sandwich deck panel with and without damage continue, and structural-health monitoring strategies for cold temperature exposures will be developed. A combined experimental, theoretical, and numerical approach will result in new techniques for structural-health monitoring and damage identification of thick sandwich deck panels. It is anticipated that, with wireless communication technologies, the developed structural-health monitoring strategies will be capable of remotely monitoring and assessing the structural integrity of sandwich bridge decks in cold regions.



Assessing Anchorage Traffic Congestion with Vehicle Tracking Devices and Intelligent Transportation System Technology

(PI Jeffrey Miller, UAA)

Traffic is increasing in most urban cities around the world, Anchorage included. The U.S. Census Bureau shows that Anchorage's population has increased by over 9% (8,000 people per year) since 2000. Increased population means greater numbers of vehicles on the road, adding to traffic congestion. The exact impact of this increase is not known, because the current means to determine congestion in Anchorage is with vehicle counters and sparsely placed video cameras that may or may not be monitored. Drivers only learn about current traffic conditions through 511 information and radio and television broadcasts, which are not always updated in a timely manner. To analyze traffic congestion and improve information availability for motorists, vehicle-tracking devices, which use a vehicle-to-infrastructure (V2I) architecture that leverages the cellular network, have been installed in 65 vehicles in Anchorage.

Using data already collected from vehicle-tracking devices, researchers have analyzed and displayed real-time traffic conditions based on the amount of time to travel along main roads in Anchorage. The vehicles into which tracking devices have been installed typically travel across the city from different locations during rush hour. Sufficient data is received from these vehicles during rush-hour traffic to accurately estimate the time it takes to traverse the city's main arteries.

Data from this project is available to the public in a web interface called FreeSim (<http://www.freewaysimulator.com>) at the URL <http://www.alaskatraffic.net>. If data exists for a specific roadway, the amount of time and average speed on that roadway will be displayed when a user puts the mouse over that roadway. Roads are color-coded to assist the user: red roads mean that traffic is moving at less than 25% of the speed limit; orange roads, 25–50% of the speed limit; yellow roads, 50–75% of the speed limit; and green roads, more than 75% of the speed limit. Historical data for the vehicles is stored in a database, and an application is being built that allows the public, ADOT&PF,

Doctoral student Wei Fan is testing S-FRP sandwich beams in a low-temperature chamber to collect data on beam responses to cold temperatures and on sensor performance.

and Municipality of Anchorage to query that data to determine custom information. Specific queries are already being answered for the municipality.

Based on the continuous flow of data being gathered, researchers expect to find answers to questions about traffic patterns, traffic delays, seasonal traffic variations, how drivers circumvent traffic congestion, and whether route changes to avoid congestion actually save travel time.

Updated Precipitation Frequency Analysis for the State of Alaska (Pls Douglas L. Kane, Svetlana Berezovskaya, and Amy Tidwell, UAF)

Planning for construction of roads and bridges over rivers or floodplains includes a hydrologic analysis of rainfall amount and intensity for a defined period. Infrastructure design must be based on accurate rainfall estimates — how much (intensity), how long (duration), and how often (frequency or probability). UAF and the National Oceanic and Atmospheric Administration are updating this important design tool with support from AUTC and ADOT&PF.

Measuring precipitation in an environment like Alaska's is difficult. Challenges include poor gauge performance in windy environments, especially for solid precipitation (such as snow, sleet, and hail); and accessing and working in remote, sparsely populated, rough, and complex terrain. Another issue is the sparseness and distribution of the gauge stations. For example, the area north of the Brooks Range, known as the Arctic Slope of Alaska, is one of the least-understood climatic regions of the country. This region, with an area of over 230,000 square kilometers, has only a handful of long-term precipitation gauges, and many of the existing gauges are unattended. The quality of reported precipitation data varies due to gauge location, type, and whether or not a rain or snow gauge shield is present. Wildlife interactions with stations are a common occurrence in remote environments

This project uses newer methodology and more advanced modeling techniques to analyze both the original data and the data collected since this information was last published in 1963. The team has compiled all data from the various resources, put it in a common format, and completed preliminary quality assurance and control. Due to a lack of detailed metadata, the proposed bias corrections for gauge undercatch will not be

made (gauge history at each station did not indicate when or if alter shields were added). This study only addresses the frequency of rainfall events; thus, researchers will define the rainy season for each station using air temperature data. Another ongoing task is to determine which station data sets, of the roughly 1,243 meteorological stations and private rain gauges throughout Alaska, can be merged (stations essentially located at the same place but with different names and data collection dates). This new information will ultimately be published as Volume 14 of the *NOAA Atlas, Precipitation-Frequency Atlas of the United States*, in a spatially-distributed electronic format.

The 2006 Southcentral flood undercut sections of the Richardson Highway between Valdez and Tazlina, Alaska. ADOT&PF personnel were on the scene and inspecting the damage as soon as the floodwaters subsided. The Precipitation Frequency Project will help state planners design appropriate infrastructure for Alaska.



Application of a Non-traditional Soil Stabilization Technology: Lab Testing of Geofibers and Synthetic Fluid (PI Billy Connor, UAF)

This project, funded by ADOT&PF and AUTC, is investigating a new technique for using geofibers and a synthetic fluid to stabilize very loose sandy and silty soils typical of Western Alaska. Lab testing focused on measuring how well these new materials might improve poor foundation soils. Tests have shown 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 moisture sensitivity of the fine-grained material.

Rodney Collins, graduate student in civil engineering, has performed the majority of these laboratory tests.

Application of a Non-traditional Soil Stabilization Technology: Use of Geofibers and Synthetic Fluid in the Field (PI Billy Connor, UAF)

This project, funded by the Federal Highway Administration, will perform a practical field test of a new technique for using geofibers and a synthetic fluid to stabilize very loose sandy and silty soils. This project is an outgrowth of an ongoing laboratory-focused study in soil stabilization. On the basis of soil testing, a site in the Matanuska-Susitna Borough near Horseshoe Lake, Alaska, was selected for application. In the coming year, researchers will work with FHWA to gather data from this test site as well as other active projects; they will also identify new test sites in the state of Washington.

This project will directly benefit a wide range of transportation construction projects by presenting engineers with soil preparation strategies that make use of locally available materials, which will significantly reduce overall construction costs. Likely construction projects include highway embankment construction and unstable slope management in addition to construction of roads and airports in remote areas. This project has provided hands-on research experience for two UAF undergraduate students.

FNSB Road Upgrading Process (PI Billy Connor, UAF)

Currently, the Fairbanks North Star Borough does not have the right tools to help it decide when to upgrade its road system. This project will help FNSB develop a rational, effective, and efficient process to upgrade roads in a manner that allows it to either pave or continue 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 has 109 local road service areas with over 470 miles of roads to maintain and service. Road conditions vary among the service areas as well

Left: ADOT&PF workers and AUTC students spread an innovative new geofiber created by Peak Fiber Technologies on a freshly prepared roadbed of loose, silty soils. Right: A close-up showing individual pieces of fiber material. To see a video of the road building process, visit <http://www.youtube.com/watch?v=Nzh-xNW4Ows>.



as among individual roads within a single service area. The most frequent budget request from service areas to the FNSB is for surface upgrades to improve drivability and reduce maintenance costs. Without a carefully designed process that considers the priorities, design options, and cost for upgrading, the funds invested in the roads cannot be maximized. A systematic and effective approach to guide decision-makers in selecting and designing appropriate road upgrades is urgently needed so that long-lasting, cost-effective road improvement solutions can be identified and achieved. This approach will include a scheme for examining and sampling the road upgrade candidates, a simplified flexible pavement design method, a model for estimating associated cost, and a Decision Support System (DSS) based on a geographic information system (GIS) platform. Issues intrinsic to the road-upgrading process such as minimizing dust, aiding emergency services, evaluating how inadequate structures will affect future paving demands, and considering the economics of the upgrading investment will be addressed. The results will be integrated in the GIS-based DSS to help FNSB decision-makers and engineers develop projects for effective and economical road improvement.

Preservation of the Alaska Highway, Phase 2

(PIs Daniel Fortier and Yuri Shur, UAF)

The Alaska Highway, the only road connecting Alaska to the contiguous U.S., crosses large areas of permafrost-rich soils. Highway reconstruction in the mid-1990s damaged the organic layer that insulated and protected the surrounding permafrost. Since then, heat transfer through the road has been melting the ground ice. The thawing and settling ground has created dips, bumps, potholes, and cracks. Throughout the past 10 years, the climate has been relatively stable, but in the near future, climate warming will undoubtedly increase permafrost degradation and damage to the road.

This project, an outgrowth of an earlier, completed AUTC project, will continue data collection along instrumented sections of the highway and lab testing of soil samples as well extensive data analysis and modeling.

This summer's fieldwork included construction of a snow shed along one section of the highway embankment. By keeping the insulating snow off the ground surface, the soil is exposed to cold air flowing under it. This promotes

convective heat transfers between cold air and the ground which is very effective for cooling, and for keeping permafrost frozen. Researchers also established a permafrost database and 3D cryostratigraphic model linked to a geographical information system that will allow evaluation of the mitigation technique's efficiency.

Project results will help engineers in Alaska and western Canada mitigate damage to the Alaska Highway, as well as to other infrastructure that crosses ice-rich soils. Project researchers are working with the Yukon Highway Public Works Department to implement new designs for mitigation of the damage caused by melting permafrost. This project has also been the focus of study for Eva Stephani, a graduate student working on an interdisciplinary Master of Science degree in geomorphologic engineering.

A General Review of Mitigation Measures for Slope Stability Problems in Alaska (PI Kenan Hazirbaba, UAF)

Unstable natural and designed slopes pose significant engineering problems for northern transportation infrastructure, driving up design, engineering, and maintenance costs. Engineers continually look for mitigation alternatives to reduce unstable slopes and related hazards in Alaska. Traditional stabilization techniques tend to be costly because they require specialized skills and equipment to ensure adequate performance, and cold climatic conditions limit the effectiveness of traditional slope stabilization methods. Recently, geofibers and synthetic fluid have been used to improve very loose sandy soils. This technology is new and non-traditional, and it requires minimal installation equipment. While using geofibers for earth slopes has been researched to some extent, stabilizing slopes with a combination of geofibers and synthetic fluid, and then applying the technology in cold region transportation infrastructures have not been thoroughly investigated.

There is a need to conduct research on alternative slope stabilization technologies in cold climatic conditions. However, to establish a baseline for such research, an extensive literature review and classification of slope stability problems are required.

The final report of this study will form a baseline for future research on slope stability and mitigation alternatives for unstable slopes in cold climatic conditions. Over the long term, infrastructure costs will be reduced.

Evaluating In-Place Inclinometer Strings in Cold Regions

(PI Margaret Darrow, UAF)

Inclinometers measure ground movement — in either a vertical or horizontal direction as appropriate — for slopes, embankments, bridge and retaining wall structures, and other applications. Current technology for vertical inclinometers relies on installing a grooved casing into a drilled test hole. Workers manually lower a two-foot-long inclinometer probe fitted with wheels down a vertical casing (or pull it through a horizontal casing). Measurements of orientation from true vertical (or horizontal) of the inclinometer at the time of measurement are recorded at specified intervals.

This technology has many drawbacks. Since data acquisition requires manual measurements, workers face expensive and potentially dangerous travel. Weeks or months often pass between manual readings due to budget considerations, causing workers to merely interpolate the recorded data. Accuracy of the data collected depends on the care and skill level of the person taking measurements. The inclinometer casing has limited flexibility and can shear when excessive ground movement occurs. In addition, the inclinometer probe length limits the amount of deformation a casing can experience before readings are no longer possible.

