UNIVERSITY TRANSPORTATION CENTER for HIGHWAY PAVEMENT PRESERVATION

CHPP NEWS

Newsletter Issue 1. March 2015

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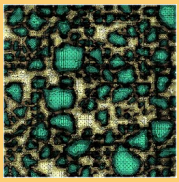

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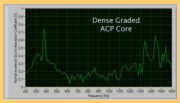

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Center for Highway Pavement Preservation

Yellowstone National Park. Photo by Syed Haider

CUTC Student of the Year

Ronell Joseph Eisma

"I won annual outstanding graduate student of the year award, sponsored by the U.S. Department of Transportation and Council of University Transportation Centers (CUTC). The award is given to students who demonstrate technical merit and research, academic performance, and professionalism and leadership. I work at MSU for the University Transportation Center on the forefront of pavement preservation research and actively volunteer with K-12 outreach programs to spread knowledge of pavements and pavement preservation with the community."

From the Director

The US highway system is the single largest public investment in history having an estimated initial cost of $3 trillion spread over many years. Unfortunately, it is steadily deteriorating, and the replacement cost could not readily be incurred without severe economic consequences. Stewardship of this investment is vital to America's commerce, defense, and mobility with benefits spanning many generations. Delaying maintenance and repairs until major rehabilitation or replacement is necessary, leads to extensive and disruptive work that increases the potential for accidents, injuries, and fatalities among motorists and road workers. An alternate to this scenario is preservation of sound roadway pavements to assure physical/structural integrity and extension of their service lives before they need major rehabilitation or replacement. Opportunities are within reach to preserve and extend the service life of the pavement infrastructure while improving safety, minimizing congestion during construction activities, and reducing energy requirements and impacts to the environment. One major impediment to widespread implementation of preservation of the pavement infrastructure by transportation agencies is lack of knowledge on how to select preservation actions and when and where to apply them to get the most benefit for the least cost – or in other words, how to apply the right preservation action at the right time to the right pavement. There are significant gaps in the understanding of pavement preservation and it will require a comprehensive and broadly supported program of research, development, and technology transfer to fill those gaps.

While significant efforts on the part of FHWA and State Highway Agencies have taken place in promoting highway pavement preservation, they mainly promote raising awareness about the need for pavement preservation, the role of preservation in transportation asset management, and the economics of preservation versus reconstruction. However, there has not been a concerted effort on research and education activities focused on highway pavement preservation. With the establishment of the National Center for Pavement Preservation (NCPP) as the national pavement preservation clearinghouse for pavement preservation to practitioners throughout the US, it was only a matter of time before a research and education center on the subject would be established.

In 2013, the USDOT designated the Center for Highway Pavement Preservation (CHPP) as a Tier 1 University Transportation Center. CHPP has received $1.4 million during the first year of the program, another $1.4 million for 2014 fiscal year, and close to $1 million for fiscal year 2015, with funding projected to extend through 2018. CHPP is one of three Tier 1 UTCs under the USDOT strategic goal of "State of Good Repair", and is the only center that is focused on pavement preservation. MSU is the lead institution and collaborates with the University of Illinois, the University of Texas, the University of Minnesota, North Carolina A&T State University and the University of Hawaii. This consortium will work on moving pavement preservation research and education forward.

The main focus of the Center is the infusion of science and innovative technology to pavement preservation. The proposed research focuses on the development of sustainable and innovative highway preservation solutions for pavements. Research activities are conducted in various areas mirroring the priorities set by the recent pavement preservation research roadmap: Innovative materials, smart health monitoring, performance modeling, mechanistic design, improved construction and quality assurance methods, data management and economic analysis for improved highway asset management. The Center sponsors research, education, outreach and technology transfer activities to promote integrated, innovative solutions for highway pavement preservation.

Please feel free to contact us for more information and explore our website for more information on our research, education and outreach activities.

