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UNIVERSITY OF DELAWARE

Delaware Center for Transportation

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Indian River Inlet Bridge – Southbound Lane Open

The four tall towers and cable stays of the Indian River Inlet Bridge are plainly visible to those approaching the new bridge along Route 1 in Sussex County. The construction phase of the bridge is completed with some final work still underway. One lane heading southbound is open. What is not readily apparent to motorists are the more than 100 fiber-optic sensors and cable embedded in the concrete and mounted on parts of the bridge which will provide a system for monitoring the bridge's performance throughout its service life.

[Continued on next page]

Message from the Director

First and foremost, I'd like to take this opportunity to wish all of our readers a happy and prosperous 2012. My professional resolution for the New Year is to do everything in my power to make sure that our grants, contracts, agreements and paperwork in general, are processed in a timelier manner than the previous 2 to 3 years. As an academic institution that strives to be the first in the nation, we owe our students the highest quality instruction, and their involvement in the most relevant and up-to-date research projects. The prompt start and conclusion of research projects require an organization and its funding agencies to be able to process contracts with the minimum amount of delay, bureaucracy and red tape. I see it as my foremost responsibility to achieve that goal for the New Year and beyond.

Perhaps the most significant development since our September newsletter was my reappointment as the director of our research center. Dr. Jerome Lewis was also reappointed as the center's associate director. I told the Secretary of Transportation, the Dean of the College of Engineering and the Chair of the Civil and Environmental Engineering department that I was honored to receive their full support and will work hard to provide the highest quality teaching, research, and public service. It is our center's goal to continue to be viewed as one of the most important sources of transportation information and knowledge in the state, the northeast region, the nation and beyond.

Agreeing to serve a third five year term was with the full knowledge that we are operating in a completely different environment than we were during the previous two terms. The most significant of these changes, is of course, the state of the world and the nation's economy. On Monday, January 23rd, the House and Senate met on Capitol Hill to decide the fate of the long-delayed SAFETEA-LU reauthorization. Democrats and republicans have until March 31st to pass a new law that, at a minimum, will maintain investment levels for federal highway, transit and safety legislation. The American Society of Civil Engineers (ASCE), which is a member of the Americans for Transportation Mobility (ATM), a coalition led by the U.S. Chamber of Commerce, has drafted a letter that will be delivered to the House and Senate. The Delaware Center for Transportation is a signatory to that letter. It basically asks the members of congress to maintain, but ideally increase, the federal funding for roads, bridges, public transportation and safety investments, so that the nation "can sustain and create jobs and economic activity in the short-term, and improve America's export and travel infrastructure, offer new economic growth opportunities, and make the nation more competitive over the long-term." My job as the director of a transportation research center is to make sure that the new bill does contain enough funding for Research and Development purposes. Consequently, Dr. Jerome Lewis and I will be attending the January 2012 Transportation Research Board (TRB) annual meeting in Washington, D.C. and participating in the session specifically dedicated to discussing the future of the University Transportation Centers (UTC). These are federally-funded transportation centers that address research problems on the national scale. This session is sponsored by the Research and Innovative Technology Administration (RITA), a division of the U.S. Department of Transportation. For the past five years, Professor Sue McNeil of our Civil and Environmental has done a fantastic job directing this Center, enhancing our transportation research and the quality of our student recruitment. We hope that State Planning and Research (SPR) funds remain unchanged, but ideally increase in the new bill. The departments of transportation for each of the fifty states receive a large portion of their research and development funds from federal SPR grants.

Despite the ongoing economic challenges, the center was able to fund four new projects for fiscal year 2012. As always, these projects were identified as the ones most closely matched to the ongoing needs at DelDOT. These were in the areas of Environmental Engineering, Traffic Safety, Geotechnical Engineering, and Bridge Engineering. In addition to these four new projects, the center also has six ongoing active projects that are being administered by the University of Delaware faculty and professional staff. Our project identification and prioritization process for fiscal year 2013 starts within the next couple of weeks.

As always, the Center has many useful and exciting programs scheduled in the coming months. For example, on February 21st, Ira Hirschman, the president of the international consulting firm of Parsons and Brinkerhoff will be on campus for a visit and a seminar. Mr. Hirschman will share his work and experience of many years as the leader of one of the most successful global civil, environmental, infrastructure and transportation companies with the audience. I encourage everyone to attend.

Again, I wish everyone a happy new year and hope that you visit our web site at www.ce.udel.edu/dct/ for all of our ongoing programs.

Ardeshir Faghri,
Director

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The design and installation team of Harry (Tripp) Shenton, Michael Chajes, Robert Hunsperger, Gary Wenczel, plus graduate and undergraduate students are being supported by a $1.2 million dollar grant from the Delaware Department of Transportation (DelDOT). The interdisciplinary team, representing the Departments of Civil and Environmental Engineering, as well as Electrical and Computer Engineering, began their research project with the initial construction of the bridge in July, 2009. With Phase I nearing completion, the next phase will include system calibration with bridge load tests, monitoring and evaluation during and after extreme events (hurricanes, earthquakes, vehicle accidents, fires on or under the bridge), as well as long-term monitoring for changes in performance due to damage or degradation.

Recently DelDOT amended the grant to add funding for installation of a security system which would be integral to the structural monitoring system now in place. According to Tripp Shenton, this system includes cameras, sensors for monitoring the pylon platforms and hatch doors, along with hardware and software for making the system operational. Once up and running it will collect over 200 points of data including the detection of intrusions such as trespass and vandalism.

It will not be long before DelDOT opens both lanes of traffic on the new bridge. An Official Bridge Dedication Ceremony is scheduled for late spring. All the while the monitoring and security systems will be collecting data and keeping those at DelDOT informed on the performance of the bridge.

Transportation Regulatory Updates

Keep an eye out for developments in two transportation regulatory fronts, because they will affect everyone with roadway design and maintenance responsibilities.

Americans with Disabilities Act – "new" sidewalk guidelines

There's nothing overwhelmingly 'new' about the (draft) Public Right of Way Accessibility Guidelines (PROWAG), and everyone was expecting that the PROWAG would be issued as a Final Rule by the end of 2011 or so, but once again, it is not to be.

The Americans with Disabilities Act (ADA) was signed into law July 26, 1990 and shortly thereafter, the U.S. Access Board enacted the ADA Accessibility Guidelines (ADAAG). These were largely focused on new buildings and building sites and we in the transportation field have done our best to adapt them to the challenges of roadways, sidewalks, and cross walks. The result has often been confusion and frustration.

PROWAG was first released as draft guidelines in 2002 and, reflective of comments, revised guidelines came out in 2005. In July 2011, the Access Board again published a draft PROWAG as a proposal for Final Rule with a comment period ending in November 2011. But the comment period was abruptly extended to February 2, 2012, so we must continue to wait.

In the interim, the Federal Highway Administration issued a 2006 memorandum to the effect that, while the PROWAG are not standards until adopted by USDOJ and USDOT, the USDOT has deemed the draft PROWAG, "the currently recommended best practices, and can be considered the state of the practice that could be followed for areas not fully addressed by the present ADAAG standards."

Nonetheless, those who must design, construct, and maintain public rights of way in accordance with ADA are anxious for a time when one set of guidelines can be consulted, particularly one focused on the public right of way. Perhaps 2012 will see PROWAG finalized.

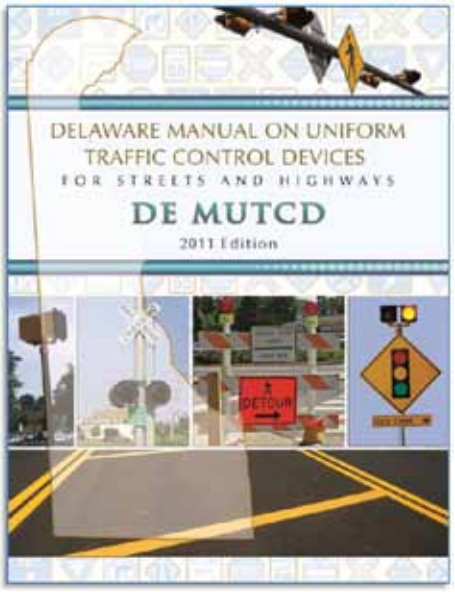
Manual on Uniform Traffic Control Devices – compliance schedule

Those who have spent time with the Manual on Uniform Traffic Control Devices (MUTCD) know that it is always a work in progress. Proposed modifications are almost always in play. So anyone who thought the 2009 MUTCD (and the resulting Delaware MUTCD, published this past summer) would remain set for long was deluding him/herself. But one proposed change in particular has everyone wondering what to do with some upcoming deadlines. The proposal in question would radically change the compliance dates (Table I-2); see the proposed changes at www.mutcd.fhwa.dot.gov.