A new type of geotechnical instrumentation incorporates Micro-Electro-Mechanical Systems accelerometers, which were first used for automotive air bags. Automated in-place MEMS inclinometer strings are a series of accelerometers connected with flexible joints and encased in watertight housing, making these devices suitable to bury directly in the ground. The AIMIS are far more flexible than grooved casing and can accommodate much greater ground movement. When the installation is accompanied by a remote power supply and a telemetry link, an AIMIS can provide nearly continuous observation of ground movement without frequent field trips. AIMIS manufacturers state that these devices are reusable, as they can be removed from one installation and placed into another, resulting in further cost savings. Since the AIMIS technology is new, its use has not been fully evaluated, especially in cold regions. Although AIMIS potentially can be reused, the techniques to extract the strings are in their infancy and are problematic. New extraction techniques for use in frozen ground may need to be created and evaluated, and as with any equipment used in cold regions, the durability of

AIMIS at subfreezing temperatures needs to be evaluated.

The objectives of this study are threefold: to compare AIMIS against the existing methodology; to evaluate AIMIS for their versatility and accuracy in cold regions; and to test AIMIS ease of use and recoverability. AIMIS will be evaluated for applications in Interior Alaska that include monitoring creep in frozen ground and identifying and monitoring a slide shear zone. Two different AIMIS products will be compared with the existing manual method and with each other, to identify any benefits of one product over another. AIMIS will be extracted from vertical installations in order to evaluate their reusability. Based on the fieldwork and data analysis, researchers will develop a set of Best Practice Guidelines for choosing AIMIS for specific applications and for AIMIS installation, monitoring, maintenance, and retrieval.

Should the AIMIS prove to be suitable for use in cold climates, transportation agencies will reduce project travel budgets and increase worker safety, and will have dependable, accurate measurements, allowing for more confidence in designs.

Margaret Darrow
completing one of the
automated in-place
MEMS inclinometer
strings installations
in the field, near
Richardson Highway
milepost 113.



Attenuation of Herbicides in Subarctic Environments

(PI David L. Barnes, UAF)

The Alaska Railroad Corporation needs effective, low-cost ways to manage vegetation growth along rail lines. This project, in partnership with the USDA Agricultural Research Service, is investigating the environmental fate, attenuation, and effectiveness of herbicides currently being evaluated for use along Alaska's transportation corridors. Questions addressed include: 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?

The herbicides have been applied near Seward, the southern end of the ARRC rail line. Researchers are tracking these applications over two years through a series of soil and groundwater samples to obtain site-specific attenuation data. They are also performing mass balance studies on the herbicides using lysimeters installed at the Experimental Farm on the Fairbanks campus. Results will yield a better understanding of the environmental fate of these herbicides in Alaska's maritime subarctic zone.

Using Shallow Anchors and an Anchored Mesh System for Cut Slope Protection in Ice-rich Soils (PI Xiong Zhang, UAF)

Permafrost soils present special problems to builders of roads and other transportation infrastructure in Alaska. When a sloped bank in a permafrost area is cut to make way for a road, the soil may thaw and slump or collapse. Six years may pass before vegetation re-stabilizes the slope. During this time, erosion increases and extends the damage, often making roadways hazardous with mud and landslides. Builders have tried many strategies for slope stabilization, some more effective (and more expensive) than others. One strategy is to use wire netting held in place by soil anchors, but there is little information on how this approach performs in Alaska's frozen, shallow, silty soils.

This project, in partnership with ADOT&PF, investigates how shallow anchors perform in frozen soils. Project outcomes include designing an anchored wire mesh system to protect and stabilize ice-rich cut slopes. Soil sampling is finished, and anchor field tests and numerical simulation analysis will be done over the next year. The findings will be useful to other types of mitigation strategies, including highway retaining walls and addressing rockslide areas.

Including Life Cycle Cost Analysis in Alaska Flexible Pavement Design Software (PI Juanyu "Jenny" Liu, UAF)

Life cycle cost analysis is a key part 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 software has been in use since 2004, there is no computerized analysis tool available to assist pavement engineers in developing this cost analysis for a given project. Including LCCA in the AKFPD software would be of immense benefit to pavement designers, allowing them to routinely improve infrastructure performance while making more cost-effective use of the design effort.

This study seeks to update the current AKFPD program and create a single software package capable of executing the economic cost analysis and structural analysis functions. Upon completion, the project will provide the updated software, a modified AKFPD manual, and case studies with complete analysis processes to help the new user navigate the software. In the past year, the project team developed a new layout for the program. It also added new modules, 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."

Alaska Hot Mix Asphalt Job Mix Formula Verification (PI 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 is the major paving material used in Alaska, assuring the quality of this material is a critical issue for contractors, ADOT&PF, and other agencies responsible for pavements. This project is assessing elements related to HMA quality assurance specifications and evaluating how well contractors meet the requirements of job mix formulas.

During summer 2010, researchers field-tested a rehabilitation and resurface project at Mile 287–305 of the Parks Highway, just south of Nenana. Asphalt mixtures with four different scenarios were sampled from nine sublots. The mixtures included 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 cores retrieved from the field. Pertinent data from ADOT&PF and from contractors at each phase of lab/design, production, and new construction were obtained, including general project information, details of the materials and JMF used in the construction, and all construction test data.

Over the next year, four primary tests for JMF properties will be conducted in the university lab, including aggregate gradation, asphalt content, mix volumetrics (e.g., air voids and voids in the mineral aggregate), and density. In addition, hot mix asphalt performance will be investigated to further verify the JMF and evaluate any impact of the construction process. These performance tests will include an indirect tension test for low-temperature performance and a dynamic modulus and rut test with a simple performance tester.

Project results will lead to revision of 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.

Load Environment of Washington State Ferry and Alaska Marine Highway Landings (PI Andrew Metzger, UAF)

Anybody riding a ferry wants it to dock safely — and for port managers, having passengers and goods in the water is never a good thing. This project aims to mitigate uncertainty and assumptions about load demands on ferry terminal structures, specifically, ferry landing structures. The project will provide information needed to safely and efficiently design ferry berthing and landing facilities, decrease the uncertainty in design criteria, and remove assumptions associated with procedures traditionally used to design these structures.

For Alaska Marine Highway System facilities, loads imposed on dolphin structures and mooring line loads are of most concern. Due to a lack of information about the magnitude of these loads or how they may be determined, AMHS engineers are forced to make (sometimes gross) design assumptions. The Washington State Ferry System also confronts these uncertainties, specifically in the design of wingwall structures that accept vessels during loading/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. Thus, the instrumentation used to monitor these facilities in operation is also similar.



A portable gyratory compactor for use in the field, in this case for applying hot mix asphalt prepared by a job mix formula. This project will lower pavement construction costs by standardizing job mix formula processes.

These similarities present an opportunity for a cost-sharing project in which the ADOT&PF and Washington State DOT are able to leverage research funding and benefit from a much more comprehensive project than either might be able to support individually. To achieve this project's goals, the research team will acquire a robust statistical sample of the metrics (strains and displacements) needed to define the design criteria (loads from vessels and waves). The data will be gathered via in situ monitoring of in-service facilities, specifically, the AMHS terminal at Auke Bay near Juneau, Alaska, and the WSF Seattle terminal in Washington.

The Response of Pile-guided Floats Subjected to Dynamic Loading (PI Andrew Metzger, UAF)

Pile-guided floats can be an alternative to stationary berthing structures. ADOT&PF is considering using floating piers at certain stops along the Alaska Marine Highway System. A potential design calls for the floats to be held in place by piles (called guide-piles) that allow vertical rise and fall during tidal

changes. The floats also undergo other varying forces, such as wind-generated waves and the weight of cargo and people as ships load and unload at the dock. There is little design information available concerning how this dynamic loading will affect the floats.

This project is developing a rational basis for estimating the dynamic response of floating pile-guided structures. Researchers will develop a dynamic analytical model for an idealized single-degree-of-freedom system, as well as a multi-degree-of-freedom system. Both models will include functions that represent wave action and vessel loading over time. At the project's end, AMHS and ADOT&PF will have a validated model and a ready-to-implement tool capable of providing any engineer with the necessary insight into good design criteria for guide-piles.

Alaska Marine Highway System Analysis (PI Paul Metz, UAF)

The Alaska Marine Highway System safely and reliably transports people, goods, and vehicles among Alaska communities, Canada, and the contiguous 48 states. AMHS has operated year-round since 1963, with regularly scheduled passenger and vehicle service to 30 communities in Alaska, plus Bellingham, Washington, and Prince Rupert, British Columbia.

During the past ten years, AMHS has carried an average of 400,000 passengers and 100,000 vehicles per year. Currently, AMHS generates almost \$50 million in annual revenue. However, like much of the nation's transportation infrastructure, AMHS facilities are aging, and the system will soon need new vessels and upgraded docking facilities. The State of Alaska already contributes to AMHS operating expenses, approaching \$100 million a year. Its goal and that of AMHS is to keep the ferries running safely, reliably, and efficiently. This project is developing a detailed picture of the Alaska Marine Highway's mission and performance, as well as its operating and financial scenarios for the next five to twenty years. This analysis takes into account the transportation needs of Alaska's coastline communities and the resources the state has to meet those needs. The results of this study will benefit ADOT&PF in planning for long-term operation of the state's extensive ferry system.

Feasibility Study of RFID Technology for Construction Load Tracking (PI Oliver Hedgepeth, UAA)

ADOT&PF is seeking more efficient business practices and processes to increase its speed in delivering supplies to work sites, optimize the workforce, and minimize costs. The current tracking process uses a computer-generated ticket carried by the truck driver to the dump point. The truck driver initially receives a cargo ticket while loading. The load weight is recorded on the ticket at a plant weigh scale. At the dump point, the ticket is handed to a ticket taker on the grade. The ticket taker records additional information on the ticket such as the time and the station of the dump point. At least four people handle this cargo tracking ticket: a truck driver, scale person, ticket taker, and an office person. A driver must maintain possession of the ticket at all times during cargo or load transportation, by state and federal regulations. A scale person updates this ticket. A ticket taker at the end records the final data. An office person tallies the day's tickets to create an account payable item (payment) to the carrier or driver. These tracking tickets must be physically stored for three years after project date of completion.

Technologies such as RFID and GPS can be used to track or record the same data. This study is exploring using new technologies to improve this process. These changes could also improve new project planning, management, and tracking of transportation operational data.

In the past year, the research team has completed a literature review, purchased the necessary test RFID equipment, installed the new system in the field, and begun data collection.

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

Messing with Mother Nature takes knowledge and work, and she is hard to outfox, especially when it comes to redirecting rivers. To protect infrastructure, however, sometimes river flow must be altered. This study focuses on two erosion-control projects built in Alaska using different design criteria. One was constructed by ADOT&PF at the Sagavanirktok River to protect the Dalton Highway; the other was built by Alyeska Pipeline Service Company at Hess Creek to protect the trans-Alaska pipeline. Though bank erosion along river bends is a natural process, lateral erosion, which causes streams to shift laterally, can expose infrastructure to serious risk. To avoid damaging or destroying the transportation system, researchers and engineers have developed several types of strategies to prevent streambank erosion, including watercourse realignment, that is, moving water away from the bank.

Project researchers gathered hydraulic data, including continuous velocity measurements, at selected points in both streams. Results from a turbulence

analysis suggest that Hess Creek was in equilibrium at the time of surveying it, while the condition at the Sagavanirktok River is unclear.

The project took an unexpected turn when the research team decided to include a hydraulic numerical model. This model is capable of simulating different flow conditions, calculates shear stress, velocity and Froude number, among other hydraulic parameters. Different scenarios were simulated by the model, showing how the river might behave under different flow conditions at different seasons.

ADOT&PF personnel and the research team are looking for opportunities to implement the model in different settings, particularly where ADOT&PF is planning river training structures. This numerical model will improve the design process for future structures by helping designers plan appropriate structures for actual river conditions. Graduate student Paul Duvoy, who is working on a Master of Science in civil engineering, has done much of the work on this model.