Best Regards,

Karim Chatti, PhD
Director, Center for Highway Preservation (CHPP)

CHPP Advisory Board

The CHPP Advisor Board was formed since the inception of the center. The board involves a group of transportation infrastructure leaders that advices CHPP leadership on research goals, education/workforce development and technology transfer activities. The most significant aspect of the Board is the involvement of stakeholders i.e., preservation practitioners from state, provincial, and local transportation agencies, industry, and academia. The experts will also assist in promoting the center activities at national and international levels, and will assist in identifying collaboration opportunities to support pavement preservation research and practices. We appreciate the involvement of the following members:

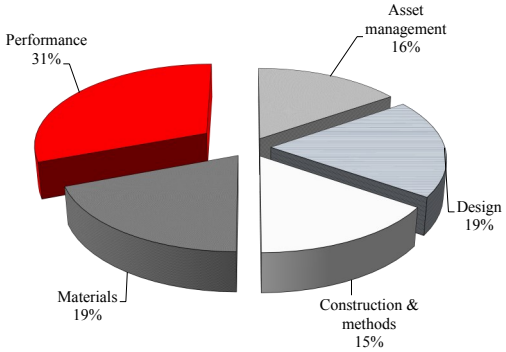
Steve Bower – Michigan DOT
Judith Corley-Lay – North Carolina DOT
James Matsuzaki – City of Honolulu
Magdy Mikhail – Texas DOT
Jim Moulthrop – FP2
Roger Olson – Minnesota DOT
Alicia Pilli – Illinois Toll-way
Amy Schutzbach – Illinois DOT

Additional experts and practitioners have been invited based on their expertise and center needs. The Advisory Board meets annually or whenever the center needs their advice.

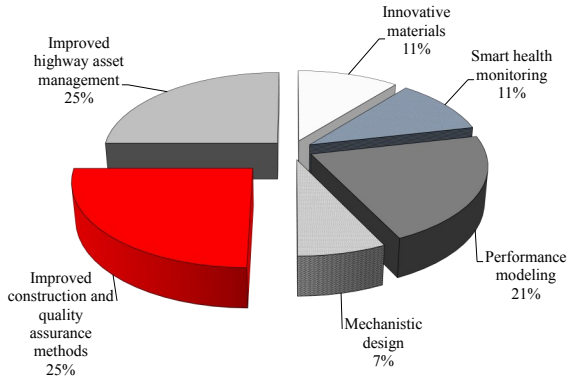
Find us online:

Research Portfolio

A total of thirteen research projects have been selected for funding. During the project identification and selection process, emphasis was given to a balanced portfolio for the research topics. The charts show the distribution of the research topics by the AASHTO Pavement Preservation Roadmap categories and CHPP research themes. It can be seen from the figure that all areas of research are well distributed among various Roadmap categories and CHPP research themes. While some of the topics address more fundamental research, the research findings will be useful in solving pavement preservation challenges in the long-term. On the other hand, some of the research studies involve more practical research to fill in the short-term knowledge gaps.



Roadmap research categories



CHPP research themes

Research Highlights

Development of an Acceptance Test for Chip Seal Projects

Emin Kutay, Michigan State University

Chip seal is one of the major preventive maintenance technique performed by many DOTs, county road departments and cities. In this method, the deteriorated pavement surface is covered by asphalt binder and uniformly graded aggregates. Typically, asphalt emulsion (sometimes cutback asphalt) is sprayed on the surface and aggregates are embedded into the emulsion. After compaction and curing of the emulsion, loose aggregates are removed by sweeping (via rotary power brooms). The primary role of the asphalt binder is to serve as a waterproof membrane that protects the pavement surface from sun, oxidation and moisture infiltration. The role of the aggregates is to act like a 'bridge' so that sufficient skid resistance is provided. In general, chip seal is applied on roadways with low to moderate traffic. Also, the condition of the existing pavement should be suitable for application of chip seal. Chip seal is not applied to heavily distressed and rough pavements. Pavements with low to moderate raveling, transverse cracking, block cracking and smooth surfaces with low skid resistance are optimal for chip seal applications. The function of an asphalt chip seal is to form a new layer above the existing pavement and prevent water infiltration. It also improves the surface texture, which enables the pavement to have better skid resistance.

