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New Portable Instrument Measures Effectiveness of Dust Control Palliatives

by David L. Barnes, Ron Johnson, Richard Wies, & Tomas Marsik (UAF).

Alaska suffers from dusty roads and airports, especially in rural areas, where paved roads and airports are few to none. Most are gravel or whatever local dirt is available – in a word: dusty.

Air quality and safety suffer, and to date, there have been no viable means to measure the dustiness – a first step to evaluate if and when to apply dust control measures. Now there is, courtesy of Alaska University Transportation Center (AUTC) and its UAF research team from Institute of Northern Engineering.

In the 2008 Road Dust Management Practices and Future Needs Conference proceedings, Jones et al. estimate that of the approximately 6,400,000 km of total road network in the U.S., about 2,700,000 km are unpaved. Unpaved rural runways increase that mileage by only a small fraction.

Vehicle traffic and wind displace the fine-grained soils from unpaved surfaces. Clouds of dust from unpaved roads and airports impact the quality of life for residences near them, and diminish visibility for travelers – impacting health and safety. Anyone who has driven an unpaved road has dodged ruts and potholes and slowed for washboard areas; on airports, aircraft bounce and skitter. These degraded areas are caused by the loss of fine-grain soil, which eventually leads to vehicle action prying loose large soil particles. Depending on the amount of surface use, repairs on a regular basis are costly.

Controlling dust from any unpaved surface is a matter of stabilizing the soil that is the wearing surface. Good design, construction, and proper materials combine to provide soil stabilization, with the goal that the wearing

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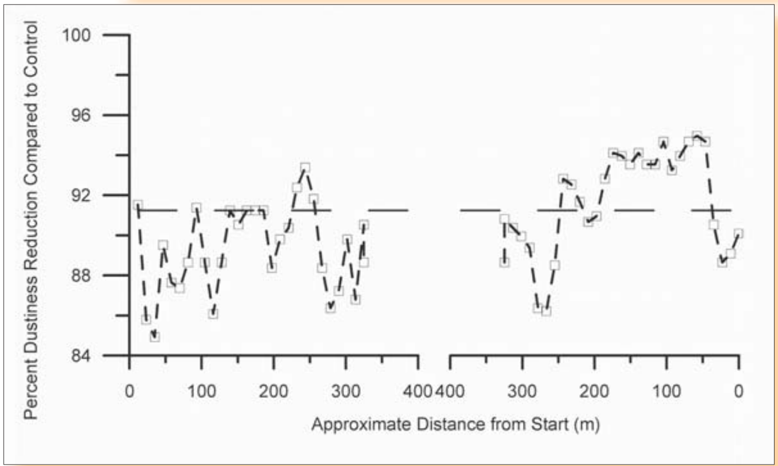

Top: All-terrain vehicle traveling a typical dusty road in Alaska.

Middle: University of Alaska DustM. Both photos by AUTC research team.

Bottom: Typical percent reduction in road dustiness as compared to an untreated control. A turnaround was required at about 300 m owing to the short length of the treated section. The horizontal dashed line represents the overall average reduction in dustiness on the treated section compared to the control section (approximately 91.3%).

The AUTC Newsletter is published semi-annually by the Alaska University Transportation Research Center, Institute of Northern Engineering, University of Alaska Fairbanks, to inform readers about our research and outreach activities.

AUTC addresses issues related to research and technology themes as identified in the Highway Research and Technology Report (April, 2002), including 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 to address multi-modal issues facing Alaska and the nation's transportation community.

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UNIVERSITY OF ALASKA FAIRBANKS

Contents

Director's Notes

What do you think of when somebody asks you about air quality? Many of us typically think only of smog. But air quality is made up of a variety of things, and can be degraded in many ways by any number of things, including vehicles, home heating systems, dust, and volcanic ash. We at AUTC are deeply concerned about the air we breathe and its effect on our health, but we go further. We're also concerned about other impacts of degraded air quality that are safety-related, such as visibility and damage to aircraft when one of Alaska's volcanos spews ash into the air.