Left: The Sagavanirktok River, near milepost 414 on the Dalton Highway (near Deadhorse, Alaska) on May 17, 2010. Note that ice and snow cover the entire river. Right: The same location, on May 29, 2010. Note that most of the ice is gone, except for some remaining ice in the bend of the river, at the bank. To see a time-lapse movie showing breakup at this spot, visit <http://ine.uaf.edu/autc/>.



AUTC Participation in Climate Change Assessment for Surface Transportation in the Pacific Northwest and Alaska (PI Ming Lee, UAF)

This project, a joint effort between the Oregon Transportation Research and Education Consortium and AUTC, comprises a preliminary assessment of the risks and vulnerabilities that climate change may pose to surface transportation infrastructure in the Pacific Northwest and Alaska.

Researchers are synthesizing data needed to characterize the regions and identify critical infrastructure and transportation operations that would be vulnerable to climate change impacts. Project results will include recommendations for more detailed research and analysis to support management of risks and opportunities and to adapt multi-modal transportation infrastructure to possible changes. UAF is providing expertise in travel-demand modeling and forecasting, and land use and transportation, as well as an understanding the unique challenges of Alaska.

Long-range Transportation Forecasting (PI Ming Lee, UAF)

In the last few years, increasing scientific evidence supports the hypothesis that greenhouse gas emissions contribute to changes in the earth's climate, with many detrimental effects already taking place. There is developing consensus among the public and elected officials about the need for action to

reduce GHG. This project will develop methodologies to forecast long-range multi-modal travel demand in urban areas that can reflect the effectiveness of strategies and policies designed to reduce vehicular-source GHG emissions. The developed methodologies will be tested with the two existing Metropolitan Planning Organization models available in Alaska: Anchorage Metropolitan Area Transportation Solutions and the Fairbanks Metropolitan Area Transportation System.

In the U.S., a major source of GHG emissions is carbon dioxide emissions from personal automobiles. The amount of CO₂ emissions from mobile sources is tied directly to the amount of fuel consumed, which is then tied to the total vehicle miles traveled. In devising effective multi-modal transportation policies and financial programs for VMT reduction (i.e., reduction in CO₂ emissions) in a metropolitan area, a travel-demand forecasting model with sufficient spatial and temporal resolution is needed to generate traffic forecasts. The forecasts will be used as inputs for air quality models such as the EPA's MOBILE6 or MOVES. MOVES, which will replace MOBILE6 as the next-generation mobile source emission model, requires traffic volume forecasts with spatial and temporal details that exceed what the current travel-demand models can produce.



Both AMATS and FMATS maintain a travel-demand forecasting model for long-range transportation plan updates. This study will use these two MPO models as case studies to examine their inefficiencies in terms of meeting data requirements for MOVES. The inadequacies in addressing the effectiveness of reflecting GHG reduction policies will also be examined. Effective methods of addressing the models' inefficiencies will then be researched and developed. The improved models will be validated and calibrated with the most current observed data, then tested with a forecasting scenario to demonstrate their capability: Can they successfully reflect the effectiveness of GHG emission reduction for a proposed transportation measure?

Model of Alaska Transportation Sector to Assess Energy Use and Impacts of Price Shocks and Climate Change Legislation

(PI Virginia Fay, UAA)

Congressional measures to decrease greenhouse gas emissions, such as cap and trade, carbon taxes, or other remedies, will impact Alaska residents and businesses. This project aims to develop a model of Alaska's transportation sector to assess the effects of GHG legislation and other factors that may affect fuel prices or use.

By better understanding the climatic effects of transportation options, state and local governments, residents, businesses, and industry can be better informed in planning their futures and the actions they take to adapt. This research is a major component of a UAA Institute of Social and Economic Research program, "Energy in the Alaska Economy." This program will enable a better understanding of the interactions among energy use, energy prices, climate policy, and economic activity. The information will be used to produce sound public policy and decisions. Initial program research includes energy use and potential impacts of rising fuel costs in Alaska transportation, tourism, and fisheries.

Alaska's economy was built around use of fossil fuels at a time when fuel was less expensive (compared to 2008).

Key industries such as fishing, mining, tourism, and transportation, as well as subsistence activities, currently depend directly on liquid fossil fuels, while the urban service economy depends heavily on the relatively low cost of living and doing business that has historically been assisted by cheap transportation

fuels. These conditions are changing rapidly and perhaps permanently. According to 2005 Energy Information Administration figures, Alaska consumes 40% more fuel per capita than any other state, and more than three times the national per capita average. This is due to a number of factors: Alaska's remoteness; scattered communities and population; limited road system and resulting dependence on air travel; status as a major world air cargo hub; and oil production, transportation and refining. As a result, Alaskans have a higher dependence on energy resources and are more vulnerable to energy price volatilities and shocks.

Economical Analysis of Using Light-emitting Diode Technology for Alaska Street Lights (PI Hsueh-Ming Wang, UAA)

During winter nights in Alaska, streetlights often remain lit more than half the day, using energy all the while. Around the nation, communities are exploring the use of light-emitting diode technology for lighting streets and reducing energy use. Already, LED technology is successfully used in flashlights and electronic billboards. Some researchers suggest that, under ideal conditions, an LED streetlight system might use 50% to 75% less energy than a traditional streetlight system, with a longer performance life, too. In general, LED devices tend to be less fragile, switching on and off quickly, without flickering. LED technology, which may be the next step in efficient indoor lighting after fluorescents, is moving into the municipal streetlight market as a possible alternative to high-pressure sodium lamps. For this reason, AUTC researchers at UAA are exploring the use of LED streetlight technology for the Municipality of Anchorage.

Converting an existing streetlight system to LEDs is not as simple as switching out a bulb. LEDs require entirely different circuitry and power supply designs, and the systems are more sensitive to changes in power supply. Installation alone of an LED streetlight system can cost a city several million dollars in immediate capital costs. However, while LED light systems can overheat in temperate climates, burning out circuitry and requiring frequent, expensive repairs, Alaska's lower environmental temperatures may provide an advantage for LED use. Some companies suggest that LED systems can last five to ten times longer than fluorescents in colder climates.



The University of Alaska Anchorage campus is testing new, self-sustaining LED streetlights. This prototype has both solar panels and a small wind turbine to collect the power necessary for the lighting system.

The UAA research team has developed a hybrid self-sustainable LED lighting system with wind and solar energy, and are testing it on the Anchorage campus. Data collected from this new system indicate that it has the potential to lead to energy independence from Alaska's grid system during summertime in Anchorage. Some of the research results may be patented in the near future. The research team specifically investigated the quality of LED streetlights on Wisconsin Street and in the Sand Lake area of Anchorage. This project has supported two graduate students and produced two research papers that will be published in proceedings for international conferences.

Evaluating the Overheight Detection System at the Eklutna River/Glenn Highway Bridge (PI Ming Lee, UAF)

The Eklutna River/Glenn Highway bridge has sustained repeated impacts from overheight trucks. In 2006, ADOT&PF installed an overheight vehicle warning system. The system includes laser detectors, alarms, and message boards. Since installation, personnel have seen no new damage, and no sign that the alarm system has been triggered. Although this is good news, the particulars are a mystery: Is the system working? Is the presence of the equipment enough to deter drivers from gambling with a vehicle that might be over the height limit? Is it worth installing similar systems at other overpasses?

This project is examining the bridge for any evidence of damage, and is fitting the system with a datalogger to record and video any events that trigger the warning system. Finally, just to be sure, researchers will test the system with (officially) overheight vehicles. Project results will help ADOT&PF determine if this system is functioning, and if a similar system installed at other bridges would be cost-effective.

Life-cycle Cost Analysis for Alaska Bridge Components (PI 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 for another decade? What will it cost to replace each? 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.

Bridge Structural Health Monitoring and Deterioration Detection: Synthesis of Knowledge and Technology

(PIs Yongtao Dong, UAF, and He Liu, UAA)

Many U.S. bridges were built during the 1960s. Evaluating the structural condition of these bridges under today's traffic loads and safety expectations is difficult. This project is developing a practical program for structural health monitoring of Alaska's bridges. Researchers are conducting a literature review to summarize the current knowledge available in SHM technology, surveying ADOT&PF staff to determine which technologies are currently in use, and making recommendations on what techniques should be pursued to implement a successful SHM suitable for cold regions.

Seasonally Frozen Ground Effects on the Seismic Response of Highway Bridges (PI J. Leroy Hulsey, UAF)

Seasonally frozen ground is stiffer than unfrozen ground. Although we think of bridges as solid and unbending, every bridge will — and should — flex a little, under the right conditions (including earthquakes). Like the ground that supports them, bridges built on deep pier foundations seem to become less flexible in winter. Currently there are no guidelines to predict to what extent seasonal changes affect a bridge's ductile performance. That is, how much effect does frozen ground have on whether a bridge's materials will flex (or not) under seismic loads without fracturing? This project studies these changes

across several years, measuring how structures respond to seasonal changes, and how bridge stiffness changes over time.

This study is a joint effort between civil engineers at UAF, UAA, and Iowa State University. The team combines seasonal field monitoring of an existing bridge, field monitoring of piers sunk in ice-rich soils, and analytical modeling of bridge structures under seismic loading. The team is currently monitoring ground temperatures at the test piles and near the test site. Findings so far indicate that frost depths at the piles are deeper than depths farther from the test area.

Measuring the Effectiveness of Rural Dust Control Strategies

(PI David L. Barnes, UAF)

Dusty, unpaved roads and airports affect the quality of life for many villages in cold regions; in Alaska alone, roughly 60% of the roads are unpaved. Of the 4.2 million miles of road in the nation, 1.7 million are unpaved, so the rest of the U.S. faces dust problems too. Dust reduces visibility on the road. Dust can cause respiratory ailments, and it can affect the harvesting of berries and other plants for people who live off the land. In addition, loss of fine material reduces road surface quality, increasing maintenance costs as well as wear and tear on vehicles. Everybody acknowledges the problem, but finding a solution is a contentious matter. 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 a subsistence lifestyle, and what can the state's thinly stretched budget afford? This project is developing a dust control research map that prioritizes critical areas. It is designing instrumentation and methodology to accurately monitor road dust production. These tools will be used to support ADOT&PF in field testing various dust control measures in several locations. So far, researchers for this project have qualitatively assessed dust control performance on unpaved runways, tested new instrumentation, and measured palliative performance with these prototype instruments at one rural road site.

Alaska Specification for Palliative Applications on Unpaved Roads and Runways (PI David L. Barnes, UAF)

For the past seven years, ADOT&PF Northern Region has been applying different dust-control palliatives to rural runways. The only guidance in

applying these palliatives has come from the manufacturers, and these are too vague to be of much practical use. As the specifications are written, ADOT&PF has found it impossible to determine whether these products are meeting their own standards or not.

This project, using UAF's new DUSTM instrumentation, is collecting data and comparing the effectiveness of newly laid palliative and palliative that has been applied one to three years earlier. From these results, researchers will develop a reasonable performance-based set of specifications that cover the application of dust-control palliatives to unpaved transportation surfaces. These specifications will make it possible for ADOT&PF to choose the best palliative for a community's needs, and hold vendors accountable for the quality of their products.

Eagle Dust Project (PI David L. Barnes, UAF)

ADOT&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 how the palliative performs, gathering data both at the test site and at nearby untreated sites. The final report will include detailed testing results and recommendations on palliative application strategies.

Dust Palliative Performance Measurements on Nine Rural Airports

(PI David L. Barnes, UAF)

In the summer of 2009, ADOT&PF applied dust-control palliatives to nine rural airport runways across Alaska. AUTC researchers will monitor these runways to assess palliative quality and durability. Measurements are taken with the UAF 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 to the fraction produced on the untreated control section.

