MID-CONTINENT TRANSPORTATION RESEARCH SYMPOSIUM

2011

Partnerships in

Transportation

Research,

Innovation,

and Training

About the Symposium

The Mid-Continent Transportation Research Symposium provides an opportunity for transportation professionals from the Midwest and beyond to network with their peers, learn about advancements and applications in their fields, and future directions for research.

Researchers and practitioners from around the country will present papers at this seventh biennial event at Iowa State University. The day-and-a-half symposium will cover a broad spectrum of transportation issues with sessions on both basic and applied research.

Special Speakers

Opening Session Speakers

Sandra Larson, Director, Research and Technology Bureau, Iowa DOT

John Adam, Director, Highway Division, Iowa DOT

Sharron Quisenberry, Vice President, Research and Economic Development, Iowa State University

Peter Appel, Administrator, Research and Innovative Technology Administration (RITA), US DOT

Luncheon Speakers

Jonathan Wickert, Dean, College of Engineering, Iowa State University

John Horsley, Executive Director, AASHTO

Banquet Dinner Speaker

Paul Trombino III, Director, Iowa DOT

Symposium Sponsors

Iowa Department of Transportation

Iowa State University's
   Institute for Transportation;
   Department of Civil, Construction,
   and Environmental Engineering;
   and Midwest Transportation Consortium

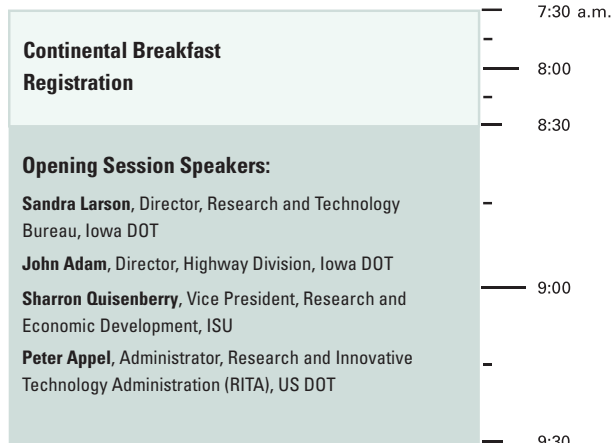The University of Iowa

University of Wisconsin's
   National Center for Freight & Infrastructure
   Research & Education

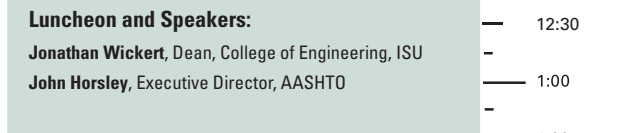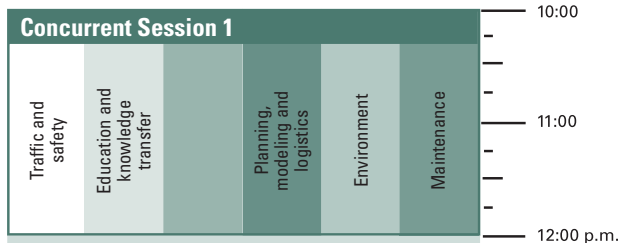Wisconsin Department of Transportation

SYMPOSIUM 2011

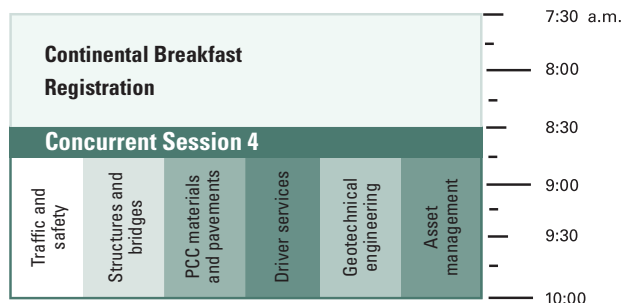## Schedule of Events // August 18–19, 2011

Thursday, August 18th

Continental Breakfast
Registration

7:30 a.m.
8:00
8:30

Opening Session Speakers:

Sandra Larson, Director, Research and Technology Bureau, Iowa DOT

John Adam, Director, Highway Division, Iowa DOT

Sharron Quisenberry, Vice President, Research and Economic Development, ISU

Peter Appel, Administrator, Research and Innovative Technology Administration (RITA), US DOT

9:00

9:30

Break

10:00

Concurrent Session 1

| Traffic and safety | Education and knowledge transfer | | Planning, modeling and logistics | Environment | Maintenance |

11:00

12:00 p.m.

Luncheon and Speakers:

Jonathan Wickert, Dean, College of Engineering, ISU

John Horsley, Executive Director, AASHTO

12:30

1:00

1:30

Concurrent Session 2

| Traffic and safety | Education and knowledge transfer | Technology considerations | Planning, modeling and logistics | Asphalt pavements | Asset management |

2:00

3:00

Break

3:30

Concurrent Session 3

| Traffic and safety | Structures and bridges | PCC materials and pavements | Planning, modeling and logistics | Asphalt pavements | Highway Engineering, Construction |

4:00

5:00 p.m.

Thursday, August 18th

Social: Meet and greet + poster session

5:00 p.m.
5:30
6:00
6:30

Banquet and Speaker:
Paul Trombino, Director, Iowa DOT

7:00

8:00
8:30 p.m.

Friday, August 19th

Continental Breakfast
Registration

7:30 a.m.
8:00
8:30

Concurrent Session 4

| Traffic and safety | Structures and bridges | PCC materials and pavements | Driver services | Geotechnical engineering | Asset management |

9:00
9:30

10:00

Break

10:30

Concurrent Session 5

| Traffic and safety | Structures and bridges | PCC materials and pavements | Driver services | Geotechnical engineering |

11:00

11:30

12:00 p.m.

LiDAR Presentation (optional):
Thomas Samson, Staff, Iowa DOT GIS

1:00 p.m.

2:00

3:00 p.m.

Session 1A
Traffic and Safety

1. Dynamic Horizontal Curve Warning Sign Impacts
Keith Knapp, Iowa LTAP

2. Designing and Operating Intersections With Signals on Rural High Speed Highways
Dennis Eyler, SRF Consulting Group
Leif Garnass, SRF Consulting Group
Adrian Potter, SRF Consulting Group

3. Estimation of Safety Effectiveness of Composite Shoulder on Rural Two-Lane Roads
Huanghui Zeng, University of Kansas

4. Minnesota County Road Safety Plans
Michael Marti, SRF Consulting Group
Brad Estochen, Mn/DOT
Mark Vizecky, Mn/DOT

Session 1B
Education and Knowledge Transfer

1. Communication is Key: A randomized trial of an intervention to increase parent involvement in teen driving
Corinne Peek-Asa, ,Injury Prevention Research Center, University of Iowa
Ginger Yang, Injury Prevention Research Center, University of Iowa
Lisa Roth, Injury Prevention Research Center, University of Iowa

2. Communication Strategies Employed in Transportation Projects
Ghada Gad, Iowa State University
Nurhidayah Azmy, Iowa State University
Jennifer Shane, Iowa State University

3. Go! Magazine
Shauna Hallmark, Institute for Transportation
Rema Nilakanta, Institute for Transportation
Shashi Nambisan, Institute for Transportation

4. Evaluation of a video-based feedback intervention for newly-licensed young drivers
Cher Carney, Public Policy Center, University of Iowa
Daniel McGehee, Public Policy Center, University of Iowa
Michelle Reyes, Public Policy Center, University of Iowa

Session 1C

Session 1D
Planning, Modeling and Logistics

1. Boundary v. Boundary; Who decides on a planning boundary and what does it mean?
Phil Mescher, Iowa DOT

2. State Highways as Main Streets: A Study of Community Design and Visioning
Leni Oman, Washington DOT

3. ADA compliant sidewalks and facilities
Deanna Maifield, Iowa DOT

4. Growing the Idaho Economy: Moving into the Future
Ned Parrish, Idaho DOT

Session 1E
Environment

1. Assessment and Recommendations for the Operation of Standard Sump Manholes as a Best Management Practice for Stormwater Treatment
Bruce Holdhusen, Mn/DOT

2. Application of Paleoflood Survey Techniques in the Black Hills of South Dakota
Dave Huft, South Dakota DOT

3. Stormwater Quality: The Changing Environment of Regulatory Requirements
Melissa Serio, Iowa DOT
Mark Masteller, Iowa DOT

Concurrent Sessions	Thursday, August 18th	10:00 a.m. — 12:00 p.m.

Session 1F
Maintenance

1. Risk Mitigation Strategies for Operations and Maintenance Activities
Kelly Strong, Iowa State University
Sayanti Mukhopadhyay, Iowa State University
Jay Mathes, Iowa State university
Jennifer Shane, Iowa State University

2. Network-level Winter Weather Safety Assessment: Database Development
Zach Hans, Institute for Transportation

3. NCHRP initiated Project 14-12, "Highway Maintenance Quality Assurance"
Crawford Jencks, NCHRP

4. TowPlow Winter Operations
Annette Dunn, Iowa DOT

Concurrent Sessions	Thursday, August 18th	1:30 p.m. — 3:00 p.m.

Session 2A
Traffic and Safety

1. Evaluating the Effectiveness of Red Light Running Camera Enforcement in Cedar Rapids, Iowa
Shauna Hallmark, Institute for Transportation
Nicole Oneyear, Institute for Transportation

2. Playground Warning Sign Vehicle Speed Impacts
Keith Knapp, Iowa LTAP

3. Evaluation of Pedestrian and Driver's Actions at HAWK Signal
Debbie Self, Charlotte DOT
Srinivas Pulugurtha, University of North Carolina at Charlotte

4. Effect of Cedar Rapids, IA Automated Speed Enforcement Cameras on Speeds along I-380
Shauna Hallmark, Institute for Transportation
Nicole Oneyear, Institute for Transportation

Session 2B
Education and Knowledge Transfer

1. SHRP 2 - Delivering New Transportation Technologies
James McMinimee, Iowa DOT

2. Arizona Transportation History
Anne Ellis, Arizona DOT

3. Best Practices: Managing Interaction between Local Authorities and Major Traffic Generators
Michael Marti, SRF Consulting Group
Tim Stahl, Jackson County

Session 2C
Technology Considerations

1. Geospatial Infrastructure at Iowa DOT
Eric Abrams, Iowa DOT

2. New LiDAR Technology Offers Faster, Less Expensive Field Data
Bill Stone, Missouri DOT

3. LiDAR information for 2-D hydraulic modeling
Dave Claman, Iowa DOT

4. DARWIN-ME Pavement Design System
Doc Zhang, Louisiana DOT

Session 2D
Planning, Modeling and Logistics

1. Innovative Funding and Design for re-designing Rail Road Crossings
Mary Jo Key, Iowa DOT

2. Travel Demand Model
Adam Shell, Iowa DOT

3. Flood Detour Traffic Analysis using the Iowa Travel Analysis Model
John Parker, Iowa DOT

4. Modeling vehicle class lagging headways for estimating passenger car equivalent: A comparative analysis between 3SLS and sure modeling approaches
Anwaar Ahmed, Purdue University
Matthew Volovski, Purdue University
Bismark Agbelie, Purdue University

| Concurrent Sessions | Thursday, August 18th | 1:30 p.m. — 3:00 p.m. |

Session 2E
Asphalt Pavements

1. Use of Reclaimed Asphalt Pavement from Ultra-Thin Bituminous Bonded Layer in Superpave Mixtures/Evaluation of the Use of Reclaimed Asphalt Pavement in HMA Mixtures
Haritha Musty, Kansas State University
Mustaque Hossain, Kansas State University
Nassim Sabahfar, Kansas State University

2. Enhanced Pavement Reflection Crack Growth Modeling Through Soft Computing
Halil Ceylan, Iowa State University
Kasthurirangan Gopalakrishnan, Iowa State University
Sunghwan Kim, Iowa State University
Robert Lytton, Iowa State University

3. Performance Evaluation of Superpave Mix Using Hamburg Wheel Tracking Device
Farhana Rahman, Kansas State University
Mustaque Hossain, Kansas State University
Kiran Uppu, Kansas State University
Cliff Hobson, Kansas DOT

Session 2F
Asset Management

1. NCHRP Projects 20-24(11) and 08-69, AASHTO Asset Management Guide: Volumes I and II
Crawford Jencks, NCHRP

2. Asset Management at the Iowa DOT's Highway Division
Brad Cutler, Iowa DOT

3. Ohio DOT Pavement Management Information System
Cynthia Gerst, Ohio DOT

| Concurrent Sessions | Thursday, August 18th | 3:30 p.m. — 5:00 p.m. |

Session 3A
Traffic and Safety

1. The Next 50 Years: Moving Toward a New Era in Roadway Safety
Peter Appel, US DOT RITA

2. An Evaluation of Retro-reflectivity of Pavement Markings on Traffic Safety
Omar Smadi, Institute for Transportation
Neal Hawkins, Institute for Transportation

3. Adaptive traffic signal control
Cameron Kergaye, Utah DOT

Session 3B
Structures and Bridges

1. ABC Decision Tool and Economic Modeling Study
Toni Doolen, Oregon State University
Benjamin Tang, Oregon DOT

2. Accelerated Bridge Construction
Cameron Kergaye, Utah DOT

3. ABC Demonstration Bridge - Design and Construction
Mike LaViolette, Jon Frerichs, HNTB Corporation
Terry Wipf, Brent Phares, Matt Rouse, Doug Hartwell, Iowa State University
Ahmad Abu-Hawash, Jim Nelson, David Evans, Iowa DOT

4. ABC Demonstration Bridge - Laboratory Testing
Mike LaViolette, Jon Frerichs HNTB Corporation
Terry Wipf, Brent Phares, Matt Rouse, Doug Hartwell, Iowa State University
Ahmad Abu-Hawash, Jim Nelson, David Evans, Iowa DOT

Concurrent Sessions	Thursday, August 18th	3:30 p.m. — 5:00 p.m.

Session 3C
PCC Materials and Pavements

1. **A method to rapidly predict service life and susceptibility to deicing salt deterioration of aggregates used in Portland cement concrete**
   Bob Dawson, Iowa DOT

2. **A Study of Aggregate Settlement in a Simulated Cement System**
   Will Hunnicutt, Iowa State University
   Kejin Wang, Iowa State University

3. **Identifying Fine Aggregates Prone to Polishing in PCC Pavements**
   Marc Rached, University of Texas at Austin
   David W. Fowler, University of Texas at Austin

4. **Drying Shrinkage Behavior of Mortars Made with Ternary Blends**
   Xuhao Wang, Iowa State University
   Kegin Wang, Iowa State University
   Faith Bektas, National Concrete Pavement Technology Center, Institute of Transportation
   Peter Taylor, National Concrete Pavement Technology Center, Institute of Transportation

Session 3D
Planning, Modeling and Logistics

1. **Planning Tools to Evaluate Transportation Network Resiliency**
   Konstantina Gkritza, Institute of Transportation
   Steve Lavrenz, Iowa State University

2. **An Enhanced Freight Activity Micro-simulation Estimator (FAME) Model using FAF3.0 dataset**
   Zahra Pourabdollahi, University of Illinois at Chicago
   Kouros Mohammadian, University of Illinois at Chicago

3. **Travel time variability for freight flows along a major Interstate corridor**
   Kaushik Bekkem, CFIRE, University of Wisconsin, Madison
   Teresa Adams, CFIRE, University of Wisconsin, Madison
   Bruce Wang, CFIRE, University of Wisconsin, Madison

4. **Comparative Contact Methods in Freight Establishment Surveys**
   Karl Sturm, University of Illinois at Chicago
   Kouros Mohammadian, University of Illinois at Chicago

Session 3E
Asphalt Pavements

1. **Effectiveness of Flexible Pavement Rehabilitation Treatments - Evidence from a National Experiment**
   Zongzhi Li, Illinois Institute of Technology
   Anwaar Ahmed, Purdue University

2. **Investigation of Warm Mix Asphalt in Iowa: Translating laboratory performance test results to field performance using the Mechanistic-Empirical Design Guide (M-EPDG)**
   Ashley Buss, Iowa State University

3. **Aggregate Retention in Chip Seal**
   Shahidul Islam, University of Illinois at Urbana Champign
   Elaine Lamm, Kansas State University
   Haritha Musty, Kansas State University
   Mustaque Hossain, Kansas State University

Session 3F
Highway Engineering and Construction

1. **Developing Rational Contingencies for Transportation Project Cost Estimates**
   Douglas Gransberg, Iowa State University

2. **Analysis of the Required Project Management Skill Set for Complex Design-Bid-Build Projects**
   Douglas Gransberg, Iowa State University
   Jennifer Shane, Iowa State University

3. **Web-based project management action research for highway projects under $10 million**
   Jose Perez Reboredo, Iowa State University
   Charles T. Jahren, Iowa State University

4. **Implementation of Safety Measures in Nighttime Construction Work Zone**
   Nurhidayah Azmy, Iowa State University
   Jennifer Shane, Iowa State University

Posters   Thursday, August 18th   5:00 p.m. — 6:30 p.m.

Quantifying traveler diversion and its impact during a weekend full freeway closure: Case study with I-894
> Justin Effinger, University of Wisconsin, Milwaukee
> Yue Liu, University of Wisconsin, Milwaukee
> Alan Horowitz, University of Wisconsin, Milwaukee
> John Shaw, Wisconsin DOT
> John Corbin, Wisconsin DOT

Rural Safety Policy Improvement Index
> Keith Knapp, Iowa LTAP

A new decision support tool for warranting detour operations during freeway corridor incident management
> Yue Liu, University of Wisconsin, Milwaukee
> Zhenke Luo, University of Wisconsin, Milwaukee

A Motorcycle Safety Survey in Kansas to Identify Issues and Causes Related to Crashes
> Mohammad Saad Shaheed, Iowa State University

Pavement Management Tools For Minnesota
> Michael Marti, SRF Consulting Group
> Gary Danielson, Kandiyohi County, MN

Minimum Cement Content for Performance and Sustainability in Rigid Pavements
> Ezgi Yurdakul, Iowa State University
> Peter Taylor, National Concrete Pavement Technology Center, Institute for Transportation
> Halil Ceylan, Iowa State University
> Fatih Bektas, National Concrete Pavement Technology Center, Institute for Transportation

Effect of Limestone Powder on PCC Strength
> Fatih Bektas, National Concrete Pavement Technology Center, Institute for Transportation
> Wenjun He, Iowa State University
> Gongbo Zhang, Iowa State University
> Kejin Wang, Iowa State University

Cost-Per-Mile Estimation Methodology for Railroads
> Jeffrey von Brown, Institute for Transportation
> Konstantina Gkritza, Institute for Transportation

Multimodal Transportation Operations and Planning Software Review and Evaluation
> Eirini Kastrouni, Institute for Transportation
> Steve Lavrenz, Iowa State University
> Jeffrey von Brown, Institute for Transportation, Iowa State University
> Konstantina Gkritza, Institute for Transportation

A Conceptual Framework for Freight Transport Modeling With Logistic Choices
> Zahra Pourabdollahi, University of Illinois at Chicago
> Kouros Mohammadian, University of Illinois at Chicago

Spatial Transferability of CO2 Emission Models Incorporating Land Use and Household Characteristics
> Doreen Kobelo, Florida State University
> Judith Mwakalonge, Prairie View A& M University
> Saidi Siuhi, University of Nevada, Las Vegas

Establishing Efficient Project-Level Strategies for Pavement Maintenance and Rehabilitation Considering Multiple Objectives using Data Envelopment Analysis
> Anwaar Ahmed, Purdue University
> Bilal Khurshid, Purdue University
> Samuel Labi, Purdue University
> Qiang Bai, Purdue University
> Muhammad Irfan, Purdue University

Concurrent Sessions   Friday, August 19th   8:30 a.m. — 10:00 a.m.

Session 4A
Traffic and Safety

1. Does Cell Phone Use have an Effect on Queue Discharge Patterns?
> Srinivas Pulugurtha, University of North Carolina at Charlotte
> Ryan Brumfield, FHWA

2. 3D Spatial Visualization Analysis of Safety Related Driving Events of Newly Licensed Teens in Proximity of Home and School
> Tika Ram Adhikari, Public Policy Center, University of Iowa
> Daniel McGehee, Public Policy Center, University of Iowa
> Michelle Reyes, Public Policy Center, University of Iowa
> Cher Carney, Public Policy Center, University of Iowa

3. Matched Case-Control Study of On-Road Bicycle Facilities and Bicycle Crashes in Iowa, 2007-2010
> Cara Hamann, College of Public Health, University of Iowa
> Corinne Peek-Asa, Injury Prevention Research Center, University of Iowa

Session 4B
Structures and Bridges

1. Imaging Tools for Evaluation of Gusset Plate Connections in Steel Truss Bridges
Barnie Jones, Oregon DOT

2. Improving Bridge Interface Rideability in Ohio
Brent Phares, Institute for Transportation
Cynthia Gerst, Ohio DOT

3. Study of the Impacts of Implements of Husbandry on Bridges
Justin Dahlberg, Institute for Transportation
Travis Hosteng, Institute for Transportation
Doug Wood, Iowa State University
Scott Neubauer, Iowa DOT

4. Preemptive Retrofits to Prevent Constraint Induce Fracture at Vertical Stiffeners
Robert Connor, Purdue University
Michael Koob, WJE
Brian Santosuosso, WJE
Bruce Brakke, Iowa DOT

Session 4C
PCC Materials and Pavement

1. FHWA's Sustainable Pavement Program
Kurt Smith, Applied Pavement Technology, Inc.

2. Sustainable Highway Rating System
Kathleen Penney, CH2M Hill

3. Life-cycle Assessment of Concrete Pavements: Impacts and Opportunities for Carbon Reductions
John Ochsendorf, MIT

4. LCA characterization of life cycle environmental impacts from pavement smoothness
Eul-Bum Lee, UC Berkeley
Alissa Kendall, University of California, Davis
Chang-Mo Kim, University of California, Davis
In-Sung Lee, University of California, Davis
Ting Wang, University of California, Davis
John Harvey, University of California, Davis

Session 4D
Driver Services

1. Engineering Design Converter for Operational Review and Outreach
Shawn Allen, University of Iowa
Yefei He, University of Iowa

2. Ignition Interlock Device
Kim Snook, Iowa DOT

3. Driver Impairment Detection
Dave Lorenzen, Iowa DOT

4. Affordable simulator-based truck driver training: challenges and opportunities
Dawn Marshall, University of Iowa
Andrew Veit, University of Iowa

Concurrent Sessions	Friday, August 19th	8:30 a.m. — 10:00 a.m.

