Session 1 - Welcome and FHWA Program Updates

RPUG 2015 Speakers' Bios and Abstracts

MODERATORS: MAGDY MIKHAIL, RPUG PRESIDENT AND DAVID HEIN, FWDUG PRESIDENT

SESSION 1-1: TPF-5(063) IMPROVING THE QUALITY OF PAVEMENT PROFILER MEASUREMENT – POOLED FUND UPDATE BY BOB ORTHMEYER, FHWA

BIOS

Experience:

- Began working in field in 1978
- Nine years with North Dakota State Highway Department
- Consultant in the private sector for 14 years
- Joined FHWA in 2001

Education:

- B.S.C.E., North Dakota State University
- Licenses and Registrations:
- P.E., North Dakota
- P.E., Minnesota

Areas of Expertise:

- Construction, Pavements, Pavement management, Asset management

Examples of recent projects done in support of the Division Offices

- Established and administering a $1.9 million pooled fund study, "Improving the Quality of Pavement Profile Measurement," with support from 21 State agencies, the Office of Pavement Technology, Federal Lands and Division offices that will assist in building smooth roads; the study will provide a definition for a reference profile, build a reference profile device, supply a localized roughness module for ProVAL, and assist with strategies for verification sites.

ABSRACT

Pooled fund updates

SESSION 1-2: TPF-5(299) IMPROVING THE QUALITY OF PAVEMENT SURFACE DISTRESS AND TRANSVERSE PROFILE DATA COLLECTION AND ANALYSIS – POOLED FUND UPDATE BY ANDY MERGENMEIER, FHWA

RPUG 2015 Speakers' Bios and Abstracts

BIOS

Mr. Mergenmeier is a Senior Pavement and Materials Engineer with the FHWA's Resource Center. His primary responsibilities include materials acceptance and pavement design and construction. He came to this position in 2007 after 7 years as Virginia DOT's State Materials Engineer. At VDOT he was responsible for overseeing the Materials Division which included preliminary engineering and construction functions, such as, pavement design and materials acceptance programs. Before VDOT, Mr. Mergenmeier worked for the FHWA for 15 years in various locations throughout the country.

Mr. Mergenmeier is a Civil Engineering graduate from the University of Kansas, and a Registered Professional Engineer.

ABSRACT

Pooled fund updates

Session 2 - RPUG/FWDUG Joint Session

RPUG 2015 Speakers' Bios and Abstracts

MODERATORS: MAGDY MIKHAIL, RPUG PRESIDENT AND DAVID HEIN, FWDUG PRESIDENT

SESSION 2-2: FHWA REFERENCE AND HP PROFILER RODEO RESULTS BY STEVE KARAMIHAS, UMTRI

BIOS

ABSRACT

Preliminary results from FHWA Reference and HP Profiler Rodeos.

Session 3 – RPUG: Surface Distresses Surveys I

RPUG 2015 Speakers' Bios and Abstracts

MODERATOR: JAMES WATKINS, MSDOT

BIOS

James C. Watkins is a long time resident of Jackson and an employee of the Mississippi Department of Transportation (MDOT). He is currently serving as the State Research Engineer for MDOT. He is the RAC (Research Advisory Committee) chairman and Transportation Research (TRB) Board representative for the Department. Mr. Watkins graduated from the University of Mississippi (Ole Miss) with a Bachelor of Science in Civil Engineering in 1989. He is a registered Professional Engineer in Mississippi, member of the National Society of Professional Engineers (NSPE), Mississippi Engineering Society (MES) and Chi Epsilon National Engineering Society. He completed MDOT's Leadership Enhancement Assessment Development (LEAD), a succession planning program, as well as Basic Supervisory and Certificate in Supervisory Management (CSM) training through the Mississippi State Personnel Board. In 2005 he was chosen to serve on the TRB Subcommittee on Vehicle Interaction and Surface Properties (AFD90). During his career, he designed, developed, and implemented the Pavement Management Systems for MDOT, which processes the condition information. Construction, and rehabilitation history and for 13,000 center-lane highway miles. He designed and developed an Environmental System in FoxPro for ARCO Chemical Company that calculates, tracks, reports, and graphs emissions in tanks, boilers, and flares. Recently, he designed and developed a software program to calculate the faulting on jointed concrete pavements using laser data collected at highway speeds.

Interesting Fact:

Mr. Watkins met and talked to actress Sandra Bullock when she was in Canton filming A Time to Kill in 1996.

SESSION 3-1: 3-D LASER DATA COLLECTION AND ANALYSIS FOR ROAD SURFACE TEXTURE BY HUMAIRA ZAHIR, KANSAS STATE UNIVERSITY AND RICK MILLER OF KSDOT

BIOS

Presenter
Rick Miller, Pavement Management Engineer, Kansas Department of Transportation

Mr. Miller earned a BS in Civil Engineering from the University of Kansas in 1988. After graduation he was hired by the Bureau of Transportation Planning at the Kansas Department of Transportation. He held several positions in planning culminating as the Statewide Planning Engineer. Responsibilities in those positions included travel demand forecasting and modeling, statewide planning, corridor analysis, break-in-access requests, origin-destination studies, and long-range transportation plans for Metropolitan Planning Organizations and the State. He served on several state and national committees related to transportation planning, freight, and planning data.

In 1998 Mr. Miller moved to the Bureau of Materials and Research in KDOT as an Assistant Geotechnical Engineer. His duties were primarily to oversee and run the optimization-based Pavement Management System and oversee, build, and run the Laboratory Information Management System. The PMS is used for decision support to help maintain Kansas highways through preservation, maintenance, rehabilitation, and reconstruction. Mr. Miller continues to oversee the development of LIMS where data related to materials testing and construction is accumulated and stored for analysis of potential changes to construction and materials practices and specifications. Mr. Miller still has these duties, but organizational changes have him in the Bureau of Construction and Materials at KDOT with a title of Pavement Management Engineer.

ABSRACT

'Road surface friction helps minimizing skidding and assists in reducing the number of roadway crashes. Since skid resistance highly depends on the characteristics of pavement texture, the estimation of texture characteristics will give useful information about the condition of the roadway. In order to assess how surface texture varies with pavement surface type, two different roadway surfaces -

one with high friction surface and the other with chip seal were evaluated. A two-dimensional (2-D) profiler measures texture profile with distance along the pavement surface as one dimension and the texture elevation as the second. A 3-D profiler can measure the pavement texture more precisely where a 2-D profiler fails to completely describe characteristics of the pavement texture. For this study, data was collected using LCMS (Laser Crack Measurement System) 3-D laser profiler and ASTM Locked-wheel skid trailer to find out the correlation between the texture depth and the skid number. Data collection was also supplemented by CTM (Circular Texture Meter) and DFT (Dynamic Friction Tester) so that lab tests can be performed with these equipment and test results can be correlated with field data.