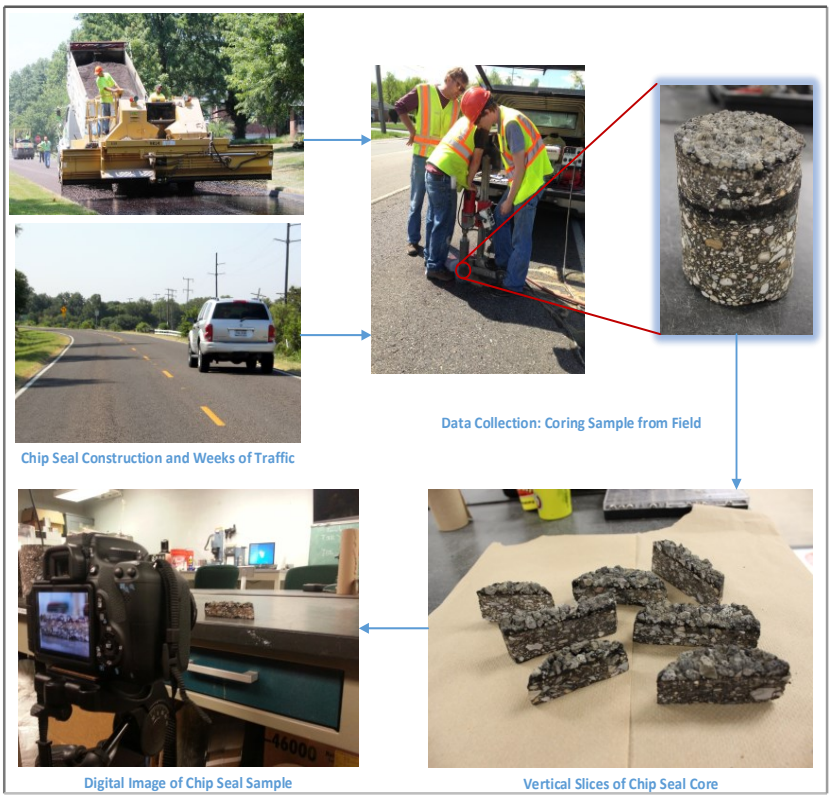


Fig. 1 Process of sample preparation for image analysis

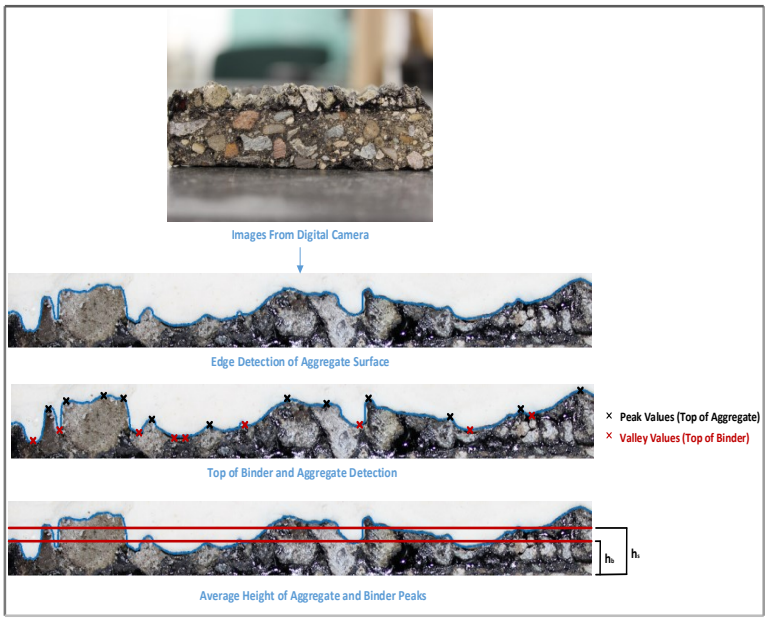


Fig. 2 Image analysis flowchart for calculating aggregate percent embedment

The aggregate embedment into the binder is one of the most significant parameters during the design process of the chip seal. The embedment depth should be 50% after initial rolling, and 70% after 2 or more weeks of traffic. Asphalt chip seals having the embedment depth less than 50% are more susceptible to aggregate loss due to insufficient bonding between binder and aggregate; whereas, asphalt chip seals having the aggregate embedment higher than 70% may cause bleeding problems on the surface of the pavement .

The goal of this project is to develop a standard test procedure to directly calculate aggregate embedment depth into the asphalt binder in a chip seal project via digital image analysis. The overall approach involves coring asphalt chip seal samples from field (see Fig.1), capturing images of vertical slices and using automated image analysis techniques to compute the percent embedment (see Fig. 2). The percent embedment can be determined by using the following equation:

$$P_e(\%) = \frac{h_b}{h_s} \times 100$$

Premature distresses such as bleeding and aggregate loss can be prevented if such a standardized test procedure is developed and implemented.