Session 4E
Geotechnical Engineering

1. Field and Laboratory Evaluation of a Mechanically Stabilized Salvaged Base Course Used in the Construction of US 12 Marmarth, North Dakota
Mark Wayne, Tensar International
David White, Institute for Transportation
Jay Kwon, Tensar International

2. Investigation of Pavement Moduli Using Non-Destructive and Laboartory Tests
Jeremiah Thomas, Kansas State University
Mustaque Hossain, Kansas State University
Quinn Stenzel, Kansas State University

3. Case histories of ground improvement methods for road or airport construction
Jian Chu, Iowa State University

4. Evaluation of Reinforced Crushed Stone Base for Low-Volume Road Bases
Brandon Bortz, Kansas State University
Mustaque Hossain, Kansas State University
Izhar Halami, PRS Mediterranean Ltd
Andy Gisi, Kansas DOT

Session 4F
Asset Management

1. Transportation Agency Tool to Analyze Benefits of Living Snow Fences
David Smith, University of Minnesota
Gary Wyatt, University of Minnesota
Diomedes Zamora, University of Minnesota
Daniel Gullickson, University of Minnesota
Dean Current, University of Minnesota

2. Average Annual Maintenance Expenditure (AAMEX) Modeling for Indiana Highway Assets: A Statistical and Econometric Analysis of the Effect of an Asset's Age on Expected Maintenance Costs
Matthew Volovski, Purdue University
Samuel Labi, Purdue University

3. A Study on the Relationship between Operational Asset Performance and Safety Performance
Jian Gao, Iowa State University
Inya Nlenanya, Institute for Transportation
Basak Aldemir-Bektas, Institute for Transportation
Konstantina Gkritza, Institute for Transportation
Omar Smadi, Institute for Transportation

Concurrent Sessions	Friday, August 19th	10:30 a.m. — 12:00 p.m.

Session 5A
Traffic and Safety

1. Development and Evaluation of Selected Mobility Applications for VII
Deb Elston, FHWA

2. Improving Traffic Operations and ITS Technology Deployment in Wisconsin Corridors
William Melendez, University of Wisconsin, Madison

3. Risk Analysis of Nighttime Construction Work Zones
Sayanti Mukhopadhyay, Iowa State University

4. Effects of Adverse Weather on Surface Transportation Mobility
Joe Olson, Public Policy Center, University of Iowa

Session 5B
Structures and Bridges

1. Precast UHPC Waffle Bridge Deck Panels and Connections for Accelerated Bridge Construction
  Sriram Aaleti, Iowa State University
  Sri Sritharan, Iowa State University
  Dean Bierwagen, Iowa DOT
  Brian Moore, Wapello County Engineer

2. Corrosion Performance of Eight Older Bridge Decks Constructed with Epoxy-Coated Reinforcing Steel in Iowa
  James Donnelly, Wiss, Janney, Elstner Associates, Inc.
  Paul Krauss, Wiss, Janney, Elstner Associates, Inc.
  John Lawler, Wiss, Janney, Elstner Associates, Inc.
  Gordon Port, Iowa DOT

3. Remote Sensing for Bridge Monitoring: USDOT-RITA CRST Phase 1 and 2
  Edd Hauser, University of North Carolina at Charlotte
  Shenen Chen, University of North Carolina at Charlotte

4. Effects of Thermal Loading on Pier Deformations in the Wakota Bridge
  Krista Morris, University of Minnesota
  Arturo Schultz, University of Minnesota

Session 5C
PCC Materials and Pavements

1. Concrete Pavement Surface Characteristics Program Results
  Paul Wiegand, Institute for Transportation

2. PCC Overlays Program Results
  Dale Harrington, Snyder and Associates

3. Geothermal Application for PCC Pavement System
  Cheng Li, Iowa State University
  David White, Institute for Transportation

4. Guidelines for Design, Testing, Production and Construction of Semi-Flowable Self-Consolidating Concrete for Slip-Form Paving
  Gilson Lomboy, Iowa State University
  Kejin Wang, Iowa State University
  Peter Taylor, National Concrete Pavement Technology Center, Institute for Transportation
  Surendra Shah, Center for Advanced Cement-Based Materials, Northwestern University

Session 5D
Driver Services

1. Off-road Vehicles, On-road Crashes: ATV Injury Surveillance as a Tool to Inform Traffic Safety Policies
  Gerene Denning
  Kari Harland
  Charles Jennissen
  Christopher Buresh

2. Driver's License Central Issuance & Image Verification
  Dave Stutz, Iowa DOT

3. Iowa High School Administrator Opinions About Graduated Driver Licensing
  Michelle Reyes, Public Policy Center, University of Iowa

4. CARFIT Program
  Kim Snook, Iowa DOT

Session 5E
Geotechnical Engineering

1. Load and Resistance Factor Design Advancements For Bridge Pile Foundations In Iowa
  Kam Weng Ng, Iowa State University
  Sherif AbdelSalam, British University in Egypt
  Matthew Roling, Flad Architects
  Sri Sritharan, Iowa State University
  Muhannad Suleiman, Lehigh University

2. MTI Geotechnical Research Program
  Bill Stone, Missouri DOT

3. Development of a Database for Drilled Shaft Foundation Testing (DSHAFT)
  Jessica Heine, Iowa State University
  Matthew Roling, Flad Architects
  Sri Sritharan, Iowa State University
  Muhannad Suleiman, Lehigh University

Iowa State University

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QUANTIFYING TRAVELER DIVERSION AND ITS IMPACT DURING A WEEKEND FULL FREEWAY CLOSURE: CASE STUDY WITH I-894

Justin Effinger[1], Yue Liu[2], Alan Horowitz[3], John Shaw[4], John Corbin[5]

Abstract

Short-term full freeway closure is a work zone strategy that is attracting more consideration by DOTs in order to allow for accelerated construction time and shorter duration of traveler impacts. Such closures are very often limited to weekends or night times. Because of the potential for large impacts on adjacent arterials, there is a need for a good understanding of traveler's diversion patterns in response to detour guidance. Although studies have shown that many drivers will choose alternate routes when they are aware of work zone delays, quantifying such patterns has not been sufficiently addressed, either in the professional literature or in practice.

This paper presents a case study on quantifying driver diversion and impacts during the I-43/I-894 full freeway closure event in October 2010 at Milwaukee, based on an effective integration and fusion of multi-source data collected with existing traffic surveillance systems along the target study region which include Volume, Speed, and Occupancy Application Suite (VSPOC) loop detectors, I-94 N/S Corridor microwave detectors, Statewide Traffic Operations Center (STOC) video surveillance, TRAffic DAbase System (TRADAS) Automatic Traffic Recorder (ATR), and Traffic Responsive Signal System (TRSS). Extensive analysis on the obtained comprehensive dataset has offered a reliable estimate of the actual traffic demand distribution over various designated detour routes and assess of effectiveness of the planned mitigating strategies. A set of rules, assumptions and guidelines based on research findings and lessons learned from the case study are also developed to better assist state DOT engineers to estimate the response of travelers, quantify the resulting impacts, design traffic mitigating plans, and assess cost-benefit before implementing future short-term full closure construction plans.

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[4]Traffic Analysis & Data Management Program Leader, Wisconsin Department of Transportation, Statewide Traffic Operations Center, Tel: 414-227-2150, Email: John.Shaw@dot.wi.gov

[5]Director of Traffic Operations, Wisconsin Department of Transportation, Statewide Traffic Operations Center, Tel: 608-266-0459, Email: John.Corbin@dot.wi.gov

Precast UHPC Waffle Bridge Deck Panels and Connections for Accelerated Bridge Construction

Sriram Aaleti[1], Sri Sritharan[2], Dean Bierwagen[3] and Brian P. Moore[4]

The AASHTO strategic plan in 2005 identified extending the service life of bridges and accelerating bridge construction as two of the grand challenges in bridge engineering. The motivation behind these challenges was to produce safer, economical and minimal maintenance bridges with a service life of 75 years at a faster rate to accommodate the country's increasing infrastructure needs. Therefore, as the nation's emphasis on the development of sustainable infrastructure continues to grow, the structural engineering profession looks for innovation in structural systems to contribute to this important development. The new and next generation of such systems may use high strength, high performance materials, deploy accelerated construction practices, improve structural performance using realistic and sophisticated computer models, or utilize combinations of several of these options.

Prefabricated full-depth precast concrete deck systems have been used previously to accelerate bridge deck rehabilitation and extend service life with reduced user delays and lower life-cycle costs. Also, using ultra high performance concrete (UHPC) for bridge applications have been proven to be efficient and economical to increase bridge longevity due to its superior structural and durability characteristics and their potential. By adopting the advantages from the previous research on UHPC and precast deck systems, a prefabricated, highly durable waffle bridge deck system using ultra-high performance concrete (UHPC) was developed as part of FHWA's Highways for LIFE program.

A full-scale, single span 60 ft long and 33 ft wide prototype bridge with full depth prefabricated UHPC waffle deck panels has been planned for a replacement bridge in Wapello County, Iowa. In support of this project, the constructability of the system as well as its critical connections and structural performance were studied through an experimental program at Iowa State University (ISU). Two prefabricated, full-depth, UHPC waffle deck (8ft x 9ft 9 inches x 8 inches) panels were connected to two, 24-ft long precast prestressed girders. The system was subjected to AASHTO service and fatigue loads. Also, the waffle deck system was subjected to load that is significantly higher than the AASHTO specified ultimate load. After ensuring the good performance at the ultimate conditions, one of the waffle deck panels was subjected to punching shear failure. The observed punching shear capacity was much higher than the previously reported values from small-scale tests. Based on the test observations and results, the experience gained from the sequence of construction events including fabrication, casting of UHPC infill transverse and longitudinal joints, the prefabricated UHPC waffle deck system concept has been recommended for use in practice. The first application of this system is expected to take place in summer 2011.

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Load and Resistance Factor Design Advancements for Bridge Pile Foundations in Iowa

Kam Weng Ng[1], Sherif S. AbdelSalam[2], Matthew J. Roling[3], Sri Sritharan[4], and Muhannad T. Suleiman[5]

Abstract

This paper will present the recent advancements of Load and Resistance Factor Design (LRFD) for bridge pile foundations, which were made possible through establishment of PIle LOad Test (PILOT) database and full-scale testing of 10 steel H-piles. Developed as part of a project in a near completion stage, PILOT is an amalgamated, electronic source of information consisting of both historical static and dynamic data for pile load tests. Although included in PILOT, the full-scale tests, conducted in clay, sand, and mixed soil profiles, were motivated to provide dynamic restrike and verification data.

Using the quality-assured data and following the American Association of State Highway and Transportation Officials (AASHTO) framework, resistance factors for LRFD were established for driven piles in Iowa. For design purposes, an in-house design method known as the Bluebook method was chosen due to its efficiency. In consideration to the routine practices of the Iowa Department of Transportation and County Engineering Offices, Iowa DOT Modified ENR formula, Wave Equation Analysis Program (WEAP), and CAse Pile Wave Analysis Program (CAPWAP)) have been chosen as the appropriate construction control methods and resistance factors for all chosen methods have been established. Compared with the AASHTO recommended LRFD Specifications, these regionally calibrated resistance factors are more efficient, improving the pile design in Iowa. Further advancements made as part of this project are: 1) refining the resistance factors established for the Bluebook method to minimize the discrepancy between designed and field verified pile resistances; and 2) incorporation of the effect of pile setup in clay profiles as part of the LRFD recommendations, thereby improving the efficiency of pile foundations in Iowa. In addition to providing these recent advancements, the improved economy of the pile design will be demonstrated through an example.

Key words: Resistance Factors—Construction Control—Pile Setup—LRFD.

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A Conceptual Framework for Freight Transport Modeling With Logistic Choices

Zahra Pourabdollahi[1], Kouros Mohammadian[2],

Abstract

Freight movements have significant impacts on transportation system and economic growth of any region. Because of the complexity of decision-making of freight transportation, freight transport models can be used as effective tools to predict freight transportation demand and to better address the impacts of these movements. Many available freight transport models are short in term of logistic elements such as, predicting the exact trip chain, considering intermediate handling facilities, determining shipment size, etc. This paper outlines a conceptual framework for freight transportation modeling by incorporating the logistic choices into a former freight transport model called FAME (Freight Activity Micro-simulation Estimator). FAME is a micro-simulation model for freight transportation in the U.S. that has been developed by the transportation research team at UIC in 2010. This model simulates commodity movements in the U.S. at a very disaggregate level of firm-to-firm, but it also lacks some of the logistic choices such as considering consolidation centers, distribution centers, warehouses, etc. This paper deals with the incorporating missing logistic elements in FAME framework and proposing a new conceptual framework. The proposed logistic model framework simulates the national freight movements in the U.S at the disaggregate level of firm-to-firm and replicates the logistic choices such as, selecting supplier, use of intermediate handling facilities, choice of shipment size, mode choice, etc. This paper proposes the conceptual framework of this micro-simulation logistic model.

Keywords: Freight transport modeling- Logistic elements - Framework.

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A Study on the Relationship between Operational Asset Performance and Safety Performance

Jian Gao[1], Inya Nlenanya[2], Basak Aldemir-Bektas[3], Konstantina Gkritza[4], Omar Smadi[5], Neal Hawkins[6]

Abstract

Asset management concepts, principles, and performance measures have recently received increased attention by transportation leaders, state agencies, and other transportation-related associations and institutes. However, to date, the improvement of safety performance achieved by an operating asset management system has not been fully studied. Past research has revealed the relationship between pavement condition and safety; roadway lighting and safety; retroreflectivity of pavement marking and safety; but the relationship between operational asset performance and safety performance has not been examined in a multivariate context. This paper investigates the relationship between various operational asset performance measures such as pavement marking retroreflectivity, pavement condition (expressed as roughness and rutting), sign inventory, and safety (crashes). To achieve this, six years of pavement marking retroreflectivity data, pavement condition data, and sign inventory data on all state primary roads were collected from the Iowa Department of Transportation. These data were integrated with corresponding crash and traffic data using GIS. Statistical models were then developed to estimate the relationship between operational asset performance and safety performance. Incorporating safety criteria into asset management can assist agencies to manage more efficiently their aging assets, instead of focusing on individual projects, increase public acceptability of proposed projects, and improve system-wide highway safety.

Key words: asset management- safety- pavement marking- pavement condition- sign inventory

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ABC Decision Tool and Economic Modeling Study

Toni Doolen[1], Benjamin Tang[2],and Ahmad Abu-Hawash[3]

Abstract

Accelerated Bridge Construction (ABC) is recognized as an important method for bridge owners to accelerate the delivery of highway bridge projects. ABC uses both new technology and innovative project management techniques to reduce the impacts of bridge construction projects on the public and to reduce total project costs. In early stages of a construction project, engineers need to assess whether elements of ABC are achievable and effective for a specific bridge location. Use of decision-making tools in early stages of planning is highly recommended for decision makers to proactively implement effective solutions. Existing cost analysis tools in the public domain arena are found to be lacking. Available project cost data are inconsistent and insufficient and not well documented. This makes ABC project decision making a challenge when reliable cost data are not readily available in the early stages of planning a project. There is now a tool available to assist bridge owners with their decision using either qualitative or quantitative data.

In this FHWA-sponsored pool funded study TPF 5(221) a set of decision making tools, based on the Analytical Hierarchy Process (AHP) were developed. This tool set was prepared for transportation specialists and decision-makers to determine if ABC is more economically effective than traditional construction for a given bridge replacement or rehabilitation project. The tool set is user-friendly, accommodates a range of construction situations, transparent as to the method of calculation and decision criteria, and customizable to maintain owner's relevance. These elements are important considerations as project decision making is influenced by

stakeholders from diverse (sometimes opposing) disciplinary perspectives. To support this development, a comprehensive literature review on a number of relevant domains such as ABC construction techniques and decision making approaches, were completed. The findings were summarized into a decision model hierarchy that was also incorporated into the decision making software.

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ABC Demonstration Bridge – Design and Construction

Mid-Continent Transportation Research Symposium
Ames, IA
August 18-19, 2011

Submitted by:

Mike LaViolette, Jon Frerichs – HNTB Corporation

Terry Wipf, Brent Phares, Matt Rouse, Doug Hartwell – Iowa State University

Ahmad Abu-Hawash, Jim Nelson, David Evans – Iowa DOT

HNTB is currently leading a comprehensive four-year study for the National Academy of Science under the Strategic Highway Research Program entitled <u>SHRP 2 R04 Innovative Bridge Designs for Rapid Renewal</u>.   The research team has gathered and evaluated proven accelerated bridge construction (ABC) details from over 200 projects and sources around the world, and developed a series of innovative ABC construction concepts that can be implemented to construct bridges in either a few days or a few weeks depending on project requirements, available construction space and project cost limitations.

As part of this project, the HNTB team has designed a demonstration bridge that incorporates proven ABC bridge construction details with the innovative use of Ultra-high Performance Concrete (UHPC) to shorten the normal bridge replacement period of six months down to only 2 weeks of traffic disruption. The demonstration bridge, which features precast concrete semi-integral abutments, precast columns and pier caps connected with high-strength grouted couplers, and an innovative modular steel/concrete hybrid superstructure. This bridge is the first in the US to construct a multiple-span continuous bridge by combining field-cast UHPC joints with simple span bridge modules that can be erected with moderate sized cranes. The enhanced durability provided by the elimination of all deck joints is seen as a major advance in long-life ABC projects.

Construction of the demonstration is scheduled for summer 2011. This paper will present the design and construction aspects of the demonstration bridge project including the finite element modeling of the innovative field-cast UHPC joints and photos/video of the construction project.

The next phases of the project include laboratory testing of the critical field-cast UHPC continuity joints to ensure its long-term reliability and ultimate load capacity. This lab testing is currently underway at Iowa State University. A companion paper will present the lab testing of this same bridge.

ABC Demonstration Bridge – Lab Testing

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Submitted by:

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This paper will present the results of the laboratory testing of the critical field-cast UHPC continuity joints to ensure its long-term reliability and ultimate load capacity. This lab testing is currently underway at Iowa State University. Lab testing includes the an investigation of the practicality of field placement of UHPC, the grindability of this material at a range of compressive strengths and the ultimate load capacity of the innovative UHPC continuity joints at each pier.

A companion paper will present the design and construction of this same bridge.

Remote Sensing for Bridge Monitoring – USDOT-RITA IRSV Projects Phase 1 and 2

Edd Hauser[1] and Shen-En Chen[2]

[1]Professor and Director, Center for Transportation Policy Studies, University of North Carolina at Charlotte, Charlotte, NC

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ABSTRACT:

This paper reports research progress of the IRSV (Integrated Remote Sensing and Visualization) project sponsored by the USDOT-RITA. Since 2007, the Center for Transportation Policy Studies at the University of North Carolina at Charlotte has teamed with several state and local departments of transportation, including Iowa, North Carolina, New York, Alabama, Florida, Los Angeles County, and the City of Charlotte. Also on our team are several consulting engineers and professional aerial photographers, who work with us in testing various Commercial Remote Sensing and Spatial Integration (CRS-SI) technologies for bridge monitoring.

Contrasting with more conventional health monitoring technologies, CRS-SI technologies in this study have been applied to any sensor that does not touch any surface of the bridge. Our database for analysis of these technologies consists of approximately 20 bridges from each of the agencies listed in the first paragraph above. These technologies are suggested as extensions of bridge inspections commonly carried out in this county. They provide output that extends the envelope of accurately quantifying actual damages to a bridge. This IRSV project focuses on the development of two CRS technologies: terrestrial 3D LiDAR scans, and spatially integrated-small format aerial photography (SI-SFAP).

After more than 100 bridge flyovers to collect SI-SFAP data, and ground LiDAR scans on most of these same bridges, the project is now on the "launch pad" of actual technology implementation, and we are exploring various avenues for funding Phase 3 in this series of projects. A critical step in implementation is the integration into existing DOT workflows. In the early stages of our project, some of these technology applications were unfamiliar to many bridge engineers. The exposure of LiDAR in various transportation applications has greatly expanded over the past few years. SI-SFAP is something like a step behind.

