Summit Features Work by Sixteen Researchers

Leading Materials Researchers Present at Summit

The Upper Midwest Transportation Materials Summit brought leading materials researchers to Houghton for a one-day summit with state DOT and transportation industry professionals.

The Upper Midwest Transportation Materials Summit was held on November 4th with a total of 109 registered participants. On November 5th, faculty, staff and graduate students provided guided tours of the concrete, asphalt and material characterization laboratories located on the Michigan Tech campus. This event was co-sponsored by the Transportation Materials Research Center (TMRC) and the University Transportation Center for Materials in Sustainable Transportation Infrastructure (UTC-MiSTI).

Sixteen researchers provided project updates in the areas of concrete and asphalt pavements, bridge and structural design and aggregate and geotechnical topics. Michael Darter, principle engineer with Applied Research Associates and Professor Emeritus at the University of Illinois at Urbana-Champaign, discussed the status of MEPDG implementation, highlighting progress in its adoption through case studies. Darter reminded the participants that the original AASHTO guide (implemented in 1960-1970) was costly and time consuming and has resulted in a gross over design of HMA and PCC pavements. Darter gave a second presentation on the SHRP 2 composite pavement project. The project is scheduled for completion in 2011 and should provide refined and validated structural and performance models, design procedures and guidelines (recommended additions to the MEPDG), construction specifications, life-cycle costing procedures and training materials.

The topic of MEPDG implementation was further highlighted by Nicholas Vitillo, Rutgers State University, who provided insight on New Jersey’s approach to implementing MEPDG. Neeraj Buch, Professor at Michigan State University and Zhanping You, Associate Professor at Michigan Technological University, presented their research on quantifying the coefficient of thermal expansion values for concrete pavements (Buch) and identifying preliminary criteria for dynamic moduli of HMA in Michigan pavements (You).
Director’s Corner

Here we are in year five of Center operations, an unexpected opportunity provided by a continuing resolution to SAFETEA-LU. While congress wrestles with funding and development of the next transportation authorization, the needs for research and technology transfer to support state and national transportation systems grow.

When word of the additional year of funding arrived, our staff quickly engaged to identify opportunities to help meet the needs of the transportation industry. Two new graduate students were supported to continue work on internal projects. Learn more about Sarah Shann and Karl Krueger and their research investigations in this publication. Our technical advisory board met in November and recommended two new research projects, one of which is featured in this newsletter. The Center coordinated and co-sponsored a fall Summit attracting more than 100 regional transportation professionals. This fall the Center also entered into an agreement to support a national pooled fund effort to provide concrete pavement training for members of the National Concrete Consortium and the undergraduate transportation enterprise program was launched.

All of these activities are meeting a need and provide great opportunities for the UTC-MiSTI to continue its work to support our national transportation system.

UTC-MiSTI Funds New Research Investigation

Selecting a Combination of Sustainable Materials for Asphalt Mixtures

Project start date: March 1, 2011
Project end date: February 29, 2012

There are a number of innovations in asphalt pavement design and construction that can positively affect the sustainability of those pavements. These innovations include the use of recycled aggregates, recycled asphalt pavement, waste shingles, warm mix asphalt and bio-asphalt generated from biomass.

The purpose of this project is to investigate methods of integrating these recycled material into a single mixture design. Engineers normally select only one of these materials for asphalt pavement design and construction. A challenge to implementing these new technologies is the lack of a systematic approach to evaluating combinations of these materials.

This research will provide a systematic approach to selecting the right combination of these components in designing an asphalt mixture. The individual materials to be considered include warm mix asphalt (WMA) and recycled asphalt pavement (RAP). Dr. Zhanping You, principle investigator (PI), and Dr. Amlan Mukherjee, Co-PI, will utilize data from existing research projects to develop a systematic approach to selecting the optimum combination of materials with performance and life cycle in mind.
The deliverable will be a set of guidelines for a life cycle assessment (LCA) based selection approach for multiple streams of materials. Drs. You and Mukherjee are both faculty in the Department of Civil and Environmental Engineering at Michigan Tech. You’s research focuses on asphalt materials including RAP and WMA, and the use of other waste and recycled materials. Mukherjee’s research focuses on planning and decision making in infrastructure system management. He develops models and implements simulations that can aid decision makers in assessing design alternatives and in exploring what-if scenarios. The goal of his research is to investigate and predict behavior of civil infrastructure systems, and develop new predictive algorithms that support the decision-making processes.

