Michigan Technological University’s (Michigan Tech) location near the northern most tip of the Upper Peninsula provides year-round outdoor adventure, wilderness and remoteness. Located eight hours from Chicago, nine from Detroit, and seven from Minneapolis, our students and faculty frequently spend their free time pursuing outdoor activities like skiing, snowmobiling, hiking, fishing, hunting, and mountain biking. In spite of this remoteness, or perhaps partly because of it, the University has a strong history of conducting applied research in the area of transportation materials.

From an early point in their Michigan Tech education, undergraduates participate in research through our successful Enterprise and Senior Design Programs. Ninety percent of the patent disclosures filed by the University include students as inventors and our student graduates benefit from a 98% campus wide placement, many averaging more than five interviews and multiple job offers.

The faculty and staff engaged in developing the strategic plan for the University Transportation Center for Materials in Sustainable Transportation Infrastructure (UTC-MiSTI) chose a different approach to how the UTC-MiSTI would conduct research. Historically, many UTCs elected to allocate a portion of their award to research administered through a traditional “call for proposals” to fund small projects. Michigan Tech is doing something different. Capitalizing on their existing research expertise in the area of applied transportation materials, the UTC-MiSTI focused on applying that expertise to develop a research program that specifically addressed sustainability. Driven by diminishing natural resources, increases in carbon emissions and green house gases, and unending supplies of waste material piling up in landfills, the “cost” of repairing, maintaining and constructing transportation infrastructure is economic, “socionomic” and “environomic”.

Our approach was to encourage faculty with expertise in transportation materials to address sustainability in their research. To prepare students to grasp the attributes of sustainability and incorporate them in their decision making and general thought processes, sustainability concepts would be integrated into the curricula. Life cycle analysis, reducing the carbon footprint, end use-reuse or new use would become considerations in research going forward. The UTC-MiSTI resources would be used to educate researchers and students to better understand these concepts, to seed future research with mini-sustainability initiatives, and develop proposals to secure outside funding for larger research initiatives that could contribute towards the cost share requirement for the Center.

As a small, Tier II UTC, we felt that we could make a greater impact on research and sustainability in transportation infrastructure materials by emphasizing our research expertise and embracing sustainability attributes in our research endeavors. Given the size of our operating budget, our approach was to not fund small applied research projects but to support the development of our researchers, technical staff and students to engage in a greater understanding of sustainability. The Center is funding internal research initiatives which provide faculty and students the opportunity to develop ideas that are then presented to potential external sponsors. These initiatives undergo review by the Center’s Technical Advisory Council to ensure that we’re meeting state and national transportation needs.

Elizabeth Hoy
Assistant Director, UTC-MiSTI
Director’s Corner

In this issue we present summaries of ongoing or recently completed externally-funded materials-related research supporting our Center’s mission. These are projects that are contributing in some way to the cost share and overmatch goals, in addition to achieving the technical goals of the Center. In turn, these projects receive support from the Center that may include hourly or supported student research assistants, technology transfer and outreach, report editing and proofing, or travel support to present at conferences and workshops.

We have also included the latest round of internally supported research initiatives conducted during our 2008 Summer Scholars program. The UTC’s Summer Scholars Program employs students as research assistants on these initiatives through hourly support. This program provides researchers with support to conduct investigations into sustainability attributes as they relate to transportation materials, which may in turn lead to externally funded research. It also provides students an opportunity to work with faculty on research, providing mentoring opportunities for graduate students and graduate level research experiences to undergraduates who are considering graduate studies. The program has been very effective at introducing research and graduate education to promising undergraduate students while allowing students and faculty to become acquainted with each other. A principal intent is to increase the number of students that choose graduate school after obtaining their undergraduate degree. A secondary intent of the program is to develop new areas of research. Overall, the program is instrumental in achieving three of our main goals: research, education, and workforce development.

- Larry

Project Summaries are Available on the UTC-MiSTI Website

We have detailed project summaries available on the UTC-MiSTI website in Adobe pdf format. Check out the Publications page at <http://www.misti.mtu.edu/publications/pubs.php> for a complete listing of all available publications.
Externally Funded Research

Efficient Use of Recycled Concrete in Transportation Infrastructure

Dr. Jacob Hiller, assistant professor in the Department of Civil and Environmental Engineering, is exploring the efficient use of recycled concrete in transportation infrastructure through a project sponsored by the Michigan Department of Transportation (MDOT). The project will focus on characterizing recycled concrete materials for use in new portland cement concrete (PCC), asphalt concrete (AC), and base layer pavement applications. This will include the characterization of recycled concrete in terms of aggregate properties, solubility of contaminants, stabilization potential, chloride content, ASR potential, freeze-thaw, performance effects on the air void system, and the overall effect on concrete physical properties. This project will provide guidelines to promote increased use of recycled concrete in high-quality, sustainable, transportation infrastructure. This will help to reduce transportation and disposal of replaced concrete elements and decrease the use of virgin raw materials.