Prediction of Service Life of Thin Asphalt Overlays for Pavement Preservation Using Pavement Deterioration Models

I.. Al-Qadi, H. Ozer, and H. Dhasmana
University of Illinois at Urbana Champaign

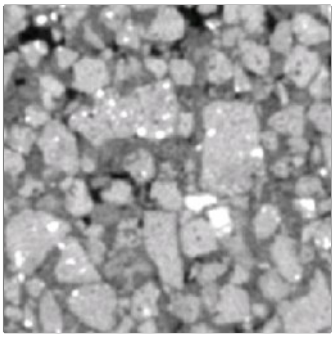
Previous researches have proved that thin asphalt overlays are considered to be one of the most effective pavement preservation methods on account of their ability to address surface distresses, relatively longer service life and low life-cycle costs when constructed over structurally sound pavements. Despite the widespread use of thin overlays, there remain questions about their life expectancy and potential role in improving pavement's structural capacity and functional properties. The proposed research work aims at characterizing the performance of thin asphalt overlays using a mechanistic approach.

The analysis of thin overlay poses significant challenges compared with the conventional techniques commonly used in the analysis of layered pavement systems. The overlays experience gradient of material properties because of aging and, possibly, moisture damage. In addition, the mixture's heterogeneity and microstructural characteristics render the application of some basic assumptions challenging; especially when the overlays are directly exposed to non-uniform and three-dimensional truck loads. Therefore, mechanistic-based performance deterioration models will be developed in this study, bridging the characteristics of the local (aggregate gradation, size, binder-aggregate, mastic-aggregate interactions, mastic, etc.) and global scales. The finite element model will be based on simple input parameters that should be available at the design and construction stage, but contain fundamental characteristics of the existing pavement, materials used, thickness, and environmental conditions.

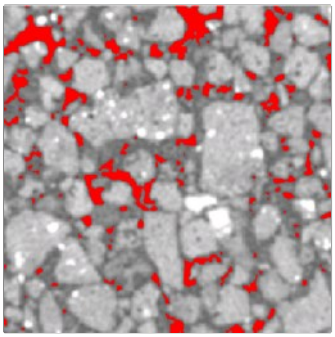
For the current study, a research approach which primarily addresses the multi scale behavior of asphalt mixes under the impact of global as well as local scale features including traffic, moisture and aging in the binder is adopted. Microstructural heterogeneity in an asphalt mix can be studied efficiently by developing Finite Element (FE) models. Use of FEM to study the attributes of different components in a limited region of the surface mix can deliver crucial information about the manner in which binder, aggregates and voids interact under certain stresses. Outcomes from the micro-scale analysis will be translated to macro-scale using linear viscoelastic functions to produce continuum level response for different thicknesses and material properties. In conjunction, some experiments are also carried out to provide inputs for the models developed and basic validation of the computational results generated.

At present, an attempt for studying the micro-scale features of asphalt mixes produced using three major binder types utilized in the state of Illinois for thin asphalt overlay construction (PG 64-22, PG 58-28 and PG 70-22) are produced. Low and intermediate temperature fracture tests are conducted using Semi-Circular Bending Beam (SCB) geometry. Digital Image Correlation (DIC) technique is used to measure surface strains and displacements on the deforming specimen (Figure 1). The DIC technique with a high resolution camera is used in this study to evaluate the effect of aggregate microstructure and binder characteristic on the failure mechanisms of asphalt mixtures used in thin overlays.

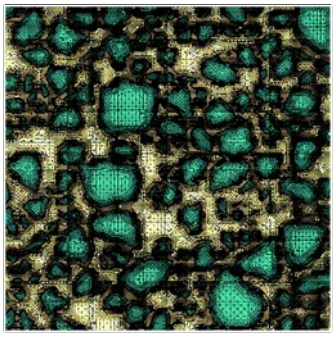
Following steps will include Finite Element modeling of the SCB test to characterize the contribution of microstructure and binder properties to fracture resistance of asphalt mixes. Micromechanical simulations of the same geometry shown above will be conducted using the steps illustrated. Following steps will include Finite Element modeling of the SCB test to characterize the contribution of microstructure and binder properties to fracture resistance of asphalt mixes. The major outcome of this study will be mechanics-based models for thin overlays. The model will be based on simple input parameters that should be available at the design and construction stages. Because the model will be based on mixture components, vehicular loading, and environmental factors, it will also provide guidance to improve the performance of thin overlays. This can be incorporated in other currently used tools such as life-cycle cost analysis and life-cycle assessment.