Two professors from the University of Wisconsin-Madison, Drs. Hussain Bahia and Tuncer Edil, presented research focusing on efforts to make pavements more sustainable. Bahia reviewed the current understanding of key sustainability indicators for asphalt pavements and identified the gaps in data along with additional research needs to improve asphalt sustainability. Edil’s presentation provided experiences with highway design and construction using recycled materials. Edil serves as the Research Director for FHWA’s Recycled Materials Resource Center.

Michigan Technological University faculty members George Dewey and Stanley Vitton presented on-going aggregate research to determine the polishing resistance of carbonate aggregates in Michigan (Dewey) and the relationship of dynamic fracture of aggregate to the sustainability of PCC materials (Vitton). Vitton’s conclusions suggested that dynamic load testing may provide a means to test concrete micro-structures to better understand friction and other properties.

Norb Delatte, Chair of the Department of Civil Engineering at Cleveland State University, discussed research to examine internal curing as a method to improve the mechanical properties and durability of concrete. This work was conducted for the Ohio DOT.

Other university researchers covered bridge deck durability topics. Upal Attanayake, Assistant Professor at Western Michigan University, provided detail on the development of analysis models to calculate load demand at joints and design models for connections between adjacent box-beams and full-depth deck panels. This research may accelerate bridge construction and provide better durability by analyzing the structural system behavior and component interaction. Elin Jensen, Associate Professor at Lawrence Technological Institute, presented an on-going MDOT project to quantify the onset and development of accelerated corrosion in reinforced concrete bridge deck members. The study included environmental and mechanical loading influences. At Missouri University of Science and Technology, John Myers’ research identified a pre-blended rapid hardening material for crater repair to allow supplies to move quickly through explosive damaged routes in Iraq and Afghanistan.

Lev Khazanovich, Associate Professor at the University of Minnesota, provided an examination of the effect of climate modeling on pavement performance. Using the Enhanced Integrated Climatic Model and concrete thermal properties, Khazanovich demonstrated that local calibration of climatic inputs in MEPDG is important. Ben Krom, Michigan Department of Transportation reported on efforts by the department and Will Hansen, University of Michigan, to improve unbounded overlay design and construction practices for longer pavement life. Michigan uses unbounded overlays as a rehabilitation treatment for severely distressed concrete pavement repair. Bill Butlar, a professor at the University of Illinois at Urbana-Champaign, provided the final presentation on achieving durable, well-bonded asphalt overlays.

In a TV 6 news interview, MDOT’s Chief Operations Officer, Gregory Johnson commented on the importance of Michigan adopting the MEPDG, “We may have been overdesigning. Some states have found that their pavement thickness is too high for the given conditions, so we may see a change in pavement design and, therefore, a savings to citizens.”

Transportation Enterprise Profile
Profile of the Michigan Tech Transportation Enterprise

Written by Dr. George Dewey

The Transportation Enterprise is one of 27 Enterprise programs at Michigan Tech University. The Enterprise program gives undergraduate student teams the opportunity to solve engineering problems supplied by our industry partners. This innovative program helps to prepare students for the real-world challenges that they will face after graduation. This program also offers valuable new opportunities and perspectives to the sponsors, businesses, and organizations that partner with us.

The Transportation Enterprise started out as the Pavement Design, Construction, and Materials (PDCM) Enterprise in 2000 as part of a generous gift from Bob and Ellen Thompson. Initially, the Pavement Enterprise was focused primarily in the asphalt pavements area. In 2005, the Pavement Enterprise broadened its technical focus to encompass all pavement types and materials. Recently the technical focus of the program was again broadened to encompass all areas of Transportation. To better reflect this broader focus, the Pavement Enterprise name was changed to the Transportation Enterprise starting in Fall Semester 2010. While the Transportation Enterprise intends to maintain a strong focus in the pavements area, it is also seeking interested students and industry partners in the rail, bridge, airports, and asset management areas.