SESSION 3-2: AUTOMATED DETECTION OF SEALED CRACKS USING 2D AND 3D ROAD SURFACE DATA BY JOHN LAURENT, AND DANA BROWN, PAVEMETRICS SYSTEMS

BIOS

John Laurent, P. Eng., MSc.

John is co-founder and CTO of Pavemetrics Systems Inc. He previously directed the computer vision and, 3D sensors group at the National Optics Institute of Canada (INO) for 18 years where 3D and laser imaging, technologies were developed that are now being used by 200 government institutions and data collection companies around the world for the inspection of roads, rails, tunnels and airports. John completed his engineering physics degree followed by a Master's degree in electrical engineering specialized in image processing at Laval University. John is also the author of several papers and patents on the subject of using lasers, optics and image processing for inspection of transportation infrastructures.

Mr. Dana Brown

Dana is the Product Line Manager for Pavemetrics Systems Inc. For more than 15 years, Dana has assisted transportation agencies with the process of adopting new UAV, mobile mapping, laser scanning and asset management technologies. While working to increase product penetration in global markets, Dana's technology and business background allows him the ability to quickly assess client's needs and identify possible gaps in current solutions. Most recently, Dana was able to address the gaps in the current DTM road surface data collection market and aid in the development of a new tool to improve precision and efficiency. Dana works with technology partners (from small companies to publicly traded companies) to integrate Pavemetric's technology into complete solutions.

ABSRACT
This presentation will thus focus on the difficulties in the automation of both sealed and unsealed cracks and will show results from automated algorithms that use intensity, shape and 3D texture data to improve the detection rates and reduce false positives.

The use of high resolution transverse 3D laser profilers for the automatic measurement of cracks is now a reality in the US as many recent DOT equipment and data collection contracts require 3D sensors for the evaluation of surface distress. The use of 3D laser profilers allows to directly measure surface defects such as cracks, ruts, pot holes and macro-texture.

While 3D techniques have proven reliable at detecting open cracks these systems have not been used for detecting sealed cracks. These sensors however also produce intensity (2D) images that are often used to detect lane markings. Using this intensity (2D) data for the automated detection sealed cracks has also proven unreliable because sealed cracks can sometimes be darker or brighter than the surrounding pavement in the images and tire marks and other features can also cause false detections.

This presentation will demonstrate that the accuracy of sealed crack detection is improved using both 2D data and texture information evaluated from the 3D data. To do this 3D area texture algorithms are described and implemented in order to generate a complete texture map of the road surface. The intensity images are also processed in order to extract dark and light areas of the appropriate geometry (size and shape of sealed cracks). The combination of the results from both sets of processed data is then used to detect and validate the presence of sealed cracks.

Examples of cases that cause problems for normal image based sealed cracks detection will be shown and the results using the improved algorithms will be presented.

SESSION 3-3: RECENT DEVELOPMENTS IN DATA COLLECTION IN AUSTRALIA BY RICHARD WIX, ARRB

RPUG 2015 Speakers' Bios and Abstracts

BIOS

Richard joined the ARRB Group (formerly known as the Australian Road Research Board) in 1990 and since then has been involved in automated pavement data measurement, both as an equipment developer and in the collection of pavement condition data.

During this time, Richard has contributed to the development of Australian standards for automated pavement data collection and has had a keen interest in the verification of automated systems used to collect pavement condition data in Australia and overseas. Additionally, he has overseen many large scale automated data collection projects for each of the Australian State Road Authorities and a variety of international projects too, most recently in Malaysia and Vietnam.

He is presently a member of the ARRB's technical advisory group which is responsible for future developments in pavement data collection. Richard is a frequent visitor to the RPUG and once again looks forward to being part of this year's meeting.

ABSRACT

It is important that test methods and specifications are 'living' documents and are regularly updated to reflect advancements in pavement condition technology. For instance, the development of 3D technologies has resulted in the collection of new data sets, as well as providing new ways of collecting common data sets such as roughness and rutting. However, there is little guidance to assist agencies in ensuring that the measurements from these devices are sufficiently accurate and meets their needs.

As such, Austroads, the overarching body for Australian road agencies, has implemented a project to update the current test methods to include these new technologies. Austroads has also just published reported on a data harmonisation in an effort to move toward uniform data collection throughout the country.

This presentation will discuss the updates to the test methods and highlights some recommendations for achieving data harmonisation. Additionally, the presentation will report on some of the 3D roughness measurement testing that has been performed, as well as providing a glimpse into some current Australian data collection trends, both structural and functional.

Session 4 – RPUG: Surface Distresses Surveys II

MODERATOR: DULCE RUFINO FELDMAN, CALTRANS

SESSION 4-1: PAVEMENT DISTRESS SURVEY AND EVALUATION WITH FULLY AUTOMATED SYSTEM BY LI NINGYUAN, MINISTRY OF TRANSPORTATION OF ONTARIO

BIOS

Dr. Li Ningyuan is currently employed with Ontario Ministry of Transportation as senior pavement management engineer. He has over 30 years of experience in highway engineering and pavement management in the areas of pavement data collection, evaluation, performance modeling and investment planning. Dr. Li has served a few TRB sub-committees over the past 10 years, including Monitoring and Evaluation, Pavement preservation and Maintenance. He is also a board member of Road Profiler User Group.

ABSRACT

Ministry of Transportation of Ontario (MTO) started to implement a full scale of automatic pavement condition data collection, evaluation and reporting to support operational management of the provincial pavement network. In addition to longitudinal and transverse profilers that measure pavement roughness and wheel path rutting on pre-defined road sections, the data collection system is equipped with Pavemetrics' Laser Crack Measurement System (LCMS) for detecting and evaluating pavement surface distresses. This presentation will focus on distress data classification collection and evaluation to meet the provincial pavement performance evaluation and rating requirements, including International Roughness Index (IRI), Surface Distress Index (SDI) and overall Pavement Condition Index (PCI). To ensure quality of the automated pavement condition assessment, a series of comparative measurements in the field were conducted to verify whether each of the stages has been accurately processed, such as pavement distress detection, classification, severity rating and density calculating, condition evaluation and reporting.

The presentation will also share with participants some of the results and conclusions from the study, including 1) comparability analysis summary of the automated pavement surface distress evaluation versus the traditional manual assessment, 2) extended applications to performance specifications for pavement rehabilitation and maintenance contracts, 3) validation and calibration of pavement performance indices to the ground truth measurements.