However, there are still significant efforts needed, hopefully with current and additional partners, to address and overcome the uncertainties of these technologies on the state-of-the-practice. Such issues are challenges that are common to many new technologies as they are implemented.   In this paper, we will describe how the nation's aging national transportation infrastructure may evolve into a test bed to help bridge engineers utilize remote sensing applications as an extension of existing bridge management and preservation practices.

A Study of Aggregate Settlement in a Simulated Cement System

Will Hunnicutt[1] and Kejin Wang[2]

Abstract

In recent years, the rheological implications of self-consolidating concrete (SCC) has been a topic of interest. The ability to understand the mechanics of segregation of aggregate is critical in properly designing SCC. Segregation of concrete greatly depends on the settling of concrete aggregate. In the present study, existing models for predicting settling velocity of aggregate in concrete are reviewed. New experimental tests are conducted to examine settling velocity of aggregate in a simulated cement system that is made with spherical particles in a solution. Different sizes and fractions of particles and solutions with various viscosities are considered. The measured settling velocities of the aggregate are compared with those obtained from the existing model proposed by Shen. It was found that a correlation exists between single particle settling velocity, group settling velocity, and the ratio of aggregate volume fraction to maximum packing density. Shen's model is an adequate descriptor of the settling velocity of aggregate, but versatility of this model may need to be further explored.

Key words: self-consolidating concrete – SCC – segregation – volume fraction

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ABSTRACT

Corrosion Performance of Eight Older Bridge Decks Constructed with Epoxy-Coated Reinforcing Steel in Iowa

By

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Epoxy coatings have been used on embedded reinforcing bars in bridge decks since the mid-1970s to mitigate deterioration due to chloride-induced corrosion. Some corrosion-related deterioration is now evident on these bridge decks, particularly those with 20 or more years of service life. To gain further understanding of the long-term performance of bridge decks reinforced with epoxy-coated bars, WJE and the Iowa Department of Transportation investigated the condition of eight different bridge decks across Iowa that were constructed using epoxy-coated reinforcing bars. During this study, several different deck factors and conditions were evaluated, including chloride content, carbonation, age, extent of deterioration, condition of epoxy coating, and corrosion-related deck deterioration. Of the eight bridge decks studied, four had epoxy-coated bars in the top and bottom mats of reinforcing, while the other four contained epoxy-coated bars for the top mat of reinforcing and uncoated bars for the bottom mat. This study examined the effect of these variables on the projected service life of these bridge decks, and compared the projected service life to that which could have been expected had these decks been reinforced with fully uncoated bars. The findings from this study will be summarized in this presentation.

Key words: epoxy coated reinforcing bars—bridge decks—chloride-induced corrosion—service life

Spatial Transferability of CO₂ Emission Models Incorporating Land Use and Household Characteristics

Judith Mwakalonge[1], Doreen Kobelo[2], and Saidi Siuhi[3]

Abstract

The observed effects of climate change have influenced policy makers from different sectors to implement or consider alternative strategies for reducing CO_2 emissions which have the highest contribution to climate change. Of all the sectors, the transportation sector accounts for almost 33% of the total CO_2 emissions. Some of the strategies in managing the reduction of CO_2 emissions from transportation sector include promotion of non-motorized travel, high fuel efficiency standards for new vehicles, low carbon fuel standards etc. Furthermore, transportation agencies are required by federal law to incorporate environment into the transportation planning process. For transportation agencies to be able to quantify CO_2 emissions resulting from their local roadway network require data for model formulation and estimation. Availability of adequate local data is a problem to some agencies thus often they borrow models from other areas with similar characteristics for application. However, literature revealed that spatial transferability of CO_2 emissions models has not been investigated in detail. This study aims to formulate CO_2 emissions models for four metropolitan areas including Chicago, Los Angles, New York, and Washington DC and evaluate spatial transferability of the estimated models. The models are estimated using data from the 2009 National Household Travel Survey. The models account for land use and household characteristics variables. The results of this study are expected to assist transportation agencies with limited data to estimate CO_2 emissions using borrowed model with informed level of accuracy.

Key Words: **CO₂ emissions, Model, Transferability**

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Effects of Thermal Loading on Pier Deformations in the Wakota Bridge

Krista Morris[i], Arturo Schultz[ii]

Abstract:

Bridges expand and contract due to daily, seasonal and yearly temperature changes. The effects of thermal loading are especially large in Minnesota and other northern States. While research has been conducted on thermal effects in bridge superstructures, there is little published literature on the effect of thermal loading on the substructure. The research described in this abstract focuses on the thermal loading in the box girder superstructure and the twin-blade, fixed-flexible pier substructure of the Wakota Bridge in South St. Paul, Minnesota.

Figure 1: Westbound lanes of the Wakota Bridge completed, the eastbound lanes were completed and opened in 2010

A previous computational study of thermal loading in the Wakota Bridge indicated that certain of the piers and spans of the bridge would be the most affected by changes in thermal loading. Subsequently, the bridge was instrumented during construction at Piers 2 and 4 and at two box-girder sections, one each in Spans 3 and 4. The gages are located at two elevations within the pier walls, and are paired along the length of the walls to provide measurements due to pier bending in both directions. The two spans are instrumented with twenty gages located within the box girder, which are distributed uniformly around the cross section at a location midway along the length of the span. Two linear string potentiometers located at the abutments of the bridge measure overall expansion and contraction of the bridge.

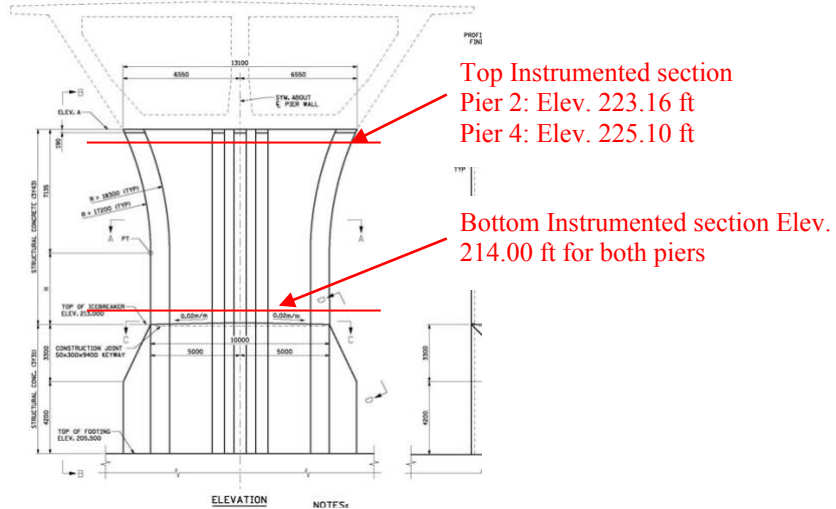# Effects of Thermal Loading on Pier Deformations in the Wakota Bridge

Figure 2: Placement of strain gages in Piers 2 and 4

Presented here is data showing the effect of daily and seasonal temperature fluctuation during a four-month period during the winter 2011. Typical data for a gage in one of the piers is shown in Fig. 3 for a one-month period in early 2011.
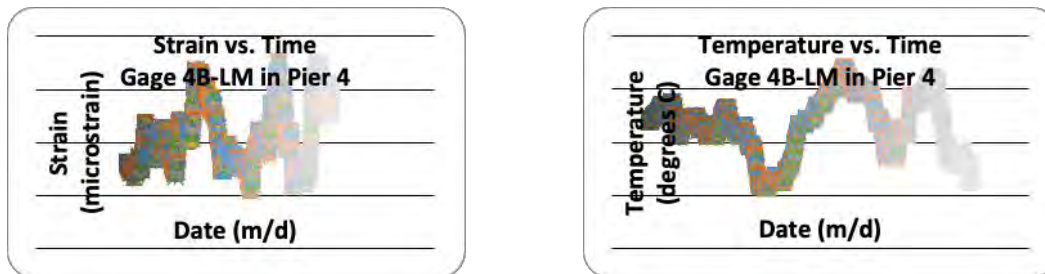

Figure 3: Typical plots of strain versus time and temperature versus time in one of the piers

The temperature and strain measurements at instrumented locations within the bridge structure are described. The superstructure strain values are correlated with the total elongation of the box girders, and the latter is determined from displacement readings taken from string potentiometers installed at the two abutments. Superstructure movement is correlated with strains in the piers.

Key Words: Thermal loading-Strain-Bridge substructure-Bridge superstructure

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Geothermal Application for PCC Pavement System

Cheng Li[1], David White[2]

Abstract

Major problems to Portland Cement Concrete (PCC) pavement system include curling, warping, freezing, thawing and cracking associated with the variation of the temperature and weather. The use of geothermal resources to control the pavement temperature and remove snow is a very creative and environmentally friendly concept. In order to test the feasibility of the geothermal system, a lab model has been built. This lab model consists of five main parts. The first part is the PCC concrete slab. The size of this slab is 6'×3'×6", and It is used to simulate the actual PCC pavement. The second part is the closed pipe loop as the heating apparatus. It is made of the ½" diameter copper pipe. The third part is the 2.5 gallons water heater that used to stimulate the geothermal resource. The forth part is the I-Buttons. 5 I-Buttons was installed in this lab model to collect the data in this system, three of them are in the concrete slab, one is on the inlet pipe wall and one is on the outlet pipe wall. The fifth part is two meters. One is the flow rate meter used for measuring the flow rate of the fluids and the other one is a watt meter used for recoding the energy consumption. There are also some other equipment in this system for stimulating the real situation, such as the valve, water pump and insulation foam skirt. In order to better stimulate the actual weather situation, this lab model was set up outdoor in Iowa State University. The experiment stage was from January 11th, 2011 to February 10th, 2011, from the observation and data analysis of the experiment, it turned out this system worked out well. The wide range of applications of this concept is the most attractive point. It cannot only solve some problems of the properties of PCC pavement, but also can increase the safety level of the pavement system.

Key Words:

PCC Pavement, Snow-Melting, Curling & Warping, Geothermal, Applications

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3D Spatial Visualization Analysis of Safety Related Driving Events of Newly Licensed Teens in Proximity of Home and School

Tika Ram Adhikari, Daniel V. McGehee, Michelle Reyes, and Cher Carney

In 2005, motor vehicle crashes (MVCs) accounted for more teen deaths (5,253) than homicide (2,219), suicide (1,809), and all forms of cancer (981) combined. Fatal crashes of teenagers, especially of newly licensed teens, are higher than for any other segment of the population. In fact, the crash rate per mile driven for 16-year-olds is roughly four times that of drivers of all ages (61.4 per 1,000 drivers vs. 16.8 per 1,000 drivers).

Existing data recorders and global positioning systems can provide data to parents on general driving behavior (e.g., speed, acceleration, location), and while there is a lack of research on traditional monitoring technologies, recent studies have shown that event-triggered video-based interventions may have the potential to improve driving safety among teens.

A byproduct of such event triggered video recorders is additional location data for safety related events (e.g., abrupt braking, steering or accelerating). Integrating naturalistic driving location data into GIS models offers new opportunities to explore spatial patterns of safety related driving events. Geospatial technologies allow the integration of multiple datasets so that data can be visualized. In this context, spatial proximity analyses and visualization can assist pattern exploration of safety related driving errors to predict driver behavior. In this paper, we investigated such safety related driving errors in the proximity of a new licensed teen's home, and in their primary destination, school.

In this analysis, forty-six newly licensed teen drivers aged 14-16 were recruited from three rural high schools in eastern Iowa. There were 1,756 safety related driving errors recorded using event triggered video recorder (see Carney et al, 2010, McGehee et al, 2007). Safety related driving errors (events) and home addresses were geocoded into a local geographic coordinate system. Spatial distribution of the safety-related events were visualized in a 3-dimensional space along with 1 meter resolution of satellite imagery, detailed road network, and a digital elevation model using the available visualization facilities of ArcGIS 10. To examine the concentration of the safety related driving errors relative to the proximity of the home and school location, different radii were created around the participant's home and school address. The safety related driving errors were aggregated in these radii and analyzed spatial variation of these events using a Chi-Square test.

Results indicated that the majority (87.25%) of safety related events (e.g., abrupt braking, steering and accelerating) occurred within 1/10th of a mile from their home and 12.75% occurred around school. A Chi-square analysis indicated that this difference is significant ((X^2 = 22, N=149) = 63.22, p<0.0001). This study suggests that 3D visualization and spatial proximity analysis are complementary each other to explore the patterns and concentration of safety related driving errors relative to home and school.

Key words: spatial visualization-- naturalistic driving data-- teen driving

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WEB-BASED PROJECT MANAGEMENT ACTION RESEARCH FOR HIGHWAY PROJECTS UNDER $10 MILLION

Authors: Perez Reboredo, Jose A[1].; Jahren, Charles T[2].

This paper reports on action research conducted to find a web-based project management system (WPMS) for the Iowa Department of Transportation (DOT). WPMSs are often used in planning and control of building projects, but can also be used to manage highway and heavy construction projects. In 2008, the Iowa DOT initiated a five-year construction period that includes several complex bridge projects (> $10 million) and sought a WPMS that would facilitate the transmittal of requests for information (RFIs) and shop drawings for these projects. Now, the Iowa DOT is considering implementing a different WPMS on smaller highway projects ($10 million) with capabilities of expanding its usage to all DOT projects.

Action research, an iterative process of continuous improvement, was used to identify a WPMS that met the Iowa DOT's needs. Through this process the research team with the help of a technical advisory committee (TAC) evaluated the effectiveness of WPMS solutions. The research team and the TAC also developed solutions that addressed immediate project needs and established ideas for subsequent implementation.

This paper describes the process of identifying a WPMS for smaller highway projects. This process involved the development of the workflow for the Iowa DOT's document management. The first workflow that was created corresponded to sign truss projects; this helped the researchers understand the document management of smaller DOT highway projects. Subsequently, several WPMSs were studied and compared to the workflow. From these, Microsoft SharePoint Server was selected as a possible solution for implementation.

Currently, additional workflows, further studies and tests are being performed to Microsoft SharePoint before it is pilot tested.

Key Words: action research – WPMS – electronic collaboration – document management - Web-based Project Management Systems

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An Enhanced Freight Activity Micro-simulation Estimator (FAME) Model using FAF3.0 dataset

Zahra Pourabdollahi[1], Kouros Mohammadian[2],

Abstract

Freight transportation is significant element of economic growth of any country. Over years, the freight transportation industry has evolved and decision making process has become more complicated. In this environment, micro-simulation freight transport models are effective instruments for behavior forecasting and will help planners and decision makers in decision making process in the freight transport industry. This paper discusses the use of a micro-simulation model for freight transportation modeling to replicate the annual commodity flows of the year 2007 in the United States. The model used for this study is called FAME (Freight Activity Micro-simulation Estimator) which is a behavioral micro-simulation model for freight transportation. It has been developed by the transportation research team at UIC in 2010 using Freight Analysis Framework (FAF2.0) dataset. The model can simulate commodity movements at a very disaggregate level of firm-to-firm. In this research work the overall FAME model is upgraded to not only use the newly released FAF3.0 dataset as the main input to the simulation, but also the models performance is significantly enhanced by improving data structure and overall data flow throughout the simulation. The enhanced FAME model is then used to simulate commodity flows of the entire United Sates. The annual flows are broken down into firm-to-firm flows and the shipment size and transport modes are determined. The simulation results of the model and its validation analysis are presented in this paper.

Keywords: Freight transport – FAME - Micro-simulation model –FAF3.0.

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Effect of Limestone Powder on PCC Strength

Fatih Bektas[1], Wenjun He[2], Gongbo Zhang[3], Kejin Wang[4]

Abstract

There are vast amounts of limestone dust at quarries around the country as a waste for disposal. The US specifications currently allow only up to 5% ground limestone, while Canada has recently permitted up to 15% ground limestone as a replacement for portland cement. Differently, Europe has been using ground limestone at much higher levels: Europe's portland limestone cements, CEM II/A-L and CEM II/B-L, contain 6% to 20% and 21% to 35% ground limestone, respectively. Around 20% of all cement sold in Europe contains between 6% and 35% limestone.

The present study is aimed at investigating effect of ground limestone powder on portland cement concrete. The limestone used in the study is fine residue from aggregate crushing operation of a local manufacturer. The limestone was further ground in a laboratory ball mill and introduced as portland cement replacement. The laboratory work was carried out in two stages – effect on mortar strength and effect on concrete strength. The limestone is introduced up to 20% into the mortar either as received or further ground forms. The strength was evaluated on 2-in cubes at 3, 7 and 28 days. In the second phase of the study, concrete mix design was made based on 564 lb cement content and water-to-cement ratio of 0.45. 4-in cubes were cast and tested at 2, 7 and 28 days.

The results of this study provide researchers and engineers with an insight on to extensive use of limestone powder in concrete in US.

Keywords: limestone powder—portland cement concrete

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Evaluation of Reinforced Crushed Stone Base for Low-Volume Road Bases

Brandon S. Bortz[1], Mustaque Hossain[2], Izhar Halami[3], and Andy Gisi.[4]

Abstract

Crushed stone bases are widely used for low-volume roads. However, shear strength of the crushed stone materials can be vastly improved by confining those in 3-dimensional honeycomb-like structures, Gocells. The objective of this study was to test a geocell design with crushed stone (AB-3) infill and a thin hot-mix asphalt (HMA) surface layer under real world traffic in order to develop a design method for the geocell-reinforced paved roads. HMA pavement test sections of 100-mm thick AB-3 geocell-reinforced base and a 300-mm thick unreinforced AB-3 base were constructed at the Civil Infrastructure System Laboratory (CISL) of Kansas State University (KSU). The sections were paved with a 50-mm Superpave HMA layer and instrumented to measure the strains at the bottom of the HMA layer and stresses on top of the subgrade. The sections were loaded to 50,000 to 70,000 repetitions of an 80-kN single axle load. The calculated and measured responses show, in the reinforced section, stresses on top of the subgrade exceeded the unconfined compressive strength of the soil. It is recommended that the geocell depth be increased along with the thickness of the HMA layer for paved low-volume roads.

Keywords: geocells – AB-3 – accelerated pavement testing (APT) – low volume roads

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Preemptive Retrofits to Prevent
Constraint Induce Fracture at Vertical Stiffeners

Robert J. Connor[1], Michael J. Koob[2], Brian J. Santosuosso[2], and Bruce L. Brakke[3]

Recently there has been an increased awareness associated with brittle fractures initiating in the web at the intersection of vertical stiffeners or bearing plates with the flange. This type of fracture has occurred in a number of bridges in Iowa as well as other states. As is well documented, crack extension by brittle fracture is of much greater concern than cracking due to fatigue. Sudden brittle fracture, such as that observed on the Hoan Bridge commonly referred to as Constraint Induced Fracture (CIF), can occur in the absence of any detectible fatigue cracks or other defects. During a CIF event the crack growth occurs instantly in an unstable, dynamic fashion. Although there has been a considerable amount of research into the cause of CIF in details that are oriented parallel to the main axis of the girder (i.e., Hoan like details), in contrast, the fractures described herein have occurred at details which are oriented vertically. At this time it is not entirely clear what factors increase the likelihood of these fractures. It is also important to note that since there is no evidence of cracking prior to fracture initiation, even the most rigorous inspection will not provide warning of the impending fracture. This is of the greatest concern in members that have been identified to be Fracture Critical.

This paper will review several case studies, discuss factors that are believed to increase the likelihood of fracture, and present retrofit strategies to mitigate the potential for failure.

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Comparative Contact Methods in Freight Establishment Surveys

Session Presentation

Karl Sturm[1], Kouros Mohammadian[2]

Abstract

This paper describes the methodology and results of a recently completed online freight establishment survey. The survey was designed shed light on freight shipping practices and to further develop an associated freight demand microsimulation model. The demand model is then be used by elected officials and transportation planners to better inform investment decisions. In dealing with the well known difficulties in securing survey responses, a variety of approaches were implemented. The individual success rates and financial costs of such contact methods as personal telephone calls, web crawling, and mass e-mailing are detailed in this paper. In all, over 115,000 contacts were attempted in all 50 U.S. states, resulting to date in 438 usable surveys, with 559 individual shipment forms completed. This level of response rate indicates both the difficulties and the expense involved in collecting information considered sensitive by potential respondents, and the importance of maximizing one's response rate using proven methods.

Key words: Freight Transportation, Travel Survey, Online Survey

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DESIGNING AND OPERATING INTERSECTIONS WITH SIGNALS ON RURAL HIGH SPEED HIGHWAYS

This paper will present various intersection geometric features to improve capacity and safety at rural intersections planned for signal control on roadways with speed limits of 50 miles per hour or higher. It will then discuss the design of traffic signals and how the elements of signal displays, traffic signal controllers and their control strategies and vehicle detection all can be brought together to provide a safe and efficient traffic signal operation in the demanding environment of high speed traffic.

Specific geometric topics that will be covered include: left and right turn lane geometry, optimizing the median geometry at a standard intersection and the emerging concept of the Super Street which features innovative intersection design and signal operation.

Specific signal topics will include: detection and timing to facilitate mainline operation, truck detection with truck priority, coordinated operation in a high speed environment and various left turn signal treatments including the flashing yellow arrow.

Traffic simulation will be used to present several of these items.

