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 as 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.
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As we continue to argue the worth and significance of transportation research to Congress, we must sell value, value, value. Here, I must offer an admonition: don’t confuse value with risk. By its very nature, research comes with risk; that is, risk that the intended value won’t be obtained, risk that the original hypothesis is wrong. At the same time, there is an excellent probability that the hoped-for value will be exceeded and that pathways to new opportunities will be opened. The particularly exciting and fascinating potential of research projects are the unanticipated benefits: an unanticipated added result, and lessons learned that apply to other projects. One of my former colleagues always reminded me that just because a particular hypothesis failed, didn’t mean the project failed. Rather, we learned what didn’t work, and gained value in knowing what not to apply in practice.

Value, worth, merit, or importance are all terms that describe how funding agencies will view a project. For example, Dr. Hazirbaba’s early efforts in strengthening fine-grained soils were funded by Peak Industries, because they saw a potential market. The Alaska Department of Transportation and Public Facilities (DOT&PF) became a partner because they saw the potential for reduced construction costs in rural Alaska.

The value to Peak is potential revenue; the value to DOT&PF is saving construction costs and improving service to rural communities — a different but equally important value. This project will take several phases to prove itself, in fact, our first field test will be in the spring of 2010. Based on this project’s known worth, we anticipate high returns from it.

In contrast, Dr. Barnes’ work on dust control probably won’t save money directly, at least not so straightforwardly as Dr. Hazirbaba’s soil-strengthening is paying dividends. It does, however, provide a quantitative measure of the effectiveness of palliatives to reduce dust, thus improving the quality of life in rural communities throughout Alaska and the rest of the nation. To do this, Dr. Barnes and Dr. Wies invented DustM, a device which measures dust off the tire of any vehicle. DustM, unlike instruments of the past, fits in a small case about the size of carry-on luggage. Alaska DOT&PF is adopting it to specify the performance of palliatives used in Alaska. Industry is excited to be able to have data to compare their products and improve them. The Alaska Department of Environmental Conservation is excited about the ability to measure the dust coming from transportation facilities in their quest to improve air quality. Indeed, measurements have shown that some palliatives reduce dust by 98% for at least a year. As a result, this project is rapidly moving into the implementation phase.

The value of each of these projects is unambiguous. Each project has clear and obtainable goals. Each has a measurable risk. As a result, funding for the projects has been readily available. So, as you review the projects in this annual report, I ask you to look at the value of each project. Many projects have immediate value, while others may lead to innovations which will have value down the road. In each case, though, value is the central criteria by which our projects must be judged.
AUTC is fortunate to have an active and engaged governing board providing direction. Their understanding of the overarching issues facing cold-regions transportation is essential to Alaska’s future. 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: www.alaska.edu/uaf/cem/ine/autc/about/board.xml
**Zhaohui Yang**
Research Faculty, UAA
Civil Engineer, structural engineering and soil interactions

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

**Kenan Hazirbaba**
Research Faculty, UAF
Civil Engineer, soils, soil testing, and other geotechnical topics

**Jill Dewey-Davidson**
Program Assistant
Coordination of program activities and documentation

**Juanyu Liu**
Research Faculty, UAF
Civil Engineer, pavement materials and related topics

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

**Ming Lee**
Research Faculty, UAF
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Serving Future Transportation Needs: Strategies to Improve Alaska DOT&PF’s Professional and Support Staff Recruitment and Retention (PI Robert Perkins, UAF)

Alaska Department of Transportation & Public Facilities continually loses personnel, both seasoned and young professional and support staff, a problem experienced by other agencies state and nationwide. This project examines recruitment and retention strategies for professional and support staff who accomplish the work of the DOT&PF—those individuals who will serve the future transportation needs of Alaska. Over the last decade, DOT&PF has lost many senior employees due to resignations and early retirement. In addition, the agency loses bright, energetic younger employees who, after gaining a few years of experience, resign for more attractive compensation packages and other personal reasons. 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, led by Robert Perkins, addresses DOT&PF’s need to attract and retain a sufficient number of qualified employees. In addition to analyzing recent changes and their impacts, this study will consider the magnitude of changes over time. As an example, this team will consider plausible future events that may cause large changes in staffing requirements.

Research findings will suggest strategies, goals, and tasks designed to help DOT&PF formulate an action plan to accomplish its mission in the future. The report will target an audience that includes DOT&PF leadership, chief-level managers, administrators, and Department of Administration personnel interested in successful long-term development of the agency’s human assets.

Positions open now

Within 1 year

5 years

Perkins explains his data detailing DOT retirement eligibility and the looming loss of key personnel.

Alaska has roughly 240 small rural airports. They all need regular inspections.
Alaska Rural Airport Inspection Program  
(PI David Barnes, UAF)

Alaska wins all the way around with this project to develop and implement an inspection program for the state’s rural airport infrastructure. The project, which will allow for long-term planning of rural airports and reduced maintenance costs, will also provide hands-on experience for the UAF civil engineering students assisting with the project, thereby contributing toward the development of our transportation workforce.

Freezing temperatures and weathering invariably affect airport runway conditions and equipment across the state, 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 on these runways; however, the remoteness of many Alaskan villages results in infrequent thorough inspections. Consistent with the AUTC’s 2008 Road map theme of maintaining transportation systems, 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.

Researchers will develop and implement the rural airport inspection program for DOT&PF, a project partner. The project is an excellent opportunity for the UAF Department of Civil and Environmental Engineering to involve its students in work with DOT&PF, providing them with applied experience in transportation engineering. Under the direction of project leaders David Barnes and Dennis Filler, students not only will learn to take proper field measurements and samples, and document the condition of the rural airports to be inspected, but also will analyze the field measurements, conduct the necessary laboratory tests on samples gathered in the field, and write reports. Through this experience, CEE students will be introduced to the challenges of transportation engineering in Alaska and the possibilities of working in this field. Some may become employees of DOT&PF, a potential benefit to both students and the agency.

Alaskan Hot Mix Asphalt Job Mix Formula Verification  
(PI Juanyu “Jenny” Liu, UAF)

Because hot mix asphalt (HMA) is the paving material in Alaska, assuring the quality of this material is a critical issue for contractors, DOT&PF, and other agencies responsible for pavements. It is vital to assess elements related to HMA quality assurance specifications and to evaluate how well contractors meet the requirements of mix designs.

This research will result in a revision of current mix design protocols and contractor payment methods as appropriate for asphalt paving in Alaska. Through a comprehensive study that includes field data collection, compilation, and analysis, AUTC researcher Juanyu Liu leads this investigation into the variability of HMA performances due to production, and verification of the HMA job mix formula. The findings of this project will greatly benefit the asphalt paving process, from job mix formula to production through construction, 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.

Dr. Liu tests the performance of Hot Mix Asphalt under cold climate conditions.
Load Environment of Washington State Ferry & 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.

Ideally, the project should result in a design point, consistent with Load-Resistance Factor Design philosophy, allowing confident use of existing design codes for materials typically used to construct such facilities. While the structures used by AMHS and WSF 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. These similarities present the opportunity for a cost-sharing project in which the Alaska DOT&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.

Including Life Cycle Cost Analyses in Alaska Flexible Pavement Design Software (PI Juanyu “Jenny” Liu, UAF)

Life cycle cost analysis (LCCA) is a key to selecting more appropriate materials and techniques for optimizing the cost and performance service life of pavement. Though Alaska Flexible Pavement Design software has been in use since 2004, no computerized analysis tool is available to help pavement engineers determine the associated LCCA. Including LCCA in the AKFPD software would benefit pavement designers substantially, offering them the ability to improve performance of the infrastructure, while also making more cost-effective use of the design effort.

This project, led by Juanyu Liu, will update the current AKFPD software, creating a single software package capable of executing the economic cost analysis and structural analysis functions. Such integration will provide a systematic and methodical approach for proper designs, together with the optimal combination of desired pavement performance and cost. Engineers and other users will be able to utilize the updated AKFPD software, a modified AKFPD manual, and case studies with complete analysis processes that will help them navigate the software.
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 (MEMS) accelerometers, which were first used for automotive airbags. Automated in-place MEMS inclinometer strings (AIMIS) 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, led by Margaret Darrow, 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, monitoring settlement of soft foundation soils under a high embankment, 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 both horizontal and 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.

Transportation agencies will experience reduced project travel budgets and increased worker safety, and will have dependable, accurate measurements, allowing for more confidence in designs.