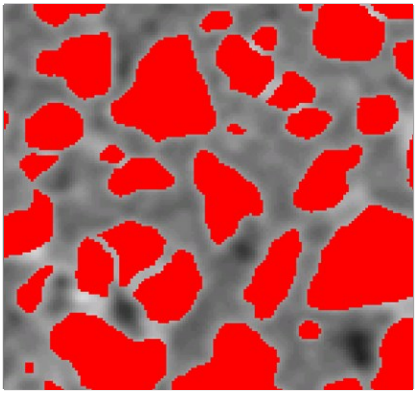
Step 1: Image acquisition



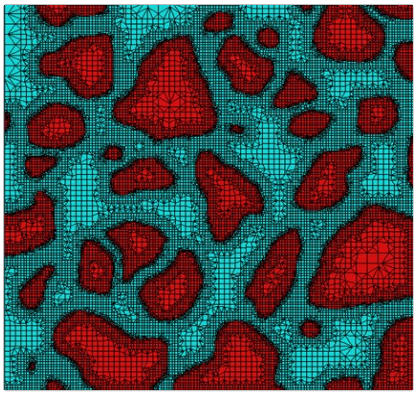
Step 2: Image segmentation



Step 3: Development of FE meshes



AC sample slice with aggregate and mastic phases shown separately (aggregates in red)



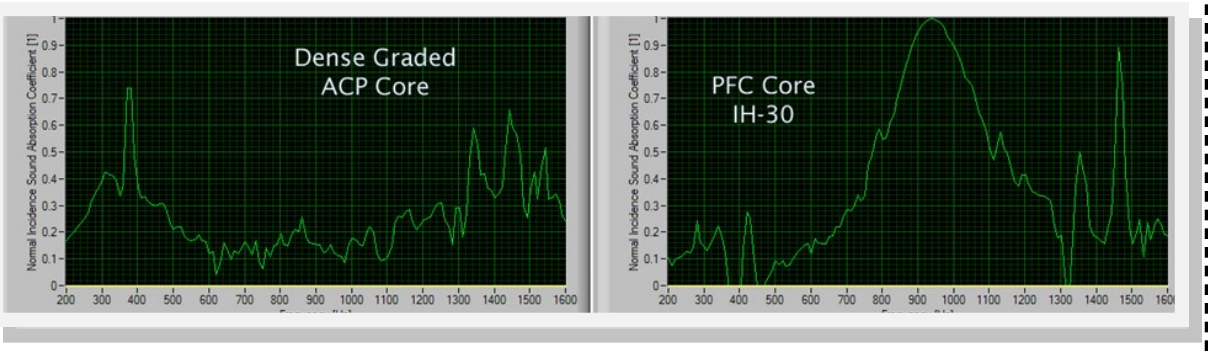
Mesh configuration of a 30x30 window size slice

Designing Quieter Pavement Surfaces

J. Prozzi, A. Smit, N. Zuniga, M. Trevino and M. Juenger
University of Texas at Austin

The objective of this project is to develop guidelines for the design and maintenance of quieter asphalt and concrete pavements. The research team is compiling an extensive pavement-noise database, comprising a variety of asphalt and concrete surfaces with corresponding noise measurements over time. The effect of different overlay asphalt mixtures will be evaluated for flexible pavements (both open and dense mixtures will be considered (as shown in the figure)) and the effect of different surface treatments (such as diamond grinding) for rigid pavements.

Close proximity and far-field noise tests in the field on both asphalt and concrete pavements will be correlated against laboratory measures towards establishing laboratory test procedures. Following these tasks, a set of preliminary guidelines will be developed to establish recommendations on and assistance in selecting appropriate candidate projects for low-noise surfaces and for designing surfaces to provide long-term noise reductions. A case study will be completed to recommend strategies for addressing noise complaints in an urban setting.



Sound absorption spectra for dense-graded AC sample (left) and a PFC sample (right)

Development of Objective Methods for Determining Damage Accumulation in Pavements Prior to Visual Distress Becoming Apparent

L. Khazanovich
University of Minnesota

Development of objective methods for determining damage accumulation in pavements prior to visual distress becoming apparent. The specific objective is to evaluate subsurface damage in concrete pavement prior to arrival at the surface.

Ultrasound and electromagnetic wave phenomena are used to interrogate the pavement. The focus is in interrogating the pavement in a non-intrusive manner for applications of core replacement or core limiting technology and in some cases in a faster, more continuous way that allows for identification of general trends in the pavement subsurface condition.

The project results will be useful in elimination or reduction in coring and will allow for a safer and less destructive evaluation of concrete pavements. Quicker and greater coverage evaluation results will allow for more informed and timely pavement preservation decisions. Early detection of phenomena that inhibit long-term infrastructure performance such as concrete pavement deterioration also has the potential of significant cost savings.