SESSION 4-2: ACCURACY AND PRECISION OF HIGH-SPEED FIELD MEASUREMENTS OF PAVEMENT SURFACE RUTTING AND CRACKING BY PEDRO A. SERIGOS, UT AUSTIN

BIOS

Pedro A. Serigos is currently a PhD Candidate at The University of Texas at Austin and works as a Research Assistant at the Center for Transportation Research. He received his Civil Engineering Professional Degree at the University of Buenos Aires, and worked in the infrastructure engineering and construction industry in Argentina for two years before obtaining his Master's Degree in Civil Engineering in 2012 and his Master's Degree in Statistics in 2015, both at The University of Texas at Austin. Serigos' research focuses on analyzing and modelling transportation infrastructure data, applied to infrastructure management. As a Research Assistant, he participated in projects related to: the accuracy and precision of automated systems for the high-speed measurement of pavement surface rutting and distresses, the characterization of pavement micro-texture for enhancing the prediction of surface skid resistance, and the determination of expected lives of different preventive maintenance techniques, among other projects. His dissertation addresses the management of uncertainties in pavement management systems.

ABSRACT

Pavement management systems rely on accurate distress measurements to support transportation agency officials in making decisions on budget planning and allocation as well as on the design of maintenance and rehabilitation strategies. Errors in measured distress data can lead to inappropriate project prioritization and increased maintenance costs. This paper presents an independent evaluation of the accuracy and precision of high-speed field measurements of pavement surface rutting, cracking and other distresses taken by different 3D systems that represent the state of the practice of automated distress collection equipment.

The rutting experiment included 26 550-ft-long flexible pavement test sections with both asphalt concrete and surface treatments. Each system's accuracy and precision was assessed by performing two evaluations using reference measurements collected by the researchers. The first evaluation assessed each hardware system's accuracy in collecting accurate full-lane-width transverse profiles. The second evaluation assessed the hardware and data processing algorithms' ability to evaluate these profiles and provide accurate rut depth values.

The surface distresses experiment included 20 550-ft. long test sections with both flexible and rigid pavements. The high-speed measurements produced were compared to manual measurements taken statically by experienced raters. In addition, each vendor's crack maps were compared to manual crack measurements and static digital images. The analysis for this paper focused on fatigue cracking, longitudinal cracking, transverse cracking and patching. Each service provider was asked to report their results with different levels of manual intervention in order to capture the change in accuracy due to manual post-processing of the data using the vendor's algorithms.
The findings from this study document the accuracy of state-of-the-art methodologies for the automated data collection of pavement surface distresses and aim to assist transportation agencies administration in making informed decisions on the type of technologies to implement for collecting distress data.

SESSION 4-3: AUTONOMOUS COLLECTION VEHICLES: TESTING THE EQUIPMENT, NOT THE DRIVER BY MIKE RICHARDSON, MANDLI COMMUNICATIONS

BIOS
Mike Richardson is Mandli Communications' pavement expert, specializing in statewide collection and airport projects. He has held this position since 2008, when he was promoted after two years in previous positions within the company.

Mike is a Civil Engineering graduate from the University of Wisconsin–Madison, and a Registered Professional Engineer in the state of Wisconsin.

ABSRACT
Testing the accuracy and repeatability of roadway profiling equipment has always been subject to a degree of human error. The data collected at validation sites is only as good as the driver operating the vehicle, or more specifically, the driver's ability to collect the exact same route multiple times. Although it is possible to obtain passable results with an experienced driver, in the end you are not only testing the equipment, but the driver as well. However, advances in autonomous vehicle systems are providing new methods for collecting pavement data. Instead of relying on an individual to drive the vehicle, the autonomous system uses a pre-set shapefile for navigation. This system minimizes the human component required for operation, and truly tests the equipment, not the driver. When comparing human and autonomous collection on validation sites, the results show a large

increase in route repeatability when the autonomous vehicle is utilized. As this technology continues to develop and be integrated there will be increased opportunities to utilize autonomous technology on roadways.

The collection of airport runway pavement data has already provided an opportunity to prove this system. Airport runways are difficult environments to collect pavement condition data on. In order to be most effective the entire width of the runway must be collected, requiring several overlapping passes with a collection vehicle. For years manual referencing has been the most popular method available for ensuring that no gaps occur in the collection. Using the autonomous system has lead to a 30% gain in efficiency in initial testing, with further testing showing the possibility for additional increases. As this technology developed further, autonomous systems will continue to improve our ability to test and utilize pavement data collection equipment.

Session 6 – RPUG: Friction and Safety

MODERATOR: BRIAN SCHLEPPI, OHIO DOT

SESSION 6-1: NON-LOCK FRICTION TEST –AN UPDATE BY JOHN ANDREWS, MD SHA

BIOS

John graduated from the Johns Hopkins University with a Physics degree and a minor in Electrical Engineering. He spent most of his working life designing, manufacturing, or managing these activities in the fields of instrumentation, automated machinery, and heavy machinery. For semi-retirement, 14 years ago he changed direction again and joined the Maryland State Highway Administration with the responsibility for highway condition data collection. His section has two multi-parameter survey vehicles, two skid testing units, two inertial profilers, an FWD with GPR, and a coring rig to deploy for this purpose.

He has also been a member of several national groups involved in improving data collection and standards writing.

ABSRACT

Traditionally, highway agencies in the US and many other countries have measured the frictional condition of the pavement utilizing equipment and methods described in ASTM E-274. This process involves locking a trailer wheel and dragging it across the pavement for a little under 60 feet (nearly 18 meters) with a film of water sprayed on the pavement in front of the test tire. The test is performed at 40 mph (~60 kph).

While this process is fairly robust, it has several weaknesses:

1. It requires a large amount of water for relatively few tests limiting most network testing to 0.2 mile (322m) sample spacing.
2. The sequence of test functions limits the minimum spacing between tests to 0.05 miles (80m).
3. Sliding friction is not representative of most vehicles on the road today.

We have developed a test that utilizes the same basic mechanical system, but performs the measurement just prior to the lock-up of the test wheel. The reported value is an average over less than 6 feet (1.8 meters). The entire test can be performed at much closer spacing (0.01miles, 16m) than the locked wheel test. This process should improve our ability to measure our network condition through

higher resolution data that is somewhat less variable and potentially more representative of the pavement condition in critical areas.

The results of approximately 4000 tests in two Maryland counties will be presented.

SESSION 6-2: SENSITIVITY ANALYSIS OF TIRE-ROAD FRICTION COEFFICIENT TO PAVEMENT TEXTURE PARAMETERS USING A PHYSICS-BASED CONTACT MODEL BY RON KENNEDY AND MEHRAN MOTAMEDI, VIRGINIA TECH

BIOS

Author:
Mehran Motamedi received his PhD in Mechanical Engineering from Virginia Tech in September 2015, where he worked as a research assistant in the Center for Tire Research for three years.
During his PhD studies, he worked on road surface measurement and classification, and rubber friction. He also designed and built a Dynamic Rubber Friction Tester.
He now works in the Advanced Tire Technology group at Bridgestone Americas. Mehran has authored numerous technical publications and has given several conference presentations in the areas of rubber friction, and dynamics and control of mechanical systems.