Geological engineer Margaret Darrow collects a split-spoon sample from a bore hole.
Seismic Performance of Bridge Foundations in Liquefiable Soils (PI Zhaohui “Joey” Yang, UAA)

During an earthquake, what happens to a bridge foundation if it is built on a frozen crust of ground that is resting on a liquefiable soil layer? How large are the loads generated by frozen crust foundation interaction during a winter earthquake, and how should a designer deal with them? How can engineers make the bridges safe, and strong enough to withstand these forces of nature? These questions are unique to arctic areas such as Alaska, but there are no seismic analysis guidelines to account for how the frozen ground crust affects bridge foundations at a liquefiable site.

This project provides, for the first time, a quantitative evaluation of the loads imposed on bridge foundations by a frozen crust with liquefaction and lateral spreading. The results will improve seismic design of highway bridge foundations where there are 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.

Liquefaction and associated ground failures were commonly observed in past major earthquakes across the world, including Alaska. In March 1964, Southcentral Alaska experienced the Great Alaska Earthquake, one of the largest in recorded history. In November 2002, the Denali Earthquake struck Interior Alaska. Both earthquakes caused extensive ground failure and structural damage, a substantial portion of which was the direct result of or related to liquefaction and lateral spreading. Lateral spreading is particularly damaging if a non-liquefiable crust (typically unfrozen clay and/or sandy soil above the groundwater table) rides atop the liquefied soil. When the ground crust is frozen, its physical properties change drastically: stiffness and shear strength increase, and permeability decreases substantially.

Researchers, led by Zhaohui Yang, hypothesize that these changes impact the liquefaction process and the consequences of liquefaction of underlying soils. The frozen ground crust forms a stiff and almost impermeable mass that restricts upward flow of water, and the frozen crust likely imposes large lateral loads as well as lateral spreading on the bridge foundations during shaking.

Project objectives include 1) gaining in-depth understanding of the frozen crust’s impact on a typical bridge foundation (e.g., steel-pipe pile and drilled shaft) embedded in a liquefiable soil layer overlying competent soils during earthquakes, 2) evaluating the loads on the bridge foundation imposed by a frozen crust, and 3) recommending guidelines for considering these loads by using a simplified pseudo-static approach.

Researchers will use numerical simulation of the soil-foundation-superstructure system with material models validated by field observations and laboratory testing results of Alaska soils. Objectives 1 and 2 will be addressed by three-dimensional coupled fluid-solid finite element analyses of a typical bridge foundation embedded in two soil conditions—one with an unfrozen crust and another with a frozen crust—considering both inertial and kinematic loading. Objective 3 will be achieved by analyzing results from Objectives 1 and 2, resulting in proposed guidelines.

Alaska DOT&PF Specification for Dust Control Application on Unpaved Surfaces (PI David Barnes, UAF)

In Alaska, dust is a problem. Besides being a major health hazard, dust is tough on vehicles traveling on unpaved roads, and aircraft landing on gravel runways are pitted by dust and gravel. Air filters clog, dust seeps in everywhere, and equipment maintenance costs rise. The contiguous U.S. has similar road dust problems, in that about 1.7 million miles of the nation’s roughly 4.2 million total miles of roadway are unpaved.
NEWLY FUNDED RESEARCH

For the past seven years, the DOT&PF’s Northern Region has applied different types of dust control, known as palliatives, to runways at approximately 33 rural airports in its region. In addition, Kawerak, Inc. (based in Nome, Alaska) has applied dust control substances to roadways in several northwest Alaskan villages. The only guidance for applying these has come from the palliative manufacturers. According to DOT&PF, specifications provided to the contractors who apply these have been minimal. In specifications as written, the requirement of “effective and evident dust palliative effect” is not quantifiable. Thus, if a dust control product and application does not perform, DOT&PF cannot argue that the contractor did not satisfy the terms of the contract. The specification also does not place any requirements on placement of the dust control product.

This project’s goal is to write a set of performance-based specifications that cover application of dust control products to unpaved transportation surfaces in Alaska. Researchers led by David Barnes will assess the effectiveness of palliatives to reduce loftable dust by using the UAF Dust Monitor, known as UAF-DSTM (pronounced dust ‘em), a portable dust instrument recently developed under a previous AUTC project. Armed with assessment results, researchers will compare the effectiveness of newly laid dust control agents against those applied one to three years prior. Information from this comparison will provide the basis for developing a reasonable performance-based specification. The research team anticipates that the specification will include measuring dust control performance using UAF-DUSTM or a comparable instrument.

An all-terrain vehicle equipped with the University of Alaska DustM.

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 project was constructed by the DOT&PF at Sag 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, led by Horacio Toniolo, will gather field data from different types of river-bend protection structures, and use the accumulated data set to evaluate whether respective structures met project objectives for Sag River and Hess Creek. The research team will describe the positive and negative aspects of the two designs under study, establish a sediment budget, and develop turbulence fields for the sites. DOT&PF and Alyeska will directly benefit by incorporating the findings from this project in new designs that are less environmentally intrusive than a standard revetment. Field data will serve as a baseline for future studies related to climate change. Turbulence fields also could provide information to improve habitat conditions in future revetment designs.
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, conducted by Virginia Fay of UAA, aims to develop a model of Alaska’s transportation sector to assess the effects of greenhouse gas emissions legislation and other factors that may affect fuel prices or use.

In addition, 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 the UAA Institute of Social and Economic Research program, Energy in the Alaska Economy. This program will enable a better understanding of the interactions between 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 inexpensive, compared to 2008.

Key industries such as fishing, mining, tourism, transportation, and subsistence currently depend directly on liquid fossil fuels, while the urban service economy depends heavily on the 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.

If greenhouse gas emissions go down, will Alaska’s energy costs go up?

Fay’s model of Alaska’s transportation sector will assess the effects of greenhouse gas emissions legislation and other factors that may affect fuel prices or use.

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, led by Billy Connor, will help FNSB to 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 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.

The goal for this study is a systematic, practical, and economical road-upgrading process for FNSB by addressing the following objectives:

- Develop a method for visually examining and sampling from candidate roads to determine upgrading needs,
- Provide a simplified flexible pavement design method,
- Estimate costs associated with upgrading alternatives, and
- Develop a GIS-based DSS platform for FNSB’s road-upgrading process.

A General Review of Slope Stability Problems and Case Histories 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 infrastructure has 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 is required. The objectives of this project, led by Kenan Hazirbaba, are to 1) review all available documents and literature published on slope stability problems and case histories in Alaska; 2) classify slope stability problems with respect to soil types and site location; and 3) establish a baseline for an investigation on alternative slope-stabilization technologies including the use of geofiber and synthetic fluid. 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.
In the U.S., a major source of greenhouse gas emissions is carbon dioxide emissions from personal automobiles.

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

In the last few years, increasing scientific evidence supports the hypothesis that greenhouse gas emissions (GHG) 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, led by Ming Lee, will develop methodologies to forecast long-range multimodal 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 (CO2) 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 (VMT). In devising effective multimodal 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 EPA’s MOBILE 6 or MOVES model. MOVES, which will replace MOBILE 6 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, and then tested with a forecasting scenario to demonstrate their capability to reflect the effectiveness of GHG emission reduction of proposed transportation measures.

**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 learn about current traffic conditions only through radio and television broadcasts and 511 information, which is not always updated in a timely manner. Vehicle-tracking devices using vehicle-to-infrastructure (V2I) architecture have already been installed in 15 vehicles in Anchorage, and this project will install them in 30 more. Further, the research team, led by Jeffrey Miller, will contact taxi fleets, emergency response vehicles, transit vehicles, shipping vehicles, navigation system companies, and any other organization that may be tracking speed, location, and direction of vehicles to leverage the data already being collected.

From all data collected, researchers will determine realistic measurements and understanding of congestion in Anchorage. As more vehicles are equipped with tracking devices, data will become more accurate and include a larger range of the city and state. Because the DOT&PF does not currently have much data on the origin and destination of individual vehicles, this project will provide that needed information. The overall delay experienced by individual drivers and the extent of cut-through and spill-over traffic due to congestion will be determined.

Data from this project will be viewable by anyone in a web interface called FreeSim (http://www.freewaysimulator.com). Current speeds of anonymous tracked vehicles will be displayed using different colors on the roads, and exact speeds will be shown. Historical data will be maintained to determine year-round traffic changes. In short, this project will provide DOT&PF and anyone anywhere in the world with the current state of traffic on roads in Anchorage and around Alaska. The novelty of this project is that data will be gathered from a continuous data flow instead of at discrete locations, as is the case with many current traffic-analysis tools. As additional resources become available, drivers will be able to view current traffic conditions during their commutes, and the system will be able to send them information about streets to take to minimize time spent in traffic.