Researchers took measurements within 30 days after the first treatment on each runway; they will follow up with another measurement one year later. Recommendations will help ADOT&PF select the most effective product out of several and plan the most efficient application schedule for Alaska's many unpaved runways.

Alaska Rural Airport Inspection Program (PI David L. Barnes, UAF)

Freezing temperatures and weathering invariably affect runway conditions and equipment, requiring high levels of maintenance and added expense. To compound this issue, many runways in rural Alaska are unpaved, which leads to erosion and subsequent undermining that eventually can cause runway surface failure. As with any unpaved surface, routine inspection and maintenance are required; however, the remoteness of many Alaska villages results in infrequent thorough inspections. A comprehensive airport inspection program will improve transportation safety and reduce maintenance costs for Alaska's transportation infrastructure, especially in rural areas where airports are the lifeline of the communities they serve.

This project is developing and implementing an inspection program for Alaska's rural airport infrastructure. Along with supporting long-term planning for airports and reducing maintenance costs, researchers are contributing to development of the state's transportation workforce.

This project involves civil engineering students with ADOT&PF, providing them with applied experience in transportation engineering. Students are learning to take proper field measurements and samples, to document the condition of the rural airports inspected, and to analyze field measurements, conduct the necessary laboratory tests on samples gathered in the field, and write reports.

Alaska has roughly 240 small rural airports, and many are unpaved. AUTC's series of dust palliative performance projects will help ADOT&PF choose the most effective products for the best value.



Developing Ambient PM_{2.5} Management Strategies

(PI Ron Johnson, UAF)

Using analyzed and modeled field data on air quality and meteorology, researchers identified major contributors of fine particulate matter (PM_{2.5}) in Fairbanks. This project was an effort to help the city meet U.S. Environmental Protection Agency air quality standards, which require reduced levels of PM_{2.5}, a pollutant.

Findings showed that during December and January, traffic is a significant contributor to PM_{2.5} at the bus barn on Peger Road, and motor vehicles are responsible for about 30% of PM_{2.5} downtown. Data on soot (black carbon) indicated that wood smoke is a significant contributor to PM_{2.5} during the heating season. A chemical mass balance model revealed that road dust, biomass burning (wood smoke), and motor vehicles are significant contributors to PM_{2.5} at the bus barn. With respect to Transportation System Management Strategies, working at home has the biggest potential to improve ambient air quality, but even if 5% of commuters worked from home, the PM_{2.5} downtown would be reduced by only about 0.4%. The research team concluded that Fairbanks will have to adopt major changes in its TSM strategies to effect significant reductions in downtown PM_{2.5} levels.

Light-emitting Diode (LED) Streetlights in Alaska

(PI Richard Wies, UAF)

This project explored whether LED streetlights could provide usable and safe illumination of Alaska roadways, based on the standards of the American Association of State Highway Transportation Officials. Having verified the performance of LED light in arctic conditions, the research team spent last winter testing the illumination and color quality of LED light. Results show that, though LED streetlights can provide usable light with much lower energy consumption than HPS streetlights, they do so with much lower light intensity. In many applications, LED streetlights would need closer spacing than high-pressure sodium streetlights in order to meet AASHTO standards for illumination of roadways of various surface types. Additional light-spectrum testing indicated that LED streetlights have a predominantly blue spectrum, although considered a white light. Visual observations by the researchers suggest that LED light causes reflections that make it difficult to see objects

AUTC makes project profiles, research publications, videos, annual reports, and newsletters available on its web site. Visit <http://ine.uaf.edu/autc> and check our database.

clearly, particularly for those who wear glasses, possibly due to the ultraviolet coating on some lenses. Thus, improvement is needed in the illuminance and color quality of LED streetlights before they are used to replace HPS streetlights.

Measuring Temperature and Soil Properties for Finite Element Model Verification (PI Margaret Darrow, UAF)

In recent years, ADOT&PF personnel have used TEMP/W, a commercially available two-dimensional finite element program, to conduct thermal modeling of various embankment configurations in an effort to reduce the thawing of ice-rich permafrost through thermally stable embankment designs. This modeling was done with historic air temperature data and input parameters derived from the literature, since site-specific data is typically not available.

The overall goal of this study was to verify the thermal modeling results produced by TEMP/W. Temperatures and soil properties were measured at two different sites underlain by permafrost in Interior and Southcentral Alaska. A sensitivity analysis of certain input parameters was conducted on models of each site. Analysis indicates that the most critical input parameter is air temperature. While historic air temperature data provided an approximation of the regional climate, this data produced model results that were too cold by several degrees. Using air temperatures measured at each site resulted in models that closely matched the measured soil temperatures, and either matched or overestimated active layer depths. Using the overestimated active layer depth for design purposes would result in a more conservative embankment construction, which is a favorable approach if a warming climate is considered.

Creosote-treated Timber in the Alaska Marine Environment (PI Robert A. Perkins, UAF)

ADOT&PF is responsible for many structures that incorporate wood pilings and other timber in Alaska waters. Most are treated with preservative to inhibit marine borers that will quickly destroy unprotected wood. Creosote is generally the most economical preservative and has been used for over a hundred years. Creosote contains many toxic chemicals and some

governments and organizations are limiting its use.

This project reviewed current science regarding use of creosoted wood in marine waters and the current regulatory matrix that controls its use, and developed recommendations for its use.

Even with best management practices, polycyclic aromatic hydrocarbons from new creosote timber will be transferred to the marine environment. Laboratory tests and field observations show that PAH chemicals slowly diffuse from the wood into the water column. The heavier PAH chemicals sink to the bottom directly, or adsorb to organic or inorganic moieties in the water and then sink, incorporating into the sediment. The lighter PAH chemicals are quickly volatilized and oxidized. Scientific observations of creosote behavior in meso-scale tests verify that the concentrations of PAH from marine piles in the water column are negligible after the first few weeks. The fate of PAH in the sediment depends on the oxygen status of the upper sediment layers. If the sediment is not anoxic, the PAH will be oxidized. With sufficient oxygen in the upper layers of sediment, the PAH concentration will initially rise, then decline. With timber treated according to best management practices, if the sediments are not anoxic and the surrounding waters are not stagnant, and the area is not already contaminated, creosote marine timbers are unlikely to have a significant long-term effect on the environment. Further, meso-scale testing indicated that effects were confined to a region close to the structures themselves.

Evaluating Liquefaction Resistance in Degrading Permafrost and Seasonally Frozen Ground (PI Kenan Hazirbaba, UAF)

Permafrost degradation in regions of high seismic activity increases the potential for soil liquefaction, which can be a serious threat to transportation and utility infrastructure, as many professionals observed during the November 2002 Denali Earthquake (magnitude Mw 7.9). This project conducted laboratory studies to investigate the liquefaction resistance of frozen and seasonally frozen ground. Researchers examined how soil liquefaction is influenced by freeze-thaw cycles throughout the year, and how liquefaction is influenced by temperature distribution in degrading permafrost. The results of this study will help establish criteria for liquefaction susceptibility in melting permafrost and soils that regularly undergo freeze-thaw cycles.

Feasibility of Electric Cars in Cold Regions (PI Jing Zhang, UAF)

Electric vehicles — cars that run on electricity stored in batteries — have drawn increasing interest from federal agencies, the auto industry, and academia as a promising path to reduced reliance on fossil fuels and elimination of pollutants. This project studied the feasibility of using electric vehicles as reliable transportation in cold regions. Researchers evaluated conditions in which the electric car is appropriate, and they addressed the use of electric cars as a mode of transportation, the optimal distance between origin and destination, and potential environmental impacts on transportation operations. Data was collected in several Alaska urban areas, including Fairbanks and Barrow, as a case study. Project results include data and analysis of electric car performance for urbanized areas in cold regions.

Results suggested that electric vehicles can be a viable option for certain users in subarctic and arctic communities. For example, researchers learned of a 1986 Chevy Sprint converted in Barrow, Alaska. The car is driven daily for three miles, from one heated garage to another. Electric cars are infamous for not going too far or too fast. Student researchers compiled energy usage on nine test vehicles during driving and while charging. Initial results showed that one test car, a Chevy Metro, used a trim 250 watt hours per mile. The study found that many variables affect electric car efficiency. As one example, in colder areas such as Alaska and Canada, some infrastructure for public heater block outlets already exists, in parking garages and at parking meters, provided primarily for engine pre-heating. When an electric car uses these outlets, its efficiency doubles. The knowledge gained through this study will assist departments of transportation in cold regions when considering adopting electric cars as an alternative transportation method.

Geological Investigations for the Dalton Highway Innovation Project as a Case Study of Ice-rich Syngenetic Permafrost (PI Yuri Shur, UAF)

ADOT&PF plans to construct a new section of the James W. Dalton Highway in northern Alaska. The new three-mile-long section of road will avoid a steep climb, making the road safer to drive. Preliminary work shows that this new section of highway will cross an area of extremely complex permafrost conditions. The area is characterized by ice-rich, syngenetic Pleistocene permafrost, which can be up to 100 feet thick and contain huge ice wedges.

(“Syngenetic” describes frozen ground that slowly grows upwards in size as sediments are deposited on the surface.) Any human activity in this sensitive area can trigger thaw settlement of soils and permafrost degradation.

The durability of roads crossing such complex conditions depends on a design based on the best geotechnical information available, continuous monitoring, and timely maintenance. The better the design, the less maintenance work required. AUTC permafrost experts Yuri Shur and Mikhail Kanevskiy helped prepare for this construction project by performing a geotechnical investigation of the area, training ADOT&PF engineers in the nature of permafrost behavior, and providing guidance in developing a methodology for describing, sampling, and testing the ice-rich syngenetic Pleistocene permafrost. In addition to supporting the best design possible for the Dalton Highway, project results will be useful for construction projects throughout the circumpolar North and will contribute to educating a new generation of engineers at the University of Alaska.

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

When spring comes to cold regions, the active layer (the top few feet of soil that freezes and thaws seasonally) thaws quickly, while deeper soil remains frozen. The active layer becomes saturated with water from snowmelt that collects atop the frozen layer. In these circumstances, roads across Alaska almost “float” on a soft foundation. Too often, poorly supported pavement buckles and sags under the weight of heavy tractor trailers and other vehicles, and it remains deformed once the soils drain and re-stabilize. One way to reduce this damage is to control the amount of fines (essentially rock dust) in a pavement mixture.

This project investigated base course materials commonly used in Alaska’s roads. Liu’s team observed changes in the stiffness of the materials, as well as how their soil-water characteristics change under freeze-thaw cycles, and how different percentages of fines and moisture influence material properties.

Field tests in Alaska’s three DOT&PF regions and subsequent lab research have been completed. Data from this study will be used to produce better pavement designs, particularly in some rural areas, where project engineers might be forced to use locally available material with high fines content.

Investigating Methods for Maturing Concrete in Very Cold Weather (PI Yongtao Dong, UAF)

This project developed and tested protocols to determine concrete curing strength during the construction process, so that building under very cold conditions can be performed safely and quickly. Researchers determined the laboratory strength-maturity correlations for concrete mix designs that ADOT&PF construction teams commonly use. Field tests were conducted in spring and summer of 2009.

This study produced a guide, with procedures and computations designed to help ADOT&PF personnel use the maturity method to better estimate the strength of concrete poured on-site.

Unstable Slope Management Program: Background Research and Program Inception (PIs Scott Huang and Margaret Darrow, UAF)

This Rapid Response Project gathered information on existing unstable slope management programs, with a focus on asset management practices in the United States and overseas. On the basis of this study, the research team summarized and recommended guidelines to develop an Unstable Slope Management Program for the ADOT&PF.

Characterization of Asphalt-treated Base Course Material (PI Juanyu “Jenny” Liu, UAF)

Asphalt-treated bases are often used in new pavements; the materials are available and low-cost, but there is little data on how these materials perform in cold regions. This study investigated four ATB types (hot asphalt, emulsion, foamed asphalt, and reclaimed asphalt pavement) popular for treating base course materials. The research team collected data on stiffness, fatigue, and permanent deformation characteristics under different temperatures.