While there is little we can do to control a volcano, there is a lot we can do to provide information to the public to ensure their safety when those events happen. The Alaska Volcano Observatory has done a great job of providing information to all of us – they can monitor ash plumes, and the direction that the wind carries them. As a result of their efforts, the aviation and aviation-related industry could watch and plan ahead during the March/April 2009 Mt. Redoubt explosions. Thus, no aircraft were damaged by Redoubt's recent activity. While many of us were inconvenienced by flight delays and cancellations, we all realized our safety came first.

Dust is a major problem, not only in Alaska, but throughout the nation. However, most of Alaska's rural communities have no pavement, and the method of getting supplies to them is by aircraft, or via barge in the summer months. The streets are dusty in dry weather and muddy when it rains. Health issues resulting from dust in our villages causes residents to pressure public officials to eliminate dust. AUTC , in partnership with the Denali Commission and the Alaska Department of Transportation & Public Facilities, is tackling this problem. Our goal is not to refine our dust control program, but to develop a program. As we began, we quickly found that we had no rapid means of quantifying the dust that comes from the tires of vehicles. So Dr. David Barnes and his team invented a method, the DustM, which is discussed in this issue. Besides being able to measure and quantify the amount of dust, the DustM also allows us to compare the effectiveness of dust palliatives. And it's small enough to be shipped easily and run on a four-wheeler, an immense boon for rural areas. As a result, we now have the opportunity to maximize our precious dust control dollars.

We're now seeing a stringent tightening of PM-2.5 limits by EPA. Medical studies have linked PM-2.5 (a very fine air particle which often contain pollutants, depending on what's happening in the area) with respiratory health. PM-2.5 can be generated from a number of sources including vehicles, home heating, forest fires, and manufacturing, to name a few. AUTC is working to understand how transportation fits into that equation. Once we have that information, we will looks for ways to reduce PM-2.5. This presents a real challenge in northern climates, because our fuel usage is greatest in the cold. Couple that with the inversions in Interior Alaska, and we have a difficult situation.

Alaska DOT&PF and AUTC have partnered to find ways of reducing emissions coming from the production of asphalt through the use of Warm Mix Asphalt. Through the addition of Sasobit or other additives, we can significantly reduce the temperature of the asphalt, thus reducing the amount of fuel oil used. This saves both money and emissions. However, research to date shows this may come at a price, since the cold weather characteristics of the asphalt are altered by the additive. Undeterred, our efforts continue to find the right balance between environmental health and performance of asphalt concrete.

This issue of the AUTC Newsletter is dedicated to our efforts to understand air quality in the North, to find ways to ensure our residents breathe clean air, and to understand how natural phenomena impact transportation.

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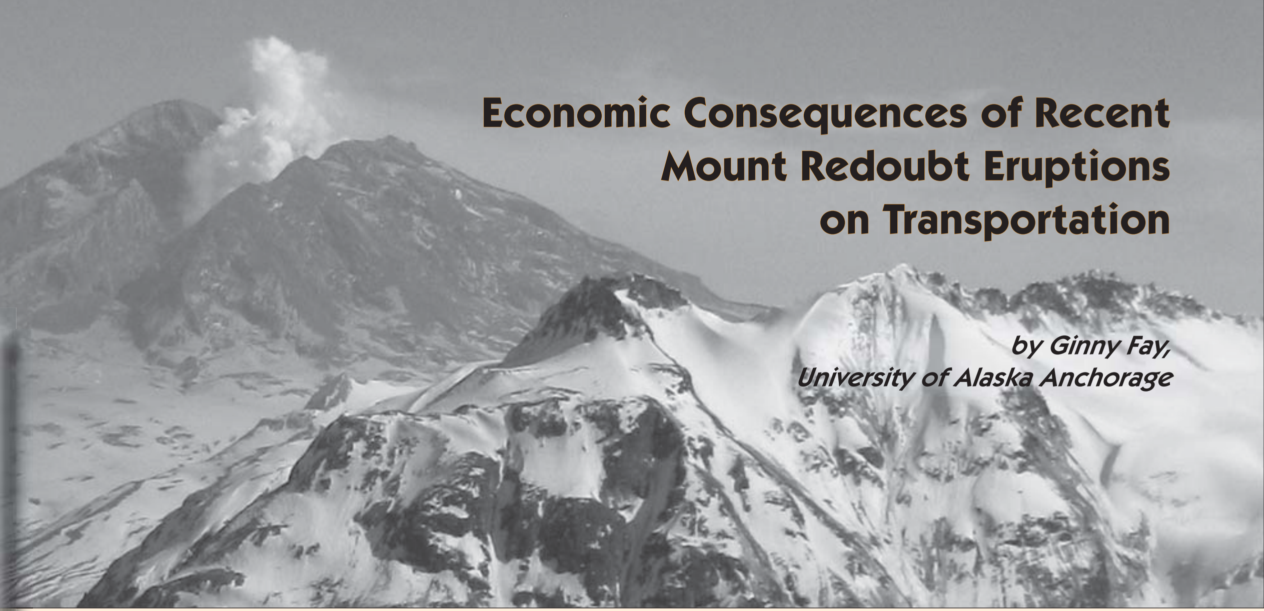