A continuous flow of data being gathered can provide answers to a variety of questions, such as Where do vehicle trips originate and terminate? How much delay does a single driver endure? What is the cumulative delay of all drivers based on the amount of congestion? How do drivers circumvent congestion during their travels, and do these route changes really decrease their total travel times? How do traffic patterns change based on seasonal variations? What impact do events that attract a large number of vehicles have on recurrent traffic? At this point, neither Anchorage nor other places in Alaska can answer these questions because traffic data is retrieved only at discrete locations.

Miller’s team will develop realistic measurements and understanding of traffic congestion in Anchorage.

Heaviest morning traffic?
Using Screw Piles in High Seismicity Areas of Cold and Warm Permafrost (PI Kenan Hazirbaba, UAF)

Deep foundation systems in seasonally frozen ground and permafrost areas are prone to pile heave due to frost action. A proper design to mitigate frost heave requires that the net forces acting on piles do not result in uplift forces and movement of structures. To ensure adequate resistance against frost heave, pile embedment in permafrost must be sufficient, typically a minimum of two to three times the thickness of the normal active zone. Lateral loading capacity becomes critical where permafrost is located in areas of high seismicity, and traditional pilings designed to resist these combined forces are costly. An alternative to traditional pilings in areas of high seismicity with seasonally frozen ground and permafrost is to use screw piles, which provide significant lateral load and uplift resistance with minimized required embedment depth. Screw piles are also relatively lightweight and easier to transport and install than traditional piles. These potential benefits could result in a significant reduction of deep foundation construction costs and make screw piles a cost-effective foundation alternative in Alaska. However, current design methods for traditional deep foundations do not address the use of screw piles in seismically active seasonally frozen ground and permafrost areas.

This project, led by Kenan Hazirbaba, aims to develop design guidelines for using screw piles as a cost-effective deep foundation alternative with seismic considerations for Alaska’s transportation infrastructure and that of other northern regions. In addition, the research will stimulate collaboration between AUTC and private industry. Due to the unknown behavior of frozen and seasonally frozen soils under earthquake loading, current deep foundation designs tend to be either overly conservative with huge economic impact, or oversimplified with significant reliability concerns. This study has the potential to improve the reliability of transportation systems by producing infrastructures that are seismically safe and economically designed. Additional project objectives include establishing a database for dynamic properties and cyclic behavior of cold region soils under seismic loading conditions; providing seismic design recommendations for deep foundations of Alaska transportation infrastructure, supplementing the current foundation seismic design codes; and completing a master study in the field of cold regions geotechnical earthquake engineering.

Screw piles are an alternative to traditional pilings in areas with permafrost and high seismic activity. Screw piles provide significant lateral load and uplift resistance, and they don’t have to be embedded as deeply.
Engineering Techniques to Control Permafrost Degradation under Roads: Preservation of the Alaska Highway, Phase 2 (PI Daniel Fortier, UAF)

Permafrost degradation under roads affects extensive regions of Alaska, northern Canada, northern Europe, Russia, and China. In many areas of Alaska and northern Canada, global warming is affecting permafrost. Roads built on permafrost, even those with proper design to protect the thermal regime of frozen soils, will become problematic with climate change. Observations and technical reports in Alaska and across the Arctic indicate that extensive road and runway deformations are occurring already due to thaw-settlement of permafrost.

Better understanding of the various processes and modes of permafrost degradation under road embankments will help effectively and economically address road degradation problems related to climate change. Air temperature increase plays a major role in the dynamics of permafrost. According to the modeled scenarios of climate warming, deepening of the active layer, degradation of the ground ice of the upper permafrost, and development of taliks (permanently unfrozen zones) are expected to occur in the near future. This will affect road embankments, likely leading to structural damage including cracking, depressions, sinkholes, and differential subsidence. The warming and reorganization of the regional atmospheric circulation will also affect the precipitation regime. Precipitation, particularly the insulating effect of snow, plays a key role in the current thermal and physical state of permafrost. Thermal erosion due to surface and groundwater flow, a poorly studied process, is likely to be instrumental in permafrost degradation. Process-based studies and improved spatial resolution of models are needed to predict the relationship and response of permafrost to changes in precipitation, runoff, and groundwater flow. Project results can improve and support transportation infrastructure-network development in the context of climate change by developing adaptation and mitigation techniques to stabilize roads built on permafrost.

This project’s specific research objectives are to 1) provide guidance to maintain and improve the test section implemented in Phase 1 of this project; 2) implement two additional mitigation techniques (insulate side slopes using grass cover and boards); 3) develop detailed 2D and 3D cryostratigraphic models of the terrain and embankment; 4) develop a geotechnical database of permafrost properties; 5) provide a geo-referenced technical description of embankment material; 6) develop a near real-time database of ground temperature linked to the 3D cryostratigraphic and road embankment models in a geographic information system; 7) assess the performance of air convection, reflection of solar radiation, and other insulation techniques already implemented; and 8) measure the process of permafrost degradation related to groundwater flow applied to road embankment.

Researchers, led by Daniel Fortier, will develop a Best Practices Guide for monitoring groundwater flow and permafrost degradation in the road infrastructure. The guide will help engineers properly address groundwater conditions when roads are built over thaw-sensitive permafrost affected by climate warming, and will include field operations and laboratory techniques for groundwater studies.

**Fortier’s team will create a near real-time database of ground temperature linked to 3D cryostratigraphic and road embankment models.**
Economical Analysis of Using Light-emitting Diode (LED) Technology for Alaskan Street Lights (PIs Hsueh-Ming Wang, UAA and Richard Wies, UAF)

Streetlights use lots of energy, especially when night lasts more than 12 hours. Communities are exploring how light-emitting diode technology (already popular in many devices from flashlights to electronic billboards) might be applied to citywide lighting systems. Some researchers suggest that under ideal conditions, an LED system might use 50 to 75% less energy than a traditional streetlight system. Under the right conditions, LEDs can have a longer performance life. In general, the devices tend to be less fragile, and they switch on and off quickly, with no flickering. Many believe LED technology is the next step in efficient indoor lighting for the U.S., after fluorescents. LED lighting technology is moving into the streetlighting market as a possible alternative to high-pressure sodium (HPS) lamps.

A UAF experiment indicates that the LED light performs better in arctic conditions — it becomes brighter as the temperature drops.

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

There is a concern with how much light LEDs actually shed on a city street. In some places where LED streetlights have been installed, people perceive that less light is produced with LEDs than with old lamps and that available light does not improve visibility. The electroluminescence emitted by an LED fixture casts a much smaller circle of light than an old-style lamp, and some argue that this will require additional streetlights placed closer together, increasing capital and energy costs.

This joint effort between UAA and UAF explores replacing traditional HPS streetlights with LEDs in urban areas of Alaska. The UAA team, led by Hsueh-Ming Wang, is developing an economic model to help the Municipality of Anchorage and DOT&PF form a replacement plan for urban lighting systems. The team is also exploring the possibility of equipping each LED streetlamp with an individual power source driven by solar or wind energy. The plan is ultimately to design, install, and monitor the performance of a prototype streetlight powered by a solar cell on the UAA campus. The UAF team, led by Richard Wies, addresses LED power use in a large-scale system, as well as whether an LED system can meet the national highway visibility standards set by the American Association of State Highway Transportation Officials. Thus far, a pilot experiment verified the performance of the LED light in arctic conditions (the light actually becomes brighter as the temperature gets colder). Another pilot project will test the system “on the ground” over the winter.

The UAA team is developing an economic model that the Municipality of Anchorage and DOT&PF will use to create a replacement plan for urban lighting systems.
Alaska Marine Highway System Analysis  (PI Paul Metz, UAF)


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, led by Paul Metz, a UAF expert in Alaska’s multimodal transportation system, 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 available to meet those needs. The results of this study will benefit DOT&PF in planning for long-term operation of the state’s extensive ferry system.

