13th Annual Inter-University Symposium on Infrastructure Management (AISIM 2017)
PROGRAM SCHEDULE

June 23, 2017

7:30 AM – 9:00 AM: Breakfast – ARMS 1028

9:00 AM – 9:30 AM: Keynote lecture – ARMS 1021 “Transportation Infrastructure Asset Management in the New Millennium: Challenges and Opportunities” Professor Kumares C. Sinha, Olson Distinguished Professor, Purdue University

9:30 AM – 10:45 AM: Presentations moderator: Tariq Usman Saeed

9:30 AM – 9:45 AM: Estimating the First Hitting Time for Track Geometry Degradation
   Silvia Galvan-Nunez and Nii Attoh-Okine (U Delaware)

9:45 AM – 10:00 AM: Modelling Tamping Recovery using Copula-Based Approach
   Emmanuel Martey, Nii Attoh-Okine (U Delaware)

10:00 AM – 10:15 AM: A Comparison of Two Resilience Metrics for Transportation Infrastructure
   YuanChi Liu (U Delaware)

10:15 AM – 10:30 AM: Pareto Efficiency Analysis of Private Toll Road Markets: Leveraging PPPs to Finance Investments in Infrastructure
   Hang Shu, Pablo L. Durango-Cohen (Northwestern University)

10:30 AM – 10:45 AM: Implementation of Electrical Resistance Measurement to Quantify Asphalt Emulsion-Based Chip Seal Curing Times
   M.A. Montoya, J.E. Haddock, W.J. Weiss (Purdue University)


10: 45 AM to 11:00 AM: Break – ARMS 1028

11:00 AM – 12:15 PM: Presentations moderator – ARMS 1021: Abdullah Jalal Nafakh

11:00 AM – 11:15 AM: An Overview of the Accelerated Pavement Testing Program: A Virginia Case Study
   Freddie Salado, Gerardo Flintsch (VA Tech)

11:15 AM – 11:30 AM: Analysis of WisDOT’s Maintenance Quality Assurance Program
   Javier Luis Vidal Carreras, Teresa M. Adams (U Wisconsin)
11:30 AM – 11:45 AM: Vibration Analysis for Health Condition Assessment of the Reinforced Concrete Girders
Ali Hafiz, Thomas Schumacher (Portland State University)

11:45 AM – 12:00 PM: Inspection System for RC Slabs of Expressway Bridges Focused on the Frequency of Generation of Potholes
Yohei Ninomiya, Kiyoyuki Kaito (Osaka University)

12:00 PM – 12:15 PM: Principal Component Analysis in the Evaluation of Track Quality Index (TQI)
Lasisi Ahmed, Nii Attoh-Okine (U Delaware)

12:15 PM – 1:30 PM: Lunch/Poster sessions/Sponsors Display - ARMS 1103 - Atrium

1:30 PM – 2:30 PM: Presentations moderator – ARMS 1021: Arash Reza Habibi-Soureh

1:30 PM – 1:45 PM: Data Analysis of Steel Bridge Infrastructure including Climate and Traffic Effects
Tian Bai, Jennifer McConnell (U Delaware)

1:45 PM – 2:00 PM: Viability of Citizen Science for Infrastructure Condition Assessment at the Neighborhood Level
Isaac C. Oti, Nasir G. Gharabeh (Texas A&M)

2:00 PM – 2:15 PM: Pavement Macrotexture: Current State of the Practice
Vincent Bongioanni (VA Tech)

2:15 PM – 2:30 PM: Geopolymer Concrete can be the Solution for Sustainable Infrastructure
Lateef Assi, Mustafa Jasim, Kealy Carter, Pual Ziehl (U of SC)

2:30 PM – 2:40 PM: Closing Remarks

2:30 PM to 3:00 PM: Break – ARMS 1103

3:00 PM – 5:15 PM: Tours of Infrastructure Labs (Bowen, Center for Aging Infrastructure)

Departure from the North West Entry of ARMS Building (Stadium Avenue)

5:15 PM – 6:15 PM: Opportunity to Tour the Campus

6:30 PM – 7:30 PM: Social Time and Dinner (PMU Faculty West Lounge – Second Floor)

7:30 PM – 8:45 PM: Closing Speeches and Awards Reception

“The ASCE Report Card: Does it Make the Grade?” Professor Jon D. Fricker, Professor of Civil Engineering, Purdue University

“Infrastructure and Commerce” Mr. Mark R. Holden, CEO and Member of the Board of Directors, A&R Logistics, Inc.
Poster Presentations

1. Multiobjective Optimization of Lane and Shoulder Widths at Rural Two-Lane Highways
   Sikai Chen, Paul V. Preckel, Yu Qiao, Qiang Bai, Wubeshet Woldemariam

2. Cost and Fuel Usage Optimization of Activating Solution Based Silica Fume Geopolymer Concrete
   Lateef Assi, Mustafa Jasim, Kealy Carter, Paul Ziehl

3. The U.S. Interstate Highway Bridge Maintenance Performance Assessment
   SeyedAli Ghahari, Saeed AlQadhi

4. Improving the Electric Vehicle Charging Station Network for Use in Trans-National Transportation
   Arash Habibi-Soureh, Thomas Hall, Tariq Saeed

5. Development of Probabilistic Design Approach for Freeze Thaw Resistance of Concrete
   Warda Ashraf, Michal A. Glinicki, Jan Olek

6. Predicting Deterioration and Service Life of Indiana Bridges: Accounting for Material Type, Design Type, Functional Class and Climate
   Tariq Usman Saeed

7. Forecasting of Highway Revenues under Various Options
   Abdullah Nafakh, Kumares C. Sinha

8. Updating State and Local Highway Cost Allocation and Revenue Attribution – A Case Study for Indiana
   Yu Qiao, Samuel Labi, Kumares C. Sinha

   Sikai Chen, Samuel Labi, Kumares C. Sinha
June 24, 2017

8:30 AM - **Chicago Trip (at no cost to attendees)** – Departure from the North West Entry of ARMS Building (in Stadium Avenue)

10:00 AM (Chicago time) - Arrive at the Chicago Navy Pier

10:30 AM - Depart Navy Pier for the Riverboat Architecture Tour

11:45 AM – Return to the Chicago Navy Pier

12:15 PM - Lunch in Chicago (location to be announced)

2:15 PM – Converge at Hancock Tower, 875 North Michigan Avenue, for skyscraper tour

4:00 PM – Start of Sightseeing at Millennium Park, Chicago

5:00 PM – Start of Sightseeing at East Randolph St, Chicago

5:30 PM – Converge at 201 E Randolph St, Chicago for departure

6:00 PM - Depart for Purdue University Physics Building 525 Northwestern Ave.

9:30 PM (Indiana time) – Drop off at Purdue University North West Entry of ARMS Building (in Stadium Avenue).
ABOUT AISIM

Background and history

The management of civil engineering infrastructure is essential to retain the value of initial investments. Engineers around the world continue to seek or develop innovative solutions for planning, designing, operating, and monitoring, and maintaining such infrastructure.

The Annual Inter-University Symposium on Infrastructure Management (AISIM) was created to help meet this need. AISIM is a full-day symposium featuring information exchange and networking opportunities primarily for graduate students, but often includes researchers and practitioners including infrastructure agencies, consultants, development banks, and other stakeholders.