Presenter:
Ron Kennedy is currently the Managing Director of the Center for Tire Research (CenTiRe) where he provides administrative oversight, communication with industry members and faculty, and promotion of the Center.
Before joining CenTiRe 1½ years ago, he worked for nearly 40 years in the tire industry at Firestone, Bridgestone, and Hankook Tire doing tire finite element methods development, advanced tire design, and tire uniformity studies.
Ron received his BS and MS degrees in Engineering Mechanics from the University of Wisconsin, and his PhD in Mechanical Engineering from the University of Akron.

ABSRACT

A major challenge in tire, as well as in road engineering, is to understand the intricate mechanisms of friction. Pavement texture is a feature of the road surface that determines most tire-road interactions, and can be grouped into two classes: macro-texture, resulting in the hysteretic component of friction, and micro-texture, resulting in adhesion. If both textures are maintained at high levels, they can help provide sufficient resistance to skidding.
A physics-based multiscale rubber-road friction model that can predict the effectiveness of the tire as it interacts with the vehicle and the pavement is developed. The method uses road profile and tire compound measurements. Good correlations are obtained between the simulation results, and indoor and outdoor experimental data. Therefore, this friction model is a reliable, convenient, fast and cheap alternative to indoor and outdoor tests for predicating the performance of tire tread compounds.
A non-contact profilometer is used to measure the macro- and micro-texture of the different road surfaces. Pavement profiles are proven to be of fractal nature. The short distance cut-off wavelength, the roll-off wavelength, the vertical cut-off distance, and the fractal dimension are the four quantities that can characterize any fractal surface, and are used in the friction prediction algorithm. The sensitivity of friction coefficient to these parameters is studied. Also, a quantitative analysis of the contribution of different wavelength bands to friction is done, and it is discovered that every decade in length scale is roughly equally important. The learnings from these efforts equip researchers with an improved insight when designing tribometers, deciding on a profile measurement device and adjusting the parameters, scheming friction and wear prediction experiments, as well as friction and wear estimation algorithms, and designing tread compounds.

SESSION 6-3: USING CONTINUOUS PAVEMENT FRICTION MEASUREMENTS TO DEVELOP SAFETY PERFORMANCE FUNCTIONS, IMPROVE THE ACCURACY OF CRASH COUNT PREDICTIONS, AND EVALUATE POSSIBLE TREATMENTS FOR THE ROADS IN VIRGINIA BY EDGAR D. DE LEÓN IZEPPI, VIRGINIA TECH TRANSPORTATION INSTITUTE

BIOS

Dr. de León has worked in the areas of pavement management and transportation engineering for over 20 years. He is currently a Senior Research Associate at the Center for Sustainable Transportation Infrastructure at VTTI working for the

Pavement Surfaces Consortium and other multidisciplinary research projects that address end-result and performance oriented specifications for hot-mix asphalt (HMA). He completed doctoral research using non-contact methods to identify non-uniformities in HMA. He has performed extensive data collection for pavement structural and functional performance, as well as pavement life cycle cost analysis, pavement design and geometric design. He is a member of the Management of Quality Assurance (AFH20) TRB Committee since 2009.

ABSRACT

The research described in this presentation develops a strategy for network crash analysis that uses friction and other data (cross-slope, texture, grade and curvature or classes of highway facilities) to improve the ability to predict crash rates. The crash rate analysis applies the well-established methodology used by the Highway Safety Manual for the identification of high accident risk areas using Safety Performance Functions (SPFs), which includes empirical Bayes (EB) rate estimation from observed accidents.

Current VDOT SPF models were modified to include skid resistance and radius of curvature (Interstate and Primary System only) to improve the predictive power of the models. A variation of the same methodology was also used to contrast the effect of two different friction repair treatments, conventional asphalt overlay and high friction surface treatments, as well as to explore how their strategic use can impact network level crash rates. The result suggests significant crash reductions with comprehensive economic savings.

Session 7 – RPUG: Texture and Noise

MODERATOR: LARRY SCOFIELD, IGGA/ACPA

SESSION 7-1: EVALUATING RELATIVE TRANSVERSE MACROTEXTURE OF PAVEMENT WHEEL PATHS TO OTHER SURFACE AREAS BY ABOLFAZL RAVANSHAD, DJ SWAN AND DEMION ORSI, FUGRO ROADWARE

BIOS

Author: ABOLFAZL RAVANSHAD

Presenter: DJ Swan

Co-presenter: Damion Orsi – 905-567-2870 / dorsi@fugro.com

As Fugro Roadware's Product Manager, Mr. Orsi has extensive experience and knowledge in the operation and collection of pavement performance data. He has successfully delivered complex pavement data collection and processing projects for State Departments of Transportation (DOTs) and developing the new automated tools for collecting, processing and viewing this data for these projects. He has managed projects totaling over 200,000 miles and been responsible for the implementation of new technology into Fugro's ARAN vehicles.

ABSRACT

The amount of available friction and texture depth are primary concerns in evaluating safety characteristics of pavement surface. Currently, the state of the practice involves collection of longitudinal macro-texture data using laser-based devices at highway speeds. The FHWA Long-Term Pavement Performance (LTPP) program has started collection of the longitudinal mean profile depth (MPD) since 2013. Few highway agencies have adopted the collection of the MPD data across the lane width and the LTPP program is also moving towards implementation of laser sensors across the full lane width. This is because the vehicle wander introduces significant variations across the data collection line, which makes the analysis challenging. In addition, the longitudinal MPD does not capture the variation in macro-texture across the lane width.

This pilot study examines the longitudinal and transverse MPD data on several LTPP test sections in Texas. While the longitudinal data were collected in both wheel paths using an FHWA profiler, the transverse data were collected using the

Fugro Roadware Automatic Road Analyzer (ARAN) vehicle, which collects up to 4000 data points. It is expected that the relative difference of the transverse MPD in the wheel paths to the transverse MPD in the non-wheel path areas would provide valuable information that can be used as a safety performance measure. This preliminary concept needs to be further investigated through a comprehensive study of pavement macro-texture, micro-texture, and friction. The developed performance measure can be implemented in network-level monitoring operations to determine areas of concern that require friction testing.

SESSION 7-2: ENHANCING PAVEMENT SURFACE MACROTEXTURE CHARACTERIZATION BY USING THE EFFECTIVE AREA FOR WATER EVACUATION BY SAMER W. KATICHA, VIRGINIA TECH TRANSPORTATION INSTITUTE

BIOS

Samer is a senior research associate at the Virginia Tech Transportation Institute. He has over Twelve years of experience in pavement engineering and asphalt materials characterization. In 1999, Samer graduated with a BE in civil engineering from the American University of Beirut and went on to obtain a Master of Science and Ph.D. from Virginia Tech in 2003 and 2007, respectively. His research over the last 5 years has mainly concentrated on pavement structural and functional evaluation, specifically in finding improved methods for pavement evaluation data analysis and interpretation to be used for pavement management decision making.