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 energy and elimination of pollutants. This project, under the direction of UAF Mechanical Engineer Jing Zhang and UAF student Michael Golub, studies the feasibility of using electric vehicles as reliable transportation in cold regions. Researchers are evaluating conditions in which the electric car is appropriate; for instance, for short trips around town or for longer trips. Researchers are also addressing the use of electric cars as a mode of transportation, the optimal distance between origin and destination, and potential environmental impacts on transportation operations. This study is being conducted in Fairbanks, an urban area in Interior Alaska, as a case study. Project results include data and analysis of electric car performance for urbanized areas in cold regions. The knowledge gained can assist departments of transportation in cold regions when considering adopting electric cars as an alternative transportation method.

AUTC projects yield results threefold. Student researcher Michael Golub is applying data from this feasibility study to new projects as well as classes on electric vehicle development.
Bridge supports can be weakened by traffic vibration or by weathering.

Decking can degrade due to factors such as heavy use and environmental stresses.

Life Cycle Cost Analysis for Alaskan Bridge Components (PI 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 ones could function for another decade or so? How much 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 transportation infrastructure. The accepted design life for a bridge is set at 75 years, but this rather 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. Led by AUTC’s Leroy Hulsey and Andrew Metzger of UAF CEE, the research team is collecting data on environmental conditions, material aging processes, repair records, and current costs. The results of this study will create a process for conducting life-cycle cost analyses for highway bridges in Alaska. This project provides state planners and bridge 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.

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

In the last two decades, Fairbanks, Alaska, has seen significant population growth. Based on the 2000 U.S. Census, it was designated an official urbanized area. The Federal Highway Administration requires urbanized areas to form a Metropolitan Planning Organization to oversee transportation planning and to manage federal highway funds. Governor Murkowski officially designated the Fairbanks Metropolitan Area Transportation System as the MPO for the Fairbanks urban area. An MPO developing a region’s transportation plans and programs to accommodate mobility needs 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. The QRS II system, which uses simple methods for travel demand forecasting, is intended for smaller urbanized areas, where traffic congestion and vehicle emissions are not significant concerns. However, with the growth of traffic in Fairbanks, and more importantly, the city’s frequent inability to meet EPA’s air quality standards, the QRS II model no longer meets the requirements set by various federal agencies.

This project, conducted by Ming Lee of UAF CEE, converts 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 will incorporate 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. Since inception of this project, Dr. Lee has provided customized training to FMATS, and a UAF graduate student has gained hands-on experience at travel demand modeling. Other agencies use the model for related studies.
Performance Analysis of the Dowling Multi-lane Roundabouts
(PI Ming Lee, UAF)

Alaska, like much of the U.S., is a late convert to roundabouts. The first multi-lane roundabouts in Alaska were constructed in 2004 at the ramp terminals of the Dowling Road/Seward Highway interchange in Anchorage. These serve as junctions for commuters accessing the Seward Highway. The roundabouts were intended to ease traffic pressure on this important commuter route. Since their completion, the roundabouts have performed as intended with minimal maintenance. 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, led by AUTC’s Ming Lee, examines the performance of multi-lane roundabouts and how drivers use them. The roundabouts are being videotaped, including the vehicle queues at entrances, between 4:45 and 6:15 p.m. on three weekdays in winter and summer. Researchers are reviewing the video records and counting individual turning movements made by motorists, they are also measuring the length of vehicle queues. Winter data recorded in December 2008 and summer data recorded in May 2009 have been collected and analyzed using RODEL and SIDRA software, programs designed for roundabout analysis. Field-measured speed and queue length have been compared with numbers predicted by the two software programs and other available roundabout design guides. The safety performance of these roundabouts is being examined and compared with that of intersections equipped with traditional traffic lights. Researchers are writing a TRB paper, documenting results. Analysis results can assist DOT&PF in determining whether and where to construct additional multi-lane roundabouts; results will also add to the database of information available to U.S. traffic planners.

AUTC’s Ming Lee focuses his research on gathering data on Alaska’s urban traffic activity and growth. His work gives decision-makers the information they need to help the state grow smoothly.

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, DOT&PF installed an overheight vehicle detection and warning system at the overpass. The system includes laser detectors, alarms, and message boards. Since installation, personnel have seen no new damage to the bridge, and no sign that the alarm system has been triggered. Although this is good news, the particulars are a mystery: Is the system functioning? Is the mere 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? Is the state getting its money’s worth or not?

This project, led by AUTC’s Ming Lee, 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 DOT&PF determine if this system is functioning, and if a similar system installed at other bridges would be cost-effective.

These roundabouts are currently operating near capacity. This project will help DOT&PF determine whether and where to construct new roundabouts.
Developing Ambient PM2.5 Management Strategies  
(PI Ron Johnson, UAF)  
Most people think Alaska has clean air, but sometimes geography and temperature conspire to violate air quality standards, especially those for fine particulate matter (PM2.5) set by U.S. Environmental Protection Agency regulations. For Fairbanks, a recent EPA tightening of air quality standards spells trouble in the way of potential fines and funding loss. An extreme inversion occurs when air temperature increases (rather than decreases) with altitude, and Interior Alaska inversions are extreme. A Fairbanks inversion acts like a lid on a pot, trapping wood smoke, car and smoke stack exhaust, and other pollutants and allowing them to build to dangerous levels in the air.

This project collects and analyzes field data relating to air quality and meteorology, with an eye toward identifying the major contributors of PM2.5—like vehicles, wood stoves, and power plants—and how we might better manage these sources. Researcher Tom Marsik is updating an improved experimental model with new data collected from downtown Fairbanks. The research team, led by Ron Johnson, developed a dynamic model that estimates the portion of PM2.5 caused by traffic from hourly traffic counts provided by DOT&PF. The team has performed a year-by-year analysis of their data to examine potential trends in automotive emissions relative to other sources, and they are experimenting with the EPA’s Chemical Mass Balance software in an effort to quantify pollution sources. Project results include developing Transportation System Management Strategies to address meeting EPA standards. Fairbanks and other areas with significant inversions and elevated PM2.5 issues may soon benefit from this project’s results.

Attenuation of Herbicides in Subarctic Environments  
(PI David L. Barnes, UAF)  
The Alaska Railroad Corporation needs effective and low-cost ways to manage vegetation growth along railroad 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 David Barnes of UAF CEE and William Schnable of UAF WERC are tracking these applications over two years through a series of soil and groundwater samples to obtain site-specific attenuation data. The researchers are also performing mass balance studies on the herbicides using lysimeters installed at the UAF Fairbanks Experiment Farm. Results from these activities will yield a better understanding of the environmental fate of these herbicides in Alaska’s maritime subarctic zone.

A previous study on the herbicide triclopyr noted a cold-related re-concentration phenomenon. Besides including a block plot study at the Fairbanks Experiment Farm to confirm that phenomenon, this project builds on results from previous studies to create the knowledge base needed to minimize environmental risks associated with herbicide application in Alaska’s sensitive, cold-region ecosystems.

UAF researchers are using a series of soil and groundwater samples to track how herbicides behave in Alaska’s sensitive, cold-region ecosystems.
Bridge Deck Runoff: Water Quality Analysis and Best Management Practice Effectiveness  
*(PIs Robert F. Perkins and Ming Lee, UAF)*

Safety, environmental issues, and cost effectiveness are factors DOT&PF must consider when building and maintaining bridges across Alaska. Most bridges cross water bodies, and all have methods to drain storm water (rain and snowmelt) from the bridge deck. This study examines whether this runoff significantly contributes roadway contaminants to nearby water bodies. AUTC researchers Robert Perkins and Ming Lee are exploring what state or federal criteria govern such situations, whether the discharge significantly degrades water quality, and what storm water management practices the DOT&PF should incorporate into new bridge or bridge replacement designs and retrofit projects. While other states have addressed these issues (their experiences may be helpful), this evaluation must take into account Alaskan regulations and the state’s cold environment, long winters, and in some regions of the state, heavy snowfall. Springtime melting of plowed snow often results in quickly draining, highly contaminated runoff. This project is producing a database of information on the bridge deck runoff of all state bridges. Researchers have gathered Best Management Practices used by other states and are identifying how these might be adapted to meet Alaska’s needs.

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

All transportation construction must include a hydrologic component, an analysis that deals with rainfall amount and intensity for a defined period. To function well, the design of these components must be based on accurate rainfall estimates — how much, how long, and how often. Such information is usually supplied by the National Oceanic and Atmospheric Administration National Weather Service, but NOAA last collected data in Alaska in the early 1960s, when the data collection record was quite short and a minimal network of rain gauges was available. Together, DOT&PF, AUTC, and NOAA are updating this important data set. This project, led by Douglas Kane and Amy Tidwell of UAF WERC, uses new methodology and new modeling techniques to analyze both the original data and data collected in the nearly 50 years since the last effort was published (1963). The research team is partnered with NOAA’s National Weather Service and has updated precipitation frequency estimates for the state, collecting rainfall records from roughly 1,243 meteorological stations and private rain gauges throughout Alaska. The team is now correcting the data for bias and other inaccuracies, and using new models for spatial distribution and frequency. This new information will ultimately be published as Volume 14 of the NOAA Atlas, Precipitation-Frequency Atlas of the United States.