The August 31, 2011 proposed amendment would change MUTCD Table I-2, "to eliminate, extend, or revise most of the target compliance dates for upgrading existing traffic control devices [signs, pavement markings, lights, cones, barricades, etc.] in the field that do not meet the current MUTCD standards." So for example, the January 22, 2012 deadline to implement a retroreflectivity assessment or management method would be extended some two years and the 2015 and 2018 dates for minimum retroreflectivity of different sign types would be removed from the list. The December 22, 2013 compliance date for signs on the back of Stop or Yield signs to not obscure the shape of those signs would be removed. Lettering height deadlines for street name signs (2012 and 2018) would be removed. And so on.

While we wait to see if the proposed amendment is adopted, more deadlines in Table I-2 will likely pass. Will the proposed amendments pass? We don't know for sure. There was considerable pushback as many transportation agencies claimed that the 2009 MUTCD revisions placed too great a financial burden on them and that will surely weigh on the determination. And when will we know? We don't know that either. While the comment docket is closed, review of comments often takes months.

If the proposed amendments are adopted, what does that mean to a road agency? First, federal law (23 U.S.C. 402(a)) requires all road agencies to have a program for systematic upgrading of substandard traffic control devices to comply with the MUTCD. Such a program must include some means of regularly inspecting/assessing devices and replacing or upgrading them when they are damaged, degraded, stolen, or have reached the end of their useful life.



Second, the lack of a specific compliance date for an MUTCD component doesn't remove your liability. Any time that a device is replaced or reconstructed it must be brought to full compliance with the MUTCD - often referred to as programmatic changes. Specific compliance dates simply establish a fail-safe date where devices must be brought up to the MUTCD standard whether they are being replaced or not.

Thus, if a specific compliance date is removed, it simply means that a particular part of the trigger has gone away. But, as devices are replaced for various reasons, you must consult the new requirements of the MUTCD and ensure they comply. If you are using federal funds for a project, you may find that your project is delayed or ineligible because of MUTCD non-compliance. Even state funded projects might have the same limitations.

Finally, MUTCD non-compliance exposes your agency to civil lawsuits. Under some circumstances, plaintiffs will argue that your agency knew of the need to upgrade devices, failed to do so in a "timely manner" and they were injured as a result. You may object to such a claim, but your attorney will be more successful defending you in court if you have a reasonable program for inspection, assessment, upgrade, and replacement of your traffic control devices.

So while the proposed changes to Table I-2 are important, we would all do well to worry less about the proposed changes and more about enhancing our program as if the deadlines were going to remain - which they might. ■

Delaware T2 Center Partners to Launch New Educational Workshops

Two new training workshops from the Delaware T2 Center have seen their inaugural run in New Castle County and we will be taking them to central and southern Delaware in January and March 2012.

Roger Bowman instructs a diverse audience on Winter Maintenance.

Winter Maintenance

The "Winter Maintenance: Snow and Ice Control" workshop is a full day look at snow and ice planning and operations through six modules: Introduction; Planning and Program Development; Pre-Season Activities; Operations/In-Season Activities; Post Storm Activities; and Post Season Activities. Brad Dennehy (City of Milford) punctuated the need for Delaware-focused winter maintenance training during conversations with Matt Carter in January 2011 (echoing similar inquiries from other municipalities) and he agreed to be an advisor to its development.

Reaching out to Joe Wright (DelDOT) for technical advice resulted in a strategy meeting with Dennehy, the T2 Center's Rusty Lee and Matt Carter, and DelDOT's Brian Urbanek, Edwin Tennefoss, and Alastair Probert, where the basic structure and content was hammered out. This "advisory council" was later joined by Roger Bowman (UD Facilities-Grounds Services) and Dan Webber (Cecil County Roads Division). Together, this group brought diverse winter maintenance expertise with rural roads, urban streets, and pedestrian pathways to assist with the development of training materials targeted at Delaware's municipal environments.

The workshop was rolled out for 35 participants at the University of Delaware's Perkins Center on November 30th. Roger Bowman graciously donated his time to assist Matt with the all day session. Roger's expertise with pedestrian pathways (25 miles, ranging from four to sixteen feet wide) and parking lots resonated with many participants who are increasingly pressured to address more than just roadways.

The Winter Maintenance workshop will be offered in both Lewes and Dover in January 2012.

MUTCD

Following DelDOT's lead (and stealing their materials wherever we could), four educational modules were developed for the Manual on Uniform Traffic Control Devices (MUTCD). The four modules reflect portions of the MUTCD that are of most common application for Delaware municipalities: Introduction and Part 1 (General); Part 2 (Signs); Part 3 (Pavement Markings); and Part 6 (Temporary Traffic Control).

With so many changes in the December 2009 federal MUTCD and the June 2011 release of Delaware's revised MUTCD, this was a perfect time to develop a set of training workshops targeted for municipal streets and assuming little or no prior expertise with the MUTCD. The presentation materials prepared by DelDOT and their consultants provided an excellent base from which to build, saving time in many areas. As the modules were developed, DelDOT's Don Webber, Mark Luszcz, and Adam Weiser were indispensible as advisors and fact checkers.

The four modules were introduced as three, 4-hour workshop sessions on December 1, 8, and 15th, again at the Perkins Center, where participant audiences ranged from 11 to 25 at the three sessions. Questions and examples from the audience challenged the instructors, Rusty Lee and Matt Carter, as well as the material itself, confirming the need for training in this area and how complicated traffic control devices can be. The three sessions will be offered again in both Lewes and Dover in January and March 2012.

These two new workshop offerings add to an expanding list of home-grown or adapted trainings targeted towards Delaware's low volume and urban roadways, allowing us to offer them frequently throughout the state at relatively low expense (and at no cost to Delaware public agencies). We plan to continue our development and adaptation of training materials, reflective of the needs of Delaware public agencies. See more details on these and other course offerings from the Delaware T2 Center at www.ce.udel.edu/dct/T2.html. ■

Rusty Lee kicks off the MUTCD training geared toward local agencies.

DelDOT to Host Quality Assurance Workshop in February

The Delaware Department of Transportation (DelDOT) will host the Mid-Atlantic Region Quality Assurance Workshop February 7-9, 2012 at the Dover Downs Hotel, in Dover, Delaware.

The states of Delaware, Maryland, New Jersey, Pennsylvania, Virginia, West Virginia, and the District of Columbia make up the Mid-Atlantic Region QAW and this annual event has been held each year since 1967. The Workshop consists of five breakout sessions devoted to the latest information on highway materials in the areas of asphalt, concrete, metals, maintenance, and soils/aggregates. The mission of the organization is, in part, "to promote, adopt and emphasize new transportation technologies and the implementation of pro active policies, practices, and procedures that ensure the real life of the transportation infrastructure equals or exceeds its design life at a minimum overall cost."

With budgets under such strain, this is a great opportunity to meet colleagues at all levels of government and the private sector, share experiences, and get caught up on technologies. Full registration, including the Tuesday night banquet and a tour of the Dover International Speedway, is only $175. Details for the event, including the agenda and registration can be found at www.midatlanticqaw.com. ■

The EDC Exchanges Come to Delaware

On December 15th, 2011, the Federal Highway Administration Delaware / Maryland District Office, the Delaware Department of Transportation (DelDOT) and the Delaware T2 / LTAP Center co-hosted the first of the Every Day Counts (EDC) Exchange Webinars at the DelDOT Administration Building in Dover.