This study produced a detailed literature review, including information from ongoing research projects, to compile the latest information concerning ATB characterization. Also completed were resilient modulus tests of ATB material commonly used for Alaska’s northern and central regions, as well as rutting tests using a Georgia Loaded Wheel Test apparatus. Researchers conducted resilient modulus tests on specimens of foamed asphalt-treated base material, fabricated in ADOT&PF labs, in all three Alaska regions; an additional test was

performed in the central region using different binder contents and soaked conditions. Statistical analysis of the effects of aggregate properties on the resilient modulus were completed and incorporated into the finalized model.

Study recommendations noted that based on the predicting equations for resilient modulus (M_R), the moduli of treated base course materials can be calculated according to treatment technique, ambient temperature, aggregate properties, and binder content.

Effects of Permafrost and Seasonally Frozen Ground on the Seismic Responses of Transportation Infrastructure Sites (PI Zhaohui Yang, UAA)

This interdisciplinary project combined seismic data recorded at bridge sites with computer models to identify how highway bridges built on permanently and seasonally frozen ground behave during an earthquake.

Two sites — one in Anchorage and one in Fairbanks — were selected for seismic site-response testing. In assessing seismic motion in frozen soil, the thickness of seasonally frozen soil, depth to permafrost and its thickness, and depth to bedrock were considered. Results show that the presence of frozen soil, particularly permafrost, significantly changes ground motion characteristics.

The research team concluded that while it is generally safe to ignore the effects of seasonally frozen ground on site response, it is not always safe to classify permafrost soil sites using only the seismic motion of the upper 30 meters of frozen or unfrozen soil, or to use code-defined site coefficients for seismic design. Study results will contribute to new guidelines that help engineers design better highway bridges and embankments in Alaska, ideally identifying how to account for permafrost effects in a simpler manner.

Performance Analysis of the Dowling Multi-lane Roundabouts (PI Ming Lee, UAF)

The first multi-lane roundabouts in Alaska were constructed in 2004 at the ramps of the Dowling Road/Seward Highway interchange in Anchorage. These serve as junctions for commuters accessing the Seward Highway. As vehicle traffic in Anchorage continues to grow, however, use of the Dowling roundabouts also increases. The roundabouts are currently operating at or near capacity, with long vehicle queues at their entrances during peak traffic hours.

This research project examined the performance of multi-lane roundabouts and how drivers use them. Analysis showed that extended queues were due to unbalanced flow patterns at the roundabouts, causing high circulating flow in front of one roundabout. This high circulating flow resulted in low-capacity, high-delay queue values. Researchers also found that accident rates and danger to pedestrians had increased in the past two years. Modeling traffic flow patterns for several possible alternatives suggested that reducing the eastbound flow rate “upstream” of the roundabout by 70% of the original flow could result in an acceptable level of delay and queue length at the eastbound approach of the west roundabout.

Preservation of the Alaska Highway, Phase 1 (PI Daniel Fortier, UAF)

The Alaska Highway, the only road connecting Alaska to the contiguous U.S., crosses large areas of permafrost-rich soils. Highway reconstruction in the mid-1990s damaged the organic layer that insulated and protected the surrounding permafrost. Since then, heat transfer through the road has been melting the ground ice. The thawing and settling ground has created dips, bumps, potholes, and cracks. Throughout the past 10 years, the climate has been relatively stable, but in the near future, climate warming will undoubtedly increase permafrost degradation and damage to the road. AUTC, working with the Yukon Highways and Public Works, explored ways to slow this permafrost degradation. Researchers selected test sites, characterized surrounding soil conditions, and installed instrumentation for long-term data collection. Team members, working with engineers at YHPW and Laval University, finalized designs for mitigating damage to the highway.

Warm Mix Asphalt (PI Juanyu “Jenny” Liu, UAF)

This project evaluated the performance of several different warm mix asphalts, investigating material properties as well as low-temperature performance, rutting potential, and moisture sensitivity. Researchers assessed engineering properties of WMA binders and mixes in the laboratory, evaluated WMA mixes in the field, and monitored emissions during WMA production and application. Findings have been presented across the state in professional seminars and pavement-design classes for both practicing engineers and traditional college students. Investigation of Sasobit-modified

binders and WMAs identified several engineering benefits to using a WMA over a traditional hot mix asphalt. WMAs using Sasobit (an asphalt additive) showed reduced mixing and compaction temperatures, improved workability and rutting resistance, and insignificant effect on moisture susceptibility. However, indirect tension tests suggested that a Sasobit WMA showed degraded resistance to low-temperature cracking. Additional tests at lower temperatures, along with a more complete thermal cracking analysis for specific environments of interest should be performed to get a more definitive answer regarding the effects of Sasobit on low-temperature cracking.

Warm Mix Asphalt: Experimental Features in Highway Construction (PI Juanyu “Jenny” Liu, UAF)

Hot mix asphalt, used in many conventional paving projects, typically is spread at temperatures between 280° and 320°F. Using warm mix asphalt, which can be applied at significantly lower temperatures (250° to around 270°F) may reduce the energy requirements (and the costs) for paving highways — if it can be used without adversely impacting pavement performance. One form of WMA involves adding small amounts of water to the dryer drum (the asphalt mixer system). ADOT&PF used this approach on a paving project near Tok, Alaska. Researchers performed simple performance tests and indirect tension tests on the new pavement to characterize the mix and to determine if there was any significant difference between the HMA and WMA pavements.

Nylon Wicking Fabrics (PI Xiong Zhang, UAF)

This project applied a privately developed geotextile as part of a road repair project on the Dalton Highway, Alaska. Researchers installed a new nylon wicking fabric under pavement to reduce or eliminate “soft spots” — areas where water pools underneath the pavement, causing rapid degradation and potholes. Researchers hope the fabric will capture water welling up through the foundation soils and route it to the side of the road, leaving the soil above drier and stronger. This project was a joint effort between Tencate, which provided the geotextile, ADOT&PF, which installed the new material, and AUTC, which provided data collection monitoring. A new project, which will collect data over the next two years, will reveal how well the material performs in this application.

Using Screw Piles in High Seismicity Areas of Cold and Warm Permafrost (PIs Kenan Hazirbaba, UAF; and Brady R. Cox, University of Arkansas)

This project, a joint effort between UAF and the University of Arkansas, developed design guidelines for using screw piles as a cost-effective deep foundation alternative to conventional pile structures in northern regions. Additional tasks included establishing a database for dynamic properties and cyclic behavior of cold region soils under seismic loading conditions, providing seismic design recommendations for deep foundations in cold regions, and supplementing current foundation seismic design codes.

Researchers performed surface wave testing at 30 sites in Fairbanks, Alaska. This project was discontinued in 2010, upon the PI's departure from UAF. AUTC is seeking an effective forum for the collected data.

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

The American Association of State Highway and Transportation Officials is developing new recommendations for bridge designs that can better withstand earthquakes. These new guidelines use pushover analysis, a technique where a computer model of a structure is subjected to increasing lateral loading until its components fail. Pushover analysis is an effective way to highlight any weakness in a bridge's performance under earthquake conditions. However, there is no single, easy-to-use program available to design engineers. No programs focus on the bridge bent design (sometimes called a pier design) most commonly used in Alaska, where steel shells encase reinforced concrete columns to improve seismic performance. This project developed software customized for pushover analysis of Alaska-style bridge bents.

Seismic Design of Deep Bridge Pier Foundations in Frozen Ground (PI J. Sri Sritharan, Iowa State University)

This project developed design methods for drilled shaft foundations customized for Alaska's bridges, soils, and temperatures. Researchers tested how reinforcing steel, concrete, and soil behaved under cold conditions. They demonstrated cold-temperature effects on moment-curvature behavior of reinforced concrete and soil-foundation-structure interaction; established setup procedures for performing material tests at cold temperatures;

discovered that temperature effects on stress-strain behavior of A706 steel reinforcement cause different behavior from that published in literature for similar reinforcement or structural steel; discovered the inadequacy of the existing method proposed for seismic design of drilled shafts (especially in cohesive soil); and developed more rational design methodology for drilled shafts in cohesive soil. The research team also prepared a review of state-of-the-art seismic design of drilled shafts. Its findings will be used to establish a new design methodology tailored to seismic regions subjected to seasonal freezing.

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

Based on the 2000 U.S. Census, Fairbanks was designated an official urbanized area. The FHWA requires urbanized areas to form a Metropolitan Planning Organization to oversee transportation planning and federal funding. An MPO uses a travel-demand model that provides information on current and future transportation system operations. Since 2001, FMATS has used the Quick Response System II, which was intended for smaller urbanized areas, where traffic congestion and vehicle emissions are not significant concerns. However, with traffic growth and the city's frequent inability to meet the EPA's air quality standards, the QRS II model no longer meets Fairbanks' needs. This project converted the old QRS II model to a more robust, state-of-the-practice TransCAD model. TransCAD (Windows-based software used by many MPOs in the U.S.) provides up-to-date modeling and forecasting methods consistent with federal requirements and with AMATS. The TransCAD conversion incorporated current population and employment data for the Fairbanks area, with calibration to the most recent traffic counts. TransCAD provides FMATS the ability to produce traffic forecasts for its long-range (up to 2030) transportation update.

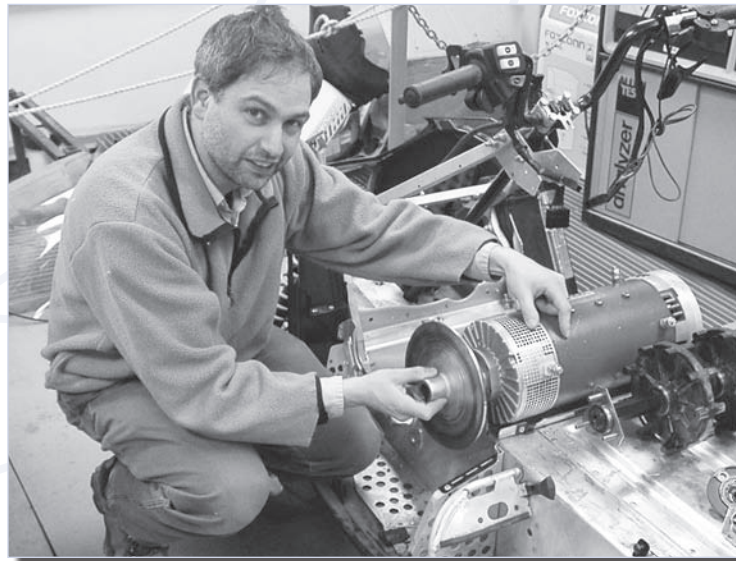
As part of implementation for this project, researchers provided customized training on FMATS to ADOT&PF staff, and other agencies have begun to use the model for related studies. Finally, a UAF graduate student gained hands-on experience at travel-demand modeling.

AUTC projects are beginning to result in practical products and positive impacts for local policy makers.

The **"Alaska Bridge Bent Pushover Software, Including Concrete Confinement" project yielded a software package** that will improve bridge design practices in cold regions. Alaska Department of Transportation and Public Facilities has implemented the pushover software developed at Oregon State University to predict the load deflection curves in the plastic range. The Snake River Bridge was the first to be designed using the software. Elmer Marx, a bridge engineer with ADOT&PF, states that the software provides a rapid, reliable analysis tool.

Three projects on how frozen ground behaves under seismic events have helped ADOT&PF shape their design policies.