A new decision support tool for warranting detour operations during freeway corridor incident management

Yue Liu[1] (corresponding author), Zhenke Luo[2]

Abstract

Traffic delays on freeway corridors due to congestion have significantly undermined the mobility and reliability of the highway systems in the United States. Most of those delays are due to non-recurrent traffic congestion caused by the reduced capacity and overwhelming demand on critical metropolitan corridors coupled with long incident durations. In such conditions, if proper routing and detour strategies could be implemented in time, motorists could circumvent the congested segments by detouring through parallel arterials, which will significantly enhance the reliability of travel in the corridor system. Nevertheless, prior to implementation of any detour strategy, traffic managers need to ensure the resulting benefits, as implementing those advanced control strategies usually demand substantial amount of resources and manpower.

This paper presents a new decision support tool to warrant detour operations during incident management. Such as tool offers the capability for responsible traffic operators to make consistent detour decisions in response to a detected incident from the system benefit perspective and with multiple affecting factors taken into account. The proposed tool is developed based on the dataset obtained from extensive simulation experiments and operational guidelines for highway agencies. The tool also features its computational convenience and operational flexibility, allowing potential users to make necessary revision and extension if more field data are available. Numerical results clearly indicate that a timely and well-justified detour decision made by the proposed tool can yield substantial benefits to both the driving populations and the entire community.

Keywords: Detour operations; Incident management; Decision support; Logistic regression;

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Drying shrinkage of ternary blend concrete in transportation structures

Xuhao Wang[1], Kejin Wang[2], Fatih Bektas[3], and Peter Taylor[4]

Abstract

Factors affecting drying shrinkage behavior of ternary blend concretes are studied. Five concrete mixes used for pavement and bridge deck structures in different states are selected and tested for both restrained and unrestrained shrinkages. The effects of blend materials and mix proportion on the concrete shrinkages are assessed. Clay content of fine aggregate in the concrete mixes is evaluated using methylene blue index tests. The results indicate that shrinkage strain rate linearly increases with clay content, cement content, paste-to-aggregate void ratio (by volume), and dosage of retarder of the concrete mixes.

Keywords: ternary blends, drying shrinkage, and cracking potential

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Development of a Database for Drilled SHAft Foundation Testing (DSHAFT)

Jessica Heine[1], Matthew Roling[2], Sri Sritharan[3], and Muhannad Suleiman[4]

Abstract

Drilled shafts have been used in the United States for over 100 years in buildings and bridges as a deep foundation alternative. For many of these applications, the drilled shafts were designed using the Working Stress Design (WSD) approach. Even though WSD has been used successfully in the past, a disadvantage of this approach is that individual sources of risk are not consistently or rationally incorporated into the design of the foundation. In addition, the different levels of variability and uncertainty of each load and resistance component are not considered. The move toward Load Resistance Factor Design (LRFD) for foundation applications solidified when the Federal Highway Administration (FHWA) issued a policy memorandum on June 28, 2000, requiring all new bridges initiated after October 1, 2007 to be designed according to the LRFD approach. This ensures compatibility between the superstructure and substructure designs, and provides a means of consistently incorporating sources of uncertainty into each load and resistance component.

The American Association of State Highway and Transportation Officials (AASHTO) recommend LRFD resistance factors for various foundation types, including drilled shafts. These factors were calibrated for generalized national soil types, resulting in an overly conservative design. Regionally calibrated resistance factors are, however, permitted by AASHTO to improve the economy and competitiveness of drilled shafts. Because of the added cost due to the use of conservative resistance factors and the limited knowledge with regards to current practice, the option of drilled shafts is not usually a preferred option for bridges in Iowa.

To improve the economy and use of drilled shafts in appropriate applications, it has been recognized that more efficient resistance factors must be established. For this purpose, development of a Database

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for Drilled SHAft Foundation Testing (DSHAFT) has been developed. DSHAFT is aimed at assimilating high quality drilled shaft test data from Iowa and the surrounding region, and identifying the need for further tests in suitable soil profiles.

This paper will introduce DSHAFT as shown in Figure 1, and demonstrate its features and capabilities, such as an easy to use storage and sharing tool for providing access to key information (e.g., soil classification details and Cross-hole Sonic Logging reports). DSHAFT embodies a model for effective regional LRFD calibration procedures consistent with PIle LOad Test (PILOT), which contains driven pile load tests accumulated from the state of Iowa. PILOT is now available for broader use at http://srg.cce.iastate.edu/lrfd/.

DSHAFT is currently comprised of 25 separate load tests provided by Iowa, Illinois, Minnesota, and Missouri State Departments of Transportation. In addition to providing a summary of the available data, this paper will open up opportunities for others to share their data through this quality–assured process, thereby providing a platform to improve LRFD approach to drilled shafts in the Midwest.

ID	State	County	Township	Section	Excavated and Installed By	Project Number	Date of Final Installation	Drilled Shaft Location
1	IA	Polk	Walnut (T-78N R-25W)	1 & 6	Longfellow Drilling, Inc.	LT-8756-1	4/12/2002	ft #1 - 42nd Street/I-235 C
2	IA	Jackson	Bellevue (T-86N R-5E)	19	Longfellow Drilling, Inc.	LT-9466	11/5/2008	. - US 52 over ICE & Mill Cr
3	IA	Polk	Des Moines (T-79N R-24W)	5	Longfellow Drilling, Inc.	LT-8756-2	8/2/2002	naft #2 - I-235 / 28th St. Ov
4	IA	Polk	Des Moines (T-78N R-24W)	3	Jensen Construction Company	LT-8854	10/25/2002	st Shaft - I235 over Des M
5	IA	Polk	Des Moines (T-78N R-24W)	36	Longfellow Drilling, Inc.	LT-8998	1/23/2004	st Shaft #1 - I-235 over UP
6	IA	Polk	Des Moines (T-78N R-24 W)	9	Longfellow Drilling, Inc.	LT-9149	3/13/2006	est Shaft 1 - 9th St. Bridge
7	IA	Van Buren	Van Buren (T-69N R-10W)	36	Longfellow Drilling Company	LT-9183	5/1/2006	t #1 - Hwy 1 over Des Moi
8	IA	Pottawattamie	Kane (T-74N R-44W)	29	Jensen Consturction Company	LT-9433	4/19/2008	Shaft - I-80 over Missouri
9	IA	Pottawattamie	Kane (T-75N R-44W)	27	Longfellow Drilling, Inc.	108026	8/22/2008	ect (Broadway Bridge Viad
10	IA	Pottawattamie	Kane (T-75N R-44W)	27	Longfellow Drilling, Inc.	108026	8/21/2008	ect (Broadway Bridge Viad
11	IA	Pottawattamie	Kane (T-75N R-44W)	27	Longfellow Drilling, Inc.	108026	8/20/2008	ect (Broadway Bridge Viad
12	MN	Hennepin	Minneapolis		Case Foundation	LT-9401	11/15/2007	ft 2 - I-35W over Mississip
13	KS	Republic	Scandia	8 & 17	Midwest Foundations Co.	LT-8718-2	3/30/2001	Shaft - US 36 Over Republ
14	MO	Jackson			Hayes Drilling, Inc	LT-8843	5/31/2002	ed Test Shaft - Grandview
15	KS	Ellsworth	Ellsworth	28	Midwest Foundations Co.	LT-8790	8/16/2001	r Union Pacific Railroad a
16	KS	Shawnee	Williamsport	24	King Construction	LT-8733	1/23/2001	ier 1 West, US 75 at 77th S
17	KY	Daviess			taylor Brothers	LT-8415-2	9/22/1998	U.S. 231 over Ohio River
18	MO	Lafayette			Jensen Construction	LT-8785	9/22/2002	issouri River Bridge - TS a
19	KS	Republic	Scandia	8 & 17	Midwest Foundations Co.	LT-8718-1	3/28/2001	Shaft - US 36 over Republ
20	MN	Hennepin			Atlas Foundation Co.	LT-9193-2	2/6/2008	- Crosstown Commons Pr
21	KS	Atchison	Atchison		Midwest Foundations	LT-9136	4/6/2006	t Pile - Amelia Earhart Bri
22	MO	Lafayette	Lexington		Massman Construction	LT-8516-2	4/27/1999	25m Lt. - Missouri River Br
23	MN	Washington	Stillwater		Case Foundation, Inc.		10/27/1995	Bridge over the St. Croix R
24	IL	LaSalle			Case Foundation Company	LT-8276	5/13/1996	he Illinois River, Marseill
25	IL	Rock Island			Civil Constructors Inc.	LT-9405	4/15/2008	shaft #1 - IL 5/ IL 84 Interch

Figure 1: DSHAFT Display Form

Key words: drilled shaft – electronic database – Load and Resistance Factor Design (LRFD)

Dynamic Horizontal Curve Warning Sign Impacts

Keith K. Knapp[1]

Three dynamic/interactive horizontal curve warning signs were installed in May 2010 along local county roadways within Minnesota. This work is part of a nationally funded research project on local rural roadway safety. It is funded by the USDOT Federal Highway Administration Rural Safety Innovation Program (RSIP), the Minnesota Department of Transportation, and the University of Minnesota. The process and criteria followed to select the rural sign installation study sites, without the existence of significant crash data, will be described as part of this presentation. In addition, the sign selection methodology and the lessons learned during the sign installation will be noted. Finally, the vehicle speed data collected one month before and after the sign installation, five to six months after, and one year after the sign installations will be summarized. This will be an ongoing project at the time of the symposium but the potential meaning of the draft findings will be discussed.

Key words: rural safety, ITS

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Minimum Cement Content for Performance and Sustainability in Rigid Pavements

Ezgi Yurdakul[1], Peter C. Taylor[2], Halil Ceylan[3], Fatih Bektas[4]

Abstract

Many concrete specifications impose minimum cementitious contents that may be in excess of that required to achieve the desired durability and strength, leading to increased costs and increased carbon loading on the environment. However, a minimum cementitious requirement hinders development of performance-based mixtures, and in many situations may lead to poor performance such as cracking due to high level of shrinkage. Therefore, minimizing the cementitious amount will not only reduce the cost but also lead to a more sustainable method of constructing concrete pavements. The main purpose of this research is to investigate the minimum cement content required with an appropriate water to cementitious ratio (w/cm) to meet given workability, strength, and durability requirements in a rigid pavement; and so to reduce carbon dioxide emissions, and costs.

This paper will present an experimental program that was conducted on 32 concrete mixtures with w/cm ranging between 0.35, 0.40, 0.45 and 0.50; and cementitious content ranging from 400, 500, 600 and 700 pcy. 16 mixtures were prepared using ASTM Type I ordinary portland cement and 16 contained ASTM C618 class F fly ash at 20% of portland cement replacement level. Fine and coarse aggregates were combined at a fixed ratio of 1:1.38 to maintain the same void content for all the mixtures. Compressive strength, chloride penetration and air permeability were determined. The test results showed that strength is a function of w/cm and independent of the cementitious content after the required cementitious content is reached, for a given w/cm. Chloride penetration increases as w/cm or cementitious content increases, when one parameter is fixed. Air permeability increases as cementitious content increases, for a given w/cm. Based on the findings, for the aggregate system used in this work, it is possible to reduce the cementitious content without sacrificing the desired strength and durability of rigid pavements, for a given w/cm.

Key words: cement content-concrete mix optimization-strength-durability-sustainability

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Performance Evaluation of Superpave Mix Using Hamburg Wheel Tracking Device

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Abstract

The Kansas Department of Transportation (KDOT) is currently focused on extending the service life of Superpave mixture overlays through better mixture selection. This study was undertaken to analyze the Hamburg Wheel Tracking Device (HWTD) test results on different surface mixes in order to improve mixture performance. The ultimate objective was to develop HWTD test result requirements for Superpave mixtures in overlays. Over the last decade, more than 100 HWTD tests on various Superpave mixtures had been done in Kansas. Each mixture was subjected to 20,000 repetitions or 20-mm rut depth, whichever comes first. The test results were recorded in terms of number of wheel passes and the corresponding rut depth. The analysis results showed that the surface mixes with higher percentage of recycle asphalt material (RAP) were more susceptible to rutting compared to the mixes with lower percentage of RAP material. The rutting performance was significantly affected by the asphalt source, mix type, and binder grade. Fine surface mixes with higher binder grade performed well compared to the coarse mix. However, volumetric mix design properties, except voids in mineral aggregate (VMA), were not significant in determining rutting performance. The rut depth decreased with increasing percent VMA for the mixes with moderate percentage (25%) of RAP materials.

Key words: Hamburg Wheel Testing Device – rut depth – recycle asphalt material – asphalt source – volumetric properties

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Evaluation of the Use of Reclaimed Asphalt Pavement in HMA Mixtures

Haritha Musty[1], Mustaque Hossain[2] and Nassim Sabahfar[3]

Abstract

Reclaimed Asphalt Pavement (RAP) is the term given to removed and/or reprocessed pavement materials containing asphalt and aggregates. The use of RAP in HMA mixtures is a good way to conserve the construction materials, to reduce costs and amount of waste. In this study RAP is the millings collected from the Novachip treated pavement. The purpose of this study is to evaluate the effect of Novachip Millings on the performance of the HMA mixes. Nine mixtures consisting of three RAP percentages (0%, 10%, and 20%) with three aggregate sources and one source of virgin asphalt cement, PG 70-22 were developed. The Superpave mix design process was used to determine the optimum asphalt content and volumetric properties for the mixtures. Performance tests will be done for rutting and moisture sensitivity to evaluate the mixtures at different RAP percentages.

Key words: Reclaimed Asphalt Pavement – Novachip Millings - volumetric properties – rutting – moisture sensitivity

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Effect of Cedar Rapids, IA Automated Speed Enforcement Cameras on Speeds along I-380

Shauna Hallmark[1] and Nicole Oneyear[2]

For consideration for either poster or session presentation

Abstract

Interstate 380 is the main North-South thoroughfare in Cedar Rapids, Iowa. An approximate two mile stretch runs through the downtown area where speeds are reduced from 65 mph to 55 mph. This stretch is elevated and contains an S-curve which can cause difficult driving conditions in winter weather. Historically, the roadway has been plagued by safety problems. During 2009 approximately 3 fatal and 33 major injuries crashes occurred on this stretch. Strategies such as traditional enforcement have been ineffective in reducing speeds, so in August of 2010 the first of four automated enforcement speed cameras was installed in this segment.

A study is being conducted by the Center for Transportation Research and Education (CTRE) in the Institute for Transportation at ISU. The study is evaluating the effectiveness of the cameras throughout this corridor. Changes in speed metrics is the measure used to evaluate the treatment. Changes are being measured across from when the cameras were first in place and not issuing citations and periods after the cameras were in place. Speed metrics studied include the percentage exceeding the speed limit by 5, 10 and 15+ mph. Additionally changes in mean and 85th percentile speeds will be studied. This presentation will present preliminary results and lessons learned.

Keywords: speed – safety – automated enforcement

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Estimation of Safety Effectiveness of Composite Shoulder on Rural Two-Lane Roads

Huanghui Zeng[1], Steven D. Schrock[2]

Abstract

There is a need for engineers and planners to understand the trade-offs of safety versus cost given the state department of transportation's fiscal constraints and a desire to continually strive to make roadway safer. Paved shoulder has been regarded as an effective safety improvement to reduce crashes (e.g. run-off-the-road, roll-over, etc). While a full-width paved shoulder might be the most desirable, there is belief that there is a diminishing safety benefit for each additional increment of paved shoulder width. Thus there may be opportunities for greater system-wide safety benefits from paving longer roadway segments with a composite shoulder than paving shorter roadway segments with a full-width paved shoulder. The object is to determine the safety benefits of composite shoulders - such as a small paved shoulder combined with turf outside of that. This approach fits within Kansas Department of Transportation's "Practical Improvements" approach to maximize benefits relative to the input costs required.

The research team will study the safety effectiveness of several typical types of composite shoulders that have already been installed in Kansas' rural two lane road based on their paved component width. Empirical Bayes (EB) Method will be applied in the Before-After study. Safety Performance Function (SPF) models developed in previous studies will be brought into the EB procedure. For each studied site, safety and traffic flow data during "before" and "after"

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periods will be obtained and combined with SPF models to make the safety estimation. Based on these results, the research team will develop Kansas specific Crash Modification Factors (CMFs) for composite shoulder compared with segments without shoulder. Finally, Benefit-Cost analysis is conducted by using these estimations and CMFs, combined with the estimated cost of crashes and the project.

Keywords: safety—composite shoulder—empirical bayes method—practical improvements

Identifying Fine Aggregates Prone to Polishing in PCC Pavements

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ABSTRACT

Surface polishing is one of the few functional failures that occur in portland cement concrete (PCC) pavements. An increase in surface polishing leads to higher incidences of skid-related accidents on highways. This type of failure is often associated with the usage of softer fine aggregate such as limestone sands.

To identify polish resistance aggregates, state agencies like TxDOT have adopted tests such as the acid insoluble residue test (AI). Because dolomite or limestone aggregates are soluble in acid they cannot pass the AI test. Some districts such as the Dallas and Fort Worth have few local sources of sands that meet the current specifications and are forced to haul aggregates from distant sources (which increases cost).

The goal of this research is to develop laboratory tests that can reasonably predict performance of concrete pavements made with different types of sand. For this purpose concrete slabs made with different sands are being evaluated for friction and texture using a circular texture meter, a dynamic friction tester, and a concrete surface polisher. To ensure that the values obtained at the lab relate to field performance, test sections constructed with 100% limestone sand and blended sands are being evaluated. Laboratory and field test results for skid will be used to identify the aggregate test that best correlates with concrete performance. Results show that some of the sands that fail the AI test have performed as well as the control siliceous sand that pass the AI test. Aggregate tests such as the micro-Deval have shown to relate more closely to the concrete performance tests performed under laboratory conditions.

PCC pavement made with 100% limestone sand showing polishing in wheel paths

Note: The presentation will include results, photos (lab and field), and a short video. Concrete samples made with different sands will also be distributed to the audience so that they can have a better feel for the type of failure being discussed in the presentation.

Guidelines for Design, Testing, Production and Construction of Semi-Flowable Self-Consolidating Concrete for Slip-Form Paving

By Gilson Lomboy[1], Kejin Wang[2], Peter Taylor[3], and Surendra P. Shah[4]

Abstract

A new type of self-consolidating concrete (SCC), semi-flowable SCC (SFSCC), has been developed for slip-form paving construction. Field applications of SFSCC have been conducted in Ames, Iowa. Based on the recent research results, guidelines for SFSCC design, testing, production, and construction are developed. This paper provides an overview of the guidelines. In the paper, SFSCC mix design methodology, quality control test methods, and special requirements for paving equipment and operations as well as post-placement techniques will be discussed.

Key words: Self-Consolidating Concrete, Slip-Form Paving, and Pavement

Format: Session presentation

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.Matched Case-Control Study of On-Road Bicycle Facilities and Bicycle Crashes in Iowa, 2007-2010

Cara Hamann[1] and Corinne Peek-Asa[2]

Format: Session presentation

Topic Summary:

In the past two decades bicycle ridership has been increasing, both for use as transportation (e.g. commuting to work) and for recreation. Along with these changes, many cities are adopting the 'complete streets' design concept, which accommodates all types of transportation modes, including bicycle facilities (bicycle lanes, shared lane arrows, 'Share the Road' signage, and paved shoulders; Figure 1). However, little is known about the effect of these facilities on crashes, especially in small metropolitan and rural areas. The scant existing literature focuses on large urban areas and generally shows that bicycle facilities are associated with increased ridership and are protective from crashes. The proposed study is needed because findings from studies in large urban areas may not be generalizable to less densely populated areas. Additionally, there is no gold standard or corresponding evidence base on safety and crash risk to guide choices in selecting optimal bicycle facilities.

Figure 1. Bicycle facilities to be studied

Share the Road signs, paved shoulders, shared lane arrows and bicycle lanes

The objective of this study is to determine the impact of different types of bicycle facilities on bicycle crash risk. To address this objective, we are currently conducting a matched case-control study using crash-sites as the cases and matched non-crash sites as the controls. Bicycle crash-sites were identified from the Iowa Department of Transportation crash database for years 2007 to 2010. We hypothesize that fewer case-sites will have bicycle facilities, compared to control-sites and that the effect of bicycle facilities on crashes will vary by facility type (some being more protective than others).

Prior to starting the current study we conducted a pilot case-control study of Johnson County, Iowa crashes from 2008. Results from our pilot study suggest that bicycle facilities are protective because fewer bicycle facilities were present at intersections where crashes occurred compared to similar intersections where crashes did not occur. 17.9% of case-sites had bicycle facilities, compared to 32.1% of control-sites. Our ongoing study will expand upon the pilot by controlling for both motor vehicle and bicycle volumes and by examining a larger number of site (147 case-sites and 147 control-sites) , crash years (2007-2010), and counties (Black Hawk, Johnson, Linn, and Scott). With our larger sample size we will also be able to compare crash risk between the different facility types, as opposed to only at the facility/no facility level. The results of this study will provide an evidence base to guide the safe design of roadways to accommodate bicyclists, leading to reductions in collisions which can increase safety for all road users during travel. The methodology and some preliminary results from this ongoing study will be available for presentation at the symposium in August.