Evaluation of Concrete Pavements with Material-Related Distress

Dr. Larry Sutter, director and professor, Michigan Tech Transportation Institute, is evaluating concrete pavements with material-related distress in a project sponsored by MDOT. The project focuses on the fine aggregate (sand) used in concrete construction contains material that in some cases can cause expansion when used in PCC. In turn, this expansion leads to the subsequent deterioration of the concrete. This expansion is more prevalent when the concrete is prepared using industrial waste materials, such as fly ash or blast furnace, as part of the concrete mixture. This research will help identify the mechanisms that causes the described expansion and will identify methods to mitigate the attack, thereby allowing for greater use of fly ash and blast-furnace in PCC mixtures.

Impact of Hydrated Cement Paste Quality and Entrained Air-Void System on the Durability of Concrete

Dr. Larry Sutter is investigating the impact of hydrated cement paste quality and entrained air-void system on the durability of concrete. This project, sponsored by MDOT, will address the fact that concrete mixtures have undergone numerous changes in recent years that involve use of more recycled materials. As the mixtures have changed, methods of specifying key design parameters have not been updated accordingly. As a result, unnecessary limitations may be put on recycled material use, or, conversely, concrete is placed that is not durable. By establishing the qualities and characteristics of hardened cement paste containing recycled materials, new specifications can be evaluated that will allow increased use of these materials while ensuring increased service life for structures constructed using these materials.

Reduction of Minimum Required Weight of Cementitious Materials in WisDOT Mixes

Dr. Larry Sutter is investigating for the Wisconsin Department of Transportation the options for reducing the minimum required weight of cementitious material in PCC. Many states have ad-
opted specifications allowing portland cement concrete pavement mixtures with less than 565 lbs/yard of cementitious materials content (CMC), which is currently required under WDOT specifications. This study will examine the durability of mixtures with lower CMC content. Portland cement production is a significant contributor to the total green house gas emissions in the world. Reducing portland cement consumption is the simplest way to reduce this greenhouse gas production. Therefore, methods of constructing concrete highways and bridges using less portland cement will greatly reduce the environmental impacts of portland cement concrete use.

**NCHRP 18-13 Specifications and Protocols for Acceptance Tests of Fly Ash Used in Highway Concrete**

Dr. Larry Sutter is the principal investigator on the National Cooperative Highway Research Program (NCHRP) 18-13 Specifications and Protocols for Acceptance Tests of Fly Ash Used in Highway Concrete. There are currently over 71 million tons of pulverized coal combustion byproducts produced in the United States, with only 39% beneficially utilized. To increase the utilization of fly ash in concrete, it is essential to have definitive performance predictors for the acceptance of fly ash. The project will investigate new test methods for characterizing coal fly ash and develop strategies that can be used on a day-to-day basis to increase the volume of fly ash used in concrete production. Increased fly ash utilization provides a net environmental benefit by reducing the material placed in landfills and reducing the demand for portland cement. The latter can significantly impact the production of greenhouse gases and reduce production of other industrial by-products such as cement kiln dust. This research will lead to new specifications for use of fly ash in highway construction that will allow for a significant increase in fly ash utilization.

**A Microstructure-Based Modeling Approach to Characterize Asphalt Materials**

Dr. Zhanping You, assistant professor in the Department of Civil and Environmental Engineering and director of the Transportation Materials Research Center, is investigating a microstructure-based modeling approach to characterize asphalt materials as part of a National Science Foundation (NSF) project. A discrete element method is used in this study to model the microstructure of the aggregate-aggregate contact/interlock. It is anticipated that the models can be used to evaluate asphalt mixture material response and performance to improve pavement materials and structural design. The project will provide a fundamental understanding of pavement materials and structures from a materials science (i.e. microstructural) stand point [to increase durability]. The modeled asphalt mixtures can be either recycled or new materials.