UAF hydrologist Amy Tidwell works with the National Weather Service to update precipitation frequency estimates for Alaska.
Measuring Temperature and Soil Properties for Finite Element Model Verification (PI Margaret Darrow, UAF)

Many stretches of Alaska’s highways show signs of damage caused by the thawing of ice-rich permafrost located under road embankments. Additionally, many older road projects were designed with slopes cut into ice-rich soils—slopes designed to thaw, slump, and flow until a new thermal equilibrium and a new slope angle stabilized. This practice resulted in more thawing ground than necessary, and more roadside erosion than current federal environmental regulations approve. DOT&PF currently uses a two-dimensional finite element program to analyze heat flow through a typical roadway embankment and its foundation soils. This program gives designers more accurate information for stable slope design and for preserving frozen soils, but such a program is only as good as the data that goes into it.

This project, led by Margaret Darrow, a UAF geological engineer, monitors ground temperature data from two existing embankments and their underlying soils, and in a back slope cut into frozen ground. Researchers have collected and preserved soil samples in their original state (that is, thawed or frozen) from each location for lab testing, including thermal conductivity measurements, water content, and unit weight. These data will be used to ground-truth DOT&PF’s modeling program, confirming the model’s ability to predict an embankment design’s impact on frozen ground. **Permafrost expert Mikhail Kanevskiy is investigating the geotechnical properties of frozen soils along the Dalton Highway. His research will contribute to better-designed roads for Alaska’s future.**

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

DOT&PF plans to construct a new section of the James W. Dalton Highway, which runs from just north of Fairbanks to Deadhorse, Alaska. Although the new section is only three miles long, from Milepost 8.5 to Milepost 11.5, it avoids 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). Imagine a network of giant walls of ice, 30 to 100 feet tall and 6 to 15 feet wide, inside ice-rich silt formed 40,000 to 10,000 years ago. These ice wedges can make up 30 to 50% of the ground structure. The area of planned road construction is located in the discontinuous permafrost zone, where soil temperatures are relatively high. Any human activity in this sensitive area can trigger thaw settlement of soils and permafrost degradation.

In 2009 UAF’s Margaret Darrow collected frozen soil samples along Alaska’s highways. Her research will help DOT&PF better predict how a road embankment will affect surrounding permafrost.
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 are helping prepare for this construction project by performing a geotechnical investigation of the area, training DOT&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 2008, researchers performed fieldwork at the study site together with a DOT&PF drilling crew; they delivered frozen cores from eight boreholes to AUTC labs for further study. Drilling results and lab tests confirm Shur and Kanevskiy’s preliminary estimations of the permafrost conditions. Besides supporting the best design possible for the Dalton Highway, project results will be useful to construction projects throughout the Circumpolar North, and they will contribute to educating a new generation of engineers at the University of Alaska.

**Using Geotextiles to Mitigate Frost-heaving in Alaska Pavements (PI Xiong Zhang, UAF)**

Frost heave and thaw weakening cause extensive damage to Alaska’s roads and airfields. Builders often battle these problems with geotextiles, essentially materials or fabrics that underlie a pavement system. Geotextiles can be expensive and labor-intensive to install, and some are more effective than others at wicking moisture away from the pavement foundation. AUTC researcher and materials specialist Xiong Zhang leads this project evaluating a new privately developed fabric. The fabric shows great promise as a more cost-effective way to reduce moisture migration, frost heaving, and thaw weakening in pavement systems installed in remote cold region areas. However, no one knows how this material will perform in seasonal freeze-and-thaw cycles. Will it keep pavements high and dry? Where is the best place for the fabric in a pavement structure: under the base, in the middle of it, or in the silty soil below? This project uses laboratory testing and numerical simulations to explore the fabric’s ability to quickly absorb water from the soil and drain it away from the pavement. Project results will assist pavement designers in Alaska, and help reduce the costs of building roads in remote areas with poor soils.

**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, led by AUTC researcher Xiong Zhang, in partnership with DOT&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. Zhang’s findings will be useful to other types of mitigation projects, including rockslide areas and highway retaining walls.

**Geotextiles may be a solution to building stable, durable runways in Alaska’s ice-rich soils.**
Stabilizing Marginal Soils with Geofibers and Synthetic (PI Kenan Hazirbaba, UAF)

Constructing airfields and roadways in western and northwestern Alaska is expensive. These areas are remote and require high transportation costs for materials and construction crews; additionally, gravel sources for a good, stable foundation are scarce. The gravel required is often brought in by barge at costs in excess of $300 per cubic meter. Builders would rather use local, available silts and sands as much as possible, but soils in these areas are often silty, soggy, and prone to erosion and collapse.

Engineers continually look for methods that allow them to improve and use local materials. One possibility is to use a new combination of geofibers and synthetic fluid. Earlier AUTC research showed that these materials improve poor, silty soils, making them suitable for use in construction projects. This project, led by AUTC’s Kenan Hazirbaba, evaluates the effectiveness and feasibility of this new technology for typical Alaskan soils. The research team is working with DOT&PF personnel, using laboratory and field tests to gain in-depth understanding of exactly how these new geomaterials improve soils. The team initiated a new testing series to look at the unconfined strength of unimproved and improved soil samples, and developed a new test setup for unconfined strength tests.

This project will ultimately provide design guidelines that address using these materials with soils, particularly soils encountered in western and northwestern Alaska. Providing such guidelines will eliminate the need for performing project- and site-specific testing, thus reducing overall construction costs. **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.**

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

Hot Mix Asphalt (a mixture of asphalt cement and aggregates that makes up the bulk of pavement) typically is spread at temperatures between 280° and 320°F, and compacted quickly. In cold regions, hot mixes can be difficult to compact, particularly if the layers are thin and the weather is cool. Contractors often struggle to compact rapidly cooling asphalt to the necessary densities. Pavements with too little compaction are weaker and have a shorter service life. Warm Mix Asphalt, which includes additives that keep it workable and compactable at a lower temperature (250° to around 270°F), makes it possible to pave roads at lower temperatures, which can extend the construction season, particularly in Alaska—a boon to road-builders. WMA is also better for the environment; it gives off fewer fumes than HMA and results in less radiated heat. Manufacturers and materials suppliers suggest that producing WMA saves 30% in energy costs, and reduces CO2 emissions by 30%. WMA can be hauled for longer distances without becoming unworkable. All these factors make WMA ideal for use in cold regions.

Although WMA is already popular in Europe and is rapidly gaining ground in the U.S., little is known about how such pavements perform in extremely cold weather, or about the best practices in applying WMA in cold regions.

This project, led by AUTC’s Juanyu Liu, evaluates the performance of several different WMAs, investigating material properties as well as low-temperature performance, rutting potential, and moisture sensitivity. Liu is assessing engineering properties of WMA binders and mixes in the laboratory, evaluating WMA mixes in the field, and monitoring emissions during WMA production and application.
Project results will give contractors and DOT&PF the information necessary to decide how suitable WMA technology is for Alaska. Liu has already tested three binders containing Sasobit, a commercial wax additive (mixtures of 0.8%, 1.5%, and 3%), based on previous research and a field trial in the Petersburg-Mitkof Highway Upgrade Project, Phase II. In general, Sasobit improved rutting resistance but deteriorated both fatigue and low-temperature cracking resistance. Liu’s findings will be presented across the state in professional seminars and pavement design classes for both practicing engineers and traditional college students.

**Alaska Bridge Bent Pushover Software, Including Concrete Confined**  
*(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 one 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, headed by Michael Scott of Oregon State University, is developing software customized for pushover analysis of Alaska-style bridge bents. Currently, Scott is working with DOT&PF engineers to user-test the new program.

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

Alaska is one of the most seismically active areas in the world, and past earthquakes have caused considerable damage to its highway infrastructure. How the ground under a bridge behaves during an earthquake is influenced by the type of soil present and whether or not it is frozen. Although some studies suggest that a frozen surface layer can reduce surface ground motion during an earthquake, no one has systematically studied how permafrost or seasonally frozen ground affects site response characteristics. Current seismic design codes do not address specifically how to take these effects into account.