The Transportation Enterprise provides a vibrant learning environment where project activities provide not only technical challenges for our students, but where concepts such as sustainability, ethics, safety, business processes, innovation, creativity, and effective communications form an essential part of the context of problem solving. Some fundamental concepts of the enterprise program are that learning and application go hand-in-hand, and that students and faculty work in a team environment on problems of significance to industry.

Each project starts out with the enterprise and faculty member working with an industry sponsor to develop a detailed scope of work identifying deliverables, an anticipated schedule, and an expected project specific budget. Individual enterprise team members are assigned prescribed responsibilities corresponding to their level of maturity, abilities, and technical education. Depending on the project, students will do background research to better understand the problem or issue, perform testing and/or analyses, develop designs, and make recommendations, all within a specified budget and schedule. Faculty members and industry mentors act as coaches and mentors, helping to guide students in this discovery based learning process.

At the end of the academic year, each enterprise team submits a detailed written report on their project that includes results and recommendations. The students also deliver a presentation to faculty, industry mentors, and our professional Advisory Board. Upon request, students can also give a presentation on-site or via video conferencing to the project’s industry partners.

How Your Company Can Participate

The success of the Transportation Enterprise Program relies heavily on the support of industry, and we seek creative and forward-thinking partners to help set a new standard for engineering education by making the following commitments:

- Sponsor a team for $10,000 plus specific project expenses for a project of interest to your industry
- Identify a real-world engineering topic that will provide an educational challenge or possible benefit to your industry
- Designate professionals as mentors who communicate with students by phone, email, and video conference about technical matters

We invite you to become an industry partner of the Michigan Tech Transportation Enterprise. To learn more about the rewards and responsibilities of participating in the Enterprise Program, we encourage you to contact:

Program Advisor, George Dewey
Associate Professor, Department of Civil and Environmental Engineering, Michigan Tech University, Houghton Michigan, 49931. Phone (906) 487-2522 email: gdewey@mtu.edu

Benefits for Industry Sponsors of the Michigan Tech Enterprise Program

- Fresh look at important engineering problems and potential solutions through the eyes of an unbiased team
- Access to unique university facilities and faculty expertise
- Exposure to the latest tools, techniques, and theories from one of the nation’s premier engineering schools
- Opportunity to affect what students learn by having them work on projects affiliated with their field of study

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In the fall of 2010 the UTC-MiSTI participated as a funding partner to launch the newly re-focused Transportation Enterprise. UTC-MiSTI pledged support of up to $5000 each, for four projects, to help leverage industry sponsorship for the program and project teams. Four projects were identified with industry sponsorship/partnership:

**CXT/CN Sustainability Assessment:**
This project will work with prestressed concrete tie supplier CXT and CN Railroad to assess CXT’s operations in the context of CN’s sustainability initiative. Initial work will focus on developing baseline data for the sustainability of concrete ties and will then develop a model to measure progress toward meeting CN sustainability goals.

**Warm Mix Asphalt Application Synthesis for the Upper Midwest:**
This project will gather information on current practices and capabilities along with lessons learned from current Warm Mix Asphalt (WMA) applications in northern climates. The final product will be a white paper and webinar provided to the Minnesota Department of Transportation and the Transportation Engineering Road Research Alliance (TERRA). This project supports the Federal highway Administration’s Every Day Counts initiative by identifying innovative WMA technologies that will work best in northern climates where freeze-thaw and other environmental attributes impact a pavement’s longevity.

**City of Houghton Complete Streets Projects:**
This project is a continuation of a multiple-year alliance with the City of Houghton. The Transportation Enterprise will continue pavement assessment efforts and update deterioration curves for select streets. The team will also look at the concept of “complete streets” for Houghton as a way to accommodate pedestrians, bicyclists, transit and cars in a multi-modal transportation network. The team will explore electric vehicle infrastructure issues for Houghton and Campus to address the question of how cities can incorporate electric vehicle charging stations into existing infrastructure. This project is being co-sponsored by General Motors.