EDC-EXCHANGE is a regularly scheduled series of "dynamic webinars". The sessions describe effective project development and delivery practices, tools and "market ready" technologies that local transportation agencies can readily implement into their programs. FHWA national subject matter experts, in conjunction with FHWA and State DOT field office experts, provide information and materials, and facilitate discussions designed specifically for local transportation managers. More information on the Every Day Counts Program and the EDC Exchange webinars can be found at www.fhwa.dot.gov/everydaycounts.

The first of this series covered project delivery by the Construction Manager/General Contractor (CM/GC) process. Described as the middle ground between Design – Bid – Build and Design –Build, CM/GC is a process used in many states to reduce project costs and shorten project delivery time while retaining high levels of project owner involvement in project design. The webinar consisted of a series of short presentations that provided information on the CM/GC process and highlighted successes using CM/GC on local projects around the country. After each presentation, there was time for a locally facilitated discussion on how CM/GC could be more widely used in Delaware. More information on CM/GC can be found at www.fhwa.dot.gov/everydaycounts/projects/methods.

The audience included representatives from FHWA, DelDOT, and the contractor and consultant communities, as well as representatives of Dover and Wilmington. The local discussion portions were particularly valuable since they gave time to not only discuss CM/GC but also to identify other roadblocks to effective project delivery in Delaware and how these roadblocks might be dealt with.

The next EDC Exchange webinar is scheduled for February 16th, 2012. The topic will be Accelerated Bridge Construction using Geosynthetic Reinforced Soil Integrated Bridge System (GRS-IBS). For more information on the EDC Exchange program or the webinars, contact Rusty Lee at elee@udel.edu via email or at (302) 831 6241 or Matt Carter at matheu@udel.edu or (302) 831-7236. ■

Research

Following are the projects funded for our FY12 Annual Research Program beginning on September 1, 2011 and ending August 31, 2012:

INTEGRATING ZERO-VALENT IRON AND BIOCHAR AMENDMENTS IN GREEN STORMWATER MANAGEMENT SYSTEMS FOR ENHANCED TREATMENT OF ROADWAY RUNOFF

This project will evaluate two technologies involving the addition of biochar and/or zero-valent iron to existing and new stormwater facilities which will reduce nutrients from DelDOT stormwater discharges.

Principal Investigators
Dan Cha and Paul Imhoff, Department of Civil and Environmental Engineering

Project Manager
Marianne Walch, Maintenance and Operations

EFFECTIVE COUNTERMEASURES FOR CRASH REDUCTION AT UNSIGNALIZED INTERSECTIONS FOR TWO-LANE UNDIVIDED ROADWAYS

The goal of this research project is to improve the safety of motorists at unsignalized intersections on two-lane undivided roadways.

Principal Investigator
Arde Faghri, Department of Civil and Environmental Engineering

Project Manager
Adam Weiser, Traffic Division

DESIGN AND CONSTRUCTION OF A GEOSYNTHETIC REINFORCED SOIL (GRS) INTEGRATED BRIDGE SYSTEM (IBS) IN THE STATE OF DELAWARE

This demonstration project will provide the necessary technical expertise to the design, construction, and long-term inspection process that can be used to enhance implementation of this technology in Delaware.

Principal Investigator
Chris Meehan, Department of Civil and Environmental Engineering

Project Manager
Jim Pappas, Materials and Research

DELAWARE SIGNAL TIMING ENHANCEMENT PARTNERSHIP (DSTP) – CORRIDORS 3 & 4

The goals of the DSTEP project are to involve students in traffic engineering services for DelDOT, to develop a continuous research program that addresses DelDOT's needs while minimizing the use of DelDOT's resources, and to maintain a high level of quality so that DelDOT may apply the results to improve intersection operations across the state. This project will involve data collection and analysis on SR4 and SR273.

Principal Investigator
Rusty Lee, Department of Civil and Environmental Engineering

Project Manager
Gene Donaldson, Transportation Management Center

DEVELOPMENT AND EVALUATION OF A RESIDENTIAL ALLOCATION MODEL USING TIME SERIES TAX PARCEL DATA, PART II

Continuation of FY11 project – a state-wide tax parcel based land use file is created to support transportation applications and travel demand forecasting in particular.

Principal Investigator
David Racca, Center for Applied Demography and Research

Project Manager
Mike DuRoss, Division of Planning

NON-DESTRUCTIVE TESTING METHODS TO EVALUATE THE INTEGRITY OF CONCRETE BRIDGE DECKS

This research project will evaluate non-destructive testing procedures to help assess the current condition and quantify the extent of deterioration of concrete bridge decks.

Principal Investigators
Thomas Schumacher and Dennis Mertz, Department of Civil and Environmental Engineering

Project Manager
Jim Pappas, Materials and Research

TRAVEL DEMAND MODELING SUPPORT FY12

Support for this project will assist DelDOT with the development, maintenance, application and evaluation of a travel demand forecasting model. The model supports planning studies for Delaware's MPOs and various DelDOT sections on an as-needed basis.

Principal Investigator
Rusty Lee, Department of Civil and Environmental Engineering

Project Manager
Mike DuRoss, Division of Planning

2011-2012 GPS TRAVEL TIME AND DELAY DATA COLLECTION AND ANALYSIS

This project entails data collection during peak travel times on roadway segments throughout the state. Each segment will be traveled at least four times for maximum accuracy. Once data collection is completed, data will be transformed into the GIS database and transported to the ARCGIS software.

Principal Investigator
Arde Faghri, Department of Civil and Environmental Engineering

Project Manager
Mark Eastburn, Division of Planning

CROSS-FRAME FORCES IN SKEWED STEEL I-GIRDER BRIDGES, YEAR 2

This research will assess the ability of bridges in Delaware to withstand strikes by overheight trucks and also identify critical bridges that need immediate reinforcement to prevent catastrophic failure if hit by a truck.

Principal Investigator
Jennifer McConnell, Department of Civil and Environmental Engineering

Project Manager
Jim Pappas, Materials and Research

ITS LAB BASELINE SERVICE FY12

The objectives of this project are to establish the Delaware Center for Transportation ITS Lab as a state of the art facility with three main focus areas: 1) service to DelDOT; 2) training for DelDOT and support classroom instruction; and 3) research for faculty and students

Principal Investigator
Rusty Lee, Department of Civil and Environmental Engineering

Project Manager
Gene Donaldson, Transportation Management Center

[Continued on next page]

Continuing active research projects sponsored by DelDOT

As each project is completed, a final technical report will be available on the DCT website: www.ce.udel.edu/dct.

STUDY AND CALCULATION OF TRAVEL TIME RELIABILITY MEASURES

Travel time reliability is a better way to assess system performance and it is important especially for shippers, freight carriers and public safety personnel as well as other users. (Ending 8/31/12)

Principal Investigator
David Racca, Center for Applied Demography and Survey Research

Project Manager
Gene Donaldson, Transportation Management Center

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) AND NONPOINT SOURCE POLLUTION

This project will help DelDOT and other permit holders meet the goal of educating the general public about pollution from runoff required by state laws. (Ending 8/31/12)

Principal Investigator
Martha Narvaez, Institute for Public Administration

Project Manager
Marianne Walch, Maintenance and Operations

USE OF RECLAIMED ASPHALT PAVEMENT (RAP) TO REDUCE PAVEMENT THICKNESS

The main objective of this project is to develop protocols and methods of using RAP filled geocell in full depth pavement thickness, through field studies. (Ending 8/31/12)

Principal Investigators
Dov Leshchinsky and Nii Attoh-Okine, Department of Civil and Environmental Engineering

Project Manager
Jim Pappas, Materials and Research

NEAR REAL-TIME MONITORING OF INDIAN RIVER INLET SCOUR HOLE EDGE EVOLUTION SEAWARD OF THE BRIDGE PIERS: PHASE II

Bridge pier scour is a problem that occurs in riverine and tidal environments. Funding for this project will be used to install a monitoring system that will image the sea bed adjacent to the bridge piers. Additionally, current meter data will yield critical forcing conditions that can be related to scour hold variability. The resulting data can be used to make informed management decisions and develop appropriate plans of action. (Ending 8/31/12)