The inaugural AISIM event was held on August 6, 2005 at the University of Waterloo and subsequent events have been held at seven other institutions (see table below).

<table>
<thead>
<tr>
<th>AISIM Sequence # and Date</th>
<th>Location</th>
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<tbody>
<tr>
<td>AISIM 1 (August 6, 2005)</td>
<td>University of Waterloo, Canada</td>
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<tr>
<td>AISIM 2 (June 10, 2006)</td>
<td>University of Delaware, Newark, DE</td>
</tr>
<tr>
<td>AISIM 3 (June 2, 2007)</td>
<td>Virginia Polytech Institute and State University, Blacksburg, VA</td>
</tr>
<tr>
<td>AISIM 4 (August 9, 2008)</td>
<td>University of Texas, Austin, TX</td>
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<tr>
<td>AISIM 5 (June 20, 2009)</td>
<td>University of Iowa, Iowa City, IA</td>
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<td>AISIM 6 (June 19, 2010)</td>
<td>University of Delaware, Newark, DE</td>
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<td>AISIM 7 (June 4, 2011)</td>
<td>Northwestern University, Evanston, IL</td>
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<tr>
<td>AISIM 8 (June 9, 2012)</td>
<td>Georgia Institute of Technology, Atlanta, GA</td>
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<tr>
<td>AISIM 9 (June 6-7, 2013)</td>
<td>University of California, Berkeley, CA</td>
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<tr>
<td>AISIM 10 (June 21, 2014)</td>
<td>Virginia Polytech Institute and State University, Blacksburg, VA</td>
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<tr>
<td>AISIM 11 (May 22, 2015)</td>
<td>University of Delaware, Newark, DE</td>
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<tr>
<td>AISIM 12 (June 11, 2016)</td>
<td>Oklahoma State University, Stillwater, OK</td>
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In the years since its inception, AISIM has carved out a critical role in graduate education pertaining to infrastructure management. Graduate students from world-renowned institutions, who represent the next generation of leaders in infrastructure management, attend AISIM each year to exchange research ideas and information.

Thus, AISIM has served as an avenue for the students to network with their peers (nationally and internationally) and has provided an opportunity for students to interact with global leaders in infrastructure.

This year, the 13th AISIM will be held at Purdue University in West Lafayette, Indiana, on Friday, June 23, 2017.
TABLE OF CONTENTS

PROGRAM SCHEDULE ...........................................................................................................i

June 23, 2017 ..........................................................................................................................i

Poster Presentations .............................................................................................................iii

June 24, 2017 ...........................................................................................................................iv

ABOUT AISIM .........................................................................................................................vi

Background and history .........................................................................................................vi

EDITORIAL .............................................................................................................................1

KEYNOTE ADDRESS ............................................................................................................3

DINNER ADDRESS ..............................................................................................................5

PAPER ABSTRACTS ..............................................................................................................9

Principal Component Analysis in the Evaluation of Track Quality Index (TQI) ..................11

Quantifying the Effect of Hurricane Wave Forces on Bridges to Support Infrastructure
Resilience for Coastal Communities .......................................................................................12

Vibration Analysis for Health Condition Assessment of the Reinforced Concrete Girders ....13

An Overview of the Accelerated Pavement Testing Program: A Virginia Case Study .......14

Estimating the First Hitting Time for Track Geometry Degradation .................................15

A Comparison of Two Resilience Metrics for Transportation Infrastructure ....................16

The U.S. Interstate Highway Bridge Maintenance Performance Assessment .....................17

Potential Hydroplaning and Highway Geometry Locations: Case Study Using SHRP Data ..18

Analysis of WisDOT’s Maintenance Quality Assurance Program ......................................19

Viability of Citizen Science for Infrastructure Condition Assessment at the Neighborhood
Level .........................................................................................................................................20

Inspection System for RC Slabs of Expressway Bridges .....................................................21

Focused on the Frequency of Generation of Potholes .........................................................21

Cost and Fuel Usage Optimization of Activating Solution Based Silica Fume Geopolymer
Concrete ..................................................................................................................................22

viii
Data Analysis of Steel Bridge Infrastructure including Climate and Traffic Effects.........23
Modelling Tamping Recovery Using Copula-Based Approach.......................................24
Geopolymer Concrete can be the Solution for Sustainable Infrastructure ..................25
Pavement Macrotecture: Current State of the Practice ..................................................26
Multiobjective Optimization of Lane and Shoulder Widths at Rural Two-Lane Highways....27
Implementation of Electrical Resistance Measurement to Quantify Asphalt Emulsion-Based Chip Seal Curing Times ..................................................................................28
Pareto Efficiency Analysis of Private Toll Road Markets: Leveraging PPPs to Finance Investments in Infrastructure.................................................................29
Improving the Electric Vehicle Charging Station Network for Use in Trans-National Transportation ...........................................................................................................30
Development of Probabilistic Design Approach for Freeze Thaw Resistance of Concrete....31
Predicting Deterioration and Service Life of Indiana Bridges: Accounting for Material Type, Design Type, Functional Class and Climate .................................................................32
Overweight-Vehicle Research that Led to Indiana’s New Trucking Law (Act 1481)............33
Updating State and Local Highway Cost Allocation and Revenue Attribution – A Case Study for Indiana ..................................................................................................................34
Forecasting of Highway Revenues under Various Options .............................................35
AISIM 13 ORGANIZING COMMITTEE MEMBERS .........................................................37
ABOUT OUR SPONSORS............................................................................................38
EDITORIAL

The theme for this year's symposium is "State of Infrastructure Management: Challenges, Sustainability & Innovation" underscores the current conditions of our aging infrastructure with respect to what is being done to ensure efficient use of resources in development, operation, maintenance and management.

The topics for this year’s AISIM symposium come from several functional areas in Infrastructure Management. With the exception of the keynote and dinner speakers, all presenters are students. In addition, graduate students organized and attended this symposium, which served as a great networking opportunity for future collaborative work.

The students’ research papers come from various phases of infrastructure development as shown in the Table 2 below (some papers have contexts or application areas that span more than one phase).

Table 2. Phases of infrastructure development addressed in the papers submitted

<table>
<thead>
<tr>
<th>PHASE</th>
<th>CONTENTS OF PAPERS SUBMITTED</th>
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<tbody>
<tr>
<td>Planning</td>
<td>Resilience metrics for transport infrastructure; Leveraging PPPs to finance infrastructure investments.</td>
</tr>
<tr>
<td>Design</td>
<td>Hydroplaning and highway geometry; infrastructure materials that promote sustainability; structural analysis of steel bridge infrastructure; silica fume geopolymer concrete; geopolymer concrete; lane and shoulder width design; design approach for freeze-thaw resistance of concrete; impact of bridge material and design type on longevity.</td>
</tr>
<tr>
<td>Construction</td>
<td>Curing times of asphalt emulsion-based chip seals.</td>
</tr>
<tr>
<td>Operations</td>
<td>Resilience of in-service bridges; resilience metrics for transport infrastructure; citizen science for infrastructure condition assessment; private tolling of roads; development of a network for electric vehicle charging stations.</td>
</tr>
<tr>
<td>Monitoring</td>
<td>Evaluation of rail track quality; health condition assessment of reinforced concrete girders; accelerated pavement testing; degradation of rail track geometry; hydroplaning and highway geometry; citizen science for infrastructure condition assessment; inspection of expressway bridge RC slabs; condition analysis of steel bridge infrastructure; pavement microtexture monitoring; deterioration rate of bridges.</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Assessing bridge maintenance performance; quality assurance of a maintenance program; effectiveness of rail track maintenance activities.</td>
</tr>
<tr>
<td>End of life</td>
<td>Factors affecting bridge service lives.</td>
</tr>
</tbody>
</table>

Also, the submitted papers address a variety of study tools, some mechanistic and experiment-based, some based on statistical or numerical modeling of uncontrolled empirical data, and others based on empirical data from controlled experiments such as SHRP’s LTPP. Besides statistical methods, the analytical tools used in addressing the various research questions include concepts in economics or operations research. Further, the submitted papers primarily address two modes: rail and highway. However, the materials-related research has far-reaching applications and implications in the design and maintenance of infrastructure in other modes including air transportation (airport runways) and waterways (port structures).
The submitted papers also address the shape of things yet to come, such as the development of sustainable materials, design of locations for charging stations for electric vehicles, and technology-based citizen science (crowd sourcing of infrastructure inspections).