**Carbonate Aggregate Characterization:**
This project is a continuation of previous efforts to develop a relationship between MDOT aggregate wear track results and material properties. Properties of selected aggregates will be determined, including their bulk and apparent specific gravity, porosity, and grain size. Other techniques such as x-ray diffraction micro-deval will also be employed to characterize the aggregate properties. These measured properties will be correlated with MDOT Aggregate Wear Index results. This high-profile project has the potential to have a national impact on selecting aggregates for pavement surface friction.

**Benefits for Student Members of the Transportation Enterprise**
- Hands-on experience solving real-world engineering problems by applying both technical and business skills
- Exposure to the complications of real engineering projects
- Learn project management skills
- Experience the importance of teamwork in engineering and the challenges associated with working on a diverse, cross-functional team
- Address multiple objectives and communicate effectively with diverse constituents.
UTC Supports National Pooled Fund Effort
Training Available for State NCC Members

The TTCC pooled fund, TPF-5(159), supports the participation of its members in the National Concrete Consortium (NCC), an organization for state highway agencies to exchange information on concrete pavement technologies and common challenges. TP-5(159) also provides NCC states with technology transfer materials and training through the National Concrete Pavement Technology Center (CP Tech Center) at Iowa State University as funding permits. In 2011, with additional support from the UTC-MiSTI, the CP Tech Center has been authorized by the NCC Executive Committee to deliver trainings to each state member of the NCC (See right for a list of available courses).

The CP Tech Center will arrange for subject matter experts to teach each course and provide all training materials. The State DOTs will work with local industry representatives to do the following:

• Select the specific subject for the training
• Identify the desired date for the training
• Arrange for the training venue
• Arrange for meals and breaks
• Identify the training audience (DOT, city, county, industry, consultants) and send out the invitations to attract a target class of approximately 40 to 50 participants

If you have interest in holding a training event this year, please contact Dale Harrington (dharrington@snyder-associates.com 515-290-4014) at Snyder and Associates who will be coordinating the training delivery on behalf of the CP Tech Center and the UTC-MISTI.
2011 NCC One-Day Training Workshop Curriculum

IMCP Manual, Integrated Materials and Construction Practices for Concrete Pavement:
This manual provides a ready reference for those involved in designing and constructing concrete pavements. Understanding concrete pavements as an integrated system and pavement construction as an integrated process will help workshop attendees optimize concrete pavement performance.

Design and Construction of Concrete Overlays:
Agencies need proactive, sustainable pavement maintenance and rehabilitation strategies that last longer at reasonable cost. In many situations, concrete overlays represent such strategies. This course is designed to provide the knowledge so pavement owners can confidently include concrete overlays in their toolbox of pavement solutions.

Roller Compacted Concrete:
Roller-compacted concrete (RCC) is an economical, fast-construction candidate for many pavement applications. It has traditionally been used for pavements carrying heavy loads in low-speed applications. However, in recent years its use in commercial areas and for local streets and highways has been increasing. This course provides detailed overviews of RCC properties and materials, mixture proportioning, structural design issues, and production and construction considerations.

Concrete Pavement Surface Characteristics:
Until recently there has been a lack of collective understanding in the concrete paving industry of what makes some concrete pavements quiet and others not. This course addresses the knowledge gained from recently completed research TPF-5(139) on how to optimize the surface characteristics of concrete pavements. Included will be guidance on better practices for surface properties, detailed instruction on how to reduce tire-pavement noise, and an overview of desirable guide specifications for various surface characteristic objectives.

Pervious Concrete Design and Construction:
This course will address the site design, structural and hydraulic design, and construction and maintenance considerations of pervious concrete pavement applications. The applications discussed in the course includes: parking areas, highway shoulders, low volume roadways, high volume wearing course overlays, curb and gutter, hydraulic and sounds mitigating structures.

Early Age Cracking in Concrete Pavements:
This course addresses the cause and prevention of early age cracking in concrete pavements. The training includes information on design, materials, construction and maintenance considerations. Included in the course is training on how to use HIPERPAVE as a tool to predict the conditions that may increase the risk of cracking.
Meet Sarah Shann

I am Sarah Shann, a student at Michigan Tech, and I'm currently pursuing a Master’s of Science degree in Civil Engineering with an emphasis in structural engineering. My hometown is Escanaba, Michigan and I am a true ‘Yooper.’