ABSRACT

Macrotexture is an important pavement surface characteristic that affects tire-pavement friction, tire/pavement noise, splash and spray, and rolling resistance. This paper proposes an improved macrotexture characterization index based on the effective area for water evacuation (EAWE) that (a) estimates the potential of the pavement to drain water better than currently use indices, and (b) provides stronger correlations with friction and noise than the mean profile depth (MPD).

The index is computed in two steps: (1) an enveloping profile calculation, which is necessary to delimit the area between the tire and the pavement when contact occurs; and (2) a definition of the EAWE, which will be the (multiple representation) index to characterize macrotexture. Comparisons of current (MPD) and proposed (EAWE) macrotexture characterization indices using 32 sections

confirmed that MPD significantly overestimates the effective area for water evacuation.

SESSION 7-3: VIRGINIA "QUIETER" PAVEMENT DEMONSTRATION PROGRAM BY KEVIN K. MCGHEE, VIRGINIA CENTER FOR TRANSPORTATION INNOVATION AND RESEARCH

BIOS

Kevin K. McGhee, P.E.
Associate Principal Scientist
Virginia Transportation Research Council

30 years of experience in road and bridge design and research
23 years as researcher for Virginia DOT
Past research: concrete pavement repair, application of advanced composites, development of smoothness incentive/disincentive specifications.
Current Research: pavement preservation, placing and finishing asphalt concrete mixtures, and general traveled surface characteristics.
Presently conducting and/or managing approximately $5M in research projects
B.S. in Civil Engineering from Virginia Tech
M.S. in Civil Engineering from The University of Virginia
Chair of ASTM E-17 on Vehicle-Pavement Interaction
Immediate past Chair of NAS/TRB Committee AFD90, Surface Properties – Vehicle Interaction

ABSRACT

This paper summarizes the findings from Virginia's recent quieter pavement research. It reviews overall condition, functional performance (ride, noise, and friction), winter maintenance and use characteristics, and other important observations made regarding a series of demonstration projects that were constructed in 2011 and 2012. The paper also summarizes results from the accelerated trafficking of Virginia materials at the National Center for Asphalt Technology Test Track.

After 4 winters in-service, the difference in measured tire-pavement noise between control surfaces and the most successful (lowest noise) quiet asphalt technology was no longer detectable with normal human hearing (<3 dB). The lowest noise

concrete surface continues to have a noticeable (approximately 4dB) advantage over the standard concrete finish. While none of the quiet pavement technologies tested thus far provide sufficient noise reduction to singularly satisfy federal regulations for noise abatement, VDOT is encouraged to continue monitoring federal policy for changes that may incorporate pavement type as a tool for mitigating noise

SESSION 7-4: LABORATORY DESIGN OF QUIETER ASPHALT SURFACES BY NATALIA ZUNIGA-GARCIA, UT AUSTIN

BIOS

Natalia Zúñiga-García is a current M.Sc. student in Civil Engineering and Graduate Research Assistant at The University of Texas at Austin. Her current reasearch is foccussed in the Area of Pavement Engineering. She obtained her Bachelors in Civil Engineering from The University of Costa Rica in Dec. 2012. She was a Civil Engineer Research Associate at the University of Costa Rica form Jan. 2013 to Dec. 2014.

ABSRACT

Ongoing concerns about the negative influence of highway traffic noise emphasize the need to design quieter pavement surfaces. To address these concerns, the Texas Department of Transportation (TxDOT) sponsored a research study to design quieter pavement surfaces. In this research, a laboratory noise test was implemented to assess the noise sensitivity of mix designs to, amongst other variables, variations in gradation and asphalt binder content, towards the laboratory design of quieter pavement surfaces.

The laboratory procedure developed is a modification of the standard ASTM E303 procedure: Measuring Surface Frictional Properties Using the British Pendulum Tester (BPT). Laboratory compacted 4 in. diameter specimens were tested. The noise generated as the rubber slider of the BPT comes into contact with the surface of the specimen is recorded with a sound pressure level meter. Additionally, surface macrotexture is measured on each specimen using a laser and surface profile envelopes are calculated in order to observe its relation with the noise generated.

With the test implemented it was possible to accurately measure noise generated on different types of pavement surfaces and provide a repeatable and standard procedure that can use laboratory compacted samples and field cores, which in turn allows further field validation. Based on preliminary results, it was found that thin

overlay mixtures (TOM) consistently produce a low noise pavement surface. In contrast to porous friction course (PFC), a well-known low noise surface, the noise design of TOM is not overly sensitive to variations in aggregate gradation or asphalt content. Indications are that PFC mixtures do not maintain their porosity over time owing to clogging and this significantly deteriorates the noise attenuating properties of these mixtures. Conversely, indications are that TOM mixtures tend to maintain their attenuating properties over time providing a long-lasting quieter pavement surface.

Session 8 – RPUG: Smoothness I

RPUG 2015 Speakers' Bios and Abstracts

MODERATOR: JOHN FERRIS, VIRGINIA TECH

Dr. Ferris has 25 years of experience in industry and academia. He spent 15 years researching chassis design, development, and advanced vehicle dynamics for Chrysler, DaimlerChrysler, and ZF Lemförder before joining the Virginia Tech faculty in 2005 as an Associate Professor. His research focus is terrain topology (high-fidelity measurement, statistical analysis, and stochastic modeling), driver-vehicle interactions, virtual proving ground development, vehicle performance (ride, handling, reliability, mobility), and automated vehicle development. The details of his contributions as founder and director of the Vehicle Terrain Performance Laboratory are found on the lab website: www.me.vt.edu/VTPL. He will serve the American Society of Mechanical Engineers (ASME) Dynamic Systems and Controls Division (DSCD) as the Recording Secretary beginning in 2016 and is the former chair the Automotive and Transportation Systems Technical Committee. He also serves the Society for Automotive Engineers as Chair of the Terrain Modeling Task Force.

SESSION 8-1: CS8800 WALKING PROFILER: REFINEMENTS AND PERFORMANCE AT 2015 FHWA BENCHMARK/REFERENCE PROFILER COLLECTIONS. BY DENNIS SCOTT, SSI

BIOS

ABSRACT

Since 2007, the CS8800 Walking Profiler, manufactured by Surface Systems & Instruments, Inc. (Auburn, CA and Manhattan, KS), has been a participating device in the FHWA/Pooled Funds study "Improving the Quality of Pavement Profile Measurement" – Priority Number One: Reference Device. In this presentation, SSI will discuss (i) refinements made to the CS8800 in advance of the 2015 data collections on various pavements at MnRoad, (ii) observations regarding the MnRoad data collections, including the performance of the CS8800, (iii) remaining issues and potential further refinements for improving reference profiler equipment performance.