Performance Monitoring of Preservation Treatments in Honolulu

A. Archilla
University of Hawaii at Manoa

This project will monitor the performance of different preservation treatments in Honolulu, Hawaii. The treatments considered

are fog seal, slurry seal, asphalt seal coat treatments currently available in Honolulu, thin lift overlay, and crack sealing.

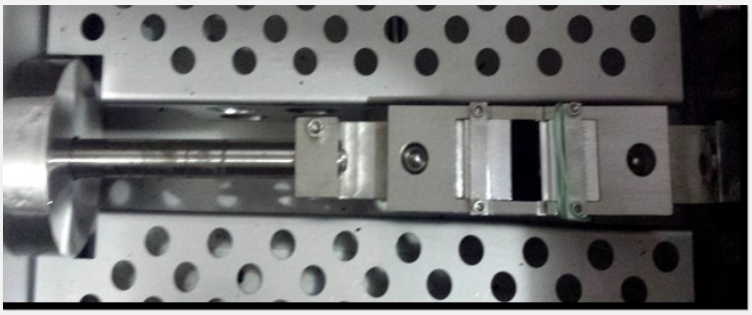
The condition of treated and control sections will be surveyed prior to the treatment application and then regularly at intervals between 3 and 4 months with the goal of quantifying the benefits of pavement preservation. The materials used for pavement preservation will be tested in the laboratory. Specifically, binder residues will be tested with a Dynamic Shear Rheometer and a Viscometer, the Wet Track Abrasion will be used for slurry seals, and several performance tests will be carried out for thin lift overlay.

The test results will be used to help in writing guidelines and potentially help explaining any unexpected behavior of the treatments.

Developing a Test Method to Investigate Water Susceptibility of Joint and Crack Sealants

E. Fini
North Carolina A&T

The project is to investigating effects of water conditioning on the adhesion properties of crack sealants; accordingly as part of the project water exposure test (WET) will be developed to characterize and evaluate extent of change in specific fundamental sealant properties. Therefore, the test can be used to predict sealant performance when it is exposed to water. The test will be applicable in areas with high humidity and precipitation frequency. Both bulk (cohesive) and adhesive properties



of several sealants will be examined. The adhesive bonding strength between sealant and crack walls and the cohesive bonding strength within sealant will be used to characterize the water susceptibility of sealant. Change in bulk and adhesive properties of sealant after water conditioning will be used as an indication of water susceptibility of the sealant.

The objective is to investigate effects of water conditioning on the adhesion and cohesion properties of crack sealants and their effects on sealant performance. The specific objectives of the research study are to (a) develop water exposure test, and (b) identify appropriate performance indicators in relation with cohesive and adhesive characteristics of sealants.

Resulting test parameters and methods could be used by sealant industry and highway agencies to rank crack sealants based on their performance in wet condition. This in turn will allow for a more robust and scientific sealant selection criteria for better performance prediction of crack sealing applications.

Research Publications

CHPP researchers prepared and produced several conference and journal papers based on the research being conducted as part of the center. In addition, to disseminate the research findings, presentations were also made at various appropriate venues and meetings. The following is the list of publications and presentations related to different CHPP research projects during this period.