**Development of Specifications for the Superpave Simple Performance Tests**

Dr. Zhanping You is also developing for MDOT specifications for the Superpave simple performance tests. This research project will conduct laboratory testing to evaluate key parameters for typical Michigan HMA mixtures. The results of the laboratory study will be correlated to field performance to develop a simple performance standard for asphalt mixture accounting for the effects of traffic loads on the key parameters of a mixture design. The research results will be used to implement the new AASHTO mechanistic-empirical design procedure. The project results will be applicable to both virgin and recycled asphalt mixtures.
Development of New Test Procedures for Measuring Fine and Coarse Aggregate-Specific Gravities

Dr. Zhanping You is developing for MDOT new test procedures for measuring fine and coarse aggregate-specific gravities. This research project will use a new technology to evaluate the specific gravity of various gradations of fine aggregates. The project will also determine if vacuum saturation of coarse aggregate, in lieu of a 24-hour soak period specified in AASHTO T85, can provide similar specific gravity values. The project can potentially provide fast and reliable test methods for determining the specific gravity of fine and coarse aggregates, thereby reducing the testing time by over 80%, which in turn will reduce reducing overall construction costs. The testing methods can be on new and recycled aggregates.

Synthesis Of Railroad Engineering Best Practices In Deep Seasonal Frost And Permafrost Areas

Dr. Pasi Lautala, assistant professor in the Michigan Tech Transportation Institute, is developing a synthesis of best practices for railroad engineering in deep snow, seasonal frost, and permafrost. The project is sponsored by the University of Alaska at Fairbanks and will identify and compare differences in techniques and methods used, including a comparison of concrete versus wooden ties. The review of current and historical design, construction, and maintenance standards of rail infrastructure will include an evaluation of utilized cross-sections and materials. Similar activities will also be conducted to investigate the past and current utilization of concrete ties in such regions. The information obtained will be central to the design and construction of the proposed Alaska-Canadian Rail Link, currently being planned. Once established, the rail link will provide greater access to the vast resources of Alaska and Western Canada.

Warm Mix Asphalt: An Environmentally Friendly Asphalt Pavement Material

Dr. Zhanping You is investigating the use of warm mix asphalt as a more sustainable paving material for MDOT. Hot mix asphalt (HMA) has been traditionally placed at a discharge temperature of between 280°F (138°C) and 320°F (160°C), resulting in high energy costs and generation of greenhouse gases. The goal for warm mix asphalt (WMA) is to use existing HMA plants and specifications to produce high quality, dense graded mixtures at significantly lower temperatures. Europeans are using WMA technologies that allow the mixture to be placed at temperatures as low as 250°F (121°C). It is reported that as compared to HMA, energy savings on the order of 30%, with a corresponding reduction in CO₂ emissions of 30%, are realized when WMA is used. It is anticipated that this comprehensive laboratory study of WMA will provide a better understanding of the performance of WMA and the results will be very valuable for implementing WMA in practice. WMA can be used in a recycled asphalt pavement project. For example, when a large amount of recycled asphalt material is used, the difficulty in compaction may be addressed with the use of additional WMA materials. Overall, there are a number of benefits such as lower energy consumption (reduce fuel costs), reduce mixing and compaction temperature, lower fumes and emissions.
They came to Michigan Tech from two sides of the world to study two different transportation materials - concrete and asphalt. However, the driving force behind their research, sustainability of transportation infrastructure, places Melanie Kueber and Shu Wei Goh side-by-side under the research and educational activities of the University Transportation Center for Materials in Sustainable Transportation Infrastructure (UTC-MiSTI) at Michigan Tech.

Shu Wei Goh is a second year PhD student from Perlis, Malaysia working with Dr. Zhanping You. He completed his undergraduate degree in Civil Engineering at Michigan Tech in 2006, during which he also worked as an hourly research assistant with Dr. You. He conducts research in the area of bituminous materials with a focus on developing sustainable asphalt pavements. He also conducts research in the area of warm-mix asphalts, recycled asphalt pavement, and the utilization of bottom ash in asphalt mixtures. He is a 2008 Dwight David Eisenhower Fellowship recipient and a 2007 and 2008 UTC-MiSTI Summer Scholar.