Principal Investigator
Jack Puleo, Center for Applied Coastal Research

Project Manager
Doug Robb, Bridge Design

INSTRUMENTATION AND MONITORING OF THE INDIAN RIVER INLET BRIDGE

This project involves installing a long-term structural health monitoring (SHM) system on the Indian River Inlet Bridge during its construction and monitoring the bridge through the first bi-annual inspection. Following this installation, DelDOT will be able to understand how the as-built bridge is functioning and through long-term monitoring, will be in a better position to efficiently and effectively manage this significant resource. (Ending 6/30/2012)

Principal Investigators
Tripp Shenton and Michael Chajes, Department of Civil and Environmental Engineering and College of Engineering respectively; Robert Hunsperger, Electrical and Computer Engineering

Project Manager
Doug Robb, Bridge Design

ITS LAB BASELINE SERVICE FY11

The objectives of this project are to establish the Delaware Center for Transportation ITS Lab as a state of the art facility with three main focus areas: 1) service to DelDOT; 2) training for DelDOT and support classroom instruction; and 3) research for faculty and students. (Ending 8/31/12)

Principal Investigator
Rusty Lee, Department of Civil and Environmental Engineering

Project Manager
Gene Donaldson, Transportation Management Center

LONG-TERM PERFORMANCE MONITORING OF A RECYCLED TIRE EMBANKMENT IN WILMINGTON, DELAWARE

This is a continuation of a one-year project requiring additional data analysis. This project will determine the environmental and engineering properties that should be monitored during the construction of shredded tire embankments including instrumentation, installation, monitoring and an analysis plan. The project will investigate what instruments are needed and how to construct plus monitor them. Delaware summer temperatures will be taken into account. (Ending 6/30/12)

Principal Investigators
Nii Attoh-Okine, Paul Imhoff, Victor Kaliakin and Chris Meehan, Department of Civil and Environmental Engineering

Project Manager
Jim Pappas, Materials and Research

DELAWARE SIGNAL TIMING ENHANCEMENT PARTNERSHIP (DSTP)

The goals of the DSTEP project are to involve students in traffic engineering services for DelDOT, to develop a continuous research program that addresses DelDOT's needs while minimizing the use of DelDOT's resources, and to maintain a high level of quality so that DelDOT may apply the results to improve intersection operations across the state. This project will involve data collection and analysis on Cleveland Avenue and SR 72. (Ending 8/31/12)

Principal Investigator
Rusty Lee, Department of Civil and Environmental Engineering

Project Manager
Gene Donaldson, Transportation Management Center

DEVELOPMENT OF SPECIFICATIONS FOR THE USE OF CONTINUOUS COMPACTION CONTROL SYSTEMS

The objective of this research project is to develop specifications that can be used to guide the application of Continuous Compaction Control technology to DelDOT field construction projects. (Ending 8/31/12)

Principal Investigator
Chris Meehan, Department of Civil and Environmental Engineering

Project Manager
Jim Pappas, Materials and Research

RESEARCH PAYS OFF

Warm-Mix Asphalt Heating Up in Virginia

STACEY D. DIEFENDERFER AND TRENTON M. CLARK

Diefenderfer is Research Scientist, Virginia Center for Transportation Innovation and Research, Charlottesville. Clark is Director of Engineering, Virginia Asphalt Association, Richmond, and Chair of the TRB Flexible Pavement Design Committee.

Warm-mix asphalt (WMA) technologies produce asphalt at temperatures that are 25°F to 100°F (14°C to 38°C) lower than the production temperatures for conventional asphalt concrete, which range from 280°F to 350°F (138°C to 177°C). In general, three WMA technologies are in use. Some WMA technologies use wax-based additives to reduce the viscosity of the binder at lower temperatures; this allows for mixing, aggregate coating, and mixture workability at reduced temperatures. Chemical additives in other WMA mixtures promote coating, adhesion, and workability. Yet other technologies introduce water; the resulting steam causes the asphalt binder to foam, which improves workability.

WMA was introduced in the United States in 2004, and the potential cost savings from reduced fuel at the plant, improved field compaction, and improved air quality have attracted interest. Several states, the Federal Highway Administration, the National Center for Asphalt Technology, and the National Cooperative Highway Research Program have conducted research on WMA (see list of online resources, page 35).

Problem

Implementing WMA raises the following challenges:

- Verifying that the pavement performance will match that of conventionally produced asphalt concrete; and
- Addressing the susceptibility to moisture—although field studies on Virginia and other states have found no definitive evidence of this problem.

WMA promises constructability and environmental benefits. Without proof that the technology provides an equivalent level of performance, however, some transportation agencies in the United States have questioned implementation.

Research Approach

In 2006, the Virginia Department of Transportation (DOT) and the Virginia Center for Transportation Innovation and Research (formerly the Virginia Transportation Research Council) constructed maintenance overlays on trial sections to evaluate the laboratory and field performance of WMA materials. The objective was to determine the potential use of the materials on Virginia's roadways.

Three research projects were initiated (*a*) to document and evaluate the construction of three pairs of hot-mix asphalt (HMA) control sections and WMA trial sections using two technologies; (*b*) to evaluate the laboratory performance of WMA materials; and (*c*) to evaluate the field performance of the trial sections.

PHOTOGRAPHS COURTESY OF KEVIN MCGHEE

The reduction in visible fumes can be seen in a comparison of conventional HMA paving (*left*) and paving with WMA (*right*).

TABLE 1 Core Air Voids

Age	Average Air Voids, % (standard deviation)					
	Trial A		Trial B		Trial C	
	HMA	WMA	HMA	WMA	HMA	WMA
Initial	7.7 (1.1)	6.7 (1.8)	9.2 (1.3)	8.1 (2.5)	7.6 (1.6)	9.4 (3.5)
3-month	6.0 (0.9)	6.8 (1.9)	8.0 (2.5)	8.3 (2.7)	9.6 (1.8)	9.2 (3.0)
6-month	6.2 (0.7)	7.8 (1.4)	8.4 (2.1)	7.9 (1.5)	7.1 (2.4)	7.4 (2.1)
1-year	5.5 (0.7)	7.4 (1.9)	6.6 (0.9)	7.3 (0.8)	7.0 (2.7)	7.6 (1.9)
2-year	7.1 (1.2)	7.5 (1.1)	9.6 (1.0)	7.4 (1.5)	6.3 (0.8)	8.6 (2.7)

Construction and Field Performance

Construction of the HMA and WMA sections for each trial followed standard HMA paving practices; the only exception was the WMA's lower production temperature. In Trial A and Trial B, the WMA used an organic wax additive; in Trial C, the WMA used an emulsion technology.

Density was measured with a nuclear gauge and cores during construction. Field cores and loose material from the plant were collected for laboratory testing. Coring and visual inspections were performed during construction and at intervals of 3 months, 6 months, 1 year, and 2 years.

Cores were tested to determine the air void contents before the extraction and recovery of the asphalt binder for performance grading. Table 1 (above) shows the differences in the air void contents of the HMA and WMA in each trial; these were not statistically significant at a level of $\alpha = .05$.

Nuclear density measurements generally supported these observations for the WMA in Trials A and B. The difference in the nuclear density measurements of the compacted WMA and HMA sections from Trial C was significant at $\alpha = .05$. Performance grading of the recovered binders indicated that the WMA from Trials A and B aged during the first 2 years in service at a slightly reduced rate from that of the HMA, indicated by a reduced rate of stiffening. No difference was measured in the performance grade between the HMA and WMA in Trial C.

Laboratory Evaluation

All mixtures for the field trials underwent laboratory testing. The volumetric properties for all HMA and WMA mixes compared reasonably well (see Table 2, below).

Specimens for the tensile strength ratio (TSR) test were evaluated for moisture susceptibility. In addition, rutting susceptibility was assessed with an asphalt pavement analyzer.