1. *Impact of Pre-existing Conditions on the Effectiveness of Pavement Preservation Treatments, Ronell J. Eisma, Syed W. Haider, and Karim Chatti, proceedings of the 94th Annual Transportation Research Board Meeting, 2015.*
2. *Impact of Thermal Inertia in Pavements and the Urban Heat Island, Sushobhan Sen and Jeff Roesler, proceedings of the 94th Annual Meeting of Transportation Research Board, 2015.*
3. *Thin concrete overlay performance, Daniel King and Jeff Roesler, proceedings of the 94th Annual Meeting of Transportation Research Board, 2015.*
4. *Assessment of Concrete Pavement Structure on Urban Heat Island, Sushobhan Sen and Jeff Roesler, paper published and presented at the International Symposium on Pavement LCA 2014 at UC-Davis from October 14-16, 2014.*
5. *Micromechanical finite element modeling of moisture damage in bituminous composite materials, Ghauch, Z., H. Ozer, and I. L. Al-Qadi, Construction and Building Materials (2014) (in revisions).*
6. *Life-Cycle Impact of Producing Bituminous Mixes with Varying Degrees of Recycled Materials, Yang, R. H. Ozer, S. Kang, and I. L. Al-Qadi, International Symposium on Pavement LCA, October 2014.*
7. *Performance Characterization of In-Place Recycled Mixtures, Hafeez, I. H. Ozer, and I. L. Al-Qadi, Journal of Transportation Engineering, 2014.*
8. *Bio-Modification of Rubberized Asphalt and Its High Temperature Properties, Ellie Fini, proceedings of the 94th Annual Meeting of Transportation Research Board, 2015.*
9. *Investigation of Effectiveness of Liquid Rubber as a Modifier for Asphalt Binder, Ellie Fini, proceedings of the 94th Annual Meeting of Transportation Research Board, 2015.*
10. *Effect of Water Conditioning on Crack Sealant's Cohesive Properties, Ellie Fini and Sassan Aflaki, proceedings of the 94th Annual Meeting of Transportation Research Board, 2015.*
11. *Investigating Effects of Water Conditioning on the Adhesion Properties of Crack Sealant, Ellie Fini and Sassan Aflaki, proceedings of the 94th Annual Meeting of Transportation Research Board, 2015.*
12. *Invited Presentation: Quantitative Ultrasonic Array Evaluation of Concrete Structures, Jorge Prozzi, Technion, Israel, April 2, 2014.*
13. *Investigation of the Relationship between Dynamic Axle Load, Roughness and Fuel Consumption, Imen Zaabar, and Karim Chatti, paper presented and published at the International Symposium on Pavement LCA, University of California at Davis, October 2014.*
14. *Estimating Vehicle Operating Costs Caused by Pavement Surface Conditions, Journal of Transportation Research Record, Volume 2455, Issue 1, page 63-76, 2014.*

Education News

K-12 Outreach

MSU Middle and High School Design Day at Michigan State University (Spring and Fall)

The focus was to involve approximately 175 students and 25 teachers in hands-on and experiential engineering education. It introduces participants to innovative, challenging and inspiring engineering designs and projects. The students and teachers worked on projects such as:

- Building a sample of asphalt pavement cross-section using crumb rubber,
- Using smart materials (piezo-electric sensors) to generate voltage as a measure of deflection.

Summer Internship Program for High School Students at MSU and UH at Manoa

The Summer Internship Program is a highly competitive six-week program that allowed high school juniors (heading into their senior year) to take a hands-on approach to working in College of Engineering research laboratories. Along the way, interns also participated in group activities and a field trip to local engineering companies. At the end, they make a presentation about what they learned during the summer.

Metro Detroit Youth Day with a Transportation and Pavement Theme

In July 2014, the Metro Detroit Youth Day, the largest youth event in Michigan, was formulated to bring together Metro Detroit area youth from all walks of life for a day of sports, fun, and constructive activities. The CHPP had rented a tent to showcase transportation and pavement-related research through hands-on experiments. The activities introduced approximately 10,000 children to innovative and inspiring engineering designs and projects.

MSU High School Engineering Institute I– June 25, 2014

Forty (40) high school students spent a week exploring engineering through lecture, lab and design sessions offered by faculty and student assistants from various programs. The residential program was designed to give in-depth experiences in engineering majors. Our focus in CHPP is to convince these students to pursue a college degree in a transportation-related area. Students spent a half day with an engineering faculty member, a graduate student, undergraduate students, and participated in short lectures, demonstrations, hands-on experiments, team-based problem solving, and tours. Participating students and teachers worked on projects such as:

- Building a sample of asphalt pavement cross section using crumb rubber (Road in a Box),
- Using smart materials (piezoelectric sensors) to generate voltage as a measure of deflection, and,
- Building a wireless monitor to measure the temperature of the pavement during deflection testing.

The event was featured in the local news in Michigan.

Development of a Highway Pavement Preservation Short Course

A short course in three different transportation-related areas was designed for use by Middle and High school teachers in their classrooms to attract students to the transportation field. The course focuses on the use of smart materials and image analysis techniques for pavement monitoring and the use of crumb rubber in asphalt as a student introduction to sustainable materials. The PowerPoint presentation and hands-on activity worksheet are available on the CHPP website.

Training Camps for High School Students and Minorities

The research investigators at the University of Hawaii reached out to high school students, females, and minorities in particular, mainly through summer camps and open-house activities. A large group of 500 to 700 students participated in a half-day event filled with engineering exhibits, games, and competitions.