This interdisciplinary project, headed by Zhaohui Yang in the UAA Civil Engineering Department, combines 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. This year Yang instrumented an Anchorage area pier-design bridge with an array of seismic and other sensors that feed data to a recorder mounted on the bridge. Yang’s team of graduate students also drilled a 6-foot-deep borehole on the site and added a digital temperature acquisition cable to collect ground temperature profiles periodically. The team collected, processed, and analyzed data (including expanding the analysis to include the MCE level hazards) through the summer of 2009. Once complete, project 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.

Research by UAA’s Zhaohui Yang will help Alaska’s engineers design better bridges and embankments for the state’s transportation infrastructure.
Evaluating Liquefaction Resistance in Degrading Permafrost and Seasonally Frozen Ground  (PI Kenan Hazirbaba, UAF)

About 85% of Alaska is underlain by permafrost (that is, ground that remains frozen year-round for at least three years) or discontinuous permafrost (areas where air temperatures hover near 32°F). When ice-rich soils thaw, they can change in a variety of ways—they may compact, slump, or grow soggy—most of which are bad news for structures built in or on changing frozen ground. Alaska is also by far the most seismically active state in the U.S.; the Alaska Earthquake Information Center locates and reports about 84,000 earthquakes each year. Permafrost degradation in regions with 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, headed by UAF CEE Professor Kenan Hazirbaba, conducts laboratory studies to investigate the liquefaction resistance of frozen and seasonally frozen ground. Two sets of tests are underway. One focuses on evaluating how soil liquefaction is influenced by freeze-thaw cycles throughout the year. The second evaluates how liquefaction is influenced by temperature distribution in degrading permafrost. So far the research team has conducted several series of cyclic strain-controlled triaxial tests on local silts at various shear strains (ranging from 0.005% to 0.3%) and temperatures (-0.2°C, 0.5°C, 1°C, 5°C, and 24°C) to explore how temperature influences liquefaction behavior. They also have analyzed data on how temperature affects liquefaction potential and the dynamic properties of partially frozen or thawed local silts. These test results help establish criteria for liquefaction susceptibility in melting permafrost and soils that regularly undergo freeze-thaw cycles.

In September of 2009 UAF graduate student Jake Horazdovsky collected data on bridge pile deformation in seasonally frozen soils to develop design guidelines for bridge designers. Horazdovsky will graduate with a Master’s degree in Civil Engineering and valuable expertise in how frozen soil and frost depths affect a bridge’s response to seismic events.

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 bridge structures respond to seasonal changes, and exploring how bridge stiffness changes over time.

This study is a joint effort between civil engineers at UAF, UAA, and Iowa State University. The team, led by AUTC’s Leroy Hulsey, 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 the near vicinity of the test site. Findings so far indicate that frost depths at the piles are deeper than depths farther from the test area. The data collected in this project is contributing to further frozen ground and seismic studies.
Seismic Design of Deep Bridge Pier Foundations in Frozen Ground (PI J. Sri Sritharan, Iowa State University)

More and more Alaskan bridges rest on drilled shaft foundations, where a shaft of reinforced concrete is constructed deep in the soil, sometimes with a steel casing. Bridge columns are built atop these foundation shafts. A bridge designer planning this relatively cost-effective and simple foundation takes into account many variables, including soil type and bridge behavior, given a moderate to large earthquake. The foundation shafts are designed to respond to earthquake events by yielding and forming a “plastic region” in particular areas; these areas “absorb” and control the forces that actually impact the rest of the bridge. Designing for the location of these plastic regions, as well as their length, depends largely on the properties of the surrounding soil. Frozen soil behaves differently than unfrozen soil, and drastically changes where and how these plastic “hinges” form. The result is that a bridge built to withstand a large-magnitude earthquake in warm weather may fail in cold weather. This project, led by Sri Sritharan, Department of Civil, Construction, & Environmental Engineering at Iowa State University, is developing design methods for drilled shaft foundations that are customized for Alaskan bridges, soils, and temperatures.

Researchers continue to test how steel, concrete, and soil behave under cold conditions. So far, they have demonstrated cold-temperature effects on moment-curvature behavior of reinforced concrete; demonstrated seismic design methodology developed for drilled shafts in cohesive soil (with appropriate verification); discovered the inadequacy of the existing method proposed for seismic design of drilled shafts (especially in cohesive soil); established setup procedures for performing material tests at cold temperatures; and discovered that temperature effects on stress-strain behavior of A706 steel reinforcement causes different behavior from that published in literature for similar reinforcement or structural steel. The research team also is conducting a review of state-of-the-art seismic design of drilled shafts. Its findings will be used to establish the new design methodology.

Preservation of the Alaska Highway (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 undoubtably increase permafrost degradation and damage to the road. AUTC, working with the Yukon Highways and Public Works, has explored ways to slow this permafrost degradation.

This research, led by Daniel Fortier, selected a test site, characterized surrounding soil conditions, and installed instrumentation for long-term data collection. Team members have worked with engineers at YHPW and Laval University to finalize designs for mitigating damage to the highway.

This embankment collapse at the edge of the Alaska Highway was caused by melting of permafrost and massive ground ice. In the future, climate warming will undoubtably increase permafrost degradation and damage to the road.
Investigating Methods for Maturing Concrete in Very Cold Weather  (PI Yongtao Dong, UAF)

This project is developing and testing protocols to determine concrete curing strength during the construction process, so that building under very cold conditions can be performed safely and quickly. So far, researchers have determined the laboratory strength-maturity correlations for concrete mix designs that DOT&PF construction teams commonly use. Field tests were conducted in spring and summer of 2009. Ultimately, this study will produce a guide, with procedures and computations designed to help DOT&PF personnel use the maturity method to better estimate the strength of concrete poured on-site.

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, University of Alaska Fairbanks, and Kansas Structural Composites, Inc., and headed by Pizhong Qiao, Civil Engineering, WSU, 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 designed and fabricated an S-FRP sandwich deck panel and several S-FRP sandwich beams and developed structural health monitoring strategies. Cold-temperature lab testing of these prototypes continues, and researchers continue to conduct analytical studies and numerical finite element simulations for the S-FRP sandwich deck panels. Structural health monitoring strategies for cold temperature exposures will be tested and validated with experimental data, with the anticipation that several new techniques for thick sandwich deck panels will be proposed and tested.

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

Asphalt-treated bases are often used in new pavements in Alaska; the materials are available and low-cost, but there is little data on how these base materials perform in cold regions. This study, headed by Juanyu Liu, UAF CEE, investigates four ATB types (hot asphalt, emulsion, foamed asphalt, and reclaimed asphalt pavement) popular for treating Alaska base course materials. The research team is collecting data on stiffness, fatigue, and permanent deformation characteristics under different temperatures. Liu and Ph.D. student Peng Li completed a detailed literature review, including information from ongoing research projects, to compile the latest information concerning ATB characterization. Using a resilient modulus testing system setup according to AASHTO T307 requirements, Liu and Li found that ATB material tested at 0°C and -10°C showed such low levels of deformation that they had to redesign their testing procedures and instrumentation. To date, using the new design, they have completed 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 (FATB) material, fabricated in DOT&PF labs in all three Alaskan regions. More resilient modulus tests of FATB will be conducted in the central region using different binder contents and different soaked conditions. Further statistical analysis of the effects of aggregate properties on the resilient modulus will be completed and incorporated into the finalized model.
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 on top of the frozen layer. In these circumstances, roads across Alaska are almost “floating” 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, headed by UAF’s Juanyu Liu, investigates base course materials commonly used in Alaska’s roads. Liu’s team observes 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 and subsequent lab research are ongoing in Alaska’s three DOT&PF regions. 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.

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. We generate 1.3 billion tons of dust per year, at a cost of $15.6 billion dollars in aggregate loss.

Dust reduces visibility on the road for drivers and pedestrians. Dust can cause respiratory ailments, and it can affect the food harvest, such as for berries and other plants, of 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. Simple 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, headed by AUTC’s David Barnes, is developing a dust control research map that identifies and prioritizes critical areas, and is designing instrumentation and methodology to accurately monitor dust production on roads.

These tools will be used to support DOT&PF in field testing various dust control measures in several locations. So far, researchers for this project have qualitatively assessed dust control (or palliative) performance on a number of unpaved runways, tested newly designed instrumentation, and measured palliative performance with these prototype instruments at one rural road site.