Economic Consequences of Recent Mount Redoubt Eruptions on Transportation

by Ginny Fay,
University of Alaska Anchorage

Above: Mt. Redoubt during recent eruption. Inset: Ginny Fay, Economist, UAA Institute of Social & Economic Research. Photos courtesy of J. Schaefer; Alaska Volcano Observatory /AK Div. of Geological & Geophysical Surveys.

Mount Redoubt, the Internet darling with more than 1,500 Facebook friends and 6,700 Twitter followers, continues to disrupt travel in Southcentral Alaska. Without extensive research it is difficult to estimate the costs of these disruptions but some major activities affected include aviation delays and cancellations, idle Cook Inlet oil platforms and oil tankers, and cleanup and repair costs.

Since the volcano had its first major explosive event on March 22, there have been at least 20 separate significant explosions. Ash plumes, measured by radar and confirmed by pilot reports, reached higher than 50,000 feet. The largest explosion on April 4 lasted more than 30 minutes and closed the Anchorage airport for 20 hours clogging the shipping system with delayed cargo and passengers stranded in and outside of Alaska.

So far, Mount Redoubt's ash clouds have canceled hundreds of airline flights, reduced the number of shipments flowing through huge UPS and FedEx cargo facilities and cut shipments of fresh Alaska seafood. Since the latest eruptions began, Alaska Airlines has canceled 300 flights, affecting an estimated 20,000 passengers.

The April 4th eruption was comparable in size to the largest explosion when Redoubt was last active for four months in late 1989 and early 1990. According to 1992 research by economists Brad Tuck and Lee Huskey, University of Alaska Anchorage, Institute of Social and Economic Research (UAA ISER), the estimated minimal costs of those eruptions were $160 million (1992$$ or $237 million 2008$$). Of that, approximately $149 million (2008$$) was attributable to aviation losses but most, $118 million, was from one episode involving a Boeing 747 that experienced extensive damage from an almost tragic encounter with an ash plume.

During the December 1989 and January 1990 eruptions, 493 domestic landings with approximately 36,000 passengers were delayed or canceled. An additional 399 international landings with approximately 92,000 passengers and 268 international cargo flights with 33.2 million pounds of freight were impacted. The operating costs of those disruptions was estimated to be approximately $31 million (2008$$).

The Ted Stevens Anchorage International Airport has changed considerably, however, since 1990 largely due to expansion of international cargo service and to a decline in the number of transit international passenger flights as a result of changes in jet fuel use that eliminated the need for a refueling stop in Alaska (from 1.5 million in 1990 to 237,000 in 2006). Annual cargo flight weight grew from 10,345 million pounds in 1990 to 27,968 million pounds in 2006. In 2007, Scott Goldsmith and Mary Killorin, UAA ISER, estimated that one in eight jobs in Anchorage is attributable to the Anchorage International Airport (see www.iser.uaa.alaska.edu for copies of publications).

International cargo carriers are the largest users of the airport and represent more than 80% of the revenue for gas-and-go service between North America and Asia. In 2007, FedEx and UPS together generated $15.4 million a year in landing fees. Alaska Airlines passenger and cargo services generated $10.5 million. Anchorage International is the premier gateway hub to Asia for FedEx, UPS and Northwest Cargo as well as China Air, Korean Air, Cathay Pacific, Northwest, Eva Air, and Japan Airlines International. In 2007 before the global recession, FedEx and UPS alone averaged 48 flights in and out of Anchorage daily.