Aside from my interest in math and science occupations, I knew civil engineering was for me when my father and I built our home between my freshman and senior years of high school. Gaining hands-on construction experience, as well as being involved in the initial architectural plans, extremely influenced my career path.

My first experience with Michigan Tech was in 2005 when I participated in Michigan Tech’s Women in Engineering program, which is a week long program for high school females to explore math, science, and engineering careers. After considering several universities for my Bachelor of Science degree, I decided to enroll at Michigan Tech for its outdoor activities, its international programs such as Engineers Without Borders, and its excellent prestige as an engineering university. As I progressed through my coursework, I found myself more interested in the structural aspects of Civil Engineering, particularly bridge design and construction.

I was fortunate to have three internships during my undergraduate degree. The first internship was in the summer of 2007 at Toyota Motor Engineering and Manufacturing in Ann Arbor, Michigan. I worked as a plant engineering intern in maintenance and operations where I learned about building facility management and bid proposals. My second internship, in 2008, was with the Michigan Department of Transportation, where I worked on crush-and-shape and new road construction sites conducting inspections, material tests, and site surveys. My most recent internship this past summer was with Kiewit Engineering Company (KECo) in Omaha, Nebraska. There, I was a structural engineering intern working on the design of temporary structures such as formwork and falsework, as well as rigging for high-risk crane picks. Through this internship, I had the opportunity to work on 10 Kiewit projects across the United States and Canada. After four and a half years and these three enlightening internships, I completed my Bachelor of Science degree in December 2010, graduating cum laude.

I chose to remain at Michigan Tech for my Master’s of Science degree to research the performance, constructability, and sustainability of using Ultra High Performance Concrete (UHPC) as a thin overlay on concrete bridge decks. I chose this topic due to my interest in bridge design and construction, as well as my interest in sustainable materials.

Ultra High Performance Concrete (UHPC) is an extremely dense and ductile material that is fiber reinforced and contains no coarse aggregate. With a 28-day compressive strength over 26 ksi and notable tensile capacity, UHPC allows for the reduced maintenance and extended service life of concrete infrastructure. If applied as an overlay, this ultra-high strength concrete can also improve the bridge carrying capacity and load transfer. UHPC has high early-strength gain, which substantially decreases construction time. Its dense matrix has negligible permeability and excellent freeze-thaw resistance that further contributes to UHPC’s attractiveness as an overlay material. I am working with Dr. Devin Harris to determine if UHPC will be an adequate and economical solution over the service-life of a concrete bridge deck.

The purpose of this research is to evaluate the feasibility of extending the service-life and reducing maintenance requirements of the nation’s bridge infrastructure. For typical bridges this
deterioration occurs due to a variety of factors, but a major contributor to the overall degradation comes in the form of deteriorating concrete bridge decks. The function of an overlay is to extend the life of the bridge deck by providing a durable wear surface, and increasing resistance to chloride ion ingress and other chemical and environmental attacks. This protection is especially needed in “salt states” like Michigan, whose harsh winters and severe freeze-thaw cycles cause accelerated deterioration of transportation infrastructure. Only halfway through my first semester as a graduate student, this research project is developing my understanding of bridge design and construction, the sustainable use of transportation materials, finite element modeling, and life-cycle analysis.

Meet Karl Krueger

My name is Karl Krueger and I am from New London, Wisconsin. I completed my undergraduate work at the University of Wisconsin-Platteville in May 2010 with a degree in Civil Engineering with emphasis on structural and geotechnical engineering. During my senior year, I was considering graduate school as an alternative career path. After a campus visit in late October I decided that Michigan Tech was the right place for me. At that time, I was planning on focusing on structural courses and research, but after a summer internship with a geotechnical firm, I changed my focus towards geotechnical engineering.

During my first semester at Michigan Tech, I worked as a graduate teaching assistant for Dr. Mattila, working in the area of construction management and assisting Dr. Mattila in his two courses in construction management. During this semester I took geotechnical engineering courses from Dr. Hodek and Dr. Vitton and I was ultimately offered an opportunity to work on a research project with Dr. Vitton.