Melanie Kueber is from Munising, Michigan, about 150 miles east of Houghton and Michigan Tech’s campus. Her first experience with Michigan Tech came in 1994 as a participant in the Michigan Tech’s Women in Engineering Program (WEI). WEI provides opportunities for high school women to spend a week on campus exploring career options in math, science, and engineering. She subsequently attended Michigan Tech and earned a BS in Civil Engineering in 1998. In 2002 she received her MS in Project Management from Northwestern University and continued on to become a licensed Professional Engineer. She started her career in the Chicago area at the Illinois Department of Transportation (IDOT) where she specialized in hydraulics and hydrology and engineering coordination with the Federal Highway Administration (FHWA) and municipalities.

After gaining experience with IDOT, she made a career change to a consulting position with Christopher B. Burke, Ltd., specializing in hydraulics and hydrology and design for construction. She began the PhD program at Michigan Tech in May 2007.

**INTERVIEW QUESTIONS:**

**What attracted you to Michigan Tech and Civil Engineering?**

**Shu Wei:** I came to Michigan Tech because of their Civil Engineering Program Rankings. I chose Civil Engineering because I wanted to help build a better world. I’ve specifically focused on transportation because, although people in developed counties tend to take it for granted, a safe and reliable transportation system is vital to a country’s development, long-term economic growth and quality of life.

**Melanie:** Through the Women in Engineering Program I learned civil engineers specialize in a variety of areas including transportation, geotechnical, structural, and environmental engineering. At that time, I was interested in geotechnical engineering, because I had a passion for geology and materials science. The information about the careers I received from the Women in Engineering Program suggested that job opportunities civil engineering were very diversified and readily available. I chose civil engineering because I could diversify my studies. Ultimately, I pursued geotechnical and transportation engineering, as well as project management, as my civil engineering focus areas.
Why are you pursuing a PhD?

Shu Wei: I decided to pursue a PhD to further develop my skills to contribute to the profession, to continue improving my communication skills, and to build an area of expertise.

Melanie: As a practicing engineer, I learned the ultimate goal of design is construction. Through my engineering career, I have had the opportunity to mentor less experienced engineers on how to apply theory to design constructible infrastructure. I want to continue teaching engineering students how to design and build sustainable infrastructure.

How have you benefited from your involvement with the UTC-MiSTI?

Shu Wei: The UTC has provided broad interactions and networking, both on and off campus. Through the Summer Scholars program, I’ve had the opportunity to work with more faculty, to be a part of a greater collaboration towards sustainable development, and develop greater unity in my research and education.

The UTC offers additional opportunities for leadership by providing opportunities for mentoring, professional development, and opportunities to improve my communication skills—both in public speaking and through poster presentations and conference/workshop participation.

Melanie: Because of the UTC, I have had the opportunity to research materials such as fibers, recycled concrete, and fly ash for use in concrete. All of these materials will greatly impact sustainability given that virgin materials are becoming increasingly scarce. I have also been encouraged to broaden my background by including chemistry coursework in my studies. Chemistry has provided me the background to approach materials by looking at internal mechanisms and to better understand how traditional materials interact, potentially affecting sustainability.

Since I have been encouraged to take this multi-disciplinary approach, I have been able to work more closely with environmental engineers. This includes my participation in the Summer Scholars program where I was able to work with and mentor an environmental engineering undergraduate student on a sustainable materials project.

What are your plans after graduation?

Shu Wei: I’d like to test my entrepreneurial ambitions by starting a transportation materials research company.

Melanie: I am very thankful for the opportunities and teachers I have had throughout my career. I appreciate all the people who took their time and energy helping me to become the engineer I am today. As a result, I would like to give back by seeking a faculty position where I can teach students. My goal is to excite students about learning and motivate them to become successful engineers and make positive contributions to society.

What do you see as your future contribution to Transportation and Society?

Shu Wei: I hope my contributions will help transportation and society achieve a new level where sustainability is the foundation of engineering, science, and technological development.

Melanie: I want to continue to develop my understanding of the sustainable use of transportation materials, life cycle analysis, and renewable energy. Through these topics as mediums for learning, I hope to lead students and work side by side with them, as students are the future. I hope to continue, as those before me, to turn aspects of these topics into research projects—partnering with industry and government to ultimately become a more resourceful society.
The Summer Scholars Program addresses the educational, research, and workforce development goals of the Center by providing students and faculty with an opportunity to work towards developing a better understanding of sustainability and materials used in transportation infrastructure. Students and faculty alike learn more about the social, environmental, and economic attributes of sustainability through internal investigations aimed at developing externally funded research ideas. As hourly research assistants, undergraduates have an opportunity to experience graduate level research in the area of transportation materials while graduate students provide mentorship and guidance as they work in teams with faculty to explore their ideas. To date, the work done during the 2007 program has yielded a number of publications and two externally sponsored research projects. Shu Wei Goh and Melanie Kueber, featured on pages 6-7, were two of the fifteen participants in the first Summer Scholars Program held in 2007 at Michigan Tech.