According to Doug Berry, UPS Anchorage operations manager, when Mount Redoubt became active in January 2009, UPS developed a contingency plan to move flights to different gateways, Honolulu, Ontario, California, and Boeing Field, Seattle, should Redoubt erupt. Since these are existing UPS gateways, there were no outside vendor costs. UPS added hours to the employees at these gateways as needed and reduced staff time in Anchorage.

During the seven days that flights were rerouted, UPS laid off staff in Anchorage, reducing the usual 140 employees to 10. UPS cargo jets were kept away from Anchorage during eruptions to avoid the potential risks, cleanup and inspection costs required from ash fall. As a result, no additional cleanup or maintenance costs were incurred. UPS also restricts flights to daylight hours to ensure pilots can see ash clouds. Anchorage lost landing fees for seven days of rerouted flights,

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Helping Fairbanks Meet New Air Quality Requirements: Developing Ambient PM-2.5 Management Strategies

by P.I. Ron Johnson, with co-P.I.s Tom Marsik, Ming Lee, and Cathy Cahill , University of Alaska Fairbanks

Above: Ron Johnson and Tom Marsik install air sampling instrumentation in a Fairbanks residential area. Photo by C. Johnson.

The United States Environmental Protection Agency (US EPA) recently tightened its air quality standards. For the Fairbanks North Star Borough (FNSB), that spells trouble. With our winter conditions, we frequently exceed the required standards, with serious consequences for area residents' health and FNSB funding, along with potential fines. A research project through the Alaska University Transportation Research Center (AUTC) fielded a team that is taking an in-depth look at existing data and potential solutions.

Extreme and relatively long-lasting inversion conditions result in violations of air quality standards for fine particulate matter (PM-2.5), resulting in the possibility of communities being labeled "non-attainment" areas according to US EPA regulations. The inversions seen in Interior Alaska are some of the most extreme in the country. Transportation and air quality officials must be prepared to make changes in these communities such that air quality regulations are met. The Borough is one such community.

To develop a strategy to bring the FNSB into compliance in the future, it is critical that we develop a better picture of the spatial and temporal variability of fine particulates in the Fairbanks airshed, and that we identify and quantify the major sources of PM-2.5. Other communities have found that major contributors include stationary sources like power plants, and area-wide sources such as wood stoves and motor vehicles.

This project will more accurately define the magnitude and extent of the PM-2.5 problem in Fairbanks by 1) collecting and analyzing additional field data relating to air quality and meteorology, 2) making estimates regarding the relative importance of transportation activities as a source term, and 3) developing Transportation System Management Strategies.

The US EPA National Ambient Air Quality Standard (NAAQS) for particles smaller than 2.5 µ in diameter (PM-2.5) was recently revised downward to 35 µg/m3 for a twenty-four hour average, and retained at 15 µg/m3 for an annual mean. An analysis of the effect of this tightened standard shows the FNSB will be in non-compliance. Contributing to our problem are:

- strong ground-based inversions,
- high per-capita fossil fuel consumption due to our large numbers of heating degree days, and
- motor vehicle inefficiencies at low temperatures.

The UAF team is using data collected by the FNSB at a number of locations during the winters of 2007-2008 and 2008-2009 to begin estimating the effect of motor vehicles on ambient PM-2.5 concentrations. At the bus barn location on South Peger Road, we found a moderate correlation between PM-2.5 and traffic flow for December and January 2007-2008, with r^2 values of 0.53 and 0.60 respectively.

For urban areas, a significant majority (over 80%) of carbon monoxide (CO) is from transportation sources. Hence, a good correlation between PM-2.5 and CO may indicate a linkage between ambient PM-2.5 and transportation activity. Regressing the average one-hour CO values versus the average one-hour PM-2.5 values for December 2007 at the bus barn led to an r^2 value of 0.73. We also found a statistically significant difference between PM-2.5 values on Sundays and on weekdays at this site, consistent with roughly double the traffic count on weekdays.