The research focused on the development of a new instrument for testing the stiffness of soil and aggregate bases. The device is modeled after a device known as the Clegg hammer, which was developed in the 1970’s. The Clegg hammer works by measuring the dynamic impact of a steel weight striking a base material using an accelerometer embedded in the steel. The Clegg has shown good correlation in measuring stiffness and density of sands, but does not work well on stiff aggregate materials or cohesive soils.

Dr. Vitton’s research involves modifying a light Clegg hammer, which is made out of a solid section of PVC, with a flexible handle attached to the PVC. As the hammer, which is now a section of solid PVC, strikes the base the impact energy is absorbed by the flexible handle and the hammer’s corresponding vibration response is then measured. The vibrational response is analyzed using various techniques resulting in a direct measure of the bases stiffness.

The benefit of having an instrument to accurately and rapidly measure soil stiffness is clear. Highway embankment design is currently performed on a purely empirical basis. That is, soil strength and stiffness are estimated based on soil density. Unfortunately, soil density is generally tested on less than one percent of the material placed during highway construction. Needless to say, given the ambiguity of density-stiffness correlations in combination with limited testing, actual engineering properties of highway embankments remain highly uncertain. Transportation engineers have recognized this problem and are currently developing a mechanistic design approach to highway embankments. An accurate measure of soil stiffness would be invaluable to an engineer using a mechanistic design. The goal of my research is to develop the Clegg hammer into a reliable tool to measure soil stiffness in a broad range of materials leading, to a new standard for compaction control testing in the near future.
About Michigan Technological University

Michigan Technological University is a leading public research university, conducting research, developing new technologies, and preparing students to create the future for a prosperous and sustainable world. Michigan Tech offers more than 120 undergraduate and graduate degree programs in engineering, forestry and environmental sciences, computer sciences, technology, business and economics, natural and physical sciences, arts, humanities and social sciences.

About the University Transportation Center for Materials in Sustainable Transportation Infrastructure

The University Transportation Center for Materials in Sustainable Transportation Infrastructure (UTC-MiSTI) at Michigan Technological University is a Tier II UTC. The Center conducts research, educational activities, technology transfer and workforce development in the areas of sustainability and infrastructure materials that address state and national transportation needs. Faculty, staff, students and industry work collaboratively to identify creative solutions to construct repair and maintain highway and airport pavements, bridges and rail systems.

Areas of material specialization include bituminous materials and asphalt binders; portland cement and ultra-high performance concretes; material characterization through petrographic analysis; aggregates, soils and geotechnical applications; and the use of recovered industrial materials including fly ash, slag, and cement kiln dust, and recycled asphalt and concrete materials. For more information on the activities of the UTC-MiSTI, visit the Center’s Website: www.misti.mtu.edu

About University Transportation Centers

The University Transportation Centers (UTC) program, initiated in 1987 under the Surface Transportation and Uniform Relocation Assistance Act, authorized the establishment and operation of transportation centers in each of the 10 standard federal regions. The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) reauthorized the UTCs for an additional six years and added four national centers and six University Research institutes (URI). The mission of the 14 UTCs was to advance U.S. expertise and technology transfer. The six URIs each had a specific transportation research and development mandate.

In 1998 the Transportation Equity Act for the 21st Century (TEA-21) reauthorized the UTC Program for an additional six years and increased the total number of Centers to 33. In addition to the ten regional Centers, which were to be selected competitively, TEA-21 created 23 other Centers at institutions named in the Act. TEA-21 established education as one of the primary objectives of a University Transportation Center and institutionalized the use of strategic planning in university grant management.

The Safe, Accountable, Flexible, Efficient Transportation Equity Act, enacted on August 10, 2005, authorized up to $76.7 million per year from Federal FY2005-2009 funds for grants to establish and operate up to 60 University Transportation Centers throughout the United States. Twenty of these centers were competitively selected during 2006, and forty centers are located at institutions named in the legislation.

The UTC program is managed by the Research and Innovative Technology Administration, U.S. Department of Transportation.