In the summer of 2009, AUTC researchers tested several dust control measures on rural runways, such as this one in Chicken, Alaska. New instrumentation allows researchers to accurately measure dust plumes caused by moving vehicles.
# Completed Research Projects

**Developing Snow and Ice Control Plans for Urbanized Areas in Cold Regions**

*PIs Ming Lee, David Barnes, UAF*

Researchers analyzed the results of conductivity and chloride concentration tests performed on soil and water samples collected in the Fairbanks study area after snow and ice began to melt. The findings suggest that DOT&PF's salting practices in the northern region do not cause conductivity and chlorine levels to exceed limits set for wastewater and agricultural regulation. In addition, the road salt used showed no heavy metal content exceeding existing federal guideline limits.

**Solving Plastic Deformation Problems for Anchorage Flexible Pavements**

*PI J. Leroy Hulsey, UAF*

Pavement rutting is a long-standing problem in terms of both safety and on-going maintenance costs in Anchorage, Alaska, where streets are generally paved with hot-mix asphalt. Pavement rutting in northern climates is caused by studded tire wear, plastic deformation, or a combination of the two.

This study addressed plastic deformation. Study results are based on a four-part approach: laboratory evaluation of hot mix asphalt cores extracted from nine rutted pavements, literature review, review of mix designs in relation to results obtained from field cores, and development of alternative rut-resistant mixes.

The project report provides suggested mix designs to minimize the plastic deformation component of rutting in the Anchorage area. Notable results include two new HMA designs. One mix, developed by UAF, is based on the Bailey method of obtaining an optimum aggregate blend in accordance with Superpave protocol. Another mix was developed by DOT&PF and tested in UAF's labs. Both mixes show promise for rut mitigation in Anchorage streets.

**Using Geofibers and Synthetic Fluids as Stabilizers for Marginal Soils**

*PI Kenan Hazirbaba, UAF*

This project explored the use of two soil stabilizers developed by Peak Civil Technologies, an Alaskan company, to improve silty soils. PCT developed a combination of two stabilizers, a plastic fiber to increase soil strength (Geofiber 3627BT) and a synthetic fluid that "replaces" water in the soil (Severely Hydrotreated Paraffinic Liquid). Early results suggest that the right mix of geofiber, synthetic fluid, and water, combined with some aging, can improve soil CBR values by at least 300%.

**Guidelines for Risk Analysis in Construction Contract Changes**

*PI Robert Perkins, UAF*

Work changes are common in construction contracts, especially for large projects. The stakes can be higher in Alaska, where a short building season and remote locations can push a project into an additional year, with extra staging costs, staffing, and scheduling nightmares. This project produced a guide for DOT&PF managers and engineers that better prepares them for judging project risk and estimating costs. A draft of this guide is currently under review at DOT&PF and may be reviewed by Alaska General Contractors.

**Evaluating Wearing Surfaces for the Yukon River Bridge**

*PI J. Leroy Hulsey, UAF*

This study considered seven different systems for durable, lightweight decking alternatives for the E.L. Patton Bridge, which carries the Dalton Highway and the Trans-Alaska oil pipeline across the Yukon River. These systems included wood on wood, wood on UHMW (ultra high molecular weight polyethylene—the same material used for applications ranging from snowboards to boat bottoms), UHMW on wood, UHMW alone, FRP (fiber reinforced polymer) sandwich panels, FRP cellular panels, and COBRA-X (a brand of high-density polyethylene material often used for railroad crossings). Experimental results indicate that a composite system of polyethylene and wood, or two layers of polyethylene, performs better than the bridge's original wood-on-wood system in all testing areas.

AUTC makes project profiles, research publications, videos, annual reports, and newsletters available on its web site. Visit www.alaska.edu/uaf/cem/ine/autc/ and check our database.
This year AUTC honors Duane Davis, a nontraditional student who joined UAF after 20 years in the workforce.

Davis’ early career took him to remote locations all over Alaska, including oil fields on the North Slope, where he took part in many infrastructure construction projects, as well as working in field investigation and laboratory testing.

In 2004, he decided to pursue degrees in both Mechanical and Civil Engineering. Three-and-a-half years later, he completed a Bachelor of Science in Mechanical Engineering and began work on a Master of Science in Civil Engineering.

During his undergraduate studies, he joined Tau Beta Pi, the engineering honor society. Currently he maintains a 3.83 grade point average, and he expects to graduate in 2010.

The prospect of merging fundamental concepts from both Mechanical and Civil Engineering to understand changes in material performance behavior in the Arctic, and using that understanding to provide useful solutions to Arctic engineering problems, interests and excites Davis. He believes that Alaska sorely needs infrastructure development, but that the state is limited by the economic costs of improving existing marginal conditions through traditional engineering solutions. New technology and new methods must replace traditional solutions that are inadequate or too costly.

Laboratory research he performed as an undergraduate student studied strength improvements for marginal soils (such as silty-sand) through the combined use of geofibers and a synthetic fluid additive. His current research examines how seasonal frost depth affects laterally loaded deep foundations.

Duane Davis prepares sensor lines for recording temperature, part of the Seasonally Frozen Ground Effects on the Seismic Response of Highway Bridges project.

Davis at the Transportation Research Board 88th Annual Meeting. To his left: Randy Machemehl, Council of University Transportation Centers President, Past Transportation Chair Norm Mineta, and RITA Administrator Paul Brubaker.

Davis works to install experimental bridge piers at the research site.
Student participation in research is a given for AUTC projects. This year AUTC projects provided research experience to 92 graduate and undergraduate students in areas from air quality to rural health quality issues. Professors routinely incorporate innovative ideas from AUTC projects into their classes. Roughly 99 undergraduate classes and 28 graduate-level classes benefit from this synthesis of education and research. AUTC contributes to 6 Master’s level programs and UAF’s Doctoral program. The number of students enrolled in these programs has increased by 25%.

Stephanie Young, undergraduate student in Civil Engineering, has participated in ongoing projects examining dust control in rural areas and on remote air strips, learning first-hand how to design and calibrate new equipment and how to collect reliable data.

Students working on AUTC research participate in project planning, field work, lab testing, report preparation, and meetings with end users and other stakeholders. AUTC students often contribute to national-level publications and present their research to a wide professional audience.

These unique, hands-on experiences offer invaluable practical job experience to students before they enter the workforce, and often influences students in pursuing an engineering-related career.

AUTC has been instrumental in extending engineering education in Alaska. Our faculty have been key in implementing a new graduate certificate in construction management, winning University of Alaska approval for a new 15-credit program in October of 2009. This program is designed for students who already have a degree in engineering or a related field. It is ideal for construction professionals who want to develop their management skills. The program is expected to produce 5 to 10 graduates a year.

AUTC continues to support the new pre-engineering program at UAS. This certificate program, with emphasis areas in Computer Systems, Electrical, and Mechanical Engineering will prepare students to transfer to larger programs, such as those available at UAA or UAF, to continue an engineering degree.

Isabelle DeGrandpré, an undergraduate, works on the Preservation of the Alaska Highway project, installing equipment to measure soil temperature.
Peng Li, who is pursuing a PhD in Civil & Environmental Engineering, is a graduate assistant on the Characterization of Asphalt-treated Base Course Materials project and group leader for students on several other projects. Li has drawn praise from colleagues — ranging from notoriously finicky lab managers at UAF to project engineers at DOT&PF — for his ability to organize a lab efficiently and synthesize the needs of a whole project team into one strong, coherent research process.

Graduate students Duane Davis and Jake Horazdovsky designed and installed field instrumentation for the Seasonally Frozen Ground Effects on the Seismic Response of Highway Bridges project. They have been collecting data and mentoring undergraduate students throughout 2009. Both students will graduate with a Master of Science in Civil Engineering this year.

Christine McCabe spent the summer collecting samples of frozen soils for the Measuring Temperature and Soil Properties for Finite Element Model Verification project. This fieldwork gave her a chance to work with DOT&PF employees and increased her experience in working with a multi-organization research team.
AUTC Outreach: Teaching, Sharing Information, Raising Awareness

In 2009 AUTC concentrated its outreach and technology transfer efforts toward serving Alaska’s professional communities, supporting ongoing career development as well as making the latest information in transportation research available.

AUTC worked to raise awareness of our work in several different forums:

- AUTC holds regular local conferences with public presentations of all our research projects, inviting professionals from Alaska’s engineering community to participate.
- AUTC and research personnel at the Alaska Department of Transportation and Public Facilities have a strong collaborative relationship. AUTC strives to incorporate state priorities for research into our own strategic goals.