**2007 Summer Scholars Students and Their Projects**

- Duane Campbell (BS) *Freeze-thaw testing to ASTM standards comparison*
- DaVaughn Dixon (BS) *Construction management and planning*
- Kyle Ellis (BS) *Effects of deicing chemicals on asphalt and PCC pavements*
- Alex Kiehri (BS) *Examination of performance based engineering and sustainability*
- Jordan Leep (BS) *Reliability-based evaluation of loading configurations for long-span bridges*
- Christopher Warren (BS) *Reduction of cementitious materials content in PCC*
- TJ Bates (MS) *Reduction of cementitious materials content in PCC*
- Corrie Craft (MS) *Sustainable concrete materials in developing worlds*
- Paul Konig (MS) *Comparative study of anchorage strengths of epoxy coated hooked bars*
- Anne Pearis (MS) *Road sub base soil stabilization using class C fly ash*
- Matt Smith (MS) *Rapid bridge construction using decked bridge girders*
- Jake Vermillion (MS) *Air void analysis of concrete*
- Baron Colbert (PHD) *Aggregate polishing and friction*
- Shu Wei Goh (PHD) *Development of Superpave performance specifications for WMA*
- Melanie Kueber (PHD) *Recycled fibers and fly ash use in pavement materials*
MiSTI Personnel Spotlight

Post Doctoral Research Assistant Dr. Yogini Deshpande

Yogini Deshpande received her doctoral degree from Purdue University in Civil Engineering with a concentration in materials. She also holds masters and bachelors degrees from Bombay University in Geotechnical Engineering and Construction Engineering, respectively. Her research interests include: sustainable construction materials including the usage of industrial wastes, multi-functional cement-based materials, and performance enhancement of cementitious systems; rehabilitation and repair materials; durability and life cycle cost analysis of concrete, infrastructure management, and infrastructure health monitoring and performance specifications.

She joined Michigan Tech in February 2007 as a post doctoral researcher with a joint appointment with the UTC-MiSTI, the Department of Civil and Environmental Engineering, and the Center for Structural Durability. Since her appointment she has initiated a research program for the development of performance specifications for polymer based repair materials. This program aims in developing performance requirements for shrinkage and cracking resistance, and durability requirements in terms of transport properties of water and chlorides. The experimental program is also aimed at developing models to understand the failure criteria of repair materials when taking the composite behavior of the substrate concrete and the repair concrete into consideration. She has developed a graduate level course on repair and rehabilitation of structures which will be taught in the Fall 2008 at Michigan Tech. The course provides information on the different examination and evaluation techniques for determining the current structural health. The course also discusses the economics, advantages and differences in different repair and strengthening techniques currently adopted in the industry.

Michigan Tech Graduate Prepares to Lead New Rail Initiative

In the fall of 2007, Pasi Lautala received his PhD from Michigan Technological University and simultaneously launched Michigan Tech into the future of rail transportation education and research through the creation of the Rail Transportation Program (RTP). The RTP is a multidisciplinary endeavor receiving start-up support from the University, the Michigan Tech Transportation Institute, and rail industry partners. The RTP will provide educational opportunities for students including rail related Senior Design projects, new courses, international experiences through the Summer in Finland program, student scholarships, and opportunities for undergraduate and graduate research experiences.

“As a graduate student pursuing a PhD in Civil Engineering, Pasi raised the University’s awareness of both the need for an educated workforce and solutions for developing 21st century rail in the United States. Rail will play an integral role in creating a more sustainable transportation system. Michigan Tech is stepping up to meet these challenges, and with Pasi’s guidance we will become a leader in rail education and research, “comments Dr. Lawrence Sutter, director of the Michigan Tech Transportation Institute.

Pasi received his BS degree from Tampere, Finland and his MS degree from Michigan Tech. His previous experience includes working with Finnish Railways and five years of railroad and highway engineering consulting experience in Chicago before his return to Michigan Tech for PhD studies. In addition to leading and coordinating the overall development of the RTP, Pasi will teach two courses related to rail transportation - International Railroad Engineering and Track Engineering and Design.
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.

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 ultrahigh 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