We encourage all participants to network among their colleagues, actively learn as much as you can about other research that is presented by your colleagues through the poster and lectern sessions, and provide input that will further enhance the quality of their work.

Purdue University welcomes you to our beautiful campus, and we wish you a pleasant and memorable stay.

*Samuel Labi (Faculty Host)*
*Professor of Civil Engineering*
*Purdue University*

*Sue McNeil (Faculty Host)*
*Professor of Civil & Environmental Engineering*
*University of Delaware*

*June 23, 2017*
KEYNOTE ADDRESS

DR. KUMARES C. SINHA

PH.D., P.E., HON M. ASCE,
OLSON DISTINGUISHED PROFESSOR OF CIVIL ENGINEERING,
Purdue University
MEMBER, NATIONAL ACADEMY OF ENGINEERING

Presentation Title: Infrastructure in the New Millennium: Challenges and Opportunities

Biography:

Dr. Kumares C. Sinha is the Edgar B. & Hedwig M. Olson Distinguished Professor of Civil Engineering at Purdue University, Faculty Fellow of the Hagler Institute for Advanced Study at Texas A&M University, and Guest Lockheed Martin Professor of Engineering at the University of Central Florida. He is a Member of the U.S. National Academy of Engineering and a National Associate of the U.S. National Academies. He served as the Director of Purdue’s Joint Transportation Research Program from 1995 to 2010.

Dr. Sinha has authored over 400 technical publications including a graduate-level textbook that is used worldwide: Transportation Decision Making: Principles of Project Development and Programming, published by Wiley. He is widely known for pioneering integrated asset-management techniques with innovative research on condition modeling, treatment effectiveness, life-cycle costing, and multi-objective optimization of system performance, and the development of decision-support software packages for infrastructure renewal and repair.

Dr. Sinha advises governments at all levels and consults for the World Bank and other agencies on transportation and infrastructure issues. He is a registered Professional Engineer and an Honorary Member of the American Society of Civil Engineers (ASCE). He has served as the President of ASCE’s Transportation & Development Institute, President of the Research and Education Division of the American Road and Transportation Builders Association (ARTBA), President of the Council of University Transportation Centers (CUTC), Member of the Board of Directors of the International Road Federation (IRF) and as a member of the Federal Advisory Council on Transportation Statistics. He serves as a member of the Executive Committee of the Transportation Research Board (TRB), SHRP2 Oversight Committee, and FHWA Research and Technology Coordinating Committee. Dr. Sinha is currently the Editor-in-Chief Emeritus of the Journal of Transportation Engineering.

For his illustrious career and extraordinary accomplishments in transportation research, education, and practice, Dr. Sinha has been the recipient of several awards and recognitions. His awards include: inaugural Lifetime Achievement Award from the International Society of Maintenance and Rehabilitation of Transport Infrastructures (iSMARTi) (2016), ASCE’s James Laurie Prize (2011), TRB’s Roy W. Crum Award (2009), CUTC’s Award for Distinguished Contribution (2005), ITE’s Wilbur S. Smith Distinguished Transportation Educator Award (2002), ASCE’s Francis C. Turner Lecture Award (2001), and ARTBA’s Steinberg Award (2000).
DINNER ADDRESS

Dr. Jon D. Fricker

Ph.D., P.E., M. ASCE,
Professor of Civil Engineering, Purdue University
Board of Directors, Greater Lafayette Public
Transportation Corporation (CityBus)

Presentation Title: The ASCE Report Card: Does it Make the Grade?

Biography:

Dr. Jon Fricker, Professor of Civil Engineering at Purdue University, is a registered Professional Engineer whose primary interests and expertise include transportation planning and asset management. He has undergraduate and graduate degrees from the Massachusetts Institute of Technology and Carnegie Mellon University, respectively. Since joining Purdue’s Civil Engineering faculty in 1980, his principal teaching and research interests have been in transportation planning, network analysis, systems analysis, public (mass) transportation, county highway programs, and highway finance.

Over the past thirty years, he has worked on a large number of research projects sponsored by the Indiana Department of Transportation (INDOT) that span a wide variety of areas, including bicycle safety feasibility studies, integrated land use-transportation modeling, developing alternative land use patterns to minimize congestion, transportation security, traffic monitoring, and origin-destination studies. A sampling of his recent work includes updating traffic impact study policies, timing of transportation asset maintenance activities, and the cost savings from grouping individual projects. Dr. Fricker has authored or co-authored hundreds of technical publications and conference proceedings. He is also the co-author of a widely-used book, Fundamentals of Transportation Engineering: A Multimodal Systems Approach, published in 2004 by Prentice Hall. He teaches a number of undergraduate and graduate courses, including Introduction to Transportation Engineering, Comprehensive Urban Planning Process, Public Mass Transportation, Transportation Planning, and Network Models and Algorithms.

Dr. Fricker's interests, expertise, and reputation as a transportation engineer are reflected in the extent of his activity with technical committees in professional societies, often in positions of leadership. He has been recognized widely for his work as he has been nominated or has been the recipient of numerous academic and professional awards, including outstanding papers for journals and conferences, awards to student chapters which he has co-advised, the ITE Technical Council Award, ASCE News Correspondent Award, and the ITE Section Newsletter Award. Dr. Fricker has had longstanding service on the Board of Directors of the Greater Lafayette Public Transportation Company, a local bus company, and the Technical Transportation Committee of Tippecanoe County in Indiana.
Mr. Mark R. Holden
CEO and Member of the Board of Directors, A&R Logistics, Inc.

Presentation Title: Infrastructure and Commerce

Biography:

Mark R. Holden was named Chief Executive Officer and a member of the Board of Directors of A&R Logistics, Inc. during 2012. Mr. Holden and his partner in MRH Holdings LLC joined private equity firm Mason Wells in acquiring A&R Logistics in December 2012. Headquartered in Morris, IL, A&R Logistics is a leading provider of dry bulk transportation, packaging, distribution and logistics solutions to numerous multinational companies within the chemical industry. With revenues over $200 million, A&R provides a comprehensive suite of services including over-the-road transportation, transloading, packaging, warehousing and end-to-end outsourced transportation management through a nationwide network of facilities, a combination of Company owned equipment and owner operators and a non-asset based transportation management division.