The TSR values of the HMA in all three trials and of the WMA from Trial B passed the 0.80 ratio requirement, but the WMA from the other two trials did not pass, suggesting that the mixes were susceptible to moisture (see Table 3, next page); nonetheless, the susceptibility was not evident in the field. With these results, the initial specification developed for WMA required a minimum TSR value of 0.60, compared with 0.80 for HMA; however, after one construction season, the specification for the minimum TSR value was raised to 0.80.

The rutting susceptibility results indicated that the HMA and WMA from Trials A and B would be expected to perform similarly. In Trial C, the WMA exceeded the maximum allowable rutting depth of 5.5 mm for a PG 70-22 mixture, but the HMA was acceptable (see Table 3, next page).

Study Implications

The field trials indicated that WMA can be placed at lower temperatures, using conventional HMA paving practices and procedures. After 2 years, cracking was

TABLE 2 Volumetric Properties

Property	Trial A		Trial B		Trial C	
	HMA	WMA	HMA	WMA	HMA	WMA
% AC	5.86	5.80	5.39	5.81	5.83	6.06
Rice SG (G_{mm})	2.501	2.502	2.604	2.597	2.487	2.464
% VTM	3.1	4.5	3.3	2.9	3.1	1.7
% VMA	15.7	16.8	9.5	16.5	16.4	15.5
% VFA	80.4	73.3	65.2	82.5	80.9	89.3
Dust/AC ratio	1.17	1.14	2.57	1.14	0.94	0.90

AC = asphalt content; SG = specific gravity; VTM = voids in total mix; VMA = voids in mineral aggregate; VFA = voids filled with asphalt.

TABLE 3 Rutting and Moisture Susceptibility Test Results

Technology	APA Rutting				TSR Values	
	HMA		WMA			
	Avg. Rutting, mm (std. dev.)	Avg. Voids, % (std. dev.)	Avg. Rutting, mm (std. dev.)	Avg. Voids, % (std. dev.)	HMA	WMA
Trial A	4.39 (0.43)	6.97 (0.15)	3.81 (0.48)	7.03 (0.06)	0.82	0.75
Trial B	2.74 (0.11)	8.53 (0.06)	2.72 (0.25)	8.53 (0.25)	0.85	0.90
Trial C	4.61 (0.36)	8.57 (0.12)	7.69 (0.67)	7.60 (0.00)	0.85	0.76

TSR = tensile strength ratio

observed along the center line of the HMA and WMA sections in Trial A, although the cracking in the WMA section was much less extensive.

The cause of the cracking was related to the paving equipment, not to the materials. No cracking was seen in any of the sections of Trials B and C. The performance of the HMA and WMA sections, therefore, was the same; long-term monitoring is planned.

Application

In 2008, Virginia DOT developed special provisions allowing contractors to use WMA technologies for maintenance overlay projects. The special provisions removed the minimum mixture and placement temperatures for WMA but required a minimum temperature of 40ºF for the base on which the WMA is placed. The density requirements for WMA were identical to those for HMA. After one construction season, the minimum TSR value for WMA, initially 0.60, was raised to 0.80, the value for HMA.

In 2009, Virginia DOT adopted a supplemental specification incorporating WMA into standard practice. The specification allows contractors to use Virginia DOT–approved WMA products and processes in lieu of HMA and requires the following:

- Superpave® mixture properties must be determined on the reheated materials;
- The minimum TSR must be 0.80 in the design and production tests;
- The initial production of new mix designs and processes must be limited to 500 tons; and
- WMA may be placed when the base temperature is 40ºF or greater.

Benefits

The research supported Virginia DOT's use of WMA as an alternative to HMA. The construction and environmental improvements benefit the agency, the industry, and the public. Contractors can increase the hauling distances from the plant to the project, can reduce energy consumption during production, and can reduce plant emissions, improving air quality. Crews benefit from the cooler mat temperatures and reduced fumes during paving. The improved compaction can increase the durability and the performance of WMA.

For more information, contact Stacey Diefenderfer, Research Scientist, Virginia Center for Transportation Innovation and Research, 530 Edgemont Road, Charlottesville, VA, 22903; phone 434-293-1933; fax 434-293-1990; e-mail: Stacey.Diefenderfer@VDOT.Virginia.gov.

Resources

Installation of Warm-Mix Asphalt Projects in Virginia. VTRC 07-R25. www.virginiadot.org/vtrc/main/online_reports/pdf/07-R25.pdf.

Laboratory Evaluation of a Warm Asphalt Technology for Use in Virginia. VTRC 09-R11. www.virginiadot.org/vtrc/main/online_reports/pdf/09-R11.pdf.

NCHRP Report 691: Mix Design Practices for Warm-Mix Asphalt. Transportation Research Board of the National Academies, Washington, D.C., 2011. http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_691.pdf.

Performance of Virginia's Warm-Mix Asphalt Trial Sections. VTRC 10-R17. www.virginiadot.org/vtrc/main/online_reports/pdf/10-R17.pdf.

www.virginiadot.org/business/resources/const/07RevDiv_II.pdf.

www.virginiadot.org/business/resources/Materials/Approved_Lists.pdf.

NCHRP Projects

Go to www.trb.org/NCHRP/FindaProject.aspx and type in the project number:

- NCHRP Project 09-47: Engineering Properties, Emissions, and Field Performance of Warm-Mix Asphalt Technologies;
- NCHRP Project 09-47A: Properties and Performance of Warm-Mix Asphalt Technologies;
- NCHRP Project 09-49: Performance of Warm-Mix Asphalt Technologies: Stage I—Moisture Susceptibility;
- NCHRP Project 09-49A: Performance of Warm-Mix Asphalt Technologies: Stage II—Long-Term Field Performance;
- NCHRP Project 09-52: Short-Term Laboratory Conditioning of Warm-Mix Asphalt Mixtures for Mix Design and Performance Testing; and
- NCHRP Project 09-53: Asphalt Foaming Characteristics for Warm-Mix Asphalt Applications.

EDITOR'S NOTE: Appreciation is expressed to G. P. Jayaprakash, Transportation Research Board, for his efforts in developing this article.

Suggestions for "Research Pays Off" topics are welcome. Contact G. P. Jayaprakash, Transportation Research Board, Keck 488, 500 Fifth Street, NW, Washington, DC 20001 (202-334-2952; gjayaprakash@nas.edu).

The mission of the Delaware Center for Transportation is to improve the movement of people, goods, and ideas, and be viewed as a valuable resource for transportation-related issues and challenges within the state, the mid-Atlantic region and beyond.

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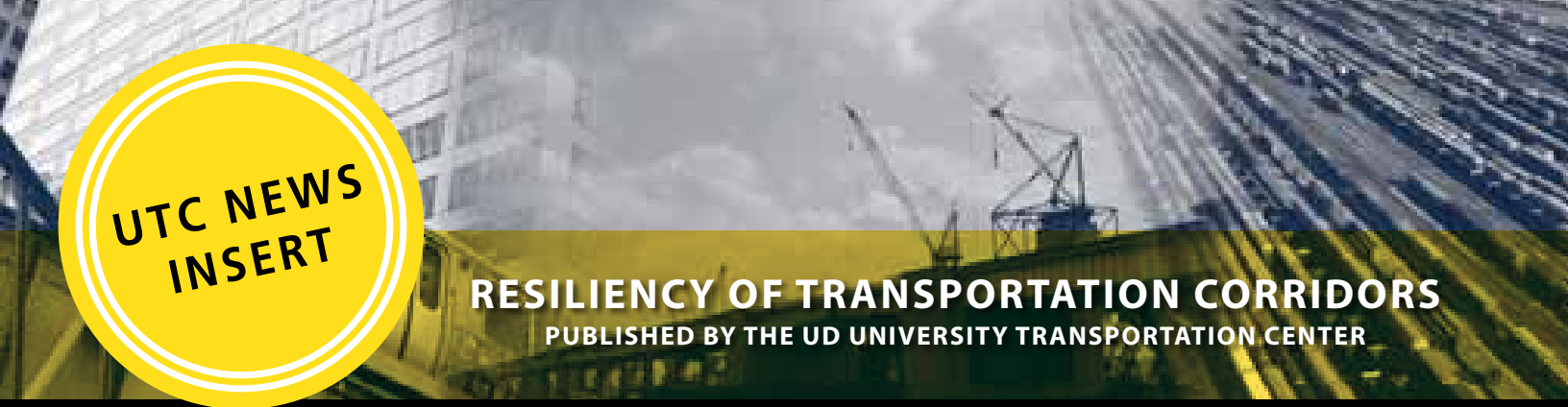

UTC NEWS INSERT

RESILIENCY OF TRANSPORTATION CORRIDORS

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SPRING 2012

Dare to be first.