The research team also developed a dynamic model that estimates the portion of PM-2.5 caused by traffic from hourly traffic counts, which were provided by the Alaska Department of Transportation & Public Facilities. While preliminary results show that in downtown Fairbanks in winter, roughly 30% of PM-2.5 is caused by traffic, we plan to refine our results once we have a complete set of data for winter 2008-2009.

Upcoming work on this project includes:

- incorporate data from winter 2008-2009 as it becomes available,
- discuss estimates of PM-2.5 emissions from motor vehicles versus other sources, and
- discuss past work we have done relating outdoor to indoor PM-2.5 levels (this is important as we spend most of our time indoors).

These inputs will provide the necessary data and background to develop a Transportation System Management Strategy. Fairbanks and other areas with significant inversions and elevated PM-2.5 issues may soon benefit from the results of this project.

New Portable Instrument Measures Effectiveness of Dust Control Palliatives

(continued from page 1).

surface be able to withstand the abrasive effects of the vehicles that it was designed for. However, local material available for road and airport construction in Alaska is often poor quality. Stabilizing the soil under these conditions requires modification through use of additives, known as dust palliatives.

Dust palliatives control dust by coating the particle surface, adding to the particle's mass; and by binding soil particles together, increasing the aggregated particle mass. Different types of palliatives range from simple (adding water to the road surface) to complex (incorporating synthetic polymers to the wearing surface). Typically, these palliatives must be reapplied on a routine basis. Determining their effectiveness and when to reapply them is subjective, and controlled most often by the road condition and the dustiness of its surface.

To reduce the potential for bias in deciding when to reapply a palliative, different methods are used to quantify dust production. These include:

- static towers equipped with measuring devices (exposure profiling), and
- vehicles equipped with measuring devices near a vehicle's rear tire to measure dust produced (mobile measurements).

Exposure profiling has limitations: it is labor intensive, and cannot be used in many places. Mobile instruments determine relative dustiness of palliative-treated surfaces. The general concept is to pull continuous dust samples from near a vehicle's rear tire and quantify dust concentration by trapping particles on a filter, or by measuring opacity of the air stream using a laser. These instruments fit in the back of a pickup truck, or in a trailer pulled by a vehicle, which is simply not practical for much of Alaska.

AUTC researchers addressed this problem by developing a small-scale, portable instrument: the University of Alaska Fairbanks Dust Monitor (UAF-DustM; *see middle photo, page 1*). It fits on most all-terrain vehicles, the vehicle of choice in rural Alaska. As a vehicle tire lifts particles, a vacuum pump takes continuous samples through an intake positioned near the tire. The vacuum pump is connected to the intake (designed by AUTC researchers and manufactured locally) by tubing. The sample is split, with a portion being passed through a filter, obtaining a mass over time (distance) of particles collected on the filter. The other portion of the sample is directed through a tube to a vendor-supplied laser (DustTrakTM) that measures the opacity of the air stream. Opacity measurements are collected at defined time intervals, typically every second, allowing for a spatial analysis of dustiness along the unpaved surface, by relating GPS points and overall dustiness.

Evaluating dust control palliative effectiveness requires measuring the treated surface against an untreated control of similar characteristics. Because soil moisture influences dustiness, dust measurements on the control section need to be taken directly before or after measurements on the treated section. Dust percent reduction on the treated section is compared to the average dust concentration on the control section. Typical results near Fairbanks, Alaska *(see graph, page 1)* illustrate the percent of dustiness reduction brought about by applying a synthetic polymer to the unpaved road surface.

UAF DustM enables easy and quick measurements of palliative effectiveness on any unpaved, treated surface. UAF DustM will aid in eliminating road and runway dust in rural communities, with anticipated reduced maintenance costs, increased safety, and better air quality.

Economic Consequences of Recent Mount Redoubt Eruptions on Transportation

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approximately 120 flights. Mr. Berry checks in with the Alaska Volcano Observatory (AVO) website four to five times daily and fully supports the recently announced $15.2 million in economic stimulus funding to modernize the facility, which minimizes the number of flights rerouted and saves operational costs. With their contingency planning and information from the AVO, UPS was able to incur minimal additional costs from eruptions. Despite Redoubt, UPS is committed to Anchorage and in the process of expanding their sorting facility at the airport.