Key words: bicycle— crash—case-control—DOT crash database— environmental study

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ABSTRACT

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Use of Hydrogen from Renewable Energy Sources in Hot-Mix Asphalt (HMA) Plant Production

by

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Use of Hydrogen from Renewable Energy Sources in Hot-Mix Asphalt (HMA) Plant Production

Kasthurirangan Gopalakrishnan,[1] *Siddhartha K. Khaitan,*[2] *and Mandhapati Raju*[3]

Abstract

More than 94% of roads in the US are paved with Hot-Mix Asphalt (HMA). The process of HMA manufacturing is an energy-intensive process which involves sorting and heating the aggregate to remove moisture from the aggregate, heating the asphalt binder to obtain sufficient fluidity of the asphalt binder for proper mixing in either batch mix plants or drum mix plants. Environmental Life-Cycle Assessment (LCA) studies have shown that, in the production of HMA pavements, major consumption of energy takes place during asphalt mixing and drying of aggregates, more than what is consumed during the extraction of crude oil and the distillation of bitumen. Currently, natural gas is the primarily source of fossil fuel used to produce 70 to 90 percent of the HMA in the US, while the remainder of the HMA is produced using oil, propane, waste oil, or other fuels. It has been estimated that energy-related CO_2 emissions, resulting from the use of petroleum and natural gas, represent 82 percent of total U.S. human-made greenhouse gas emissions.

According to some estimates, the production of HMA consumes 237,000 BTU/t (275 MJ/t) energy and produces 44 lb CO_2/t (22 kg CO_2/t). With the recent push towards sustainable, low-energy, low-emissions and environmentally friendly pavement construction methods, recent studies are focusing on low-temperature asphalt technologies (Warm-Mix Asphalt [WMA], Cold-Mix Asphalt [CMA], foamed bitumen, etc.) that have reduced production energy requirements apart from other benefits and development and implementation of energy saving guidelines targeting changes in

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aggregate storage and drying processes, and plant combustion efficiencies for optimized fuel usage.

This study proposes and investigates the feasibility of using of wind energy stored in hydrogen fuel cells as a clean source of energy for operating an HMA production facility. On-site installation of wind turbines, photo-voltaic panels, and solar water heaters are currently being contemplated and investigated upon by factory owners and companies with a commitment to move to carbon neutral operations and generating all energy from renewable sources to power their facilities. Thus, it is not inconceivable that the HMA production facilities could be equipped with wind mills in the near future to extract wind energy. Since wind blows intermittently, the extracted wind energy will be stored in the form of hydrogen which is considered a lightweight, compact energy carrier, for later use, thus creating a ready source of electricity for the HMA plant when wind is not present or when electricity demand is high. Through the use of hydrogen-based energy, the primary sources of greenhouse gas emissions from the HMA plant can be significantly cut down and the resulting cost savings can be enormous. The same technology can be employed in the production of low-temperature asphalt mixes which can yield even greater environmental and economic benefits.

Keywords: Hot-Mix Asphalt (HMA), renewable energy, greenhouse gas emissions, hydrogen, wind.

The implementation of warm mix asphalt (WMA) has led to many research questions. Iowa State University and the Iowa Department of Transportation have recently completed a field and laboratory evaluation of warm mix asphalt based on performance testing results. The field study consisted of samples procured from four different field produced mixes. The statistical analysis was performed based on the results of dynamic modulus (E*) testing and showed statistical differences between HMA and WMA results. The purpose of this research is to answer the question of how these statistical differences in the laboratory testing will translate to field performance. The mechanistic-empirical pavement design guide (M-EPDG) provides a model of what will happen in the field based on various pavement structure designs, actual weather data, various traffic loads and material properties. The E* data from the actual laboratory data can be used as an input to the model and pavement response data is measured. A statistical analysis is performed on the model results to evaluate whether the differences in the E* laboratory data translate to statistical differences in field performance. The purpose of this research is to determine if WMA produces a product with similar field performance as HMA and also to evaluate the M-EPDG model. Since the WMA and HMA samples were field produced, actual pavement distresses can be evaluated in the future and compared to what the model has predicted.

Investigation of Pavement Moduli Using Non-Destructive and Laboartory Tests

Jeremiah Thomas[1], Quinn Stenzel[2], and Mustaque Hossain[3]

Abstract

The design and therefore, the performance prediction of a hot-mix asphalt (HMA) pavement are based on the initial properties of new aggregates and binder in the HMA mix. However, traffic loading and the environment cause the pavement to deteriorate, and the initial properties of the HMA mix change. This study investigates six Kansas roadways to determine how the pavement modulus is affected by aging. Two in-situ non-destructive tests, Falling Weight Deflectometer (FWD) and Portable Seismic Pavement Analyzer (PSPA), were conducted on each roadway.. The HMA moduli were also determined in the lab by testing cores from the test sections. Finally all these moduli were correlated.

Keywords: aged asphalt—modulus—overlay design

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Evaluation of a video-based feedback intervention for newly-licensed young drivers

Michelle L. Reyes[1,2], Daniel V. McGehee[1,3], and Cher Carney[1,4]

Background More than 3500 teenagers died in motor vehicle crashes in 2009. Crash risk is relatively low when teens are learning to drive with an adult but increases about 10-fold when independent driving begins [1]. Five Midwest states, including Iowa, have some type of restricted minor license or school permit allowing teens under the age of 16 to drive unsupervised. Little is known about how these younger drivers compare to the traditional 16-year-old driver. Our previous studies of video-based feedback for young drivers have shown that the technology has the potential to improve driving safety [2-4]. Because these previous studies did not include a true control group, they could not evaluate the role of natural maturation.

Objective To evaluate video-based feedback on the rate and type of safety-relevant events captured on video event recorders for three groups of newly-licensed young drivers:

- 14.5- to 15.5-year-old drivers who hold a minor school license

- 16-year-old drivers with an intermediate license who are driving unsupervised for the first time

- 16-year-old drivers with an intermediate license who previously drove unsupervised for at least 4 months with a school license.

Methods The young drivers' vehicles are equipped with an event-triggered video recording device for 24 weeks. Half of the participants receive feedback regarding their driving, and the other half receive no feedback at all and serve as a control group. The number of safety-relevant

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events per 1000 miles (i.e., "event rate") was analyzed for the first 39 participants to complete the study. Ultimately 90 participants (30 in each group) will be enrolled.

Results   On average, the young drivers who received the video-based intervention had significantly lower event rates than those in the control group. This finding was true for all three license groups. Among the 16-year-olds who received the intervention, those with driving experience had lower event rates than those without experience. Once the intervention was removed, event rates increased for the school license holders but not for either group of 16-year-olds. Rather than the expected decrease in event rate due to maturation, event rate appears to increase for the control group teens who did not have independent driving experience.

Conclusions   This analysis considered about half the data that will be collected in this study. So far there is strong evidence that giving young drivers video-based feedback, regardless of their age or level of driving experience, is effective in reducing the rate of safety-relevant events relative to a control group who did not receive feedback. Conclusions about the specific effects of age and experience, with and without the intervention, are expected once data collection is complete.

Keywords   teen drivers, event-triggered video, school license, intermediate license

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Cost-Per-Mile Estimation Methodology for Railroads

Poster Session

Jeffrey T. von Brown[1], Konstantina Gkritza [2]

Abstract

The railroad industry is expected to see increased demand in the next 30 years. This demand will put a strain on the infrastructure and its ability to provide timely and efficient service. Various technologies are available to increase the capacity of these rail lines, but these efforts will fail to meet the needs in time, and trackage will either need to be added to existing routes, built as new routes, or upgraded to a higher speed classification. Being able to anticipate these costs is a challenge, as few rail miles are built each year and there are numerous variables involved. This poster presentation proposes a methodology to estimate the cost per mile [CPM] for adding, building, upgrading, and maintaining a railroad line in the United States. These estimates take into account the costs for right-of-way, the design and build, materials, communications and signaling, and electrification. In addition to the inputs, this presentation will show a comparison of the CPM estimates with those suggested in other studies and those incurred in actual projects. This CPM estimation methodology can be applied when planning expansion of current or future routes to calculate costs based on top speed, geography, land use, number of tracks, and motive power. This methodology is currently used in investment planning for railroad infrastructure as part of an ongoing NSF-funded project, Netscore21, which models for the first time the interdependency of transportation and energy networks to optimize the selection of fuel and generation technologies while balancing cost, resiliency, and sustainability.

Key Words: Railroad, Cost Estimation, Planning

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Tools to Assess Transportation Resiliency with Respect to Investment & Operations

Steve Lavrenz[1], Konstantina Gkritza[2]

Abstract

The paper will present a workable definition for transportation resiliency across various planning horizons, and will address the use of conventional planning tools in order to assess said resiliency.

A literature review was conducted to identify common definitions for resiliency across a variety of industries, such as nuclear power generation, healthcare, and communications. Based on these findings, a definition for transportation resiliency was formulated, and the various components of this definition were discussed. Particularly, this definition considers transportation resiliency in the context of long-term investment and short-term operations, and details various differentiating factors between the two planning horizons. Next, various events, such as natural disasters, terrorist attacks, etc. were envisioned for both investment and operations effects, and the potential responses to each event type were theorized. A review of real-life critical events that have impacted and defined transportation resiliency were then described, along with a discussion of ways in which existing and future transportation infrastructure can be better prepared for such occasions.

Once the review of transportation resiliency was complete, several case studies of hypothetical transportation events were considered. Conventional software tools, such as TRAGIS and CARVER2, analyzed these events in order to rank the relative infrastructure resiliencies in each case. The resulting resiliency "scores" were then evaluated for strengths and weakness, with the end result being a discussion of items for improvement among different network links.

Finally, the paper will discuss how this consideration of transportation resiliency fits into the broader context of national transportation and energy policy. The end result will be a succinct and implementable process for considering transportation resiliency, as well as a review of the tools available to public and private agencies to identify weaknesses in current systems.

Key Words: resiliency-interdependency-operations-investment

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Multimodal Transportation Operations and Planning Software Review and Evaluation

Presentation

Eirini Kastrouni[1], Steve Lavrenz[2], Jeff von Brown[3], Konstantina Gkritza[4]

Abstract

NETSCORE21, an ongoing project at Iowa state University and funded by the National Science Foundation, studies the interdependencies between energy (generation, transmission, distribution) and transportation (transportation fuels, technologies and fleets), while accounting for sustainability, cost, and resiliency over a time horizon of 40 years (2010 – 2050). In order to calibrate the transportation system components of the NETSCORE21 software (NETPLAN), a review of already-available public and private simulation software has been conducted, so as to better assess the contribution of NETPLAN into modeling air, highway, waterway, and railroad transportation (both passenger and freight). Each model is reviewed with regards to various factors, such as resiliency to attack or natural event, environmental sustainability, interdependency with other networks, and routing logic that dictates the path of travel to be chosen. The review has highlighted certain software that are worthy of further consideration, where software functionality mimics desired features, or allows a comparison of system accuracy and performance. Furthermore, several publicly-available software packages were selected for further discussion and testing, and the corresponding results. These packages include CARVER2 and TRAGIS, and are used to evaluate and compare various transportation resiliency and routing logic scenarios. The review and comparison between these models will identify the attributes not currently available in any of these models that our proposed software (NETPLAN) would provide.

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The primary format of this submission will be a presentation, including a visual representation of the different software systems and their relationship to one another. A non-analytical paper will be included with the presentation, and it will provide a solid framework from which transportation researchers can pursue further review and testing of transportation modeling technologies.

Keywords: transportation software – modeling – interdependency

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Study of the Impacts of Implements of Husbandry on Bridges

Justin Dahlberg[1], Travis Hosteng[2], Doug Wood[3], Scott Neubauer[4] and Ahmad Abu-Hawash[5]

Abstract

Traditional bridge design and bridge rating are based upon codified procedures that examine a bridge's capability to resist traditional highway-type vehicles. It is known, however, that other vehicles (e.g., farm/agricultural vehicles or implements of husbandry) have characteristics that are quite different from traditional vehicles; specifically, they tend to have different wheel spacing, different gage widths, different wheel footprints, dynamic coupling characteristics, and others. Currently, the Bridge Rating Engineer must make assumptions about how highway bridges resist these non-traditional vehicles. It is desired to understand how these agriculture loads are distributed through the structural elements comprising the bridge and to assess the magnitude of the dynamic loads these vehicles impose. Further, it is desired to know what methods of analyzing bridges for these loads are acceptable, so that accurate bridge ratings may be produced.

A research study is in progress that includes sponsors and cooperators from Iowa and several other states, as well as a federal agency. The overall objective of this study is to determine how the implements of husbandry distribute their load within a bridge structural system and to provide recommendations for accurately analyzing bridges for their loading effects. To achieve this objective the distribution of live load and dynamic impact effects for different types of agricultural vehicles will be determined by load testing and evaluating two general types of bridges. The types of equipment studied will include but is not limited to; grain wagons/grain carts, manure tank wagons, agriculture fertilizer applicators, and tractors. Once the effect of

these vehicles has been determined, recommendations for the analysis of bridges for these non-traditional vehicles will be developed.

This presentation will focus on the <u>first</u> of the three following overall project tasks: 1) load testing and evaluation of approximately 10 bridges in Iowa, 2) development of engineering/code based comparisons, and 3) the development of analysis recommendations. Ten test bridges located in Iowa were load tested and evaluated. The presentation will describe load tests performed on two bridges types with single spans: 1) timber stringer with timber decks and 2) steel stringer with timber decks.   The following vehicle variables included vehicle type, speed, lateral positioning, and vehicle weight. The load test results will include experimental data evaluated against typical bridge design parameters and against measured highway vehicle behaviors.

Key words: implements of husbandry—bridge load testing—heavy agricultural vehicles—lateral live load distribution—bridge field testing

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Risk Analysis of Nighttime Construction Work Zones

Sayanti Mukhopadhyay[1], Jay Mathes[2], Hida Azmy[3], Jennifer S. Shane, Ph.D.[4], Kelly Strong, Ph.D.[5]

Abstract:

The last half of the 20th century and the beginning of the 21st has witnessed an unparallel increase in urban congestion. According to a 1990 Federal Highway Administration study, the total cost of traffic congestion for 50 urban areas was estimated to be $ 43.1 billion and this represented a 10% increase ($39.2 billion) in the economic impact of the congestion since 1989 (Jose Holguin-Veras, 2001). This increasing volume of traffic along with demand from the motoring public to minimize work zone delays during peak travel time has led to the scheduling of some highway maintenance and construction activities during nighttime hours. However, risks in the construction nighttime work zones are numerous. Research has been conducted to identify different types of nighttime work zone risks and different types of measures that may be adopted in each case. The goal of the present research study is to identify the major risks related to nighttime construction work zones, analyze their impacts, develop a methodology to mitigate or minimize those risks and generate practical and useful guidelines to manage those risks rendering a safer nighttime work zone. This research is based on the information obtained from literature reviews, surveys (conducted nationally with state transportation agencies) and interviews with specialized personnel about the issues involved in nighttime work zone. This paper presents the risks found through this research and a discussion of how DOTs across the nation are addressing or mitigating these risks.

Keywords: Nighttime construction work zones - risk identification – risk mitigation – circadian rhythm

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Implementation of Safety Measures in Nighttime Construction Work Zone

Nurhidayah Azmy[1] and Jennifer S. Shane, Ph.D.[2]

Abstract

Highway work zones constitute a major safety concern for transportation agencies, the legislature, the highway industry, and the traveling public. The demands for rehabilitating highways, and improving mobility and safety, have resulted in many more projects being constructed at night. The significant hazards imposed due to nighttime construction activities are attributed to the factors such as decreased visibility, higher vehicle speeds, and driver impairment by alcohol, drugs, and fatigue, and age-related vision reduction. These factors considerably enhance the exposure of the traveling public, highway workers, and pedestrians to work zone hazards. The Federal Highway Administration (FHWA) estimated that construction-related activities contributed to about one-half of the fatalities occurred in nighttime work zones.

A comprehensive literature review was performed to determine the safety measures and practices that have been implemented by the transportation agencies in minimizing nighttime work zone accidents and fatality. Additionally, a survey was distributed to all States' Departments of Transportation (DOT) enquiring about their current practice and opinions regarding the safety aspects of nighttime projects. In order to gain more insights on the DOTs current safety measures for nighttime work zones, semi-structured interviews were conducted with ten DOTs based on their responses in the survey.

The results from the survey and interviews indicate that several safety measures are being implemented during nighttime construction, which include personal protective equipment (PPE), safety management techniques, and work zone traffic control planning. It was found that by applying the right safety management techniques and proper traffic control planning of the work zone prior to conducting nighttime construction, the risk of workers and travelling public can be minimized.

Key words: nighttime construction—construction safety—construction work zone

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Communication Strategies Employed in Transportation Projects

Ghada M. Gad[1], Hida Azmy[2], Jennifer S. Shane, Ph.D.[3]

Traffic congestion places a significant and serious burden on the public and threatens the economic vitality of the nation. A significant portion of traffic congestion is attributable to roadway construction and maintenance activities (10% to 24% reported in various studies). Since the public does not always understand or appreciate the need for the road construction or maintenance work, it is vital for the transportation agencies to exercise proper communication. Prior to and during construction, different agencies such as State Departments of Transportation (DOT) should develop strategies to ensure relevant information pertaining to the construction work are disseminated to the public. Those strategies include communicating with the road users, the general public, area residences and businesses, and appropriate public entities information about the construction work zone and its implications for their safety and mobility. A well-planned and implemented public information and outreach campaign may help mitigate relevant issues by warning drivers of upcoming work zones and supply information to drivers both pre-trip and en route. It is important that the information provided is credible, accurate, and timely. This papers aims at examining the different communication strategies used by the State DOTs to inform the different stakeholders about the ongoing transportation projects. Results of a survey administered to the 50 state DOTs, and case studies conducted in 10 states are presented in this paper. The results presented may serve as a guide to different entities involved in transportation projects on the current effective communication methods employed, and the types of information that are necessary to be relayed to the public.

Keywords: transportation projects - communication strategies

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"Average Annual Maintenance Expenditure (AAMEX) Modeling for Indiana Highway Assets: A Statistical and Econometric Analysis of the Effect of an Asset's Age on Expected Maintenance Costs"

Matthew Volovski[1] and Samuel Labi[2]

Abstract

Routine maintenance expenditures make up a significant fraction of the overall life cycle costs incurred by highway agencies and thus constitute a key input in life-cycle cost evaluation. Most life cycle cost analyses have proceeded only with very rough approximations of average annual maintenance costs due to difficulty in acquiring data on routine maintenance costs. This difficulty, in turn has been due to inconsistency in pavement section reference points and in reporting periods used in routine maintenance activities (often carried out in-house on force account) and other databases. In addressing this issue, this paper uses data meticulously collected and collated from in-house maintenance records and other data sources to develop a cohesive and comprehensive data set which includes over 6,000 miles of pavement sections in the state of Indiana, a mid-western state located in the wet-freeze climatic zone of the strategic highway research program. Applying an array of statistical and econometric techniques to develop the annual average maintenance expenditure models (AAMEX), the paper identifies a number of explanatory variables that significantly influence AAMEX and examines the sensitivity of the response to each of these variables.

Key Words: average annual maintenance expenditure (AAMEX) models, in-house maintenance, routine maintenance, statistical and econometric modeling

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ABSTRACT

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Title: Communication is Key: A randomized trial of an intervention to increase parent involvement in teen driving.

Format: oral presentation preferred

Summary:

Drivers in their first six months of licensure have the highest crash rates of all drivers, leading to high rates of injury for themselves, their passengers, and those they hit. Parents play a critical role in the driving experience of their children. Policy approaches, such as Graduated Driver's Licensing Systems, and educational programs that encourage parents to define driving rules and restrictions have shown some success in reducing teen risky driving. However, methods to increase parental involvement in teaching driving skills and encouraging safe driving behaviors have not been widely tested. Such interventions can augment existing GDL systems by increasing parental knowledge and involvement in learning to drive.

The long-range goal of this research was to develop a sustainable and generalizable intervention that to reduce crashes and related injuries among teen drivers by increasing safe driving practices. We conducted a randomized trial of "Communication is Key," an educational intervention for parents of newly licensed adolescent drivers to increase parental involvement in teaching driving skills and safe driving behavior. The intervention will has two components: driving skills and safety goals, and a communication strategy to improve parent communication techniques. The intervention included specific driving goals that parents discuss, demonstrate, and pratice with their teen. This project was conducted in a rural population, so skills for driving on rural roads were be included. The delivery of the intervention used motivational interviewing, a successful and age-appropriate health behavior communication technique that has shown great success in related health fields.

163 parent-teen dyads were randomized into intervention and control groups. Our findings indicate that teens have much higher expectations of their driving frequency and conditions than reported by their parents, which presents opportunity for conflict in communication. The communication that parents report having with their teens is unrelated to the teen's driving safety attitudes; however, the communication that the teens report having with their parents is strongly tied to teen's driving safety attitudes. From this we conclude that the quality as well as the quantity of communication is important. These findings present a strong baseline for the proposed intervention.

Our evaluation suggests that parents were able to learn and apply motivational interviewing and did engage in structured teaching on specific driving goals when provided with materials to guide these activities. Furthermore, the teens of parents who were involved in the intervention reported a higher quality and quantity of safe driving communication as well as reduced risky driving behaviors than teens whose did not participate in the intervention, although these results did not reach statistical significance. This program can be widely implemented in many settings, including schools, workplaces, and driver's education programs.