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University Transportation Center

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Message from the Director

I often say "I have never met a transportation problem that I don't like." To be more specific, I have not met a transportation problem that I don't find interesting. From my role on national committees to work with my graduate students, I am continually testing this hypothesis. I want to share three examples of activities that have shed light on the context and challenges involved in providing transportation services to meet society's needs in the 21st century that make interesting problems.

The first example relates to the context in which we undertake transportation research. I am currently the chair of a Transportation Research Board policy study Committee on National Research Frameworks: Application to Transportation. The study's objective is to identify opportunities to improve the innovation process for surface transportation in the United States by drawing on lessons learned from the transportation sector in other countries and from the non-transportation sector in the United States. The study has provided an opportunity to take inventory of all the different mechanisms we have for transportation research in the United States and explore models used in other sectors and abroad. This review has served as reminder of the important role of the University Transportation Centers program as a mechanism for addressing some of these interesting problems and developing our next generation of transportation professionals.

The second example pertains to our ongoing UTC funded research on climate change and transportation. This research is described in more detail in this newsletter but I want to highlight the reasons why this research is important and challenging. First, the impacts of not addressing climate change are enormous yet there seems to be no urgency. Second, while the debate over the occurrence of climate change has subsided in the scientific community, the debate continues in the political arena. There is rarely consensus that the problems exist and must be addressed. Third, the uncertainty surrounding the magnitude and the extent of estimates of climate change, and the lack of downscaled regional estimates that are specific to a facility, type of service or network means that we are unable to capture the impacts for a specific location and understand how these impacts relate to the transportation services being provided. Fourth, transportation agencies are facing fiscal crises and lack resources for maintenance and improvement of existing facilities. Funding strategic improvements to address climate change is rarely an option. Finally, the importance of both mitigation of (reducing Green House Gases) and adaptation to (modifying infrastructure, operations or behavior in response to) climate change must be understood and communicated to decision makers and the public. Given the evidence that climate change is occurring, and the long time frames involved in transportation planning, our work has focused on exploring opportunities to react to the evidence of climate change using processes that are consistent with and complementary to existing transportation planning practices. While this approach focuses on regional solutions to a much larger scale problem, the process identifies projects that can then be input into the larger transportation planning process. This process then provides an opportunity for public and political scrutiny and evaluation.

The final example is an exciting UTC funded research project initiated this fall. Marcia Scott from the Institute of Public Administration, working with MPA students Arthur Wicks (also a UTC fellow) and Eileen Collins are looking at *Low-Cost, Intercity Express Bus Industry within the Northeast Corridor*. While intercity bus service is now the fastest growing mode of intercity transportation in the United States, intercity bus industry operations raise a number of policy questions including safety concerns. The importance of this study was underscored by a number of serious bus accidents earlier in 2011. Other transportation policy issues include the industry's unregulated environment, lack of intermodal linkages, operating inconsistencies among carriers, level of service vs. demand for service, impact on federally-supported transportation modes and competition among other intercity modes within the Northeast transportation corridor. We are looking forward to hearing more about this study in the near future.

These three examples illustrate the range of interesting and challenging transportation problems and the wealth of opportunities for research. The US DOT Secretary of Transportation's strategic goals (safety, state of good repair, economic competitiveness, livable communities, and environmental sustainability) underscore the breadth of issues and we see all of these goals being addressed to some degree by our ongoing UTC research. While individual projects focus on specific areas, all of our research is undertaken in the broader context of delivering transportation services, and as part of that we are contributing to developing the next generation of transportation professionals.

Sue McNeil
Professor, Department of, Civil & Environmental Engineering

Mosi London, Gillian McCarthy, Sekine Rahimian and Sue McNeil at the AISIM barbeque.
Photo Credit: Mohab El-Hakim, University of Waterloo

AISIM 2011

The 7th Annual Interuniversity Symposium on Infrastructure Management (AISIM) was held in June 2011 at the Northwestern University in Evanston, Illinois. This student run symposium provides an opportunity for students to present work in progress and network with other students. AISIM6 included a tour of Chicago transportation infrastructure, a keynote address by Steve Schlickman, former director of the Regional Transit Authority a networking event and conference barbeque.

The participants from the University of Delaware in the 2011 conference and their topics were:

- London, Mosi, "Application of Data Envelopment Analysis Method to the Transportation Performance Index"
- Rahimian, Sekine, "Modeling Transportation Systems after a Disaster"

Professor Sue McNeil and Gillian McCarthy also attended.

The 8th AISIM will be held at Georgia Institute of Technology on June 9, 2012. AISIM will be held in conjunction with the second Infrastructure Management Bootcamp (June 4-15), an intensive two week advanced infrastructure management course. Watch the UTC website for more information!

Brownbag Discussions

This Fall the UD UTC hosted four brownbag discussions. The first held on September 28, Professor David Ames and Sue McNeil presented their project on the Impacts of Climate Change on the I-95 Corridor. Professor McNeil explained that this project builds on the work of three students:

Chance Malkin
Climate Change and Rising Sea Levels: A Geographic Information Systems Analysis of the Potential Impact on Railroad Corridors in New Castle County, Delaware," Report, Summer Research Experience, August 2009

Michelle Oswald
Evaluation of Climate Change Adaptation Tools for Transportation and Land Use Planning," Analytical Paper, December, 2010.

Development of a Decision Support Tool for Transportation Adaptation Practices in Response to Climate Change," PhD Dissertation, May 2011.

Weifeng Mao
"The Impacts of Sea-level Rise on I-95 Corridor in Delaware," Analytical Paper, May 2011.

She then reviewed background and terminology and the results and directions for future work. Professor Ames then provided a more detailed analysis of the various types of land uses and transportation facilities that will be impacted along the I-95 corridor.

The second brownbag was held on October 19. During this brownbag, graduate student Leslie Mills presented the results of the research on the impacts of climate change on pavement performance. Leslie explained the framework used to connect the climate models (MAGICC: Model for the Assessment of Greenhouse-gas Induced Climate Change and SCENGEN: Scenario Generator), and the parameters used to characterize climate in the Mechanistic-Empirical Pavement Design Guide (MEPDG). Using a series of simulations pavement performance is tracked over time for three different sites. The research demonstrated that the framework is a useful tool and that for these three sites, climate change will not have a significant impact on pavement performance in the near term.

The third brownbag (November 11) was an interactive session on transportation and dance conducted by Lynnette Overby and her undergraduate assistant, Paige Glassman. Professor Overby from the Theater Department has developed curricula to teach transportation concepts through dance in elementary schools. At Elk Neck Elementary, Dr. Overby and her assistant taught lessons involving the industrial revolution, how to read a bus map, and early modes of transportation utilizing dance concepts such as space, time, force and body movement. Their assessments have shown a marked improvement with the student's retention of the concepts as well as engaging them in the creative process.

In the final brownbag of the semester (December 8), Professor Jennifer Righman McConnell described her research on "Investigation of Load-Path Redundancy in Aging Steel Bridges." The research has focused on the analysis assumptions that ignore some of the inherent strength of bridges and how that strength is measured and degrades with age. A lively discussion provided interesting insights into the perception of bridge strengths from a policy point of view.