According to Anchorage International spokesperson Linda Bustamante, "Anchorage is firmly established as a major cargo hub because of its location, the "payload/range" equation and competitive rates/fees. The Anchorage airport and Fairbanks International Airport comprise the Alaska International Airport System (AIAS). When there are flight interruptions at Anchorage (wind, ash fall, etc.), flights are able to divert to Fairbanks. Anchorage does not have equipment for early eruption detections but relies on information from the AVO, FAA and National Weather Service. Airport Operations and the airlines were updated frequently with accurate information. AVO's ability, along with that of NWS, to track and predict the ash cloud and ash fall has greatly increased the safety and air carrier ability to operate during volcanic events." While ash cleanup costs are similar to snowstorm plowing costs, the airport has not yet assessed the loss in landing fees.

On the oil transportation front with the Redoubt Volcano still active and potentially explosive, officials have given up trying to restart the nearby Drift River oil terminal anytime soon, indefinitely idling about 10 oil platforms in Cook Inlet. According to Alaska Department of Revenue officials, the state is losing about $45,000 a day in missed royalty payments as a result of the closure. These ultimately should be only delays in payments, which will resume when oil activity and shipping can resume.

On the plus side of the ledger, some Kenai Peninsula opportunists are asking up to $250 a pound for ash from Redoubt Volcano and report sales across the Lower 48 via eBay. As of April 23, there were 16 Redoubt ash ads posted on eBay.

Will Warm Mix Asphalt Help Alaska Extend Pavement Life & Reduce Costs?

by Juanyu Liu, University of Alaska Fairbanks

Hot mix asphalt and Alaska's frequently cool summer temperatures are not compatible companions when it comes to compacting that asphalt.

The result? Weak pavements and shorter service life – as well as greater maintenance costs during that brief service life, promptly followed by more construction costs. Occasionally, contractors face fines for not meeting contract requirements.

The fix? The Alaska University Transportation Center and Alaska Department of Transportation & Public Facilities are working on a cooler mix.

Ever since the first asphalt pavement was built in the early 1900s, mixing aggregates and asphalt at high temperature (more than 300°F) has been widely accepted by the pavement industry as the major method of manufacturing hot mix asphalt (HMA). However, in cold regions such as Alaska, hot mixes can be difficult to compact, particularly if there are thin layers and cool weather. 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 – an all too common problem across Alaska.

Adopted from Europe, warm mix asphalt (WMA) uses additives in asphalt binders that are designed to soften the binder, allowing workability and compatibility at lower temperatures (a processing temperature range of 250°F ~ 275°F) than traditional HMA. The lower temperatures required to prepare WMA reduce the viscosity of the asphalt binder at a given temperature, allowing the aggregate to be fully coated at a lower temperature. WMA is also better for the environment. Manufacturers and materials suppliers indicate energy savings on the order of 30%, with a reduction in CO_2 emissions of 30%. Applying WMA reduces energy consumption costs and allows contractors to continue processing at lower air temperatures, thus making the process ideal for cold regions where cooler temperatures are more prevalent. This means Alaska wins on two fronts: environmental considerations and reduced construction and maintenance costs.

Among all the modern WMA technologies in both Europe and America, the organic additive Sasobit is the most adopted technology in the U.S.; is is simple to use and it obviously improves the viscosity properties of asphalt binder and concrete. Although various research and field demonstrations in the U.S. have evaluated the Sasobit-modified WMA, few studies focused on its performance during paving in extreme cold weather conditions such as those in Alaska.

In a joint effort, AUTC and AKDOT&PF are investigating the properties of Sasobit-modified asphalt mixtures for Alaska's conditions. Project objectives include: a) characterizing the asphalt binder modified with Sasobit in different contents according to Superpave criteria in the laboratory, b) assessing the engineering properties of mixtures modified with Sasobit in the laboratory, c) evaluating field performance of WMA mixes during production and laydown, and d) determining the suitability of WMA technology for Alaska's conditions.

During the first two weeks of September 2008, the research team conducted a full-scale field test and demonstration using Sasobit on the Petersburg-Mitkof Highway Upgrade Project, Phase II. Workers handled the mix similarly to HMA and had no difficulties. The team also conducted field surveys during and after construction on the test site. There was no smoke, and the team achieved field density in all cases.