Mr. Holden was appointed by the Governor of Indiana to the Indiana Blue Ribbon Panel on Transportation Infrastructure in October 2013. In addition, the Governor of Indiana also appointed Mr. Holden to the Indiana Commission for Higher Education in 2013. Mr. Holden was also appointed to the Board of the Indiana Economic Development Committee by Governor Daniels in 2006.

A CPA, Mr. Holden spent the first 11 years of his professional career with Arthur Andersen & Co. in Indianapolis, IN. He graduated cum laude from Ball State University with a BA and a double major in Accounting and Finance with a Spanish minor. In October of 2014, Mr. Holden received the Ball State University’s Distinguished Alumni Award, the highest honor to recognize alumni for their loyalty and significant contributions to their professions, communities, and society. Mr. Holden also received the Ball State University President’s Medal of Distinction in 2013 and the Award of Distinction in 2007 from the Miller College of Business at Ball State. Mr. Holden serves on the Board of Directors of the Ball State University Foundation.
PAPER ABSTRACTS
Principal Component Analysis in the Evaluation of Track Quality Index (TQI)

Lasisi Ahmed*, Nii Attoh-Okine

Department of Civil & Environmental Engineering, University of Delaware, Newark, DE, USA

ABSTRACT

The importance of track geometry degradation models in railway engineering cannot be over-emphasized. According to the Federal Railroad Administration (FRA), track geometry-caused derailments represents around 13% of the overall train derailment causes in 2015. A good track degradation model will aid the establishment of track infrastructure maintenance policies. The result of these model can be used to evaluate derailment potential. However, without a proper understanding of the track geometry parameters, an accurate degradation model may not be feasible. Based on the characteristics of track geometry data, a good number of the parameters dispersed through a high dimensional space can be expressed by a low-feature representation without losing essential properties of the original data. The principal component analysis (PCA) is certainly capable of summarizing the behavior of track geometry parameters for each section while maximizing the variance through an optimally chosen linear combination.

Since the PCA is an unsupervised learning method, it is necessary to initially classify track sections (without and without defects) using the best performing classification obtained from the result of training several models (Support Vector Machines, Neural Networks, Discriminant Analysis and K-Nearest Neighbors) on the track geometry data. The classification is based on the thresholds considered by the FRA for selected individual track geometry parameters at each section of the track. The principal components of each class and section is potentially crucial to characterizing the track geometry at each section. The end result is a low dimensional representation of parameters that not only explains the spatial behavior of track geometry but can also be used as a measure of track quality.

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Quantifying the Effect of Hurricane Wave Forces on Bridges to Support Infrastructure Resilience for Coastal Communities

Alaa W. Hameed*, Thomas Schumacher

Civil & Environmental Engineering, Portland State University, Portland, OR, USA

ABSTRACT

Due to the massive destruction that caused by the extreme events of Hurricane Ivan (2004) and Katrina (2005), studying and quantifying the effects of wave forces on coastal infrastructure has received significant attention over the past decade. A focus has been on the need for adequate design and safe performance of coastal bridges, since they represent critical links in the infrastructure network. While guidelines for the design of coastal bridges have been developed (by AASHTO), the dynamic behavior of such structures has still not been studied adequately. This research is based on a large dataset that was collected from extensive large-scale tests performed at Oregon State University in 2008. The objective of this study is to investigate and quantify the dynamic response of bridge superstructures during hurricane wave impact. First, the effect of superstructure inundation on the overall damping characteristics was studied. Since the setup contained a mix of damping types: friction, and viscous damping, an investigation of which type was involved and to what extent was performed. In the subsequent studies, equations for the induced horizontal and vertical forces will be derived to provide engineers with more accurate means to estimate wave force effects.

This research will provide (1) engineers with more accurate tools to estimate dynamic effects due to hurricane wave forces as well as (2) agencies with the means to better understand which bridges are vulnerable to damage during future events. Overall, this research aims to improve infrastructure resilience and sustainability for coastal communities.

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Vibration Analysis for Health Condition Assessment of the Reinforced Concrete Girders

Ali Hafiz*, Thomas Schumacher

Civil & Environmental Engineering, Portland State University, Portland, OR, USA

ABSTRACT

Asset management tools are used by transportation agencies to make informed decisions regarding bridge maintenance and repair. These tools require quantitative data regarding the condition and changes thereof. This data can be provided from non-destructive evaluations such as vibration analysis. Cracking of the girders is a commonly observed deterioration process in non-prestressed girders and may decrease their durability and service lifetime. While cracking does not reduce the ultimate capacity of a structural member, it does allow exposure of the steel reinforcing bars to the environment, which may initiate corrosion. In this paper, vibration analysis is presented as a condition assessment tool to estimate the amount of cracking in a concrete bridge girder, which is associated with its overall health. A 16 ft long and 2 ft deep T-girder was first loaded at mid-span (= 0.5L), followed at 0.75L, to induce cracking. Prior to loading, as well as in between the two loading sessions, a specialized hammer equipped with a load cell was used to strike the beam at different locations along the girder. Accelerometers attached to the girder were employed to measure its dynamic response due to the hammer impulse. Using the Fast Fourier Transform (FFT) allowed to observe changes in the natural frequencies of vibration, which directly related to the cracking imposed on the girder between vibration testing. One interesting finding is that the higher modes of vibration, which are not typically analyzed, provided more meaningful information for characterizing the presence of cracking. This research directly supports infrastructure resilience and sustainability efforts by providing condition assessment data used in bridge asset management.

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An Overview of the Accelerated Pavement Testing Program: A Virginia Case Study

Freddie Salado*, Gerardo Flintsch

Virginia Polytechnic Institute & State University, Blacksburg, VA, USA

ABSTRACT

Road administrators often have to make decisions regarding the maintenance and rehabilitation of the road network with limited information about the performance of pavements. The Heavy Vehicle Simulator (HVS) is increasingly used as an Accelerated Pavement Testing (APT) tool to study the pavement performance in a shorter period and more controlled conditions. The Virginia Department of Transportation (VDOT) has initiated a research project, in a jointed effort with the Virginia Tech Transportation Institute, to study the behavior and performance of different pavement materials and structures under accelerated loading using a HVS.

Six pavement sections with different structures were instrumented from subgrade to the top layer with strain gauges, load cells, and thermocouples. The first two sections were constructed to test the performance of a 5 inches of a Cold Central Plant Recycling (CCPR) base with different surface thicknesses. The next two sections were designed with a pavement mixture that was designed for a lower number of gyrations than the current VDOT standard. Finally, the last sections were used for a reflective cracking study; they include a jointed concrete pavement, which will be overlaid with surface mixes of 1.5 inches that will be modified using asphalt rubber and polymer modified asphalt binder. The concrete was built with joints of 3/8 inches wide that will reflect the cracking on the surface. The paper will present an overview of the instrumentation and construction process of the pavement sections and some of the lessons learned.

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Estimating the First Hitting Time for Track Geometry Degradation

Silvia Galvan-Nunez*, Nii Attoh-Okine

Department of Civil & Environmental Engineering, University of Delaware, Newark, DE, USA

ABSTRACT

Track-caused accidents are a major factor of train derailments in the United States. Determining the failure time is critical for safety purposes. Traditionally, failure time in track geometry has been modeled using censored data. However, unless it is an accident due to extreme events, track geometry fails as a result of an underlying degradation process. The first hitting time (FHT) is referred to the probability distribution of the time at which the degradation path first reaches a safety threshold. The purpose of this presentation is to show the formulation and implementation of the FHT in railway track geometry degradation using track geometry inspection data. The underlying degradation path is modeled as a Wiener process with drift and the FHT follows an inverse Gaussian distribution. The results provide a more robust representation of track geometry failure time using degradation data.