Key Words: Teen driving; randomized trial; communication style; risky driving behavior

Risk Mitigation Strategies for Operations and Maintenance Activities

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Risk Mitigation Strategies for Operations and Maintenance Activities

Presentation Format

Abstract

Mobile operations and highway maintenance work can be among the riskiest activities of state highway agencies. In both frequency of accidents and severity of losses, moving operations rank among the highest in highway operations. A literature review of research in risk mitigation in mobile operations in other states indicates that the topic has been addressed, but typically in very narrow topics (e.g. weather, nighttime operations, etc.). Few studies have analyzed risk in moving operations and maintenance work using an integrated, system-level analysis. The study reported herein provides such a broad examination. The risks are identified and assessed through expert panel review, national surveys, and analysis of crash data in Iowa to identify the risk level associated with various potential hazards in mobile operations. The hazards are categorized into four main areas: Activities, Environment, Equipment, and Other.

Key Words: Risk, Highway Operations and Maintenance, Safety

Minnesota County Road Safety Plans

Michael M. Marti (SRF Consulting Group)[1], Brad Estochen (Mn/DOT)[2] and Mark Vizecky (Mn/DOT)[3]

Abstract:

At part of the Minnesota Towards Zero Deaths program, to address the issue that over 50% of the state's fatalities occur on the rural highway system, Mn/DOT is currently funding the development of Road Safety Plans for all 87 counties in the state of MN. Each plan will result in a county specific prioritized list of low-cost safety projects that the counties can use to obtain funding. The project is unique as Mn/DOT is providing local agencies federal funds to develop these plans to address safety. This project, led by a team of CH2MHill and SRF Consulting Group, started in Sept 2009 and will take three years to analyze crash data in each county and develop specific plans for every County. At the time of the NLTAP Conference the project will be halfway completed, with 46 plans implemented. This is a significant project that many states are monitoring; the process can be replicated by others to address road safety.

This presentation will give an overview of the process, an update on the status of the County Road Safety Plans, lessons learned and next steps.

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Pavement Management Tools For Minnesota

Michael M. Marti(SRF Consulting Group)[1]and Gary Danielson (Kandiyohi County)[2]

Abstract:

Recently the Minnesota Local Road Research Board has funded the development of multiple tools focused on Pavement Management:

- ***DVD: "Do the Right Thing at the Right Time" (2010, 10 minutes)*** – This professionally developed DVD was developed to assist local agencies understand and communicate the benefits of pavement management. The DVD is targeted at non-users of Pavement Management or Engineers wishing to convince their elected officials to implement a program
- ***Pavement Management Workshop (2009)*** - Provides an overview of the benefits of pavement management along with a detailed review of various pavement management software programs that are used in Minnesota. Workshop participants will leave with the knowledge to evaluate and implement a pavement management system.
- ***"Implementation of Pavement Management in Minnesota" Report (2009)***: A resource guide was developed that describes, in detail, the various pavement management system software programs available and innovative and high-impact examples of the use of pavement management systems in Minnesota. This guide was developed to help agencies evaluate and implement a pavement management system.
- ***Pavement Management System Software Program Comparison Matrix (2009)***: A matrix was developed to provide an objective review of the pavement management system software programs currently used by agencies in Minnesota. This matrix does not favor or recommend one pavement management system product over another, but rather serves as a neutral source of information and comparison of software programs.
- ***Pavement Management Systems Brochure (2009)***: This brochure is intended to educate local agencies on what a Pavement Management System is, why it's important and provide information on the resources that are available.

During this session, the presenters will show the recently completed DVD and educate the audience about the importance of pavement management and highlight the various tools that are available.

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Best Practices: Managing Interaction between Local Authorities and Major Traffic Generators

Michael M. Marti (SRF Consulting Group)[1] and Tim Stahl(Jackson County)[2]

Abstract:

The Local Road Research Board recently funded the development of an online document that presents guidelines for Minnesota county engineers on how to interact with developers of "wind farms" (technically known as large wind energy conversion systems or LWECS) regarding road-related issues. Construction of LWECS requires hauling of a significant number of heavy loads on local roadways, potentially causing damage to the roadway surface. This document provides county engineers with guidance on how to work with LWECS developers to preserve the roadway surfaces. The committee that provided input for this document was comprised of Minnesota county engineers that are currently going through or have completed this process. It includes sample documents, experience from current or past projects, research information and a calculator to quantify the impact of traffic on roads. County engineers in other states, other road authorities, and wind power developers themselves also may find this information valuable. While this tool is focused on LWECS's, it is broad enough that it could also be used when a county is dealing with any other enterprise that impacts the roads under its jurisdiction.

This presentation will guide the audience through the use of the electronic interactive PDF and will educate them on how they could use this tool within their agency.

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Aggregate Retention in Chip Seal

Shahidul Islam[1], Elaine Lamm[2], Haritha Musty[3] and Mustaque Hossain[4]

Abstract

Chip seal is a widely-used preventive maintenance treatment of flexible pavements. One of the major issues with chip seal is the damage caused by loose aggregates from newly-placed chip seals. Lack of compatibility between aggregate and asphalt emulsion results in chip loss. Normally, local aggregates are always preferred for chip seal construction. Selection of proper aggregate and asphalt emulsion is important to maximize aggregate retention in chip seal. In this study, limestone and gravel (both precoated and uncoated), recycled asphalt pavement (RAP), and synthetic lightweight aggregates were used with two polymer-modified asphalt emulsions to find the aggregate-emulsion combination that would result in maximum aggregate retention. A statistical analysis was conducted to study the compatibility between different types of aggregates and emulsions. The results showed RAP has the lowest chip retention.

Key words: Chip Seal – Polymer Modified Asphalt Emulsion – Recycled Asphalt Pavement – Synthetic Light Weight Aggregate - Aggregate Retention

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Effects of Adverse Weather on Surface Transportation Mobility

Dr. Paul Hanley[1] & Joe Olson[2]

Abstract

Snow, rain, fog and extreme temperature all can have tremendous effects travel mobility. This report analyzes how adverse weather conditions impact the mobility of travelers using surface based transportation modes. Survey data from travelers across the state of Iowa containing trip logs for 12 months were analyzed. Environment, such as rural or urban, was considered in the investigation as well as type of mode. Trips were then correlated with weather data for the same 12 months using GIS and SPSS analysis. The full results of the analysis will be completed in May of 2011.

Key words: adverse weather – transportation mobility – travel patterns

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MODELING VEHICLE CLASS LAGGING HEADWAYS FOR ESTIMATION OF PASSENGER CAR EQUIVALENT: A COMPARATIVE ANALYSIS BETWEEN 3SLS AND SURE MODELING APPROACHES

Anwaar Ahmed[1], Mathew Volovski[2], Bismark R.D.K. Agbelie[3], and Samuel Labi[4]

Abstract

A traffic stream is typically composed of passenger cars, sport utility vehicles, recreational vehicles, single unit trucks, and combination trucks. These vehicles have different physical (length, width, etc) and operational characteristics (acceleration/ deceleration capabilities). Traffic density which is expressed in passenger cars per mile per lane is typically calculated using passenger car equivalencies (PCEs) by converting mix traffic stream into an equivalent passenger car stream. This study presents an alternative methodology for PCE estimation using lagging headways for the different vehicle classes. Lagging headway, which is the actual space consumed by a following vehicle in a traffic stream, is the distance from the rear bumper of a leading vehicle to the rear bumper of the following vehicle. This study uses field data from an urban freeway in Indiana (I-465). Three-stage-least-squares (3SLS) regression and seemingly unrelated regression (SURE) models were estimated to predict lagging headways for passenger cars, single unit trucks, and combination trucks. The average lagging headway was estimated for passenger cars, single unit trucks, and combination trucks. The ratio of average class lagging headway of truck class to that of passenger car was used to estimate PCE. The 3SLS model results are more intuitive as compared to SURE model results.

Keywords: Lagging Headway, Passenger car Equivalent, Level of Service,

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Effectiveness of Flexible Pavement Rehabilitation Treatments –Evidence from a National Experiment

Anwaar Ahmed[1], Samuel Labi[2] and Zongzhi Li[3]

Abstract

Aging infrastructure and funding limitations necessitates the use of efficient preservation techniques for deteriorating highway infrastructure. Using data from Long Term Pavement Preservation (LTPP), Specific Pavement Study-5 (SPS-5), this paper evaluated the performance of eight flexible pavement rehabilitation treatments. The effectiveness was measured in the short term (magnitude of IRI drop) and the long term (service life and the area bounded by the treatment performance curve). The post-treatment performance models were developed for each rehabilitation treatment and these were used to assess the benefits of the treatments. The study results revealed that initial pavement condition is an influential factor of long term effectiveness. Pavements which were treated in good condition were significantly more effective compared to pavements treated in poor condition depending on added thickness, surface preparation and mix type. It was also shown that overlay thickness, surface preparation and type of mix have profound impact on long term effectiveness of the rehabilitation treatments. 5-inch treatment were on average more effective by 47 % in terms of estimated service life and 35 % in terms of area bounded by performance curve, than 2-inch treatment. Compared to pavements receiving minimal surface preparation, pavements receiving intensive surface preparation were generally more effective by 25 % in terms of estimated service life and 49 % in terms of area bounded by performance curve. There was marginal difference in effectiveness of pavements using virgin or recycled mix. Generally, the paper determines that the aggregate approach provides more noise-free data and more intuitive results compared with the disaggregate approach.

Keywords: Pavement Rehabilitation; Effectiveness analysis, Performance modeling

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Playground Warning Sign Vehicle Speed Impacts

Keith K. Knapp[1]

There are a variety of warning signs in urban areas that focus on occasional hazards. This project focused on the potential vehicle speed impacts of installing the typical playground (i.e., teeter-totter) sign at three locations in Bloomington, Minnesota. Park activity and on-street parking activities were collected in addition to the vehicle speed data along each roadway. These data were collected approximately one month before and one month after the sign installations. This presentation will discuss the site selection and data collection processes used as part of this project. In addition, the vehicle speed results will be presented and interpreted. Finally, the potential impacts of these results on the text of the Manual on Uniform Traffic Control Devices (MUTCD) will be discussed. This project may not yet be finalized by the time of the symposium but should be very close to completion. All the data have been collected

Key words: urban safety, playgrounds, warning signs

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ABSTRACT

Does Cell Phone Use have an Effect on Queue Discharge Patterns?

Srinivas S. Pulugurtha[1] (corresponding author) and Ryan M. Brumfield[2]

Anecdotal evidence indicates that a large number of drivers are distracted, often by cell phones, while waiting at traffic lights. These drivers tend to be slow to react, causing unnecessary delay for other road users. To test this effect, queue discharge patterns and cell phone usage patterns were analyzed for thru movements at four intersections in Charlotte, North Carolina.

Data was simultaneously recorded in two formats: (1) on location and (2) at the Charlotte Department of Transportation (CDOT) Traffic Management Center (TMC) with the use of a video camera. Field data collection was used to observe cell phone usage behavior while video footage was used for observation of vehicle headways. These data were then used for analysis.

Of the over 3700 drivers observed, about 13.3% were talking on a cell phone and approximately 1.8% were texting while driving. The saturation headways and start-up lost times of queues containing cell phone users were compared with queues lacking the presence of cell phone users. Results show that although text messaging has a clear negative impact on discharge patterns, talking on a cell phone has an insignificant effect. Secondary analyses imply that drivers talking on a cell phone have a stabilizing effect because they likely perform worse than attentive drivers but much better than those engaged in a visually demanding distraction. Findings also show that the performance of drivers talking on a cell phone is fairly consistent while the performance of non-users is inconsistent due to myriad other distractions with widely varying effects on driver abilities. The performance of texting drivers was found to be the most variable, perhaps due to the sporadic, often intense visual demands associated with texting while driving.

Keywords: driver, cell phone, talking, texting, queue discharge, signalized, intersection

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ABSTRACT

Evaluation of Pedestrian and Driver's Actions at HAWK Signal

Srinivas S. Pulugurtha[1] (corresponding author) and Debbie R. Self[2]

The focus of this presentation will be on an evaluation of pedestrian and drivers' actions at sites with **H**igh intensity **A**ctivated cross **W**al**K** (HAWK) signals. Data (traffic counts, average traffic speed, pedestrian and driver yielding behavior, the number of pedestrians trapped in the middle of the road and pedestrian-vehicle conflicts) collected during morning (AM) and evening (PM) peak hours at study sites in the City of Charlotte, North Carolina were used for evaluation.

Descriptive and statistical analyses (one-tail two sample T-test and two proportion Z-test) were conducted 1) to analyze and compare the data collected before and after the installation of HAWK signals, and, 2) to analyze and compare the data collected at sites with HAWK signals with the data collected at control sites (with no countermeasures) and sites with other pedestrian safety countermeasures (traffic signal for pedestrians and in-pavement lighting system). Further, analysis was also conducted to analyze change in pedestrian and drivers' actions over time (before installation; one-month, three-months, six-months and twelve-months after installation).

Results showed an increase in average traffic speed at one of the HAWK signal sites while no specific trends were observed at the other two HAWK signal sites. The installation of HAWK signals did not have a negative effect on pedestrian actions at two out of the three HAWK signal sites. A decrease in the numbers or proportions of drivers not yielding to pedestrians, pedestrians trapped in the middle of the street and pedestrian-vehicle conflicts was observed at all the three HAWK signal sites. However, these improvements were statistically significant at a 95 percent confidence level at only one of HAWK signal site. The numbers or proportions of drivers not yielding to pedestrians, pedestrians trapped in the middle of the street and pedestrian-vehicle conflicts at HAWK signal sites was observed to be lower than those observed at control sites and sites with other pedestrian safety countermeasures.

Keywords: HAWK, pedestrian, driver, yielding, speed, trapped, safety

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Iowa High School Administrator Opinions About Graduated Driver Licensing

Michelle L. Reyes[1,3] and Daniel V. McGehee[2,3]

Abstract

The objective of graduated driver licensing (GDL) systems is to allow young drivers to acquire driving experience before gaining full driving privileges. Modern GDL systems reduce exposure to high-risk conditions (e.g., driving with passengers, late night driving) while still allowing young novice drivers to gain the experience they need to become good drivers (e.g., Williams & Shults, 2010; McCartt et al., 2010). Because high school administrators in Iowa are directly involved with the granting of teen driving privileges through approving minor school licenses as well as waivers to the intermediate license nighttime driving limitation, their opinions about potential enhancements to Iowa's GDL laws are of interest to policy makers. The potential enhancements considered in this survey were increasing the duration of the instruction permit phase, limiting the number of passengers for newly-licensed teen drivers, and limiting unaccompanied nighttime driving for newly-licensed teen drivers.

All high school principals in the State of Iowa were invited to participate in an online survey that asked a variety of questions related to teen driving safety in general and proposed GDL enhancements in particular. An overall response rate of 21% yielded a sample of 64 administrators that was highly representative of Iowa high schools in terms of geographic location, population density, and student enrollment.

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The results showed that:

- Nearly half the administrators report being only a little (40%) or not at all (8%) familiar with the graduated driver licensing laws in Iowa.

- Nearly two-thirds agree (38%) or strongly agree (27%) that teens in Iowa should be required to hold an instruction permit for 12 months instead of the current 6 months.

- Four out of five administrators think that newly-licensed teen drivers in Iowa should not have more than one non-family teen passenger; 60% strongly agree and another 20% agree.

- Administrators were likely to agree with changing the nighttime driving limitation for newly-licensed drivers from the current time of 12:30 am.

  o Half the administrators agreed (29%) or strongly agreed (21%) that these drivers should not drive after 10 pm.

  o About two thirds of the administrators agreed (48%) or strongly agreed (18%) with the 10 pm limit if waivers for school activities or work were offered.

  o Only 8% responded that they would not be likely to agree with a night driving limitation that began at 11 pm.

In conclusion, high school administrators in Iowa broadly support the considered enhancements to GDL. Though the respondents were quite representative of Iowa high school administrators, the small sample size is a limitation.

Keywords: teen drivers, supervised driving, instruction permit, passenger restriction, nighttime driving limitation

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Rural Safety Policy Improvement Index

Keith K. Knapp[1]

This presentation will discuss the Rural Safety Policy Improvement Index (RSPII) project. It will include a discussion of the results from Phase I and II portions of this project. The first phase of the project included an evaluation of the feasibility of a RSPII and the identification of some policy-related safety measures that could have an impact on rural roadway safety if they were introduced or improved. The second phase of the project included the state-by-state calculation of the potential rural roadway safety impacts connected to six policy-related safety improvements. The results of these calculations will be described. The six improvements considered include automated speed enforcement, primary seat belt laws, sobriety checkpoints, graduate licensing programs, universal motorcycle helmet laws, and the use of ignition interlocks. The challenges to the implementation of RSPII process and the six policies within the rural environment will be noted. Recommendations for the application of the process will be provided.

Key words: rural safety, safety policy

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A Motorcycle Safety Survey in Kansas to Identify Issues and Causes Related to Crashes

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Abstract

Over the past few years, motorcycle fatalities have increased at an alarming rate in the United States. Motorcycle safety issues in Kansas are no different from the national scenario. Analysis of motorcycle safety situations based solely on crash data might not be enough to arrive at conclusions about motorcycle riders, since those characteristics are linked only with a special segment of motorcycle riders having crash experience. In other words, characteristics of motorcycle riders without crash experience should be taken into consideration to make fair conclusions about motorcycle rider characteristics in Kansas.

Accordingly in this study, a questionnaire was prepared with the intention of identifying issues highlighted in the basic crash data. The survey was carried out to understand the behaviors of motorcycle riders and their perception towards helmet law in Kansas. The objective of this survey was to obtain information from motorcycle riders irrespective of being involved in a crash, in order to get a general idea about their behaviors, perception towards helmet laws, crash contributory factors, and difficulties associated with different motorcycle maneuvers while riding. About 272 registered motorcycle riders in Kansas responded to the survey questions in this study. As the first step, simple percentages were calculated for the survey questions to get an idea about the overall situation. A section in this survey asked the respondents to subjectively rate several factors according to their contributions to cause a crash. Several factors associated with the age of the respondents were also looked into from the survey responses. Crude odds ratios were also calculated for crash contributory factors and difficulties associated with motorcycle maneuvers based on the crash involvement of the respondents.

The study revealed that helmet usage was found to be high among motorcycle riders, with almost half of the respondents always wearing helmets while riding motorcycles. About half of the respondents knew the current form of helmet law in Kansas and a majority of the respondents opposed a mandatory law being enforced in Kansas. When it came to different crash contributory factors, 71% of the respondents considered drivers of other vehicles as the single biggest threat to their own safety. When looking at differences based on different age groups of the respondents, co-relationships were found for motorcycle types and riding experience with the age groups of the respondents. Based on the crash involvement of the respondents, crude odds ratios showed that poor road surfaces, speeding, conspicuity problems, and road surface features (like pavement markings) were considered highly crash-contributory factors by the respondents. The

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respondents also reported a higher level of difficulties, especially in association with making a left turn in front of oncoming traffic, slowing down suddenly, low-speed parking maneuver, emergency stopping, and riding in thunderstorm.

Key Words: motorcycle safety-helmet law-motorcycle survey

Transportation Agency Tool to Analyze Benefits of Living Snow Fences

David J. Smith[1], Dean Current[2], Daniel Gullickson[3], Gary Wyatt[4], Diomedes Zamora[5]

Abstract

A benefit and cost analysis tool was developed for the Minnesota Department of Transportation's (MnDOT) living snow fence (LSF) program. This transportation agency tool calculates global and site-specific economic, transportation and environmental benefits and the opportunity costs to landowners. This aids in prioritizing snow problem areas and developing landowner payment programs. Results from the application of the tool on U.S. interstate and U.S. and Minnesota (MN) highway snow problem areas in MN suggests an expansion of the program in the study agency and to other states with snow precipitation is justified. LSF are plantings of trees and/or shrubs set back from the right of way along the upwind roadside to minimize drifting and blowing snow problems on the roadway.

Blowing and drifting snow are costly realities for transportation agencies in regions with significant snow precipitation. Drifts that are large and heavy enough to be unmovable by standard plows require specialized equipment to keep roadways passable. Blowing snow can require extra trips by standard plows, increased plow time, and increased usage of sand and salt. Analysis of automatic vehicle location (AVL) system data and field surveys are used to estimate these cost savings from LSFs.

Snow fences can decrease travel time and reduce the severity and number of snow related accidents. The number and type of vehicles affected during these events is estimated from average daily traffic flows. A study in Wyoming shows that snow fences along interstate 80 have reduced accidents during blowing snow conditions by seventy percent (Tabler 1982). An analysis of accidents in Minnesota from 1995 to 2005 found over nine thousand snow related accidents in snow problem areas including sixty four fatal and one hundred and thirty one incapacitating accidents (URS Corporation 2008).

In addition LSF also provide environmental services such as wildlife conservation, hunting opportunities, and carbon storage and sequestration. The MnDOT LSF program includes collaboration with Soil and Water and Conservation Districts (SWDC), the USDA Farm Service Agency and the Natural Resources Conservation Service (NRCS). Coordinating the LSF program with the Conversation Reserve Program (CRP) and the Environmental Quality Incentives Problem (EQIP) provides additional resources that can reduce the transportation agency's share of the landowner payments by sharing in the cost of establishment and annual landowner payments. This lowers financial barriers to development and expansion of a program with substantial economic net benefits.