Joey Yang's (UAA, "Effects of Permafrost and Seasonally Frozen Ground on the Seismic Responses of Transportation Infrastructure Sites") work on response spectra has shown



that frozen ground does not adversely impact the response characteristics of a structure. However, work by Sri Sritharan (Iowa State University, "Seismic Design of Deep Bridge Pier Foundations in Frozen Ground") and Leroy Hulsey (UAF, "Seasonally Frozen Ground Effects on the Seismic Response of Highway Bridges") has shown that we must consider frozen soils when looking at the soil-foundation-structure interaction. This knowledge is now included in ADOT&PF's pile designs.

Research conducted at North Carolina State ("Ductility of Welded Steel Columns," Kowalsky) has confirmed that the pile/pile cap connections that have been popular in Alaska are inadequate for earthquake loading. While they meet strength requirements, they do not meet the plastic deformation requirements. As a consequence, ADOT&PF no longer accepts these systems.

The UAF DUSTM, an instrument for dust measurement, is the result of a series of studies (see pages 30-31 in this report) on measuring and controlling fugitive dust from unpaved roads. The rugged and portable UAF DUSTM mounts on the back of an all-terrain vehicle. As the ATV tire lifts particles, a vacuum pump takes continuous samples through an intake positioned near the tire. The vacuum pump is connected to the intake by tubing. The sample is split, with a portion being passed through a filter, obtaining a mass over time (distance) of particles collected on the filter. The other portion of the sample is directed through a tube to a vendor-supplied laser that measures the opacity of the air stream.

Opacity measurements are collected at defined time intervals, typically every second, allowing for a spatial analysis of dustiness along the unpaved surface, by relating GPS points and overall dustiness. The UAF DUSTM is now an integral part of ADOT&PF's dust management program. It is used not only to determine the level of dust, but is part of the specification for judging the performance of dust palliatives.

As a result of a series of Vegetation Management projects conducted by David L. Barnes (UAF), **the Alaska Railroad is now able to use herbicides along parts of its rail line.** Dr. Barnes showed that herbicides applied in Alaska perform similar to those in temperate climates.

As part of an outreach project, **AUTC completed an engineering guide, “Evaluating and Upgrading Gravel Roads for Paving.”** This manual is based on work with the Matanuska-Susitna Borough of Alaska over the last four years. A team assembled by the Mat-Su Borough evaluated the performance of chip seals and gravel surfaces. The new manual guides non-engineers through the process of upgrading local, low volume roads.

Yuri Shur and Mikhail Kanevskiy (UAF), as part of the “Geological Investigations for the Dalton Highway Innovation Project as a Case Study of Ice-rich Syngenetic Permafrost,” contributed significantly to **the ADOT&PF’s plan for highway maintenance.** ADOT&PF used this study to determine whether or not to realign this section of roadway. AUTC personnel provided training to ADOT&PF drillers and geologists on how to recognize different types of permafrost and to interpret how each type will impact road construction over it. Use of this knowledge is becoming routine in subsurface investigations over permafrost.

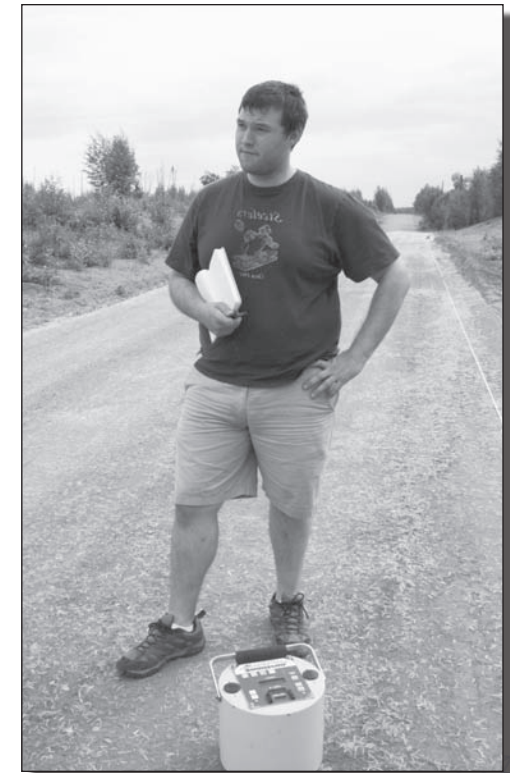
Thanks to the work of Ming Lee (UAF) and the “Converting the Fairbanks Metropolitan Area Transportation

System to TransCad,” FMATS has made the conversion to TransCad for travel demand forecasts. AUTC provides training and support to the Metropolitan Planning Organization in the use of TransCad.

As part of the “Electric Car Feasibility in Cold Regions” project, using Argonne Lab’s GREET 1.8b, student researchers were able to model emissions from electric cars. Researchers used previously collected data from electric utility companies regarding the sources of electric power generation.

The **AUTC team created a two-credit course, ES 166 Electric Car Conversion,** which emphasizes the environmental advantages as well as the feasibility of driving electric cars in the Arctic. This course will be taught throughout Alaska, and perhaps in other arctic region countries.

Several projects have included videos that summarize field projects and collected data. These include a video on application of geofibers and synthetic fluid as part of a road project by students Rodney Collins and Peter Jackson (see <http://www.youtube.com/user/fsrwc5>), and stop-action videos demonstrating changes in ice and erosion along the Sag River, part of a project lead by AUTC researcher Horacio Toniolo (see <http://ine.uaf.edu/autc/>).



Opposite: Student Michael Golub applied data from the AUTC “Electric Car Feasibility” project to classes in electric car conversion as well as to the benefit of UAF’s entry in the Society of Automotive Engineers’ Clean Snowmobile Challenge. Top right: An all-terrain vehicle equipped with the UAF DUSTM. Bottom right: Student Rodney Collins participated in soil stabilization strategies and shot video as part of the application of a “Non-traditional Soil Stabilization Technology: Use of Geofibers and Synthetic Fluid in the Field” project.

Eva Stephani, originally from Quebec City, Quebec, Canada, is the AUTC 2010 Student of the Year. Eva, who received a Bachelor of Engineering in Geological Engineering from Laval University in Quebec in May 2009 (which incorporated her UAF undergraduate studies in 2007-2008), is a dual Canadian and United States citizen. While her native language is French, she has rapidly adopted English as her advanced second language. She is continuing her engineering and earth sciences education via a Master of Science curriculum in UAF's Civil and Environmental Engineering graduate program. With her current graduate work, she is pioneering interdisciplinary studies in geomorphological engineering, and is benefitting northern tier roadways and other transportation infrastructure in the process.

Eva has contributed to AUTC projects since 2006, including reconnaissance work to identify potential road test section sites in Alaska and the Yukon and geotechnical characterization of permafrost cores. She currently is working on AUTC's "Preservation of the Alaska Highway" project. Eva has significant innovative input on several project aspects, such as incorporating geographical information systems, capturing information in a database, and modeling using 3D technology in a way that can be extrapolated and applied to the entire Alaska Highway.

Daniel Fortier and Yuri Shur, Eva's graduate program co-advising professors, note that Eva's record demonstrates "professionalism, leadership and [an] excellent capacity to communicate scientific results."

Eva has received numerous scholarships and awards, including a scholarship from the National Research

Eva Stephani collecting samples in the field with research faculty member Mikhail Kanevskiy.

Council of Canada for her Master of Science project, the 2009–2010 Institute of Northern Engineering tuition award, the National Science Foundation Graduate Research Fellowship Honorable Mention, the 2007–2008 Flint Hills Resources Undergraduate Research Award, and the Olav

Slaymaker Award (best student poster in the field of geomorphology) for a presentation of her work at the 2008 Canadian Geophysical Union Conference in Banff. The Slaymaker Award is a particularly remarkable achievement, because Eva won it as an undergraduate student competing against Master's degree students and Ph.D. candidates at the conference.

Eva has published numerous technical reports, including being coauthor on the AUTC final report for the Preservation of the Alaska Highway research project. Her undergraduate thesis was on the cryostructures of permafrost cores for that project. Eva has an outstanding record of presentations in scientific conferences. She was first author on papers in nine international scientific conferences and symposiums, and coauthor on several others. She has become an outstanding AUTC ambassador.



Eva Stephani at the 89th annual meeting of the Transportation Research Board.

Undergraduate Stephanie Young helped collect data for the “Dust Control: Measuring and Improving Palliative Effectiveness for Rural Alaska” project.



Spring 2010 was a milestone for AUTC, when six students — our largest group of graduates since our program began — completed advanced degrees through the UAF College of Engineering and Mines.

Each student gained practical experience by working on various AUTC research projects. In addition to their classroom studies, these students gained experience that will be valuable in their future careers, including project planning, field work, lab testing, report preparation, and meetings with end-users and other stakeholders. They have specialized in finding practical solutions to transportation needs in arctic and subarctic communities, both urban and rural. They have already presented their research through national-level publications and professional conferences.

AUTC has benefitted from their hard work and individual talents, and they will be a valuable asset to the transportation community wherever they go.

Left: Graduate students Jake Horazdovsky and Duane Davis install instrumentation in a bridge pile. **Below:** Peter Jackson helped spread geofibers and shot video for the “Non-traditional Soil Stabilization Technology: Use of Geofibers and Synthetic Fluid in the Field” project.



AUTC Creates Opportunities for Students

28 students participated in research projects

Undergraduate Students

Brittany Bunch, Pre-nursing
Steven Cehula, BS
Michael Elbert, BSEE
Dalton Ellingson, BSEE
Jacob Horazdovsky, BS
Peter Jackson, BS
Christine McCabe, BS
Timothy Menard, BS
Ricky Pitts, BS

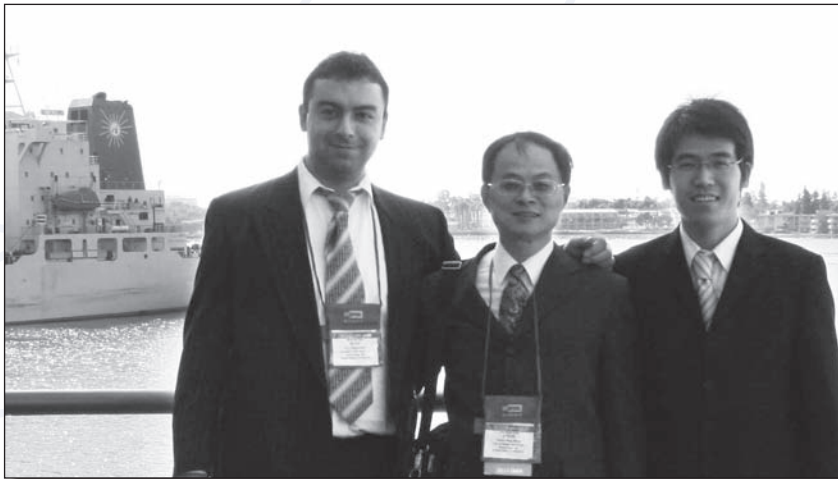
Graduate Students

Erica Betts, PhD
Rodney Collins, MS
Yildiz Dak, MS
Duane Davis, MSCE
Paul Duvoy, MS
Wei Fan, PhD
Travis Haller, MS
Xuping Huo, PhD
Jonathan Hutchinson, MS
Lin Li, MS
Peng Li, MS, PhD
Qiang Li, MSCE
Nicolas Lopez, MS
Jayashree Narayanan, MS
Ruiqiang Song, PhD
Eva Stephani, MS
Erin Trochim, MS
Ting Yang, MS
Lei Yao, MS

In 2010, AUTC outreach focused on making state-of-the-art information available to practicing professionals and building strong relationships with other organizations.

In June of 2010, AUTC hosted the annual **Center for General Aviation Research meeting**. At this conference, researchers, members of the Federal Aviation Administration, members of other Centers of Excellence, and industry representatives discussed current and future research related to general aviation.