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A Comparison of Two Resilience Metrics for Transportation Infrastructure

YuanChi Liu*

Department of Civil & Environmental Engineering, University of Delaware, Newark, DE, USA

ABSTRACT

With growing awareness of the impacts of climate change, keeping transportation infrastructure systems resilient is emphasized in US legislation Fix America’s Surface Transportation (FAST) Act. A resilient infrastructure is able to anticipate, absorb, adapt to, and recover rapidly when hazards occur. This paper explores the influence of the recovery sequence for links in a hypothetical road network disrupted by flooding, which in turn influences rapidity, one of four features of resilience, defined by Bruneau. Two performance metrics, the recovery ratios during reconstruction and the modified Network Robustness Index (NRI), are used to quantify the resilience of transportation infrastructure. Recovery ratio is set for the construction sequence based on a limited origin destination matrix, and the modified NRI is used for recovery strategy on priorities determined by disrupting one link at a time. This paper provides the insights by applying these two different metrics to a case study.

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The U.S. Interstate Highway Bridge Maintenance Performance Assessment

SeyedAli Ghahari*, Saeed AlQadhi
Lyles School of Civil Engineering, Purdue University, IN, USA

ABSTRACT

In the United States, agencies such as the U.S. Department of Transportation and the General Accountability Office are engaged in oversight and accountability of state highway agencies and therefore emphasize the need for regular systemwide monitoring of transportation infrastructure condition in response to highway expenditures. As parts of efforts to address this issue, the nature of the relationship between the funds expended on a jurisdiction’s infrastructure maintenance and the resulting condition, must be determined. This paper investigates such a relationship specifically for interstate highway bridges. The study offers plausible explanations of the observed differences in the resulting overall bridge condition across the states. The framework and results of this paper shows how oversight agencies can increase the overall accountability of individual highway agencies with respect to the taxpayer dollars expended on their bridge infrastructure.

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Potential Hydroplaning and Highway Geometry Locations: Case Study Using SHRP Data

Kenneth Velez*, Gerardo Flintsch

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ABSTRACT

Hydroplaning occurs when there is loss of contact between the vehicle’s wheel and the pavement, due to an accumulation of water on the road, resulting in the loss of grip and loss of control. There is a need to understand their relationship between the road geometry and the water accumulation and how this water accumulation can result in an increase in the potential for hydroplaning crashes. By modifying the geometry, water accumulation can be controlled, preventing skidding and the potential hydroplaning crashes.

The objective of this research is to analyse the Strategic Highway Research Program 2 (SHRP2) database of the Naturalistic Driving Study with roadway geometrical characteristics to identify critical conditions that can be causing hydroplaning crashes or near-crashes. The importance of this research is to identify locations where hydroplaning has occurred, understand where water accumulates and find common geometric factors that contribute to increase the potential risk of hydroplaning crashes. The findings can be used to identify high risk location for hydroplaning at road network level and serve as a base for further studies and to validate models developed in this field.

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Analysis of WisDOT’s Maintenance Quality Assurance Program

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ABSTRACT

Compass is the maintenance quality assurance program (MQA) developed by the Wisconsin Department of Transportation. The program estimates highway maintenance conditions based on field reviews. Raters only survey a limited number of highway segments distributed across the state. Therefore, coherence and accuracy are vital during the sampling process. A separate quality assurance team re-tests five percent of the samples. Comparison between both teams allows assessing consistency and spotting systematic error patterns. Findings from the analysis are used to identify emphasis areas for future training. In its 16 years of operation, Compass has undergone continuous revisions and improvements. This paper focuses on the quality assurance of the sampling process. The authors review its effectiveness and suggest ways of improvement.

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Viability of Citizen Science for Infrastructure Condition Assessment at the Neighborhood Level

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ABSTRACT

Inventory and condition data of infrastructure assets are critical for effective management of these assets. However, for local communities, these data are often outdated and incomplete. Citizen science offers a nonconventional, but potentially effective, method for collecting these data. Citizen science is a process in which individuals that may not have acquired formal education as scientists are engaged in scientific projects. This process is beginning to find a more diverse application beyond its original domain in natural and environmental studies. The need for approaches to collect data that would have been unaffordable to collect has further made citizen science more attractive. This study investigates the applicability of citizen science to infrastructure condition assessment at the neighbourhood level, focussing on storm-water infrastructure. Using an inspection method that balances simplicity and data usefulness, condition data for storm-water infrastructure in vulnerable neighborhoods in the Houston area were collected by teams of trained inspectors and teams of citizen scientists independently. Condition ratings of both trained inspectors and teams of citizen scientists were computed and tested for reproducibility. Agreement between performance standard ratings of citizen scientists and trained inspectors were also assessed. Results of field trials reveal that public-works agencies can harness the potential in citizen science to improve the quality and availability of infrastructure data for planning and decision making at the local level.

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Inspection System for RC Slabs of Expressway Bridges
Focused on the Frequency of Generation of Potholes

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ABSTRACT

It is empirically known that the generation frequency of potholes on bridge surface pavement is influenced by the deterioration state of bridge decks. On the basis of this concept, in this study, a statistical model to estimate the frequency of generating potholes is proposed. Specifically, the authors develop a composite model consisting of the generation model of potholes and the deterioration model of decks. The process of generating potholes is modeled by Poisson process. On the other hand, the process of deteriorating decks is formulated by Markov process. In addition, in order to estimate the parameters of the proposed model, the estimation methods are developed by employing the Bayesian estimation method, using the Markov Chain Monte Carlo method. Both deterioration processes are expressed by inspection data of pavement and decks. However, these two kinds of inspection data are not always obtained at the same time due to the nature of actual inspection work. Therefore, an estimation method for correcting such a systematic sampling bias is developed. Finally, the effectiveness of the methodology proposed in this study is analyzed using inspection data from existing expressway bridges.

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Cost and Fuel Usage Optimization of Activating Solution Based Silica Fume Geopolymer Concrete

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ABSTRACT

Development of sustainable construction materials has been the focus of research efforts worldwide in recent years. Concrete is a major construction material; hence, finding alternatives to ordinary Portland cement is of extreme importance due to high levels of carbon dioxide emissions associated with its manufacturing process. Geopolymer concrete is a potential solution; however, concerns about the high cost and the low real fuel energy efficiency are obstacles against its increase in the market share.

In this paper, the current cost and fuel (thermal energy) usage are calculated. In addition, the cost and fuel usage were optimized based on previous experimental results. The results show that geopolymer concrete cost can be reduced using Portland cement in low percentage replacement (5-35%). The required fuel usage (thermal energy) for producing geopolymer concrete was lower than Portland cement. Using Portland cement and reducing sodium hydroxide concentration not only reduce the cost of geopolymer concrete but also reduce the fuel usage. Based on the results of the study, the sodium hydroxide and silica fume have a significant role in the fuel usage and the cost. Three new mixtures were proposed to reduce the cost. Additionally, the fuel usage was 30% lower than Portland cement. Marketing and communication plans showed that geopolymer concrete industries could be profitable because geopolymer concrete can be used for varied civil engineering applications including sidewalks, concrete panels, etc.