Key words: benefit cost tool; blowing; environment; fence; drifting; snow

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Travel Time Variability for Freight Flows along a Major Interstate Corridor

Kaushik Bekkem, Teresa M. Adams, Bruce X. Wang

Abstract

Travel time reliability is one of the key indicators for freight performance measurement. Traffic congestion at any time of day and the corresponding variations in travel times causes potentially costly disruptions. Also, the efficient and reliable freight movements allow manufacturers to produce and distribute goods for both local and distant customers. The Value of Delay and travel time variability/reliability are fundamental parameters driving the private sectors' response to public freight projects and policies such as corridor construction and tolling. This research looks at the travel time variability and related reliability measures of congestion on freight flows along major interstate corridors and help prioritize improvements in to region's transportation system.

The travel time variability is calculated and analyzed using data including archived truck GPS based data collected and processed results made available by the American Transportation Research Institute (ATRI) through the Freight Performance Measurement Initiative by FHWA, and the HPMS data. The project's current scope looks at I90/94 interstate freight corridor between Hudson and Chicago. Reduction in travel time variability and any travel time savings has an economic value associated with it and also may result in reduction of vehicle operating costs (VOC). The perceived value of delay by various shippers is determined using a logit-model based evaluation of traveler survey collected from freight shippers in state of Wisconsin. Discrete choice models along with spatial data along I90/94 corridor will be used to study this travel time variability, with respect to factors including time/value of delay, to determine the major factors and thus to help identify & prioritize the transportation congestion improvement projects and reduce the VOC of freight movements.

Keywords: *travel time variability, freight corridor, vehicle operating costs, value of delay*

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Field and Laboratory Evaluation of a Mechanically Stabilized Salvaged Base Course Used in the Construction of US 12 Marmarth, North Dakota

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Abstract

The FHWA was in the process of conducting a pooled fund study to evaluate the potential use of Intelligent Compaction (IC) in public sector road construction as a means of verifying compaction quality control. The report by White et. al. (2010) covers IC research performed in cooperation with the North Dakota DOT. Since construction of US 12 was designed considering use of a salvaged base course, layer coefficient of 0.10, researcher's implemented use of a geogrid mechanically stabilized section to examine compaction performance of mechanical stabilization through use of readily available IC machines and contrasted to results of control sections. Further, field testing included light weight falling deflectometer (LWD), Falling weight deflectometer (FWD), Dynamic Cone Penetrometer (DCP), nuclear density gauge (NG), and in-situ bore hole shear testing. This paper summarizes this work in context to a unique program of laboratory testing which included particle image analysis, resilient modulus (AASHTO T307) and permanent deformation (NCHRP 598) testing of the salvaged base.

Several key findings from the full-scale and laboratory studies are discussed in the paper. In particular, the concept of uniformity/isotropy of materials used in road construction. This is important for design and construction of rigid and flexible pavements alike. Results from IC equipment in the form of machine drive power (MDP) semi-variograms, field bore hole shear testing, laboratory resilient modulus and permanent deformation test results are all used to explain field behavior and suggest implementation for future projects. The authors believe that results from both laboratory and field evaluation is necessary to better predict behavior of unbound and mechanically stabilized materials.

Key words: mechanically stabilized, salvaged base, geogrid

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Improving Traffic Operations and ITS Technology Deployment in Wisconsin Corridors

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Abstract

The Wisconsin Department of Transportation (WisDOT) has been an early adopter of traffic operations and intelligent transportation systems. WisDOT established a Traffic Operations Infrastructure Plan (TOIP) with two primary goals: to develop a methodology and associated tool to evaluate operational projects in the same manner as infrastructure projects, and to integrate technology deployments into the planning process. The TOIP includes an operationally-oriented methodology and provides deployment recommendations integrating three areas: Freeway Surveillance and Ramp Control, Travel Warning and Information Systems, and Traffic Signal Systems.

One of the principal results of the TOIP methodology is a Deployment Density Class (DDC) recommendation for every segment of roadway, in the form of a baseline, low, medium, or high operational deployment recommendation. The DDC is reached through the analysis of 10 critical operations-oriented inputs, which include mobility, safety, environmental conditions, and special events.

Based on the DDC results, the corridors were prioritized to identify corridors with the greatest needs for traffic operations investment. The top corridors were defined as Priority Corridors (6 corridors) and Emerging Priority Corridors (8 corridors), resulting in 14 corridors included in the 2008 TOIP.

The TOIP was intended to be re-visited, re-evaluated and eventually updated as part of ongoing planning activities. The 2010 TOIP incorporates new data that reflects recent changes to the corridor highways. The changes are likely to re-prioritize the order of corridors included in the Priority and Emerging Priority categories.

Preliminary analysis for the 2010 TOIP update revealed that the priority score has changed for all the corridors; some increased while others decreased. Of the 10 criteria assessed for the TOIP, the most notable increases in priority score were due to increases in AADT, crashes and percent of trucks. Some of the corridors experienced up to a 40% increase in some criteria. While some decreases in priority score were due to decreases in criteria, some decreases are attributed to infrastructure improvement, such as bypass, interchange improvement, and lane expansion.

The Priority Corridors list remain basically unchanged. The Emerging Priority Corridors list had two significant changes: Wisconsin Heartland (Green Bay to Eau Claire), which is recommended to be included on the list as an Emerging Priority Corridor, and Peace Memorial Corridor (Eau Claire to Superior), which now scores too low to be included in either the Priority or Emerging Priority list. The differences between the 2008 and 2010 Priority and Emerging Priority corridors

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were identified through a comparison of the number of corridor miles that fall into each recommendation category (baseline, low, medium, and high).

The purpose of this paper is to describe the TOIP methodology and to compare the new 2010 update results with the results outlined in the 2008 TOIP. It is also intended to describe the 2009 implementation plan and the 2010 Communication System Layer (CSL), which identifies statewide communication infrastructure needs.

Key words: intelligent transportation systems – traffic operations – traveler information systems

Composite Resilient Moduli of Pavement Foundation Layers

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ABSTRACT

Laboratory resilient modulus (M_r) tests were used to study the effects of composite pavement foundation layers. Subbase and subgrade materials from five test sites were used to perform 129 resilient modulus tests on single material and composite material samples. Ranges of dry unit weights and moisture contents for each material were selected from in situ conditions.

Statistical analysis software was used to investigate the significance of moisture content, dry unit weight, back saturation, layering, and sample disturbance on resilient moduli. Single material samples were compared to composite material samples to determine if the different variables had a significant effect on the resilient moduli.

Overall, large variances in moisture and unit weight values between specimens tended to cause the variables to be significant in explaining the variation in resilient moduli. As expected, layering was a significant variable in many analyses for both granular and cohesive materials. Disturbance was also found to be significant. Many times, variables had smaller p-values when combined with other variables. This indicated that combinations of variables are important factors when judging significance and therefore other multiple variables affected the resilient moduli values.

Key words: resilient modulus, pavement foundations, layered samples

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The DARWIN-ME is a significant advancement in pavement design, but requires significantly more inputs from designers. Many data sets need to be pre-processed before their use in the new software, such as Weigh-In-Motion (WIM) traffic data. Louisiana Department of Transportation and Development leads a state pooled fund study with nine participating state DOTs and agencies to expand the functions of a software program called Prep-ME with comprehensive database features to store and process the data of traffic, material, climate, etc. To help states use DARWIN-ME, the expanded software and service should:

1. Adopt mature quality control algorithms of participating states for WIM data quality control and assurance and eliminate bad WIM data for DARWIN-ME and other purposes. A portable version of quality checks for traffic data can be available to field data collection crew.
2. Recognize the differences in loading patterns or traffic groups and estimate the full axle load spectrum data occurring under different conditions based on large amount of WIM data, such as the data of LTPP.
3. Fully comply with the data input requirement of DARWIN-ME and fill any potential gaps if identified.
4. Customize Prep-ME for participating states
5. Prepare and conduct training for the personnel of participating states.
6. Provide participating states technical support throughout the three-year period

It is envisioned that through this pooled-fund study, a possible nationwide platform for the data preparation of DARWIN-ME can be established with guideline and supports provided to individual states for implementation.

Geocell-Reinforced Crushed Stone Base for Low-Volume Roads

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ABSTRACT

Crushed stone bases are widely used for low-volume roads. However, shear strength of the crushed stone materials can be vastly improved by confining the material in geocellular confinement systems or geocells. Geocells are 3-dimensional honeycomb-like structures. The objective of this study was to test a geocell design with crushed stone (AB-3) in-fill and a thin hot-mix asphalt (HMA) surface layer under real world traffic. A 50-mm HMA pavement test section over a 100-mm thick AB-3 geocell-reinforced base and a 300-mm thick unreinforced AB-3 base were constructed at the Civil Infrastructure System Laboratory (CISL) of Kansas State University (KSU). The sections were instrumented to measure the strains at the bottom of the HMA layer and stresses on top of the subgrade. The unreinforced section was loaded with 50,000 repetitions of an 80-kN single axle load. The reinforced section was loaded with 70,000 repetitions. The calculated and measured responses show, in the reinforced section, stresses on top of the subgrade exceeded the unconfined compressive strength of the soil. It is recommended that the geocell depth be increased along with the thickness of the HMA layer for paved low-volume roads.

Keywords: geocells – AB-3 – accelerated pavement testing (APT) – low volume roads

INTRODUCTION

Low volume roads make up approximately 80% of the world's road structures. Use of crushed stone in these bases has been wide spread. In Kansas, this crushed stone material is known as AB-3. The material has a dense gradation with a large percentage of fine material. Depending on the fine material present, the AB-3 can lack enough stability to withstand heavy traffic. An economical system is needed to increase the shear capacity of the AB-3 materials. Geocellular confinement systems, geocells, are three-dimensional honeycomb-like structures filled with an in-fill of an available material. Geocells can be used in AB-3 road bases to enhance the shear strength and in turn, trafficking ability of the geocell-reinforced bases.

Geocells can be made from different materials. Originally, geocells were made from high-density polyethylene (HDPE) strips 200 mm wide and approximately 1.2 mm thick. These strips were then ultrasonically welded together. The geocells were collapsed for shipment and then placed on the surface of the subsoil and propped open in an accordion fashion with an external stretcher assembly. An in-fill material was then placed in the geocells and compacted using a vibratory compactor (Koerner 1994). Although the configuration remained unchanged, there have been advancements in the materials used to manufacture geocells. The geocells used in this study are a NEOLOY™ polymeric alloy (nano-composite alloy of polyester/polyamide nano fibers, dispersed in a polyethylene matrix) or New Polymeric Alloy (NPA).

Due to its 3-D structure, geocells are mainly used for confinement applications more than any other planar geosynthetic reinforcement (Yuu et al. 2008). Dash et al. (2001, 2003, and 2004) and Sitharam et al. (2005) have demonstrated the use of Geocells for increasing bearing capacity and reduce settlement of soft soil foundations. Without proper testing, geocells will fail to gain acceptance as a viable low volume road building tool. Very little research has been done using geocells as base reinforcement in paved roads (Yuu et al. 2008).

In 2009, the University of Kansas (KU) and Kansas State University (KSU) did joint research on unpaved NPA geocell-reinforced bases over weak subgrade. Three different in-fill materials were used in the study: crushed stone, AB-3, Reclaimed Asphalt Pavement (RAP), and quarry waste (Pokharel et al. 2011 and Han et al. 2010). The study resulted in the following conclusions for NPA geocell-reinforced unpaved roads:

1. A 170- mm NPA geocell reinforced base can outperform a 300-mm crushed stone base (Pokharel et al. 2011);
2. RAP is the best performing in-fill material (Pokharel et al. 2011);
3. The NPA geocell increased the stress distribution angle (Pokharel et al. 2011; and
4. A thicker (50 mm to 75 mm) cover is needed to minimize the damage to the NPA geocells (Han et al. 2010).

This study was expected to extend those results to low-volume paved roads.

STUDY OBJECTIVE

The objective of this study was to test a NPA geocell design with AB-3 as the in-fill material and a thin hot-mix asphalt (HMA) overlay under real world traffic.

STUDY APPROACH

To achieve the study objective, pavement test sections were constructed at the Civil Infrastructure System Laboratory (CISL) of Kansas State University (KSU). The test sections consisted of a NPA geocell-reinforced AB-3 base and an unreinforced AB-3 base. The unreinforced section was loaded with 50,000 repetitions of an 80-kN single axle load while the reinforced section was loaded with 70,000 repetitions.

FACILITIES

CISL houses an accelerated pavement testing (APT) machine and three pits of approximately the same size, 6.1-m long, 4.9-m wide, and 1.8-m deep, for constructing test sections. The reaction frame of the APT machine covers a distance of 12.8 m and applies a load of 80-kN single axle load with air-bag suspension on dual tires. The wheel assembly is belt driven by a 20-HP electric motor, while the load is controlled by hydraulic pressure. The tire pressure used in this study was 552 kPa. The moving wheel has a frequency of 0.167 Hz (i.e. 6 sec/pass) at a speed of 11.3 km/hr (Lewis 2008). The machine is fitted with stepper motors to allow the machine to simulate traffic wander. For this test, the wander was setup with a truncated normal distribution between -150 mm and +150 mm. The distribution can be seen in Figure 1.
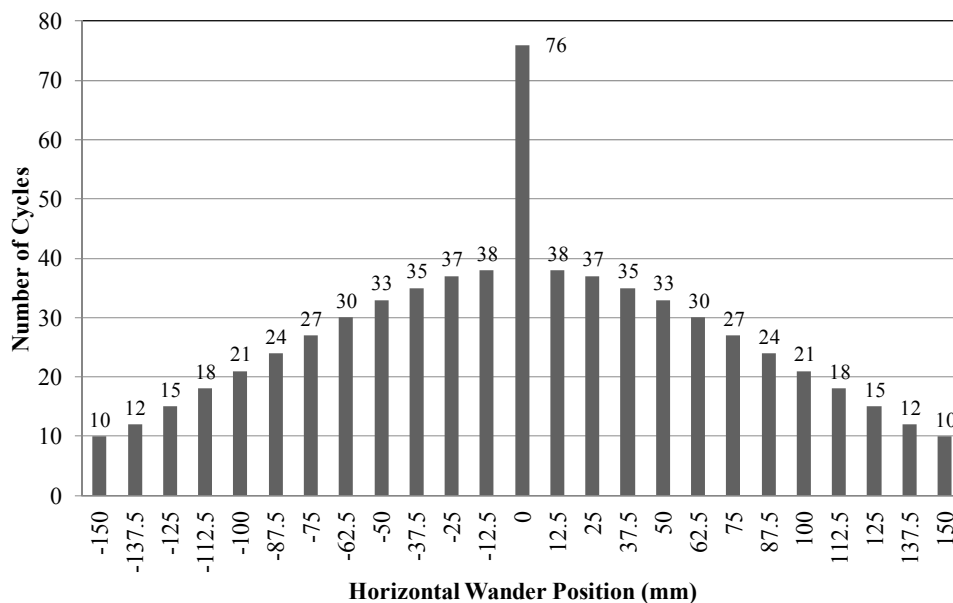
Figure 1. Lateral Wander of APT Machine

In this study, the pit was divided into two lanes (6.1 m long by 2.45 m wide). The subgrade for each lane was a clay (A-7-6) compacted to a CBR of about 6%. To separate the base and subgrade, a non-woven geotextile was used. The NPA geocell-reinforced base layer was constructed following recommendations from Pokharel et al. (2011) and Han et al (2010). The NPA geocells were laid out in a near circular pattern with 250 mm in the wheel direction (also the seam direction) and 210 mm in the transverse direction. Also, the optimum NPA geocell height found by Pokharel et al. and Han et al. was 75 mm. Thus, the height of the NPA geocells in this study was 75 mm. A cover of 25 mm of AB-3 was placed over the NPA geocells after they were filled with AB-3 and compacted. This cover thickness was lowered since an HMA wearing surface would be constructed. The control or unreinforced base layer was 300-mm layer of AB-3. Both lanes were covered with 50-mm HMA layer of a Superpave mixture with 12.5 mm Nominal Maximum Aggregate Size (NMAS).

MATERIALS PROPERTIES

NPA Geocells and Geotextile

The NPA geocells used in this study are NEOLOY™ polymeric alloy (nano-composite alloy of polyester/polyamide nano fibers, dispersed in polyethylene matrix) (Han et al. (2010)). The polymeric alloy has a similar flexibility at low temperatures as HDPE, along with an elastic behavior similar to engineering thermoplastics. The NPA geocells used in this study are made of materials with a tensile strength of 19.1 MPa and secant elastic modulus of 355 MPa at 2% strain. Han et al. (2010) performed the tensile test at a strain rate of 10%/minute at 23 °C. The NPA geocell had a wall thickness of 1.1mm and two perforations of 350 mm^2 each on one pallet of the NPA geocell. The geotextile used as a separator between the subgrade and base was a 3.5-oz. non-woven geotextile.

Subgrade

An AASHTO (American Association of State Highway and Transportation Officials) A-7-6 clay was used in subgrade construction. Han et al. (2010) found the optimum moisture content to be 21% with a maximum dry density of 1.61 g/cm^3. An approximate California Bearing Ratio (CBR) of 6% was reached in the pits at a moisture content of 21%. Plastic Limit (PL), Liquid Limit (LL), and percent finer than 75 μm sieve tests were conducted at KSU and were found to be 22%, 43%, and 97.68%, respectively. The Plasticity Index was 21 (Bortz et al. 2011).

Base Course

AB-3

AB-3 is a well-graded base material that is used in a variety of low-volume road applications. Figure 2 shows the gradation for AB-3 as specified by the Kansas Department of Transportation (KDOT)..The AB-3 material used in this study was the same as the one used in previous studies (Pokharel et al. 2011 and Han et al. 2010). Pokharel et al. (2011) found a mean particle size of (d_{50}) of 4.4 mm, a coefficient of curvature of 1.55, and a coefficient of uniformity of 21. The optimum moisture content of 10.2 % would produce a CBR of 45%. The maximum dry density was determined to be 2.13 g/cm^3. The AB-3 was compacted at a moisture content of 9.2% in the control lane and to about 9% in the NPA geocell lane.
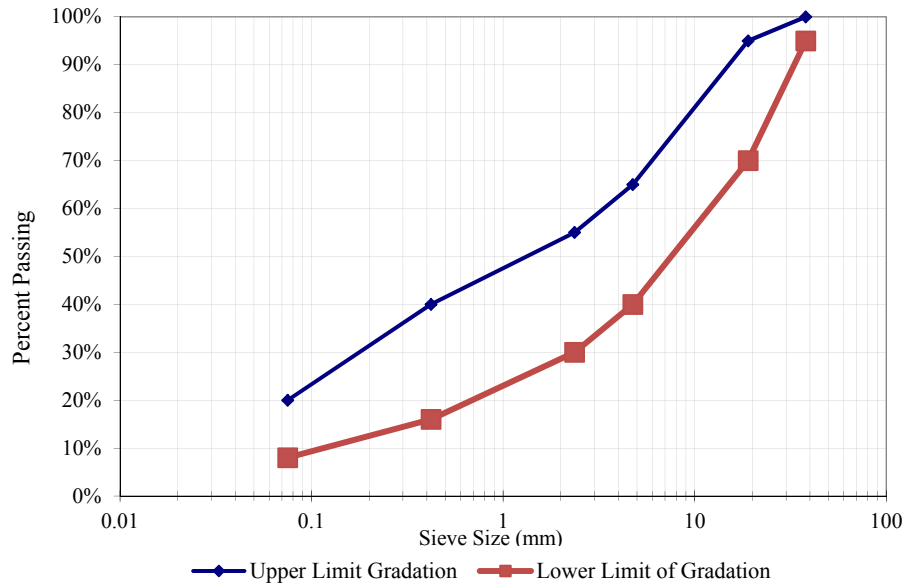
Figure 2. AB-3 Gradation Specified by KDOT (KDOT 1104 1990)

Hot Mix Asphalt

A 50-mm HMA layer was placed over the base layer. The HMA was produced and laid by a local asphalt contractor as seen in Figure 3. A Superpave mixture with 12.5 mm NMAS and fine gradation, known as SM-12.5A in KDOT, was used. The aggregate blend consisted of 26% 19-mm rock, 17% 9.5-mm chips, 20% manufactured sand, and 17% concrete sand. A PG 70-28 binder was used. The in-place density was 92% (2.25) of theoretical maximum specific gravity. The mixture air void content at N_{design} was 4.04%. The final cross section of the lanes is shown in Figure 4.
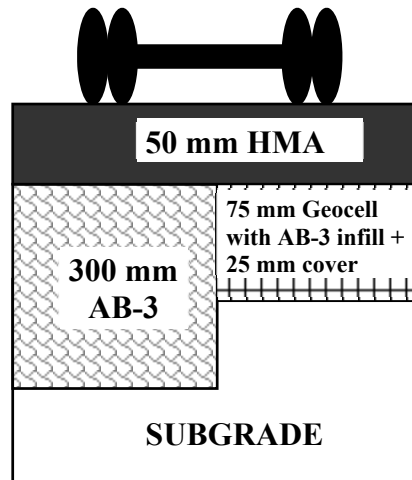

Figure 3. Paving test sections

Figure 4. Cross-section of test lanes

INSTRUMENTATION

The lanes were instrumented with pressure cells on top of the subgrade and two strain gages at the bottom of the HMA layer. Thermocouples in the HMA layer were also placed. The NPA geocells were instrumented with five strain gages per lane. The instrumentation layout can be seen in Figure 5.