Senator Mark Begich discussed the importance of general aviation to Alaska and to the nation. He praised CGAR for its pioneering of automatic dependent surveillance-broadcast techniques, which are crucial to the next generation of air transportation systems, as well as its work on low-power runway lighting and educational activities. Conference participants made presentations concerning lighting requirements for helicopter landing pads in urban environments, making real-time weather information available in the cockpit, integrating unmanned aerial systems in the national airspace, runway friction and low-power runway lighting. Approximately 70 people from all over the U.S. attended.



AUTC Director Billy Connor attended the annual **Transportation Association of Canada meeting in Vancouver, BC**. At this meeting he presented the impacts and uncertainties related to climate change in Alaska and participated in a roundtable discussion of these impacts. While we recognize the changes in climate, we have not fully assessed the potential impacts. Unfortunately, Alaska has not performed a vulnerability study. The Canadian government has performed these analyses for several communities in Canada. Their researchers found that the impact of climate change is directly related to design, and that some design practices are more tolerant to climate changes than others.

AUTC was a contributing sponsor to the **2009 Alaska Asphalt Pavement Summit, held in Anchorage, Alaska, November 18–19**. Around 125 people attended to discuss issues surrounding pavement construction in cold regions. UAF's Jenny Liu gave a presentation on pavement research at AUTC. This presentation is available online at <http://ine.uaf.edu/autc/>.

AUTC shares information and expertise with other cold regions professionals.

AUTC researchers Yuri Shur and Billy Connor visited Barrow, Alaska, at the request of the airport manager. They examined settlement areas in a new runway and provided an assessment of how the settlement damage will impact the airport's maintenance costs. The new runway is constructed adjacent to the old runway, which was built on ice-rich permafrost.

The manager feared that warming trends along with construction activities would require frequent re-leveling of

University of Alaska Anchorage Professor Hsueh-Ming Steve Wang (middle) and his students, Oleg Bukhtiyarov (left) and Lei Yao (right) attended the INFORMS meeting in San Diego, October 11–14. They presented their findings on the “Economical Analysis of Using Light-emitting Diode (LED) Technology for Alaska Street Lights” project.

the runway surface after construction is completed in the summer of 2011. Barrow, the northernmost community in Alaska, has no road access. Once the contractor leaves, asphalt for leveling will not be available. Shipping in material is prohibitively expensive.

While Shur and Connor found no evidence of permafrost degradation beneath the runway, they predict a little early settlement in the embankment, which should diminish with time. However, the runway apron shows signs of degrading permafrost, which is likely to continue.

In 2010, AUTC completed participation in the Mat-Su Borough Chip Seal Program. Since 2007, **AUTC has provided expertise and assistance in evaluating materials, to the Matanuska-Susitna Borough** as they develop a chip-sealing program to reduce maintenance costs and improve safety by reducing dust on local roads. This project, funded by the Alaska Legislature, will ultimately yield a procedure for successfully resurfacing existing roads with minimal preparation.

AUTC is working with other universities to develop and implement course modules leading to robust online learning programs.

AUTC, as part of the Region X Transportation Consortium, is working to create a four-year Transportation Education Development pilot program.

This working group, lead by Michael Kyte of the National Institute for Advanced Transportation Technology at the University of Idaho, is developing four course modules, which will be delivered via a unique distance-based learning environment. This project will also test the efficacy of the modules in meeting program goals and provide means to disseminate materials and lessons learned to a national audience. AUTC Director Billy Connor is part of the management team for this project, and UAF faculty member Ming Lee is part of the module development team.

A collaborative effort between UAF and Washington State University will yield a web-based highway geometric-design course module.

Researchers, led by AUTC's Ming Lee, are identifying key issues in geometric design, applying and improving established and proven effective models for developing curriculum materials, adapting materials for multiple diverse settings, assessing student learning and attitudes toward the modules, and considering a revision cycle to improve the materials.

The modules integrate a variety of learning tools and presentation techniques, including brief video lectures by university faculty and practicing engineers; videos of actual designs with commentary; problem solving and analysis; design criteria; printable reference documents; engineering design scenarios; and design documents such as drawings, reports, and specifications. The final layout of modules will be based on an agreement among all project team members.

AUTC offers support for Alaska's Local Technical Assistance Program.

AUTC contributed to several joint projects with LTAP, the Local Technical Assistance Program. LTAP, funded by the Federal Highway Administration, is part of a nationwide network with an organization in every state. LTAP seeks to improve the quality and safety of the surface transportation system through interactive relationships and information exchange. Alaska R&T2 (Alaska's LTAP) assists local governments through research, training, and technical assistance, to keep the state and other transportation agencies informed on new technologies and best management practices.

This year AUTC contributed funds and expertise to a range of LTAP events; to learn more, read the ADOT&PF/LTAP newsletter available at <http://www.dot.state.ak.us/stwddes/research/assets/pdf/10v35n1.pdf>.

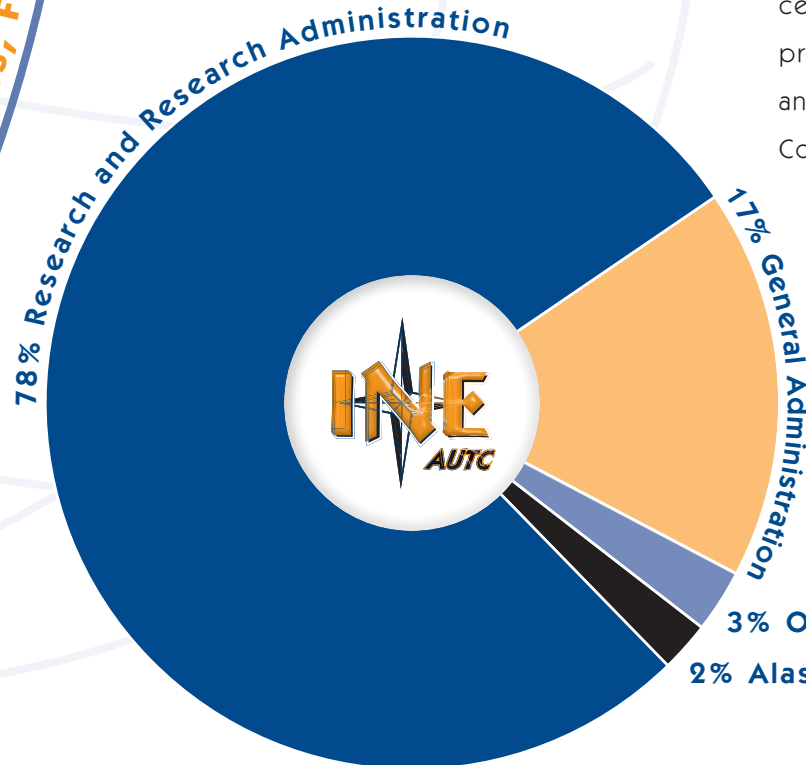
AUTC partnered with LTAP and ADOT&PF to offer a series of courses on Construction Management.

AUTC researchers Bob Perkins and Larry Bennett planned and organized a series of classes tailored to the needs of practicing engineers and other professionals working in the field of construction. Classes offered included "Project Management Boot Camp," "Managing Change Productively," "Cross-functional Project Team Building," and "Advanced Dirt." These courses were also available to university students through the UAF Center for Distance Education and the University of Alaska Statewide Corporate Programs.

AUTC is raising awareness about our programs.

In 2009 AUTC produced a promotional video highlighting its current research projects and the center's mission. This video is available at <http://ine.uaf.edu/autc/>.

Resources, Funding, and Expenditures



AUTC by the Numbers:

- The Region X Northwest Transportation Consortium expanded to include Montana
- AUTC contributed to 2 “pooled funds” projects
- AUTC is collaborating with 8 other universities
- AUTC received 35 proposals this year and funded 19
- AUTC had over \$4 million in expenditures last year

AUTC is growing in size and in public awareness, and attracting funds from federal agencies in addition to the U.S. DOT. Response to AUTC requests for proposals have grown as our faculty and center become better known. UA support for projects is increasing, primarily through matching funds, and participation by other state and local agencies, including the Alaska Department of Environmental Conservation and the Fairbanks North Star Borough.

The Alaska Department of Transportation and Public Facilities continues to be the predominant source of matching funds for AUTC.

The benefits of that partnership are mutual. ADOT&PF has helped fund projects such as dust management, fiber reinforcement of marginal soils, numerous materials-related projects, and a program of soil structure interaction in frozen soils.

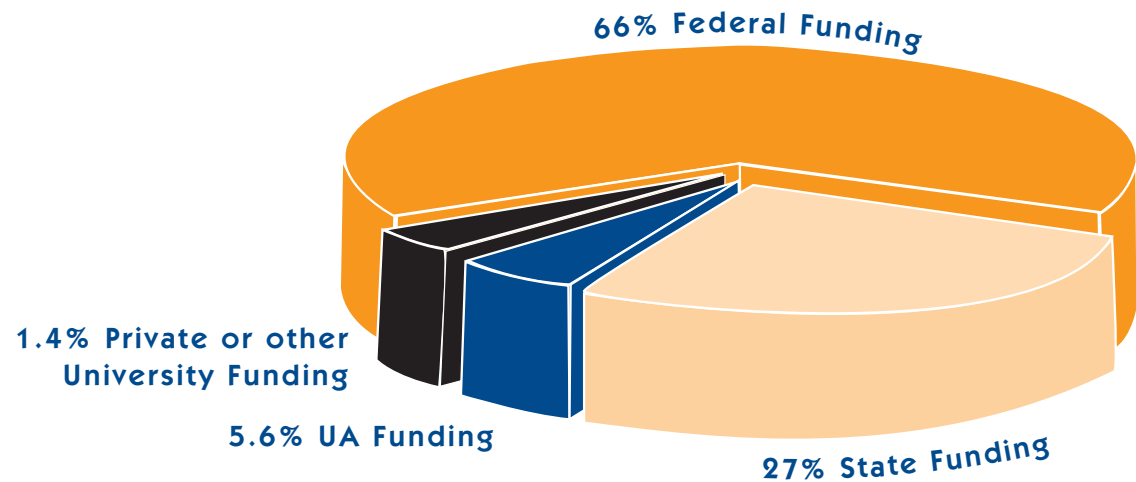
- 3% Outreach and Education
- 2% Alaska R&T² (Alaska LTAP)

In an effort to improve the efficiency of our project-selection process, AUTC and ADOT&PF have agreed to coordinate our separate project selection processes. The process will consist of a joint meeting of the governing boards to establish research priorities for the upcoming year. Shortly thereafter, AUTC researchers will work with ADOT&PF staff in a two-day meeting to develop and prioritize Phase I proposals to be incorporated into the AUTC process. These proposals will compete with proposals from other sources on an equal basis. However, the selection committee, which includes representatives from ADOT&PF, will have the benefit of knowing ADOT&PF priorities.

Perhaps the greatest challenge facing AUTC is knowledge management.

It has been said that if we incorporated existing knowledge into our daily work, we would move ten years ahead almost instantly. AUTC is looking for innovation in the delivery of information. Reports alone do not work; nor do training methods that have a high density of information.

Over the next year AUTC will work with ADOT&PF and the engineering community to develop learning tools that provide the practitioner the ability to find information quickly and in a useful format. It will explore the use of PowerPoint with voice-over, video, YouTube, and other delivery methods. The focus will be on just-in-time delivery of information.



AUTC seeks to alter the status quo through new technologies, application of existing knowledge, and transfer of knowledge to those who need it *when they need it*.

This effort requires that AUTC not only foster change in the research and professional communities, but also continuously reinvent itself.

No longer can AUTC simply develop new ideas and technologies. It must work hand-in-hand with agencies to integrate its products into the fabric of the transportation community. This means it must at times become the student, allowing the agency to be the teacher. Both time and funding must be included in the project for that interface.

The role of AUTC is changing as the expectations of the transportation community change. It must constantly adapt to new paradigms.