The best locations to start the business were proposed, including some cities in the north east or east of the United States such as Cleveland, Milwaukee, and Charlotte. Internationally, China was considered the best place to start the business due to the availability of raw materials and affordable prices.

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Data Analysis of Steel Bridge Infrastructure including Climate and Traffic Effects

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ABSTRACT

Bridge deterioration is a widespread issue. This is caused by an interaction of numerous environmental and structural variables, making the influence of any single parameter difficult to quantify. Thus, a multi-scale data analysis approach has been proposed to first identify outlier bridges that are performing significantly better or worse than their counterparts, when adjusting for different environments (e.g., snowfall, humidity, average daily traffic). Subsequent data analysis steps will focus on more refined evaluation of these outlier bridges. This paper discusses the process of identifying the outlier steel bridges. This is completed by first collecting NBI data, climate data, and chemical data from six states in different climates and combining this information in a geographic information system (GIS) database. Then multivariate regression analysis is used to identify positive and negative outliers while accounting for different site conditions. Two periods of models, 1992 to 1995 and 1998 to 2015, with each similar deterioration trend will be found. Validation of the multi-linear regression models that are developed is also presented.

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Modelling Tamping Recovery Using Copula-Based Approach

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ABSTRACT

Assessing and maintaining track geometry within acceptable limits are key components of railroad infrastructure maintenance operations. Track geometry condition has a significant influence on rider comfort and safety. To maintain the ride quality and safety of the track, track geometry maintenance activities such as tamping are performed. Tamping enhances the track geometry quality but fails to return the track geometry to an as-good-as-new condition. If prognostic tamping strategies are to be employed, there is the need to know beforehand the effectiveness of tamping which can be evaluated by the amount of improvement or recovery in track geometry condition.

Most studies have evaluated tamping recovery using deterministic techniques which assume that tamping recovery is dependent on the track geometry quality prior to tamping. However, they fail to capture the uncertainty of the recovery values. Probabilistic approaches are increasingly being used to account for the uncertainty but fail to model the underlying dependence between the variables which may exhibit nonlinear dependences such as tail or asymmetric dependence. To accurately model the tamping recovery phenomenon, this research employs copula models in combining arbitrary marginal distributions to form a joint multivariate distribution with the underlying dependence. Copula models are used to estimate the tamping recovery of track geometry parameters such as surface (longitudinal level), alignment, cross level, gage and warp.

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Geopolymer Concrete can be the Solution for Sustainable Infrastructure

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ABSTRACT

There is a global focus on reducing greenhouse gas emissions and identifying solutions to reduce the negative impact of business on the environment. While there is no single solution, developing an alternative to Portland cement, which is responsible for 10% of CO2 emissions worldwide, represents a great opportunity for researchers and practitioners alike. This paper evaluates an alternative to Portland cement concrete, a geopolymer concrete, which utilizes waste materials such as fly ash, furnace slag, and metakaolin. The fly ash-based silica fume activating solution geopolymer concrete analyzed in this research not only offers a solution for waste materials that can be problematic for the environment, but it also reduces CO2 emissions during production. As such, the FSA geopolymer concrete is an excellent solution for sustainable infrastructure. Despite the good structural properties of the FSA geopolymer concrete, this alternative to Portland cement concrete faces obstacles with respect to adoption as contractors, construction companies, and prospective customers lacking information about availability, structural properties and positive environmental impact. In this research, a rough cost and fuel usage analysis have been evaluated. The results indicate that the cost of the FSA geopolymer concrete mixture is competitive with Portland cement and that the fuel used in the production of this mixture is 40% lower than Portland cement. In addition, marketing efforts to address the product knowledge gap are proposed.

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Pavement Macrotexture: Current State of the Practice

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ABSTRACT

Macrotexture is a band of pavement texture wavelengths that is critical to several pavement-tire interactions. Chief among these are wet pavement friction and wheel splash and spray because these two interactions can affect the safe diving conditions of a roadway. Pavement noise, tire wear, and rolling resistance are also affected by macrotexture. In this work, macrotexture is analyzed broadly. The most common measurement and parameters to describe macrotexture are reviewed. Finally, information on state departments of transportation current practices are presented.

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Multiobjective Optimization of Lane and Shoulder Widths at Rural Two-Lane Highways

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ABSTRACT

Lane and shoulder widths are important factors of highway safety; generally, wider lanes and shoulders help to reduce crashes. In practice however, due to physical limitations of the right-of-way or statutory restrictions, it may be the case that the existing overall width of the roadway (lanes plus shoulders) cannot exceed a certain value. For a given overall roadway width constraint, wider lanes mean there will be smaller space for shoulders, and vice versa. It is not clear if a cross-sectional configuration with wide lanes and narrow shoulders is safer compared with one with narrow lanes and wide shoulders. Clearly, for a given total roadway width (TRW), a compromise must be reached between shoulder and lane widths in order to maximize the user benefits costs of safety without unduly incurring excessive the agency costs of construction and preservation. This compromise, expressed as the ratio of lane width to shoulder width, will generally depend on the total roadway width, lane and shoulder pavement material types and costs, and traffic volume, among other factors. In order to optimize lane and shoulder width ratios within a given TRW, this paper proposes a framework that formulates the problem as an optimization problem to minimize the total (agency and user) life-cycle cost of the roadway. First, the relationships are established between lane/shoulder widths and user costs (crashes), and also between lane/shoulder widths and the agency costs (of lane/shoulder construction and preservation). The sensitivity of the optimal solution to different evaluation inputs (such as the relative weights between agency and user costs) is also analyzed. Using the developed framework, the paper presents a number of decision support charts that can be used by highway agencies to determine the optimal lane and shoulder widths under a given set of conditions including the highway functional class and the total available roadway width.

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Implementation of Electrical Resistance Measurement to Quantify Asphalt Emulsion-Based Chip Seal Curing Times

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ABSTRACT

Due to its ease of use, favorable economics and effectiveness, asphalt emulsion-based chip seals are one of the most widely used preventive maintenance treatments for flexible pavements. The main advantage of applying emulsified asphalt is the low-temperature and low-volatile emission application. However, one inherent concern of asphalt emulsion-based chip seals is curing time. The curing time for the chip seals depends on many factors, such as the asphalt emulsion and aggregate types, aggregate moisture content, emulsion and aggregate application rates, and environmental conditions (e.g., temperature, wind speed, relative humidity, and solar radiation). Currently, no field technique is available that can quantify when sufficient mechanical strength has developed in the binder to allow traffic on a newly sealed roadway or to remove the surplus aggregate from a fresh chip seal. The implementation of an electrical resistance measurement as a quality control tool to manage the uncertainties related to asphalt emulsion curing is discussed. Furthermore, the implementation of such an approach has great potential as an early-life performance tool for diverse asphalt emulsion applications.