Professor David Ames presents during the Brownbag Discussion

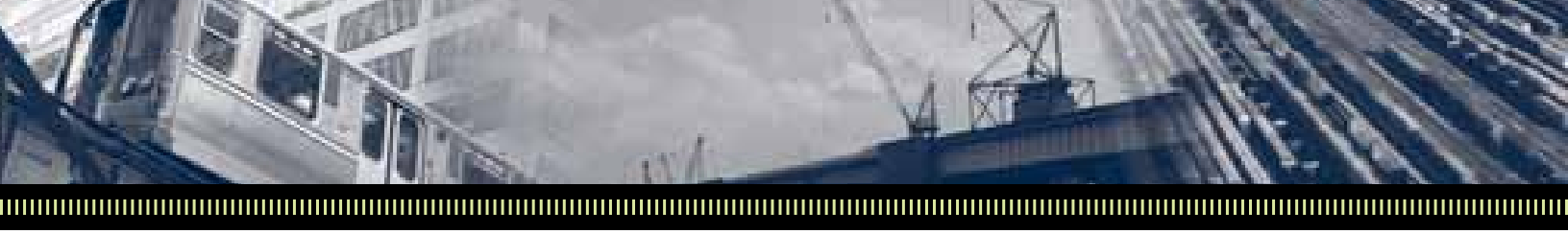
Student of the Year

UDUTC's 2011 Student of the Year is Laura Black. Laura is a PhD candidate in the Department of Civil and Environmental Engineering at the University of Delaware. She holds a Bachelor of Civil Engineering in Civil and Environmental Engineering with Honors and a minor in History, an MA in Urban Affairs & Public Policy and a MCE in Infrastructure Systems, all from the University of Delaware (UD).

Laura was a research assistant for several UTC funded and related projects including:

- Transportation Performance Index
- Infrastructure Security & Emergency Preparedness,
- Understanding the Impacts of Climate Change on the I95 Corridor in Maryland and Delaware

Laura also served as a mentor for an undergraduate in the UTC summer research program and an active participant in organizing the Annual Interuniversity Symposium on Infrastructure Management at UD in 2010. Most recently she has been instrumental in getting the Delaware Signal Timing Enhancement Partnership (DSTEP) project (a partnership between UD, Delaware Department of Transportation and a consultant) off to a successful start including coordination and training of undergraduates. In 2010 she was awarded a GAANN (Graduate Assistantships in Areas of National Need) Fellowship focused on transportation infrastructure. She is also engaged in teaching and is working towards earning the Higher Education Teaching Certificate. The title of her dissertation is "Investing in Interdependent Infrastructure."



UTC Projects on Climate Change and Transportation

Projects

UNDERSTANDING THE IMPACTS OF CLIMATE CHANGE ON THE I-95 CORRIDOR

Principal Investigators

David Ames and Sue McNeil

Graduate Research Assistants

Weifeng Mao and Michelle Oswald

THE IMPLICATIONS OF CLIMATE CHANGE ON PAVEMENT PERFORMANCE AND DESIGN

Principal Investigators

Qiang (Joshua) Li and Sue McNeil

Graduate Research Assistant

Leslie Mills

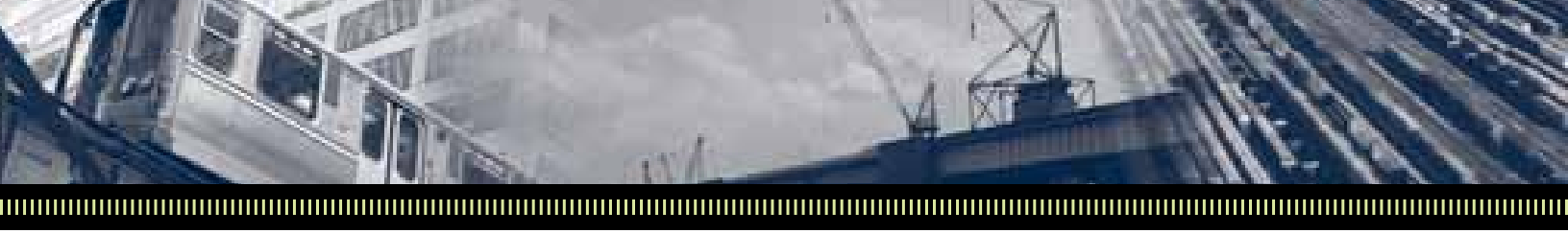
Two UTC projects have been exploring the impacts of climate change. The first project was initiated in 2009 and has focused on understanding the issues, the extent of possible impacts and strategies for adapting to climate change. The second project emphasizes understanding the potential impacts of climate change on pavement performance and how these changes might be accounted for in the pavement design. Both projects required us to understand the climate change models and what they might mean for this region.

Scientific studies predict that climate change will accelerate in future years, and have a significant impact on the built and natural environment. Mitigation efforts such as setting limits on emissions will not be sufficient, or timely enough to avoid all potential impacts of climate change. Therefore, in order to prepare and protect societies, economies, and the environment, adaptation efforts are necessary. Implementing designs that are responsive to climate change-induced factors to reduce impacts through transportation adaptation practice is fundamental to regional transportation planning in Delaware. Potential climate change impacts specific to the state of Delaware include increases in heat waves and very hot days, rising sea level and increases in intense precipitation events. Building on studies by Delaware Department of Natural Resources and Environmental Control models of inundation due to sea level rise, this study explores methods for analyzing potential climate change impacts on transportation infrastructure in Delaware, specifically the I-95 corridor. The application of a decision support tool for transportation adaptation titled, Climate Change Adaptation Tool for Transportation: Mid-Atlantic demonstrates the impact of different options under a variety of scenarios. A case study using the tool is implemented at the regional level for the Wilmington Area Planning Council (WILMAPCO). The methods implemented for adaptation planning in northern Delaware provide an example of how agencies throughout the country can begin to adapt to climate change. This study sets the stage for future work on the identification, prioritization and funding of adaptation projects.

In the second study the role of historic climatic patterns, reflecting local climate and incorporating assumptions about a reasonable range of temperatures and precipitation levels in highway design are explored. Given anticipated climate changes and the inherent uncertainty associated with such changes, a pavement could be subjected to very different climatic conditions over the design life and might be inadequate to withstand future climate forces that impose stresses beyond environmental factors currently considered in the design process. This paper integrates two tools: MAGICC/SCENGEN to address the potential climate change and its uncertainty, and the Mechanistic-Empirical Pavement Design Guide (MEPDG) software to analyze the deterioration of pavement performance, to explore the impacts of potential climate change and its uncertainty on pavement performance and therefore pavement design. Three important questions are addressed: (1) How does pavement performance deteriorate differently with climate change and its uncertainty? (2) What is the risk if climate change and its uncertainty are not considered in pavement design? and (3) How do pavement designers respond and incorporate this change into pavement design process? This paper develops a framework to incorporate climate change effects into the mechanistic-empirical based pavement design. Three test sites in the North Eastern United States are studied and the framework is applied. It demonstrates that the framework is a robust and effective way to integrate climate change into pavement design as an adaptation strategy. Furthermore, current pavement designs appear to be fairly immune to short term climate change but over the next few decades consideration should be given to checking if the historic patterns are reflecting the anticipated change in climate.

For more information see the research products listed below.