SESSION 8-2: ROADBOT DUAL LINE LASER BENCHMARK ROAD PROFILER BY PAUL TOOM, ICC, CHERRY SYSTEMS

BIOS

Paul is professional electrical engineer registered in British Columbia Canada. He received his engineering degree from the University of British Columbia in Vancouver in 1975 and his MBA from Queen's University in Kingston Ontario in 2001. His broad ranging career interests have included analog and digital electronic design, software, road testing instrument design and utility power system design. He has worked for power utilities, for Olympic organizing committees and for his own company, Cherry Systems, based in Vancouver BC. Paul was the Energy Director for the Vancouver 2010 Olympics, and unlike Super Bowl 2013, made sure there were no power outages at any of the venues over the 17 days of competition and ceremonies.

He has developed surface profiling instruments since the late 80's and holds several US and Canadian patents in the associated technologies. Paul works closely with ICC in the development of reference profiling products, most notably the SurPRO. He likes to develop and prove the concepts and then hand over the product to ICC's expert manufacturing team to implement as a final professional product.

ABSRACT

The presentation describes the development of a new autonomous robotic road profiler that produces benchmark quality profiles using a patent pending dual line laser method. The profiler, named "Roadbot", uses two LMI Gocator 2342 line lasers together with several inertial instruments to derive a very accurate profile with short waveband extending to 3" (76mm). The method utilizes tire bridging filters to emulate vehicle tire behaviour and orients the lasers to make the profiler insensitive to longitudinal and transverse textures resulting from tining or grinding. Profiles are unfiltered similar to the rod and level method with accurate end elevations. The profiler is driven by electric motors and uses servos for steering and control of the platform which mounts the lasers and inertial instruments. It is guided by computer vision and follows profile markings on roads using chalk line or string line without operator intervention. Radio beacon and other guidance means will be added. The profiler will autonomously make multiple closed loop profiles, turning 180 degrees at the ends of the profile line using a unique technique and immediately produce PPF and ERD profiles at the end of the process. Using an ultra-stable constant speed drive, the profiler solves problems of acceleration noise affecting inertial instruments in walking profilers and errors

caused by tilting of the instruments in the transverse direction. Finally, it detects distance calibration targets that can be placed at intervals of 100 feet or so beside the profile line and auto-calibrates the Distance Measuring Instrument (DMI) for very high accuracy, which is essential for cross correlation of profiles in the short waveband extending down to 3" (76mm). The profiler will be manufactured and marketed by ICC.

SESSION 8-3: ACCESSING PAVEMENT ROUGHNESS IN URBAN ENVIRONMENTS BY RAJ BRIDGELALL AND JERRY DALEIDEN, FUGRO ROADWARE

BIOS

Author
RAJ BRIDGELALL, NORTH DAKOTA STATE UNIVERSITY

Presenter
Jerry has over 30 years experiences in pavement design and evaluation, including 5 years with Texas State Dept. of Highways & Public Transportation. He got his Bachelors and his Masters in Civil Engineering from University of Illinois. He is been the Director of Fugro's Pavement Engineering Group for the past 18 years.

Jerry is Happily Married for 30+ years, and the Proud Parent of six young adults.

ABSRACT

By definition, the International Roughness Index (IRI) is the accumulated absolute rate difference between the sprung- and unsprung-mass motions of a Golden Car simulated to move at a fixed reference speed. In theory, therefore, the IRI ignores any variations in actual vehicle speed and suspension responses. The fixed mechanical response of the Golden Car and the fixed reference speed constrain the IRI to summarize only the roughness produced from a narrow set of spatial wavelengths of the elevation profile. Consequently, the IRI cannot reflect the true roughness that riders experience when traveling a segment at different speeds and in different vehicles.

This study expands on previous work that developed a method to transform sensor data from many connected vehicles to characterize ride quality, for all facility types, at any speed. The method resulted in a road impact factor (RIF) transform

that compresses voluminous data from the inertial and geospatial position sensors aboard vehicles to produce a single index summary of roughness that is directly proportional to the IRI, at any fixed speed. Unlike the IRI, the RIF-index reflects the actual roughness that users experience when traveling the segment. Averaging the RIF-indices for a given speed band produces a summary of ride quality with ever increasing precision as the number of traversals from connected vehicles increase. The technique is applicable for all facility types, including local and unpaved roads.

The case studies evaluate the correlation between the IRI derived from an inertial profiler and the simultaneously produced RIF-indices using a smartphone aboard the vehicle. The results validate the direct proportionality relationship between these indices.

Session 9 – RPUG: Smoothness II

RPUG 2015 Speakers' Bios and Abstracts

MODERATOR: JOHN ANDREWS, MD SHA

SESSION 9-1: BOEING BUMP INDEX COMPUTATIONS FOR AIRPORT PAVEMENT ROUGHNESS BY INJUN SONG, SRA

BIOS

Dr. Injun Song is a project manager and task lead with SRA International, Inc. He has worked on pavement characterization and evaluation projects at the FAA's NAPTF since 2005. He received Ph.D. degree from Texas A&M University in 2004 and P.E. license from Delaware's Engineering Licensing Board in 2012. He has experienced in pavement design and evaluation, involved in airport pavement evaluation projects. Currently, he is a member of ASTM International and a vice-chair for E17, Tire Pavement Interaction, and subcommittee chair for E 17.33, Methodology for Analyzing Pavement Roughness. He was a chair to develop a new standard for CA Profilograph simulation, ASTM E2955 – 13, "Standard Practice for Simulating Profilograph Response to Longitudinal Profiles of Traveled Surfaces", corresponding to the FAA's AC 150/5370-10F, "Standards for Specifying Construction Of Airports" and ICAO Annex 14

ABSRACT

In Advisory Circular 150/5380-9, Guidelines and Procedures for Measuring Airfield Pavement Roughness, the Federal Aviation Administration (FAA) describes the procedures for measuring airfield pavement roughness and differences of smoothness/roughness in highway industry from airfield pavement roughness. The Advisory Circular does not recommend the use of inertial profilers that include highpass filtering for measuring profiles which are to be used for computing Boeing Bump Indexes (BBI) or simulated airplane accelerations on airport pavements.