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Pareto Efficiency Analysis of Private Toll Road Markets: Leveraging PPPs to Finance Investments in Infrastructure

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ABSTRACT

This paper studies capacity investment and pricing decisions of firms in a private toll road market franchised by a government. We model the interactions among private firms as in a general oligopoly market with demand system determined by a simple road network with multiple substitutes and complements. To simplify the model, each road segment is assumed to be owned by one firm. We begin the paper by describing the effects of tolling and capacity decisions on social welfare as well as private firms’ profits. To understand the tradeoffs in the design of stable and efficient franchising mechanisms, we then characterize two classes of Pareto Optimal strategies, aggregate optimal and decentralized optimal. The former consider the tradeoffs between social welfare and the aggregate private sector profits, whereas the latter take into account the individual firm’s profits. We describe the relationship between these two approaches, and show that both perform well in certain situations. A two-stage Bertrand model is built to investigate outcome of oligopolistic competition among private participants. An interesting result is that private firm may not invest optimally in first stage (capacity investment), as their consideration on second stage’s (pricing) competition. Moreover, we can show that, sometimes, firms’ choices in Subgame Perfect Nash Equilibria are neither aggregate optimum nor decentralized optimum. Extensive numerical examples suggest that flexible subsidy mechanisms for governments can lead to the implementation of Pareto Optimal strategies.

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Improving the Electric Vehicle Charging Station Network for Use in Trans-National Transportation

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ABSTRACT

More than 150,000 electric vehicles (EVs) were purchased in 2016 in the US (Forbes, 2017), the most ever in one year, and EV purchases are expected to continue rising at a rapid rate. For example, by 2040 it is expected that yearly EV sales will exceed 8 million in the US alone (Bloomberg, 2016). With such increases of EVs on the road, there will also be a need to increase the availability of EV charging stations. Furthermore, while EVs are well-suited for short-distance urban driving, there are challenges associated with long-distance inter-state driving. These challenges relate to limited vehicle range and long vehicle charging times which further augments the need for improved EV charging station networks. In response to these challenges, a creative analysis is required to accommodate the increases in EVs and achieve the goal of complete EV usability irrespective of where it is driven. Such an analysis may help determine the best locations for EV charging stations, and in what numbers they should be built based on trip, vehicle, charging, environmental, and other factors. This poster discusses these factors, the data which is needed, and the proposed methods which may be used to push towards the goal of more widespread EV usage. By optimizing charging station networks, EV stakeholders can be better equipped to serve the public.

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Development of Probabilistic Design Approach for Freeze Thaw Resistance of Concrete

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ABSTRACT

This paper features the development of a probabilistic design approach for concrete while subjected to freeze-thaw (F-T) exposure condition. As a part of this design approach, a sensitivity analysis was performed among several concrete mix parameters to identify the factors that have strong correlations with the F-T resistance of concrete. This sensitivity analysis was performed on 150 sets of experimental F-T test results collected from the literature. The F-T performance level was defined as a discrete measure of the frost resistance of concrete. Finally, a new model to predict the F-T damage of concrete incorporating the variability of the concrete mix parameters (as selected from sensitivity analysis) was established in this paper. This model was developed using the data set collected for ASTM C 666 test results from literature for concrete mixtures containing ordinary Portland cement (OPC) without any supplementary cementitious materials. Additional experimental test results were utilized to validate the model. The reliability of the model was further demonstrated using several examples of conventional concrete compositions. The proposed model can be used for the probabilistic prediction of the F-T performance of any concrete mixture. Furthermore, the effects of the number of F-T cycles, air content, paste content, and w/c ratio on the F-T performance of the concrete mixes are demonstrated in this paper using the developed model. Accordingly, this model provides the opportunity to optimize the concrete mix proportion for the required performance level of concrete under F-T exposure condition.

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Predicting Deterioration and Service Life of Indiana Bridges: Accounting for Material Type, Design Type, Functional Class and Climate

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ABSTRACT

In order to account for material type, design type, functional class and climate in the deterioration modeling, this paper uses empirical data from Indiana bridges spanning 1992–2014 for predicting deterioration and service life of these bridges. The superstructure design types considered are cast-in-place concrete (slab, stringer, and arch-deck) and prestressed concrete (stringer, T-beam, box-beam multiple, and box-beam single). A number of factors are found to have statistically significant influence on the deterioration of the concrete superstructures’ physical condition consistently across all design types, and other factors are found to be significant only for some design types. The paper also carries out sensitivity and marginal effects analyses to quantify the strength of effect of the influential factors on superstructure deterioration. Using the developed models, the paper establishes service lives for each concrete superstructure design type and compares the findings with those of past studies. The developed models can help highway agencies to carry out condition-based scheduling of bridge superstructure rehabilitation and reconstruction and to identify the materials and designs that are best suited to specific climates.

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Overweight-Vehicle Research that Led to Indiana’s New Trucking Law (Act 1481)

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ABSTRACT

The Indiana DOT commissioned this study to evaluate the impacts of overweight divisible load permits on revenue, asset consumption, alternative transportation modes, and Indiana’s economic development and economic competitiveness relative to other Midwestern states.

The results of the analysis indicate that overall, the overweight commodities divisible permit structure arising from HEA-1481 is not expected to dramatically change the consumption of Indiana’s pavement and bridge assets, but it will lead to a slight increase in the revenue collected per permit and a slight decrease in the gap between consumption and revenue. However, the gap between revenue and consumption is still significant: for the pre-HEA-1481 and the Emergency Rule periods, the consumption-revenue gaps were estimated as approximately $33 million and $30 million, respectively. From an operations standpoint of mobility and safety, it was estimated that HEA-1481 will have an ambiguous impact due to the twin but opposing effects of traffic impairment and trips reduction associated with overweight vehicles; the net effect depends on the prevailing characteristics of the traffic stream and extent of overweight loading. Overall, HEA-1481 is expected to help protect the highway bridge and pavement infrastructure by providing incentives for less-damaging loading behavior, reduce the gap between revenue and consumption, increase the economic competitiveness of trucking operations relative to other states, and provide a more industry-friendly environment for increased economic development in the state of Indiana.

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Updating State and Local Highway Cost Allocation and Revenue Attribution – A Case Study for Indiana

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ABSTRACT

This study was commissioned by the Indiana DOT to investigate the cost responsibility and the revenue contribution of highway users with regard to the upkeep of Indiana’s state and local highway infrastructure (pavements, bridges, safety assets, and mobility assets). The highway users were represented by the 13 FHWA vehicle classes, and the study was based on 2009-2012 data on expenditures and revenues. The study framework duly recognized the dichotomy between attributable and common costs. For allocating the attributable costs to the vehicle classes, ESALs, AASHTO loading equivalents, and PCEs were used; for allocating common costs, VMT was used. For each vehicle class, the share of revenue contribution was compared to the share of cost responsibility to determine respective equity ratios and thus to ascertain the extent to which vehicles in each class may be underpaying or overpaying their cost responsibilities at the current time. Pavement and bridge expenditures were found to have a dominant share of the overall expenditures on Indiana’s highway system. The inability of user revenue sources to cover the total highway expenditure and the consequent partial reliance on non-user sources seem to constitute a rather unstable funding situation particularly because the non-user sources are characterized by significant variability. On the basis of the expenditures and revenues associated with the various user groups (vehicle classes) over the analysis period, this study found that inequities exist, albeit in varying degrees, among the highway user groups. Of the 13 vehicle classes, classes 1–4 were found to be overpaying their cost responsibilities while classes 5–13 are underpaying. For example, vehicle class 2 is overpaying its cost responsibility by 10% while vehicle class 9 is underpaying by 19%.