[Continued on next page]



Products

THE IMPLICATIONS OF CLIMATE CHANGE ON PAVEMENT PERFORMANCE AND DESIGN

Qiang Li, Leslie Mills and Sue McNeil, Final Report, University of Delaware University Transportation Center, September 25, 2011

www.ce.udel.edu/UTC/20110926_FinalReport_Pavement_ClimateChange.pdf

LITERATURE REVIEW: TRANSPORTATION ADAPTION IN RESPONSE TO CLIMATE CHANGE

Michelle Oswald, Working Paper, University of Delaware University Transportation Center, Summer 2009

www.ce.udel.edu/UTC/Presentation%2009/Literature%20Review%20Climate%20Change%20Adaptation%20_Oswald_090728.pdf

THE IMPACTS OF SEA-LEVEL RISE ON I-95 CORRIDOR IN DELAWARE

Weifeng Mao, Analytical Paper, Master of Arts, Urban Affairs and Public Policy

University of Delaware, May 2011

www.ce.udel.edu/UTC/Mao_5-19AP-1.pdf

EVALUATION OF CLIMATE CHANGE ADAPTION TOOLS FOR TRANSPORTATION AND LAND USE PLANNING

Michelle Oswald, Analytical Paper, Master of Arts, Urban Affairs and Public Policy, University of Delaware, May 2011

www.ce.udel.edu/UTC/Oswald-Analytical%20Paper_2010.pdf

DEVELOPMENT OF A DECISION SUPPORT TOOL FOR TRANSPORTATION ADAPTION PRACTICES IN RESPONSE TO CLIMATE CHANGE

Michelle Oswald, PhD Dissertation, Department of Civil and Environmental Engineering, University of Delaware, May 2011

www.ce.udel.edu/UTC/Michelle%20Oswald-phd%20dissertation%20FINAL.pdf

TRANSPORTATION PLANNING IN RESPONSE TO CLIMATE CHANGE: METHODS AND TOOLS FOR ADAPTATION IN DELAWARE

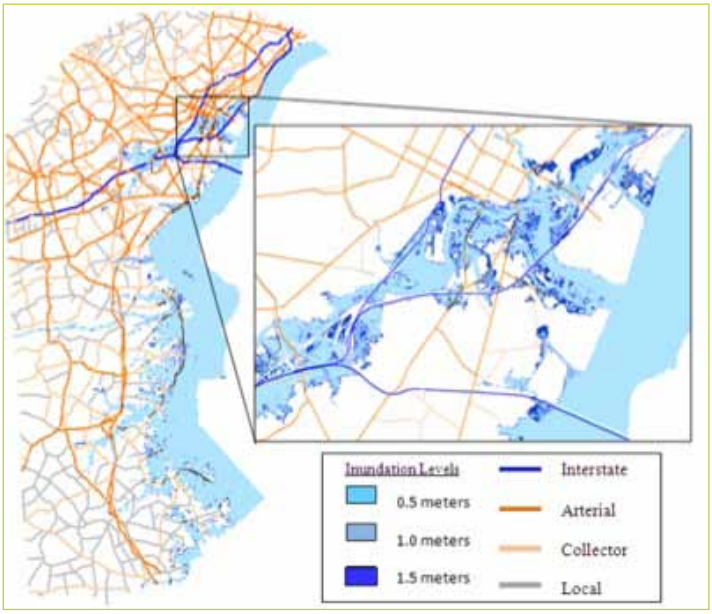
Michelle Oswald, Sue McNeil, David Ames and Weifeng Mao, presented at the 91st Annual Meeting of the Transportation Research Board, Washington DC, January 2012

Available on CD-ROM

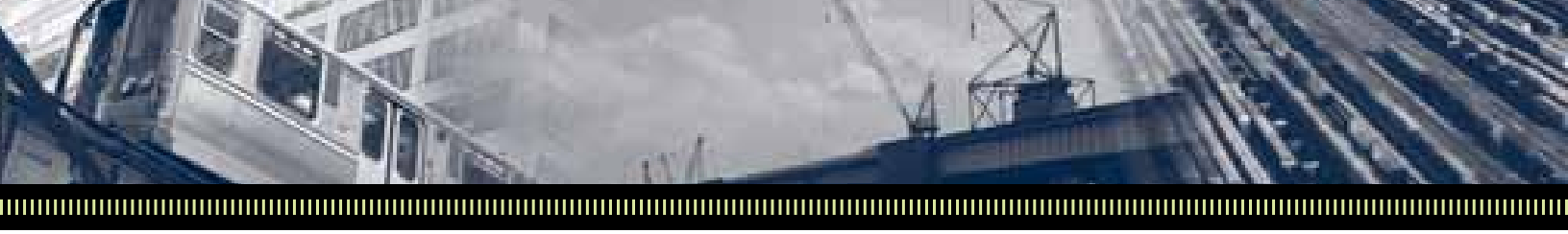
EXPLORING THE IMPACT OF CLIMATE CHANGE ON PAVEMENT PERFORMANCE AND DESIGN

Qiang Li, Leslie Mills, Sue McNeil, and Nii Attoh-Okine, presented at the 91st Annual Meeting of the Transportation Research Board, Washington DC, January 2012

Available on CD-ROM



New Castle County Sea Level Inundation

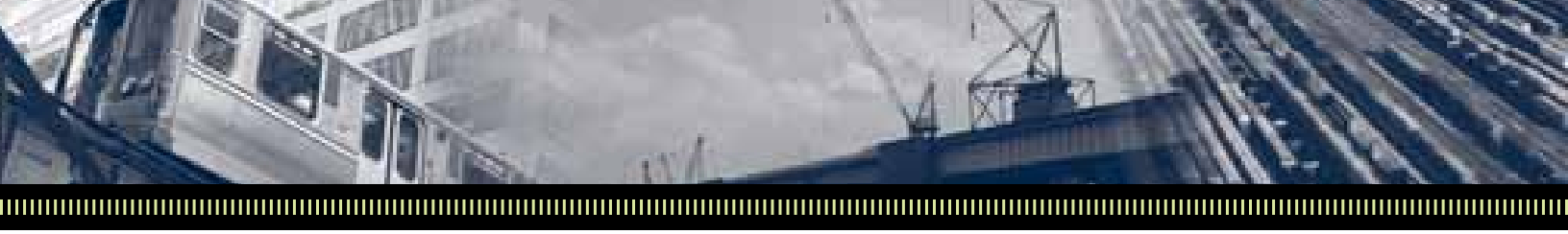


Participation in TRB Annual Meeting

Again University of Delaware faculty and students are participating in the Transportation Research Board annual meeting to be held in Washington DC in January 2012. Scheduled speakers are listed in the following table.

University of Delaware Presentations at the Transportation Research Board Annual Meeting, Washington DC, January 2012.

SESSION	DATA AND TIME	LOCATION	PRESENTATION TITLE	PRESENTER
344 - Innovation and Improvements for Pavement Management Systems	Jan 23 2012 2:00PM-3:45PM	Marriott	Developing Pavement Performance Models for Delaware	Leslie Mills, Nii Attoh-Okine and Sue McNeil
358 - Transportation Systems Performance Measurement	Jan 23 2012 2:00PM-3:45PM	Hilton	Using Data Envelopment Analysis to Explore State Transportation Infrastructure Performance and Economic Health	Mosi London, Sue McNeil and Qiang Li
414 - Innovations in Transportation and Land Development	Jan 23 2012 4:15PM-6:00PM	Hilton	Multiobjective Land Development Optimization Model	Reza Taromi, Michael DuRoss, Bintong Chen, Ardeshir Faghri and Tracy Deliberty
541 - Current Issues in Energy, Climate Change, and Alternative Fuels in Transportation	Jan 24 2012 10:45AM-12:30PM	Hilton	Transportation Planning in Response to Climate Change: Methods and Tools for Adaptation in Delaware	Michelle Oswald, Sue McNeil, David Ames and Weifeng Mao
638 - Implementation of Flexible Pavement Mechanistic-Empirical Pavement Design Guide	Jan 24 2012 4:15PM-6:00PM	Shoreham	Exploring Impact of Climate Change on Pavement Performance and Design	Qiang Li, Leslie Mills, Sue McNeil, Nii Attoh-Okine
804 - Status of Long-Term Bridge Performance Program	Jan 26 2012 8:00AM-12:00PM	Marriott	Panelist	Dennis Mertz



2012
Upcoming Events and Opportunities

Brown Bags
MARCH: Marcia Scott, Arthur Wicks, and Eileen Collins, "Low-Cost, Intercity Express Bus Industry within the Northeast Corridor", Location TBD.

DCT/UTC Distinguished Lectures
FEBRUARY: Dr. Ira Hirschman, Vice President with Parsons Brinckerhoff and head of PBs Economics Practice, "Economic Costs of Freight Transportation Supply Chain Disruptions."

Research Showcase
MAY: Research Showcase, Dover, DE

Deadlines
MARCH 1: Summer undergraduate research applications http://www.ce.udel.edu/UTC/Undergraduate.html

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To be added to the email distribution list, email Marikka Beach (marikka@udel.edu).