1: A spring flood on the Yukon River destroyed buildings in Eagle City, Alaska, in 2009. The Falcon Inn (pictured here) was shifted off its foundation. Photo courtesy of D. Barnes.

2: Alaska Senator Mark Begich (center) met with a team of students who represented the University of Alaska Fairbanks in the 2009 Clean Snowmobile Challenge. The students created a snowmachine that would operate completely on electrical power supplied by batteries, as opposed to a combustion engine. On the left is student Mark Nelson; on the right, student and AUTC research project assistant Michael Golub. Photo courtesy of Tom Moyer, Alaska Congressional delegation, Fairbanks office.

3: UAF Civil Engineering faculty member and AUTC researcher Yuri Shur at a field site near the Dalton Highway, Alaska. Photo by M. Kanevskiy.

4: An Alaska Railroad engine passes on the lower UAF campus. Photo courtesy of INE staff.

5: UAF Electrical Engineering faculty member and AUTC researcher Richard Wies. Photo by K. Hansen.

6: Washington State University PhD student Wei Fan performs dynamic testing of a Smart Honeycomb Fiber-reinforced Polymer (S-FRP) sandwich beam prototype as part of the “Smart FRP Composite Sandwich Bridge Decks in Cold Regions” project. Photo courtesy of P. Qiao.

7: AUTC student researcher Eva Stephani carries instrumentation into a field site as part of the “Preservation of the Alaska Highway” project. Photo courtesy of AUTC staff.

8: UAF Geological Engineering faculty member and AUTC researcher Margaret Darrow completes the installation of an automated slope monitoring device. See page 22 to learn more about Margaret Darrow’s research. Photo courtesy of ADOT&PF.

9: AUTC student researcher Duane Davis (right) explains his bridge pile installation at a field site for the “Seasonally Frozen Ground Effects on the Seismic Response of Highway Bridges” project. On the left is ADOT&PF’s Angela Parsons, research engineer. In the background is AUTC researcher Xiong Zhang. Photo by K. Hansen.

10: UAF CEE faculty member and AUTC researcher Dave Barnes checks instrumentation on the UAF DUSTM, an innovative new tool for gathering reliable data on airborne dust. To learn more, see pages 30-31 and 38. Photo courtesy of AUTC staff.

11: Andrew Metzger ascends a ladder after inspecting the installation of strain gauges on piling at the Auke Bay Ferry Terminal in Juneau, Alaska. See page 8 (“Ductility of Welded Steel Columns”) for more information about this project. Photo by J. Hutchinson

12: Alaska has roughly 240 small rural airports. To learn more about AUTC contributions to Alaska’s small plane infrastructure, see page 31. Photo by M. Kanevskiy.

13: To learn more about this photo, see page 19 and the “Updated Precipitation Frequency Analysis for the State of Alaska” project. Photo by M. Coffey, ADOT&PF.

14: The trans-Alaska oil pipeline is 800 miles long, running from the North Slope of Alaska to Valdez. The support poles holding up the pipeline are designed to stabilize the frozen foundation soils by dissipating heat through the fins at the top. The supports also allow both vertical and horizontal movement during an earthquake. Photo by G. Holdmann.

15: Applying herbicides along a section of the Alaska Railroad. AUTC projects have studied herbicide effectiveness and dissipation over time. Photo by AUTC staff.

16: CEE faculty member and AUTC researcher Horacio Toniolo travels the Sag River as part of the “Field Study to Compare the Performance of Two Designs to Prevent River Bend Erosion in Arctic Environments” project. See page 26 to learn more. Photo by AUTC staff.

17: Snowmachines and dog sleds are common parts of Alaska’s transportation infrastructure. Photo courtesy of S. Colt.

18: An aerial view of tundra on the North Slope. Repeated freezing and thawing of soils over permafrost creates a distinctive polygon pattern. Photo by M. Kanevskiy.

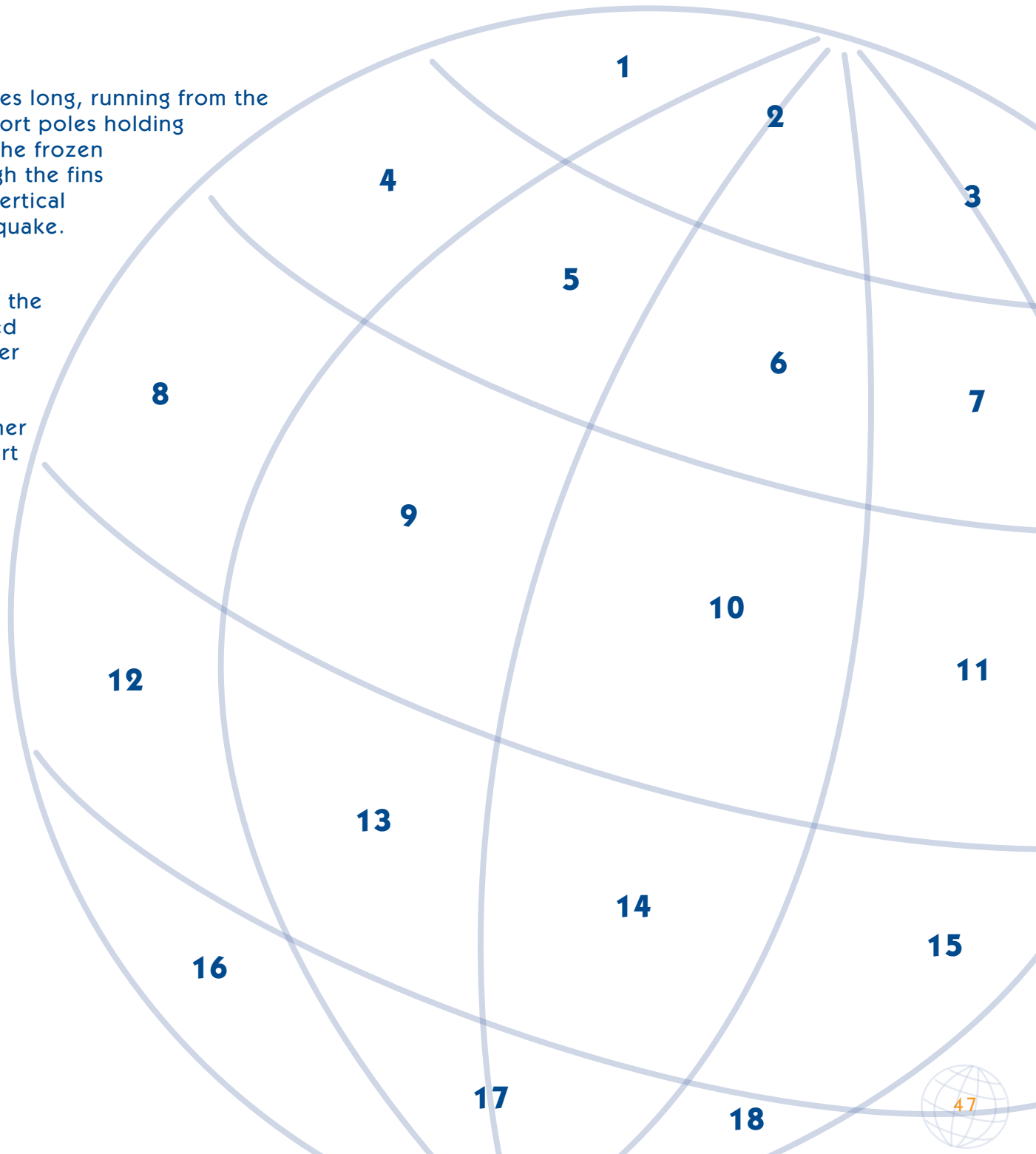


Photo Credits – Inside

Page 2: Photo of AUTC Director Billy Connor by INE staff.

Page 4: Photo of Amit Armstrong courtesy of A. Armstrong. Photo of Rick Kessler courtesy of R. Kessler. Photo of Bob Pawlowski courtesy of B. Pawlowski. All other board member photos by INE staff.

Page 5: Photos of Zhaohui Yang and Robert J. Lang courtesy of University of Alaska Anchorage. Photo of Sonia Nagorski by E. Hood. All other photos by K. Hansen.

Page 6: Photos of installing sidewalk de-icing system by Zhaohui Yang, UAA.

Page 7: Photo of truck distributing synthetic fluid courtesy of AUTC staff. Photo of geofibers mixed with soil by K. Hansen.

Page 9: Photos by R. Perkins.

Page 10: Photo of the E.L. Patton Bridge courtesy of ADOT&PF. Closeup of bridge decking by UAF grad student Zach Jerla.

Page 11: Photo of pavement construction by J. Liu.

Page 12: Schematic showing Shake Table Model courtesy of Z. Yang.

Page 13: Photos of student Travis Eckhoff operating the UAF DUSTM in the field courtesy of D. Barnes.

Page 15: Map showing traffic activity in Anchorage produced by J. Milller, using FreeSim software.

Page 16: Model of bridge foundation undergoing liquefaction-induced soil lateral movement courtesy of Z. Yang.

Page 17: Photo of ice and meltwater on bridge walkway by Y. Dak.

Page 18: Photo of Washington State University graduate student Wei Fan by P. Qiao.

Page 19: Photo of flood damage to the Richardson Highway by M. Coffey.

Page 20: Photos of geosynthetic fiber application by graduate student Peter Jackson.

Page 22: Photo of Margaret Darrow courtesy of ADOT&PF.

Page 24: Photo of gyratory compactor by J. Liu.

Page 26: Photos of spring breakup on the Sagavanirktok River courtesy of AUTC staff.

Page 29: Photo of self-sustaining LED streetlights on the UAA campus by H-M Wang.

Page 31: Photo of small planes on rural Alaska airfield by M. Kanevskiy.

Page 38: Photo of Michael Golub and electric snowmachine by K. Hansen.

Page 39: Photo of UAF DUSTM courtesy of AUTC research team. Photo of graduate student Rodney Collins by P. Jackson.

Page 40: Photo of Eva Stephani (lower left) courtesy of B. Connor. Photo of Stephani and Matt Dillon (upper right) by M. Kanevskiy.

Page 41: Photo (top) of undergraduate Stephanie Young and UAF DUSTM courtesy of D. Barnes. Photo (bottom left) of Jake Horazdovsky (left) and Duane Davis (right) by K. Hansen. Photo (bottom right) of Peter Jackson by B. Connor.

Page 42: Photo of UAA student Oleg Bukhtiyarov (left), Hsueh-Ming “Steve” Wang (middle), and Lei Yao (right) courtesy of Wang.

Back Cover (clockwise, from 12:00)

1: UAF’s entry in the Society of Automotive Engineers’ Clean Snowmobile Challenge. Photo courtesy of M. Golub.

2: Alaska has the highest number of pilots per capita of any U.S. state. Air travel remains the most efficient way to travel around the state. Photo of airplane by M. Kanevskiy.

3: The trans-Alaska pipeline. Photo by G. Holdmann.

4: Creosote-coated dock piers encrusted with mussels and algae at a Southeast Alaska ferry port. Photo by A. Metzger.

5: A steel gangway, part of a system for loading and unloading ferries at an Alaska port. Photo by A. Metzger.

6: Mount Redoubt, an active stratovolcano just west of Cook Inlet, in the Kenai Peninsula Borough, about 100 miles southwest of Anchorage. The volcano erupted in 2009. Photo by S. Boatwright.

7: The Lowe River, which runs through Keystone Canyon, near Valdez, Alaska flooded in 2006; the floodwaters and subsequent landslide closed both the Richardson Highway and the trans-Alaska pipeline for ten days. Photo courtesy of ADOT&PF.

8: The Hurricane Gulch Bridge, part of the George Parks Highway, which connects Anchorage and Fairbanks. The steel arch bridge was opened in 1971. Photo by S. Boatwright.

Photo Credits – back cover

Alaska University Transportation Center: One research center, three campuses, 586,400 miles of laboratory space.