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Forecasting of Highway Revenues under Various Options

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ABSTRACT

Throughout the United States, state highway revenue, which is dominated by receipts from fuel taxes, has failed to keep up with expected investments required for infrastructure preservation and improvement. The reasons for this trend include the increasing fuel efficiency of vehicles, slowing of the growth in vehicle-miles of travel, and the erosion of the purchasing power of the dollar due to inflation. This development motivates highway agencies not only to seek revisions of existing funding structures but also to consider potential alternative sources.

To establish and implement an effective and efficient financing strategy that incorporates potential new funding sources, it is necessary to model the possible outcomes of these sources in terms of their impacts on revenue stream and to study the sensitivity of these outcomes with respect to changes in key revenue factors such as vehicle-miles of travel and fuel price. In addressing this issue, this study utilized data on amounts of travel, fuel price, and other primary information to enhance the existing models for state highway revenue forecasting in Indiana.

To facilitate implementation of the study results, the existing revenue forecasting software package was enhanced to include traditional and new revenue sources, to estimate revenue under several different scenarios, and to analyze sensitivity of revenue to changes in input factors such as fuel price, per capita income, gross domestic product, driving age population, and traffic growth rate. The package provides annual forecasts for both existing and alternative highway revenue sources in Indiana. Short-range forecasts for fuel tax revenues were also estimated.

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In 1884, brothers Peter and Andrew Kiewit formed a small masonry partnership in Omaha. With a focus on people, integrity, excellence, and stewardship, the brothers shaped the foundation of what the company stands for today. Across North America and Australia, Kiewit operates as a network of connected districts providing numerous opportunities for people to work on a wide range of projects. The company’s business focuses on four major areas: Infrastructure (including transportation), Energy, Building, and Mining.

Indiana LTAP provides technical assistance and training to the highway, road, and street departments of all 92 counties, 117 cities, and over 450 towns in Indiana. These local agencies are responsible for over 80,000 miles of roads and streets in the state. LTAP provides technical assistance through newsletters, direct communication (telephone and internet), publications, training programs, and workshops and seminars on subjects pertaining to roads and streets.

The Center helps local government offices to develop or acquire state-of-the-art analytical tools to perform their responsibilities cost-effectively. For example, the Hazard Elimination Project for Existing Roads and Streets (HELPERS) program has helped to increase safety on local roads by identifying traffic safety concerns on this network and providing low-cost solutions.

Indiana LTAP’s clients include city and town street commissioners & street department employees, county highway engineers, supervisors, and county highway employees, city mayors and town managers, county commissioners, county surveyors, MPOs, police organizations, consultants, and contractors.
A&R Logistics, Inc. was founded in 1969, and has since evolved as a leading provider of dry bulk transportation and innovative supply chain solutions. For over 40 years the company has provided bulk logistics solutions for customers in the chemical & plastics industries. With a modern fleet exceeding 800 trucks and 1,200 trailers. A&R logistics backed by $1 billion in private equity and has made significant investments in assets, technology and operations.

A&R offers a variety of transportation and logistics solutions via bulk transportation, transloading, packaging, warehousing and end-to-end transportation management. The company has an extensive network of 23 terminals and 10 warehousing/packaging facilities nationwide. A&R Logistics provides these world-class capabilities while also maintaining the highest safety and regulatory compliance. A&R Logistics, Inc. corporate headquarters are located in Louisville, Kentucky, with Commercial Headquarters in Houston, Texas, and Customer Service Headquarters in Morris, Illinois.

Applied Pavement Technology, Inc. (APTech), a consulting firm that specializes in pavement engineering, provides effective solutions for designing, evaluating, rehabilitating, and maintaining airport and roadway pavements. Since its founding in 1994 by Katie Zimmerman, a celebrated researcher and practitioner, APTech has grown to have branches at locations spanning the continental USA -- Nevada, New York, Texas, Washington, and Wisconsin while maintaining its Urbana, Illinois headquarters.

APTech works with clients at all levels of government (federal, state, and local) in the United States and abroad, and helps its clients to identify appropriate pavement designs and management strategies. These include life cycle based strategies that not only preserve the pavement network cost-effectively but also incorporate state-of-the-art pavement designs and technologies.
The Purdue Climate Change Research Center (PCCRC), a community of researchers working with the perspective that human and natural systems should be studied as an integrated whole, serves as a collaborative hub for interdisciplinary research on climate change.

The Center brings together faculty, postdocs, students and professional staff from 23 departments across 8 of Purdue’s academic units to address the challenges and complexities of climate and related global change. Research teams explore the causes and impacts of climate change, improve predictive models to project future climate conditions, and pursue novel ideas for mitigation and adaptation.

PCCRC supports the ambitious, innovative ideas of its researchers by breaking down disciplinary and administrative barriers to help ideas take shape. The Center does this in a variety of ways that include consulting with individual faculty members about opportunities, providing seed funding to explore high-risk interdisciplinary research, offering experienced guidance to support and develop a project or program, and by convening as many opportunities for cross-disciplinary conversations as possible. Therefore, the Center serves as a fertile ground where new ideas are sparked or where existing ideas take shape.

Purdue University Discovery Park, lives in an era of not only great promise – with exponential advances in sciences, technology and engineering – but also great challenge – with complex problems requiring comprehensive solutions. This center of technology is a place where challenge and innovation converge, a hub where researchers move beyond traditional boundaries, collaborating across disciplines and with policy makers and business leaders to create solutions for a better world.

Nestled on 40 acres on the southwest edge of Purdue’s West Lafayette campus, the complex of facilities provides open, collaborative research environments where interdisciplinary projects are connected throughout Purdue, Purdue Research Park and the world. Discovery Park answers the call to global challenges by focusing on disruptive innovation at the convergence of traditional STEM disciplines and novel digital solutions. Their mission is to accelerate world-changing interdisciplinary research, advance transformative education and enhance the commercialization activities of faculty, students and staff.
The Indiana Chapter of the American Concrete Pavement Association (IN-ACPA) represents the concrete pavement contractors, cement manufacturers and related material and equipment suppliers serving the concrete paving industry in Indiana. IN-ACPA provides technical, educational and governmental affairs services advocating the use of Portland cement concrete pavement (PCCP) for highways, airports, local roads and streets, and site paving installations.

IN-ACPA was established in 1988 as a chapter of the American Concrete Pavement Association (ACPA). IN-ACPA is not-for-profit trade association (501(c) 6) based in Indianapolis under the direction of an annually-elected Board of Directors. The organization works in partnership with federal, state and local agencies, designers, scientists and others involved in research, planning, design, construction, maintenance and rehabilitation of concrete pavements.

The Asphalt Pavement Association of Indiana (APAI) is a professional association which includes membership of the premier producers, suppliers, contractors, and service providers of asphalt and asphalt-related products from across Indiana. The association works in conjunction with numerous agencies, including the Indiana Department of Transportation (INDOT) and the Indiana Department of Environmental Management (IDEM), as well as organizations such as the Indiana Association of Cities and Towns (IACT) and the Indiana Association of County Commissioners (IACC). APAI has a connection with Purdue University through the Joint Transportation Research Program (JTRP). On the national scale, APAI has partnerships with the National Asphalt Pavement Association and the Federal Highway Administration (FHWA).

Through its extensive committee structure and active member involvement, APAI shares solutions to common problems, benchmarking best practices, and continuously improving products with the objectives of providing smooth, quiet, cost-efficient, and sustainable asphalt pavements. APAI annually hosts numerous technical and educational workshops which assist in disseminating knowledge and help the association accomplish its objectives.
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