This presentation will introduce backgrounds of BBI development, standards, and computer programs for BBI computations. Details of BBI computations, the FAA Advisory Circular / International Civil Aviation Organization (ICAO) /ASTM activities, and related computer programs for the BBI will be presented. FAA researches on wavelengths from pavement surface profiles showed the rationale to restrict the use of profilers using highpass filters. The BBI procedures to simulate straightedge on the pavement surface was successfully applied to compute asphalt pavement rutting and upheavals at the National Airport Pavement Test Facility (NAPTF). Case studies for profile data collection and analysis using data from in-service domestic airfield pavements, California type profilograph simulation, and

B-737 simulator study at the FAA Mike Monroney Aeronautical Center will be discussed as well.

SESSION 9-2: METHODOLOGY TO PREDICT ROUGHNESS CHARACTERISTICS OF FLEXIBLE PAVEMENT SYSTEMS IN TEXAS BY NARAIN HARIHARAN, FUGRO ROADWARE

BIOS

Mr. Narain Hariharan joined Fugro Roadware in 2015 and works out of their Austin office. He serves as a project engineer and traffic analyst in the LTPP project for the Southern region. Mr. Hariharan has previously worked as a paving engineer in the heavy construction industry and also interned at the TXDOT area office in Corpus Christi. Mr. Hariharan completed his Bachelors in Civil Engineering in 2011 from one of the top universities in India and has also completed his Masters in Civil Engineering from Texas A&M University, College Station in 2013. During his Masters, Mr. Hariharan worked under the guidance of Dr. Dallas Little and focused his study on several topics in Pavement engineering including ionic subgrade stabilization, flexible and rigid pavement design, roadway infrastructure management etc. Mr. Hariharan has recently developed a software named 'Mr.TxES' that allows users to analyze the roughness characteristics of flexible pavements with emphasis on subgrade properties for pavement systems in Texas and hopes to expand his methodology for other locations in the United States.

ABSRACT

The objective of this study was to predict the roughness characteristics of flexible pavement systems in Texas as a measure of loss of serviceability index over its life cycle. An important component of the successful design of pavement structures in Texas is the assessment of the accumulation of pavement roughness due to shrinking and swelling clayey subgrade soils. The vertical movement of expansive subgrades along with the design traffic loads influence the time history of pavement performance, and this predicted history of roughness and serviceability is a design basis for flexible pavement systems. Recent research studies have indicated that accurate laboratory measurement of the suction compression index, γh, is critical in determining the vertical movement of soils. For this purpose, a series of laboratory tests and investigation was conducted on candidate soil samples from the SH130 corridor in central Texas. In the process, an empirical relationship was established between vertical movement and the moisture index of

the site under investigation. This led to establishing a database for parameters governing the ride quality of pavement systems throughout Texas based on site specific information of climate, basic soil properties and traffic. A software named 'Mr.TXES' was developed to incorporate the findings and represent a time history of the deterioration of pavement serviceability as a measure of roughness. 'Mr.TXES' has the capacity to perform comprehensive sensitivity analysis to evaluate the impact of key parameters in the long-term performance of the pavements and to facilitate decision making on funding for maintenance and rehabilitation (M&R) of specific pavement sections in Texas.

SESSION 9-3: INVESTIGATION OF CURLING AND WARPING ON US 34 NEAR GREELEY, COLORADO BY DAVE MERRITT AND GEORGE CHANG, TRANSTEC GROUP

BIOS

Author

Mr. Merritt has been involved with numerous pavement research efforts, including PCC mixture optimization research, demonstration of intelligent compaction for base and HMA pavement construction, demonstration of high friction surfacing materials for enhancing friction at horizontal curves, efforts to quantify and evaluate curling and warping of PCC pavements, development of innovative texturing techniques for PCC pavements, and efforts to develop performance specifications for pavement construction in a rapid renewal environment. He has also been involved in numerous pavement design, data collection, and analysis efforts. This has included the design of several precast prestressed concrete pavements, analysis of pavement performance and behavior, and organization of several data collection efforts for pavement surface characteristics and pavement behavior.

Presenter

George is known as the ProVAL man! Dr. George Chang is recognized as the world expert on pavement smoothness and intelligent compaction technologies. His research, teaching, specification development and software tools have helped made significant technology advancements in the above fields. The websites he develops and maintains, ProVAL (www.RoadProfile.com) and Veda/Intelligent Compaction (www.IntelligentCompaction.com), evolve into the one-stop shopping for pavement smoothness and intelligent compaction for soils, subbase and asphalt. He has been leading the US national deployment effort of intelligent compaction with the FHWA since 2007. He has also been leading the FHWA ProVAL Support team since 2000.

ABSRACT

In 2012, a 9-inch-thick jointed concrete pavement was constructed on US Highway 34 near Greeley, Colorado over the existing reclaimed asphalt pavement. Following construction it was observed that the eastbound lanes had smoothness problems related to slab curl and warp while the westbound lanes did not. Considering that the designs were identical for both the eastbound and westbound lanes, CDOT initiated a research project to understand why this difference in roughness caused by curl and warp occurred such that steps can be taken to mitigate this issue on future projects. For the investigation, pavement profile data were collected during winter and summer conditions during four different periods of the day to examine the effects of slab curling on roughness. Pavement slab temperature data were also collected for correlation with the profile data. Slab curvature was analyzed using the Second Generation Curvature Index (2GCI) developed under previous FHWA research project, and HIPERPAV was used to evaluate early age pavement behavior using the actual construction conditions. This paper will summarize the various analyses that were conducted under this research project for CDOT and the conclusions and recommendations resulting from the study.

Session 10 – RPUG: Smoothness III

MODERATOR: LADONNA RODWEN, ILDOT

SESSION 10-1: CASE STUDY: IRI SPECIFICATION IN RIGID PAVEMENTS, FIRST EXPERIENCE IN COSTA RICA BY ANA ELENA HIDALGO ARROYO, UNIVERSITY OF COSTA RICA

BIOS

Ana Elena Hidalgo Arroyo

Academic Training
Civil Engineer of Universidad de Costa Rica.
Candidate MSc, Roads and Transportation Engineering, University of Costa Rica

Professional Experience
I work at the National Laboratory of Materials and Structural Models of the University of Costa Rica (LanammeUCR)
• Period: 2009 -present
• Position: Technical Auditor
• Functions : Technical Audits in road infrastructure projects (road maintenance and construction of new projects).

ABSRACT

The project study is one of the two sections of the Panamerican Highway running through Costa Rica and is vital for the tourism, economic and productive development of the northern part of the country. The project has four lanes, two in each direction with a length of 30.4 miles, and is located between Cañas and Liberia main cities. It is a nationwide major rigid pavement project which has a pavement surface condition (IRI) specification that is set as a payment parameter.

This study includes the measurement and calculation of IRI in some project sections, as well as an analysis of data compliance according to the specification and pay factor estimation associated with the roughness value obtained in these sections. Also, the study includes the analysis of the pavement sections with initial high roughness values where a diamond grinding technique was applied.