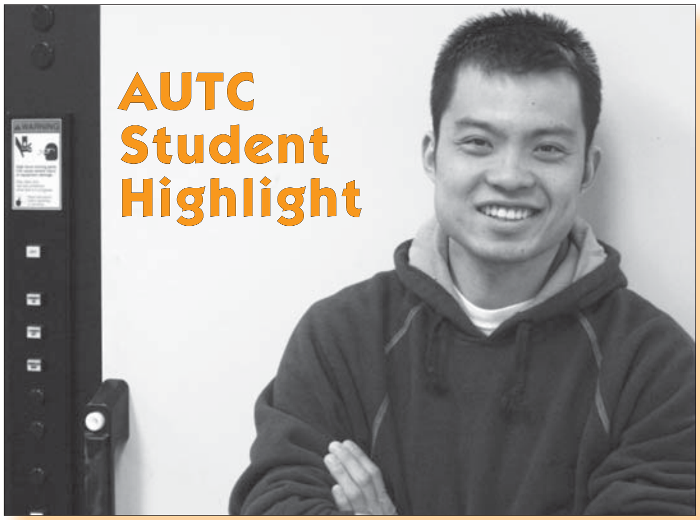
In the laboratory at UAF, the team conducted tests to characterize the Sasobit-modified binders according to Superpave criteria. Three Sasobit contents (0.8%, 1.5%, and 3%) were selected based on previous research and the results of the Petersburg field trial.

The Brookfield viscosity test showed a decrease of more than 59ºF (15ºC) for both the mixing and the compaction temperatures when using the Sasobit additive.

The team also investigated the correlation between the content of Sasobit and Superpave Performance Grading (PG) of binders. Both the high and low temperatures of PG increased when increasing the Sasobit content. Increasing the Sasobit content from 0 to 0.8%, 1.5%, and 3%, caused the asphalt PG to increase one grade from 58-28 to 64-22, 70-22 and 76-16, respectively – resulting in a stiffer asphalt.

In general, Sasobit improved the rutting resistance of pavement, but lowered its resistance to both fatigue and low-temperature cracking. Researchers are conducting further performance tests of both lab-fabricated specimens and of loose mixtures and cores collected from the field.

Top: A thermometer placed on newly applied and compacted warm mix asphalt shows a surface temperature of 219°F, roughly 60 degrees lower than a good working temperature for traditional hot mix asphalt. Right: This nuclear density gauge, used at the at the St. Petersburg field site, shows that the newly applied asphalt has been compacted to a very good density of 94.55%



PhD student Peng Li in the UAF AUTC Advanced Materials Laboratory. Li has become a leader in upgrading and organizing soils and asphalt labs at UAF.

Peng Li, who is pursuing a PhD in Civil & Environmental Engineering at the University of Alaska Fairbanks, is something of a renaissance man, equally adept at fieldwork, project coordination, and lab work. Li supplements his already rigorous graduate studies with additional online studies in materials and workshops in geosynthetics and asphalt technologies.

Li is a graduate assistant on an AUTC project, "Characterization of Asphalt-treated Base Course Materials, " and group leader for students on several other projects.

For the ATB project, Li drew on several knowledge areas — civil, electrical, and mechanical engineering — to develop an experimental setup for resilient modulus testing within a Cox environmental chamber.

Li is already making a name for himself professionally, with three peer-reviewed papers and two conference publications in print. He serves as lab instructor for a class on asphalt materials, guiding both undergraduate and other graduate students through materials preparation and complex lab testing.

Li has also drawn praise from colleagues — ranging from notoriously finicky lab managers at UAF to project engineers at the Alaska Department of Transportation & Public Facilities — for his ability to organize a lab efficiently and synthesize the needs of a whole project team into one strong, coherent research process. Mentor and advisor Juanyu Liu says that, in addition to being a skilled project manager, Li is "a solution-oriented person" as well as "an effective leader."

Li is also a member of the ASCE student chapter and a member of the Chinese Association at UAF. AUTC is proud to count Peng Li among our up-and-coming researchers.

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