DOT&PF personnel and AUTC researchers meet regularly to discuss research goals and priorities.

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, from engaging the next generation of engineers to giving local builders the latest information on soils and foundations.

AUTC supported Alaska Construction Career Days in Anchorage and Fairbanks, reaching 1,050 students at both high school and middle school levels.

AUTC contributed to several professional seminars targeting practicing engineers. These included:

- Leadership Development for the Engineer. A total of 62 people attended the Fairbanks and Anchorage sessions.
- Writing that Works (Anchorage, 19 attendees).

AUTC and Alaska R&T2 also combined forces to sponsor a National Highway Institute course on Application of the Federal Highway Administration Traffic Monitoring Guide. This course made it possible for 25 engineers to become familiar with the nationally mandated procedures aimed at developing the data and information needed to support programs such as the Highway Performance Monitoring System (HPMS), pavement management, safety management, congestion management, and environmental management.

UAF professor of CEE Bob Perkins offers classes in support of career development for practicing engineers.

Dennis Filler, UAF CEE faculty, appeared in a Discovery Channel video on the possibility of an underwater tunnel connecting the US and Russia.
AUTC partnered with University of Alaska Statewide Corporate Programs

AUTC worked with UACP to offer professional level courses in construction management areas.

The University of Alaska Statewide Corporate Programs (UACP) is an educational organization established in 1999 by University of Alaska President Mark Hamilton to serve the training and education needs of business and industry.

UACP is specifically designed to respond to the training and educational needs of Alaska’s workforce. UACP partners with Alaska business entities, government agencies, and nonprofit organizations to train today’s employees and shape tomorrow’s workforce.

UAF Civil & Environmental Engineering faculty Bob Perkins offered classes in:

- Construction Claims: Prevention, Administration, and Dispute Resolution (26 attendees)
- Contract Negotiations (21 attendees)
- New Technology for Construction, GPS, GIS, and Others (16)
- Construction claims case studies, bridge emphasis, Juneau and Fairbanks (92)
- Construction claims case studies, non-bridge emphasis, Sitka and Fairbanks (9)
- New technology for construction, Anchorage and Fairbanks (15)
- Managing risk, Fairbanks and Sitka, (3)
- Negotiation basics: construction management, Anchorage and Fairbanks (15)

These for-credit courses are part of UAF’s new Graduate Certificate in Construction Management.

UACP and UAF also offered several non-credit day-long seminars in Fairbanks and Anchorage, including Arctic Construction (26 attendees) and Recruitment, Retention, Succession for Managers: a Professional Development Opportunity for Managers of Engineering, Construction and Technical Projects in Alaska (20 attendees).

AUTC is working with other universities to develop and implement a course module Leading to an online learning program in Highway Geometric Design.

This 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 curricular materials, adapting materials for multiple diverse settings, assessing student learning and attitudes towards 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 from 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 of all project team members.

AUTC is contributing to public awareness of engineering projects and economic opportunities for Alaska.

AUTC researchers published 14 Transportation Research Reports in 2009.

Director Billy Connor and UAF CEE faculty member Dennis Filler appeared in a Discovery Channel Video on Mega Engineering: Solving the Rail Divide. Engineers hoping to connect continents across the Bering Strait also have to figure out how to accommodate the different rail track widths used in North America and Russia. Visit http://dsc.discovery.com/videos/mega-engineering-solving-the-rail-divide.html to learn more.

AUTC is working to engage the next generation of Alaska’s engineers, contributing to events at high schools and middle schools.
AUTC continues to address Alaska's needs with an eye toward national priorities. Over the last year, we have found that many of our parochial issues indeed have national implications. Dust control is an excellent example. While we would like to think Alaska has cornered the market on dusty byways, the US alone has over 1.4 million miles of gravel roads. The knowledge we gain is no doubt directly applicable nationally and internationally.

Fugitive dust from roadways is both a health concern for those adjacent to gravel-surfaced roads and a safety issue due to reduced sight distances. AUTC has set in motion an aggressive program to eliminate dust emanating from transportation facilities. We have partnered with the Alaska Department of Transportation & Public Facilities, the Denali Commission, local communities, and industry in this effort. To date, DOT&PF and local communities have treated many airports and community roads with dust palliatives and soil stabilizers. AUTC has developed a portable prototype device capable of measuring real-time dust raised by vehicle tires. Through this effort, we have determined that several products developed by dust palliative producers reduce dust by as much as 91%. Over the coming year, we will extend this project to determine the working life of the palliatives.

One side benefit to minimizing dust is reduced road-maintenance costs, with less need for grading and surface replacement. Most communities find that a two to three year life makes these palliatives affordable. We are providing industry with our data so that they can improve their products.

Climate change continues to be a focus. AUTC is heavily involved in the Governor’s Climate Change Adaptation Advisory Group, which is preparing recommended policy for the State of Alaska. As most scientific literature notes, Alaska's climate is changing more rapidly than anywhere else in the nation. We have an opportunity to disseminate our experiences to the nation.

For example, many of our coastal communities are threatened by beach erosion due to storms that occur during periods when the coast was historically protected by sea ice. Warming has kept the ocean free of ice later, well into the stormy early-winter period. As a consequence, we must evaluate our transportation infrastructure to ensure that affected communities have an evacuation route. We must also define future transportation corridors to minimize the impact of these changes.
AUTC seeks projects that fundamentally change the way we manage our system. Challenges such as climate change, rising energy costs, increasing construction costs, and increasing demands on our transportation system strain dwindling funding resources throughout the United States.

We challenge our researchers to stretch their creativity to ideas like finding a replacement for asphalt, designing a flexible concrete, or perhaps developing bridge-monitoring systems that provide engineers with information about the long-term health of any given bridge. Why not find new and better ways to turn unstable soils into reliable foundations? Why not use Intelligent Transportation Systems to provide a driver with the information necessary to adjust to current highway conditions? After all, the greatest advantage of a university is that it creates a space where researchers are encouraged to challenge codes and standard practices. Many of the projects in this report do exactly that.

AUTC takes a leadership role in educating transportation engineers for the future. We work in partnership with the UAF College of Engineering & Mines, the UAA School of Engineering, and the new pre-engineering certificate program at UAS. In addition we work with industry to accelerate the education of engineers already in the workforce. In 2009, the UA Board of Regents approved UAF’s new Construction Management graduate certificate, and the first group of students entered the program. This new certificate will represent the skills needed to effectively manage construction projects.

We also work with industry to provide other transportation skills such as geometric design, traffic management, inspection, and materials testing training, and others.

AUTC is focusing on our future through innovation, education, and partnerships. Our goal is to challenge our researchers and students alike to stretch their imaginations to solve cold regions transportation issues, to look beyond standard practice, and to challenge conventional wisdom.

Clint Adler, Chief of Research at the DOT&PF has issued AUTC a challenge to step out in front and become a leader in research, education workforce development, and workforce retention. AUTC eagerly accepts this challenge.
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Page 24: Photo of Margaret Darrow (top) courtesy of AUTC staff.

Page 24: Photo of Mikhail Kanevskiy (bottom) by E. Stephani.

Page 25: Photo of Xiong Zhang by INE staff.

Page 26: Photo of Warm Mix Asphalt (top) by J. Liu.

Page 26: Photo of stabilized soil sample (bottom) by K. Hansen.

Page 27: Photo of Zhaohui Yang courtesy of UAA staff.


Page 29: Photo of Alaska Highway embankment collapse by E. Stephani.

Page 30: Photo of asphalt application by J. Liu.

Page 31: Photo of Dennis Filler measuring airborne dust on a rural runway by D. Barnes.

Page 33: Photos of Duane Davis (bottom left and right) by K. Hansen. Photo of 88th Transportation Research Board Meeting courtesy of the Council of University Transportation Centers.

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Page 35: Photo of Peng Li (top left) by INE staff. Photo of Christine McCabe by M. Darrow. Photo of Duane Davis and Jake Horazdovksky (bottom right) by K. Tape.

Page 36: Photo of AUTC and DOT personnel by K. Hansen. Photos of Robert A. Perkins (middle) and Dennis Filler (right) by T. Paris, UAF Marketing and Communications.

Page 37: Photo of student participating in Engineering Week on the UAF campus by K. Hansen.
AUTC — One research center, three campuses, 586,400 miles of laboratory space.