The analysis inferred the following questions:

• Is the IRI specification too strict to be applied in a rigid pavement compared to a flexible pavement?
• Is it the IRI value a quality acceptance or a pay parameter?

The National Laboratory of Materials and Structural Models of the University of Costa Rica through the Technical Audit Unit, performs audits of new pavement projects, such as this case, with the main objective ensuring materials quality, and pavement structure performance through the analysis of IRI, FED, GRIP Tester measurements, and the evaluation of construction practices and processes in order to comply with national technical specifications.

SESSION 10-2: LONG-TERM PERFORMANCE OF WHITETOPPING AS A REHABILITATION TECHNIQUE OF AN ASPHALT PAVEMENT – A FLORIDA CASE STUDY BY ABDENOUR NAZEF, FLORIDA DOT

BIOS

Abdenour is a Pavement Systems Evaluation Engineer with the Florida DOT. He has over 24 years of experience in material testing, pavement characterization, forensics and performance evaluation. He is responsible for managing FDOT in-house experimental and sponsored research projects, and for evaluating new pavement products, test equipment and practices. Abdenour is a registered Professional Engineer with a bachelor's and Master's degree from the University of Florida.

ABSRACT

In 1988, a unique type of concrete overlay, namely whitetopping, was placed on asphalt pavement sections of SR-5 in Volusia County, Florida. The whitetopping project was divided into 19 sub-sections with different combinations of design factors including three dowel-bar configurations (12 in. center to center, in wheelpaths only, no dowels), three slab thicknesses (6 in., 7 in. and 8 in.) and five slab lengths ranging from 12 to 20 feet , all using a Jointed Plain Concrete Pavement (JPCP) design. The Florida Department of Transportation has been monitoring smoothness and structural performance for the last 27 years to determine the optimum combination of design factors which provides the best long-term performance.

This study evaluated the effect of longitudinal ground surface texture on smoothness and the magnitude of faulting measurements using three different laser sensors including single-spot, wide-spot and Ro-line. It was determined that the single spot laser is not appropriate for measuring faulting or smoothness of the

longitudinally textured pavement due to the relatively small laser footprint and the effects of vehicle wander over the longitudinal grooves.
Furthermore, results of a multi-factorial regression data analysis indicate that dowel bar configuration has the most significant effect on smoothness and faulting performance while the effects of other design factors, like slab thickness and length, are not significant. To date, eight out of nine whitetopping test sections with 12 in. center to center dowel configuration perform better than the conventional JPCP control section with identical dowel bar spacing configuration.

SESSION 10-3: DEVELOPMENT OF NETWORK LEVEL TARGETS AND VALIDATION OF CONSTRUCTION GOALS IN NORTH CAROLINA BY DON CHEN, UNIVERSITY OF NORTH CAROLINA AT CHARLOTTE

BIOS

Don joined the University of North Carolina at Charlotte in 2009 and since then has been involved in Pavement Management System related research projects, dealing with both windshield and automated data.

During this time, Don has contributed to the development of performance models, determination of weight factors for Cost-Benefit Analysis, and evaluation of trigger values on decision trees. Additionally, he has overseen the development of North Carolina specific network level IRI targets and validation of construction targets.

He is currently a member of TRB AFH10/ABJ50 Sub-Committee on Construction Information Systems. Don is a Civil Engineering graduate from the Iowa State University, and a LEED AP (Leadership in Energy and Environmental Design, Accredited Professional).

ABSRACT

International Roughness Index (IRI) is one of the most important pavement performance parameters. For DOT engineers, it is a measure of pavement surface distortion or variation in pavement surface elevation; it can be used to trigger appropriate maintenance treatments, approve new and rehabilitated roadways, and determine contractors' performance incentives. For the traveling public, roughness is an indicator of a comfortable ride; it is directly used by the public to judge pavement condition, it also affects user costs, including fuel, repairs, and vehicle depreciation. Although Federal Highway Administration (FHWA) has several

recommended IRI thresholds, they are not locally calibrated and thus do not necessarily reflect the ride smoothness perceived by the traveling public in North Carolina. This study was conducted to address this issue. The key goal of this study is to develop the relationship between perceived ride quality (comfort) and measured IRI. To this end, candidate roadway sections were selected, research participants were recruited, and in-vehicle and pavement condition data were collected and analyzed. It was concluded that in North Carolina, if the measured IRI value of a roadway section is less than 103 inches/mile, most likely this section would be rated as "Acceptable" by the general driving public; most likely a section would be rated as "Unacceptable" if its measured IRI value is greater than 151 inches/mile. If the IRI value is greater than 200 inches/mile, the roadway section is considered as "Very Unacceptable". In addition, it was recommended that the target initial IRI value for a new construction project should be between 60 and 70 inches/mile for a "smooth" pavement and for a "perfect" or "very smooth" roadway section, the IRI value should be between 50 and 60 inches/mile. The findings of this study can be used extensively by the Pavement Management Unit (PMU) to select timely pavement maintenance treatments, and thus to strategically manage North Carolina's roadway system in a cost effective manner and by the NCDOT Construction Unit to validate smoothness measures.

SESSION 10-4: ROAD ROUGHNESS VERSUS RIDE COMFORT WHICH CONSIDERS ROAD USERS; OUR CUSTOMERS BY ERIC PERRONE, AGILEASSETS

BIOS

ABSRACT

Many surveys show that a comfortable ride is the goal of the riding public and most pavement engineers in highway agencies. In the 1950's, Francis Hveem in the California Division of Highways and William Housel, Professor of Civil Engineering, University of Michigan, both independently developed "Profilographs" in their attempts to better measure ride comfort. In 1960, Bill Carey and Paul Irick developed the Present Serviceability Index which took the roughness information from these two profilographs and the BPR Roughometer and compared them to develop a scale of rider opinion ranging from 1 to 5, where 5 was excellent, which they call the Present Serviceability Index or PSI. At about

the same time, Canadian highway agencies developed a Ride Comfort Index (RCI) ranging from 0 to 10 which fulfilled the same purpose as the PSI.

These two measures were used for 30 + years to define ride comfort in terms of road roughness measurements and rider comfort evaluations. They are the basis of all AASHO and Canadian pavement design equations and design guides from 1960 until 1999 +/-.

Since roughness is the basis of ride comfort indices, a great deal of effort has gone into comparing profiler equipment and ride measurements and improving those measurements over the last 30 years. However, along the way all the effort to improve measurement equipment and our natural engineers talent for detailed measurements and accuracy have caused 80% of highway agencies to drop ride comfort indexes and to concentrate on roughness alone in the form of IRI. This paper discusses these issues and shows that it is now necessary to go beyond roughness and to recreate a universal ride comfort index that all agency personnel, road users, and legislators across the world can use to understand the quality of our highways in a common language.