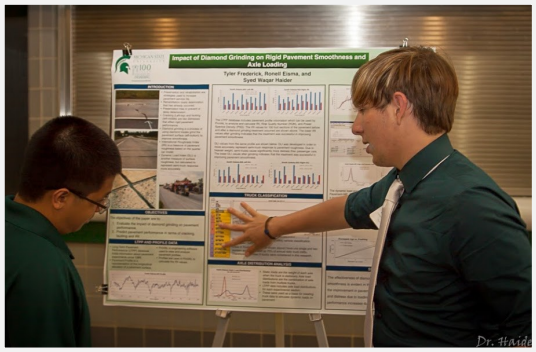
High School Education and Outreach at MSU

In November 2014, CHPP organized an entire session at McDonald Middle School (East Lansing, MI) where students participated in short lectures, demonstrations, hands-on experiments, team-based problem solving. Participating students and teachers worked on building a sample of asphalt pavement cross-section using crumb rubber, then used piezoelectric sensors to generate voltage as a measure of deflection. The team that designs a pavement with the least amount of deflection and cost won the competition.

Workforce Development

Summer Research for Undergraduates

CHPP offered summer research opportunities for high-achieving undergraduates. The intent of this program was to encourage students from all consortium partners (MSU, UT-Austin, UIUC, NCA&T, and UH) to consider pursuing graduate degrees and to provide them an early opportunity to become involved in research by working full-time on a substantive, faculty-guided research project and participating in professional development activities, including attending weekly seminars and completing periodic writing assignments. On July 25, 2014, the students presented posters summarizing their research. The students had opportunities to engage in engineering research, interact with faculty and students from across the College of Engineering, and develop essential skills for success in graduate school.



Transportation and Pavement Preservation Seminar at NCA&T

On October 1, 2014, a full day seminar was organized for students and transportation professionals. Three presentations about various aspects for highway pavement construction, maintenance and rehabilitation. The event was organized through CHPP in collaboration with ASCE and ITE society chapters. Talks were delivered by experts from North Carolina DOT and Piedmont-Triad Transportation partnership. In addition, the students presented their research during a poster session.

Technology Transfer

Transportation and Pavement Preservation Seminars and Meeting at the National Level

The CHPP benefitted from the National Center for Pavement Preservation's (NCPP's) efforts to provide outreach and technology transfer to the broad transportation community and practitioners. The CHPP used the NCPP's links with a variety of state and local highway transportation agencies and private companies to accomplish its professional development mission.

Upcoming Events

NGSS Compliant Introduction to Engineering Teacher Workshop—May 2015

The objective of the workshop is to enhance the integration of design day activities into the school curriculum. Students and teachers will be engaged in hands-on experiential engineering education. The outreach and research experience for teachers (RET) coordinators will present ways in which these activities can be used in Next Generation Science Standard (NGSS) aligned engineering curriculum. Participating students and teachers will learn about engineering by members of the MSU CEE department. The day will also include transportation engineering lab tours and hands on activities. A tentative date for the workshop is May 1, 2015.

Pavement Sustainability though Pavement Preservation Workshop at the ASCE T&DI Conference-June 2015

The objective of the workshop is to disseminate the research results by training students and professionals. This workshop will be conducted at the upcoming ASCE T&DI conference (June 7-10, Miami, 2015) and will provide an overview of recent research and implementation examples on the application of pavement preservation techniques to enhance the pavement sustainability. This workshop will cover the following:

- Introduction to pavement preservation and its methods
- Assessment of existing pavement and selection of treatments for preservation
- Construction and QC/QA, for preservation
- Performance of treatments and their impact on safety, noise, durability etc.
- Effect of pavement preservation on LCCA and LCA

The workshop will combine well established best practices as well as some recent research findings.

Texas University Transportation Center Undergraduate Internship (UTC-UI)

The University of Texas at Austin (UT) will host a group of undergraduate students from several disciplines as part of the University Transportation Center Undergraduate Internship (UTC-UI). Students from Civil Engineering, Electrical Engineering and Computer Sciences, and Physics are encouraged to apply.

Center for Highway Pavement Preservation

A UTC under the USDOT Theme of State of Good Repair

ILLINOIS — UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

North Carolina Agricultural and Technical State University

MICHIGAN STATE UNIVERSITY

UNIVERSITY OF MINNESOTA

THE UNIVERSITY OF TEXAS AT AUSTIN

UNIVERSITY of HAWAI'I® MĀNOA

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