The pressure cells were Geokon Model 3500 pressure cells. The H-Bar strain gages consisted of Texas Measurements PML-60-2L gages epoxied to 2 aluminum pieces as suggested by Lewis (2008). The thermocouples used were a Type T. The strain gages placed on the NPA geocells were Vishay C2A-06-250LW-120. During placement of the HMA layer, some of the H-Bar gages were damaged.
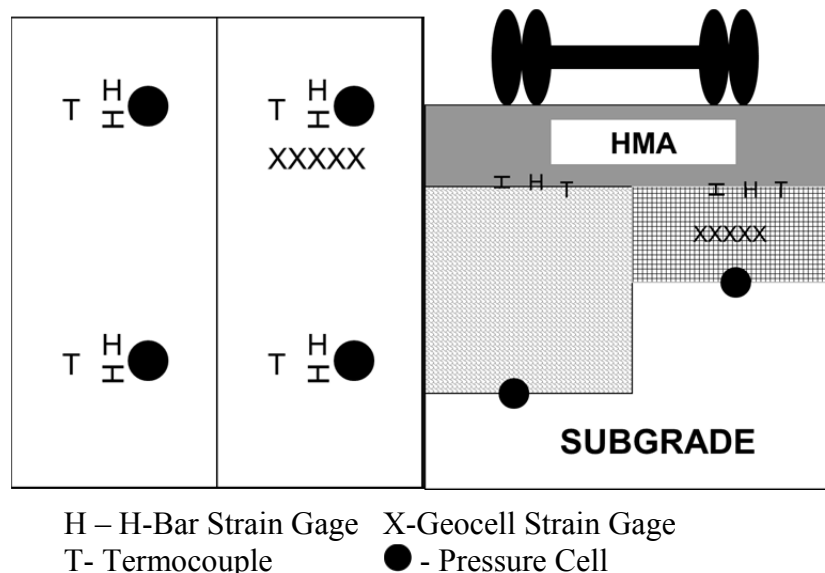

H – H-Bar Strain Gage   X-Geocell Strain Gage
T- Termocouple   ● - Pressure Cell

Figure 5. Instrumentation of test lanes

RESULTS

Rut Depths

The test lanes were subjected to the moving wheel test. The rut depths were measured in two different ways. First, a profile was taken with a transverse profiler (Lewis 2008). The profiler is a 4.27-m long piece of aluminum tubing with a 5-cm^2 cross section. A Chicago Dial Indicator digital gage is mounted to a movable slide on the beam. The gage produces a digital output and sends data to a spreadsheet. Three fixed reference points, at every 1.5 m of lane length, were placed on the HMA on outside of the lanes. Measurements were taken every 12.5 mm. The second method of measuring rut depths was using a sight level and measuring stick. The elevation of the wheel path was taken every 305 mm. These measurements were compared to a set reference point inside of the CISL building. Typical profiles for each lane can be seen in Figures 6 through 9.

As seen in the figures the lane in the reinforced lane deteriorated quickly. After only 10,000 passes, the transverse profile showed an average rut depth of 12.5 mm. The failure rut depth for this study was set at 12.5 mm. The average longitudinal depression depth was 10.77. The unreinforced section fared better with transverse rut depth and longitudinal depression depths of 5.69 and 0.91 mm, respectively. A summary of the ruts depths with the applied number of load cycles can be seen in Table 1. The unreinforced lane received 70,000 passes while the NPA geocell-reinforced section AB-3 received only 50,000 passes due to scheduling of a 38-mm overlay.
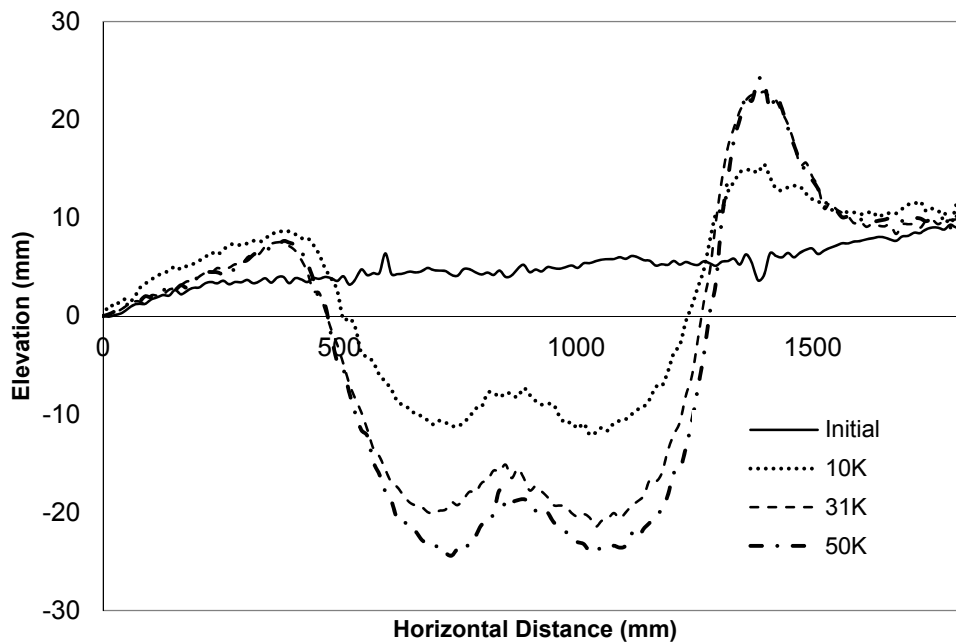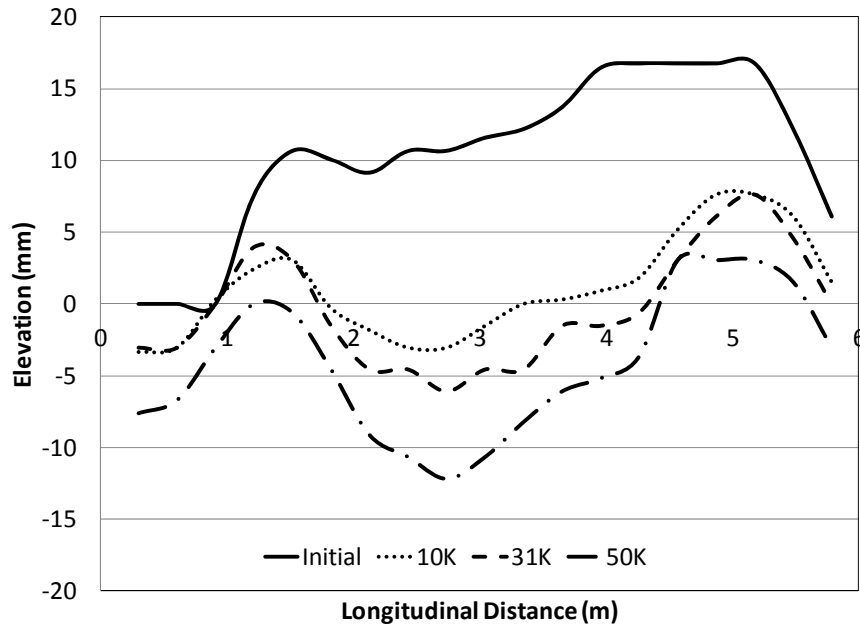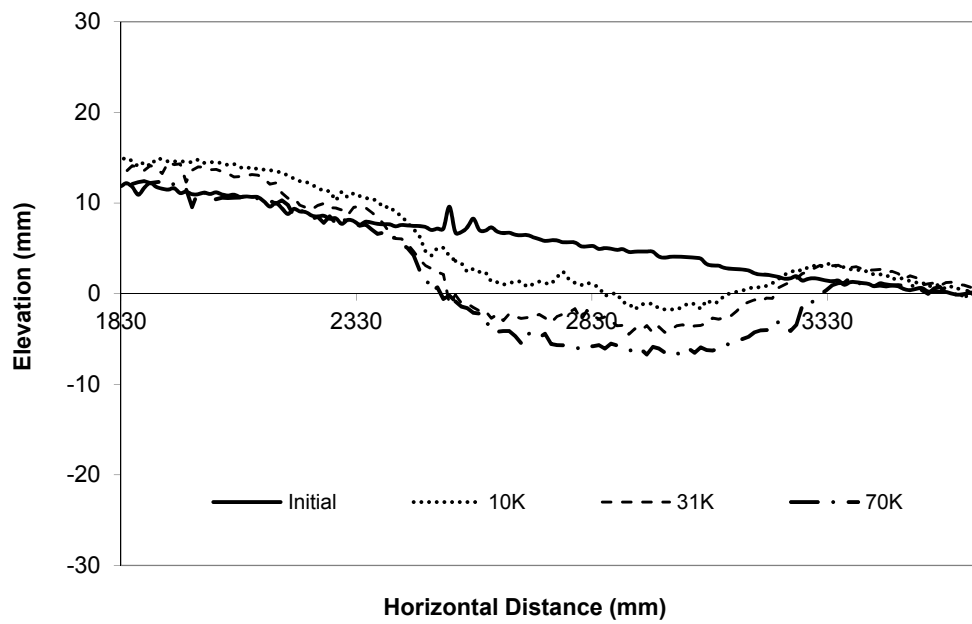

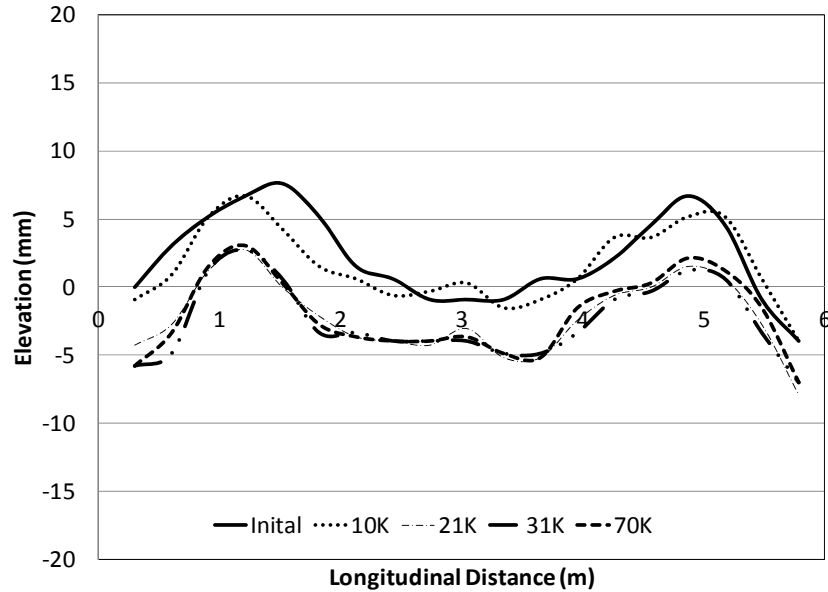**Figure 6. NPA geocell reinforced AB3 lane typical transverse profile**

Figure 7. NPA geocell reinforced AB-3 lane longitudinal profile

**Figure 8. Unreinforced AB3 lane typical transverse profile**

Figure 9. Unreinforced AB-3 longitudinal profile

Table 1. Average rutting depth

	Average Rut Depth (mm)				
Cycles (in thousands)	10	20	31	50	70
Unreinforced AB3 - Longitudinal	0.91	4.67	4.88		4.67
Unreinforced AB3-Transverse	5.69	7.23	9.74		11.44
Reinforced AB3 - Longitudinal	10.77		12.50	15.75	
Reinforced AB3-Tansverse	12.54		16.89	19.11	

Vertical Stresses

Pressure cells were placed above the subgrade and just below the geotextile. The pressure was recorded for a full wander (676 passes) each time. The top 50 peak pressures were averaged and presented in Figure 10. The pressure on the subgrade in the NPA geocell-reinforced AB-3 lane (GC AB3) was well above the unreinforced AB-3 (UR AB3) lane. It is to be noted that the stress at in the NPA geocell reinforced lane surpassed unconfined compressive strength of 105 kPa of the subgrade soil .

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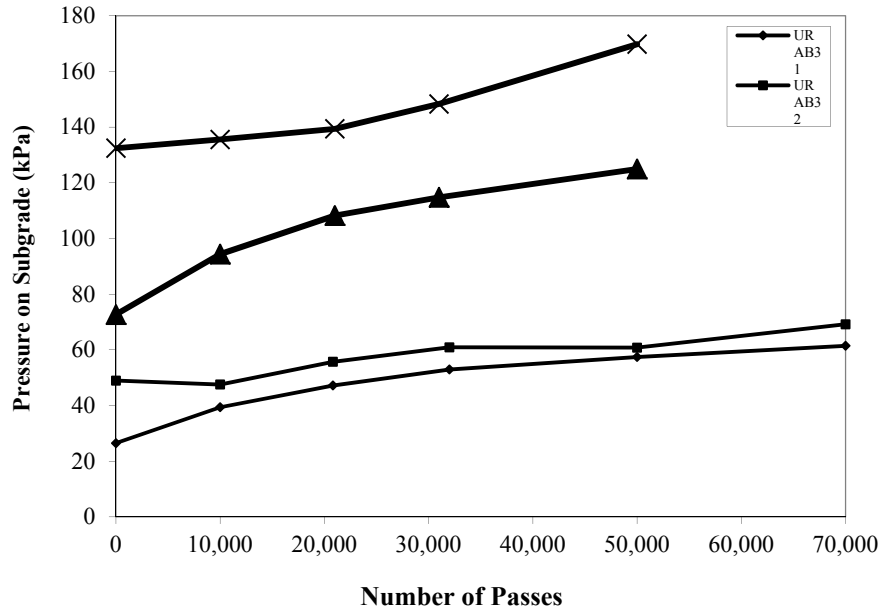
Figure 10. Pressure on Subgrade

FWD Testing and Data Analysis

After paving, KDOT conducted Falling Weight Deflectometer (FWD) tests on the pavement. During FWD testing, seven sensors were used at offset locations of 0, 203, 305, 457, 610, and 914 mm. From the FWD results, the modulus of each layer was backcalculated using the software package EVERCALC from the Washington State Department of Transportation. To minimize the root mean square (RMS) error, deflection from only first four sensors were used in the backcalculation. These sensors were used to take into account the shallow subgrade (the CISL APT pits are underlain by a 230-mm Reinforced Concrete slab) and the effects of the concrete walls of the pits. The layer moduli were used in the KENPAVE software in the KENLAYER program for computing strain at the bottom of HMA layer and stress at the top of the subgrade. KENLAYER provides solution for an elastic multilayer system under a circular loaded area. These calculated responses were compared with the measured responses under the moving wheel load. Tables 2 and 3 list these responses. As can be seen in Table 2, the unreinforced AB-3 lane had much lower pressure on the subgrade in both cases. This is attributed to the unreinforced AB-3 base being four times thicker than the NPA geocell reinforced base.

Table 2. KENLAYER Comparison of Pressure on Subgrade

	Unreinforced AB-3	Geocell Reinforced AB-3
	Pressure on Subgrade	Pressure on Subgrade
KENLAYER (kPa)	58.32	132.01
MEASURED (kPa)	41.76	124.94
% Difference	-28.40%	-5.36%

Strain at the bottom of the HMA layer

The strain at the bottom of the HMA layer was measured with the H-Bar strain gages. Table 3 lists both calculated and measured strains. The lower than expected strain in the reinforced AB-3 lane could be attributed to the beam effect of NPA geocells described by Pokharel et al. (2011) and Han et al. (2010). The base layer and HMA layer acted like a beam and could move together, reducing the strain at the interface.

Table 3. KENLAYER Comparison of Strain at the Bottom of HMA Layer

	Unreinforced AB-	Geocell Reinforced AB-
	Strain (Below HMA)	Strain (Below HMA)
KENLAYER	-0.000363	-0.000902
MEASURED	-0.000369	-0.000273
% Difference	-1.62%	69.75%

Using KENLAYER, a comparable unreinforced section was determined based on similar responses. The equivalent unreinforced layer would be approximately 200 mm. The pressure on the subgrade would be approximately the same as the smaller reinforced section. Using the knowledge gained from this study, a new design and construction was completed. The new NPA geocell-reinforced design consisted of 100 mm of HMA over a 100 mm NPA geocell with 50 mm of cover.

CONCLUSIONS

In this study, a polymeric alloy NPA geocell reinforced base with AB-3 as in fill materials and one unreinforced AB-3 base course were studied in an accelerated pavement testing. The following conclusions can be drawn from this study.
1. A 25-mm cover over the NPA geocells is too thin due to the irregularities in the heights of NPA geocells and subgrade. A 50-mm cover over the NPA geocells would ensure a better compaction over the NPA geocells and would also make construction easier.
2. A 75- mm thick NPA geocell reinforced base layer approaches the maximum capacity of the NPA geocells. A 100-mm thick NPA geocell would enhance the load-bearing capacity of the base layer.
3. The subgrade must be protected in order to ensure better performance of the paved road. The applied subgrade stress should be less than the unconfined compressive strength of the soil.
4. A HMA layer of 50 mm is too thin for the wheel load. The minimum thickness for the HMA layer is recommended to be 100 mm.

ACKNOWLEDGEMENTS

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Spatial Transferability of CO_2 Emission Models Incorporating Land Use, Household, and Trip Characteristics

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ABSTRACT

Model transferability is the application of the previously estimated model parameters to a new application context. This study formulated CO_2 emissions models for four metropolitan areas namely Chicago, Los Angles, New York, and Washington D.C. and evaluated the spatial transferability of the estimated models. Furthermore, each of the four models is used to predict the observed CO_2 emissions in its estimation data and three other regions. The models are estimated using data from the 2009 National Household Travel Survey. The models incorporate land use, trip, and household characteristics. The results show that model transferability produce reasonable prediction for regions with similar characteristics. The results of this study are expected to assist transportation agencies with limited data to estimate CO_2 emissions using borrowed model with informed level of accuracy.

Key Words: **CO_2 emissions, model transferability, land use, household**

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INTRODUCTION

Model transferability is the application of the previously estimated model parameters to a new application context. The estimated model parameters can be transferred temporally or spatially. Temporal transferability refers to the application of model estimated from data from one temporal context to another temporal context for the same geographical region. Spatial transferability involves the application of a model estimated from one geographic region for prediction in a different geographic region for the same time-period. Transferability can significantly reduce data collection efforts and costs associated with data collection and model development. Many past studies (Karasmaa, 2007; Badoe and Miller, 1995; Atherton and Ben-Akiva, 1976) have investigated model transferability. Most studies, however, have been focused on transferability of travel demand models and no similar efforts have been done in CO_2 emissions models. In part, this is explained with the evolvement of the CO_2 emissions modeling. Considering the data limitation for CO_2 emissions modeling, model transferability is more essential in assisting transportation agencies with limited data to formulate CO_2 emissions models and estimate emissions from different transportation investments.

Incorporating CO_2 emissions estimates in transportation planning process is an important step to understand the impacts of different projects on CO_2 emissions at the planning level. Recognizing this challenge, among others the US Environmental Protection Agency developed vehicle emissions modeling (Motor Vehicle Emission Simulator (MOVES2010a)) for use by transportation agencies in preparing the emissions inventory for state implementation plans and transportation conformity determination. The model allows the user to specify vehicle types, time-periods, geographical areas, pollutants, vehicle operating characteristics, road types, etc. However, data limitations at MPO level for many transportation modes for estimating CO_2 emissions (ICF, 2005) may pose challenges to small agencies with limited resources.

The primary objective of this study is to investigate spatial transferability for CO_2 emissions models. This study first formulates CO_2 emissions models incorporating land use, household socioeconomic, and trip characteristics for four different regions. Furthermore, each of the four models is used to predict the observed CO_2 emissions in its estimation data and three other regions. The rest of the paper is organized as follows; the second section presents the description of data used, descriptive analysis, and model specification. Results and discussion are presented in the third section followed by conclusions. The last section presents the list of references cited in this study.

DATA

This study makes use of the 2009 National Travel Survey Data (NHTS) and four (4) Metropolitan Statistical Areas (MSA) namely Chicago, Los Angeles, New York, and Washington D.C. This data has information pertaining to household characteristics, trip characteristics, vehicle characteristics, and land use characteristics for more than 150,000 households in the U.S. The study uses only observations that have complete information on travel time, fuel type, vehicle type, vehicle miles of travel, and vehicle fuel efficiency. The study uses all the eight vehicle types including autos, vans, sport utility vehicles, pick-up trucks, other trucks,

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recreational vehicles, motorcycles, and golf carts. Further, the study considers all the fuel types including gasoline, natural gas, electricity, and diesel. However, the percent of other than gasoline fuel types in the sample was very small for all analyzed MSAs. The following section describes the procedure used to determine the observed CO_2 emissions and different models for estimating CO_2 emissions for gasoline and diesel vehicles.

DESCRIPTIVE ANALYSIS

Figure 1 presents the average kilograms of CO_2 per household per year for selected household characteristics. As observed, households with more vehicles and income make more trips and therefore significantly affect CO_2 emissions. Regardless of the MSA, the very low income (<=$5000) household produces about half the CO_2 of high income households. Population density per square mile at block level affects CO_2 emissions negatively. From the figure, it is shown that regardless of the MSA, households residing in very low density (0-99) population per square mile produce more kilograms of CO_2 emissions compared to households in very dense (25k-999k) population per square mile. Comparing the four MSAs, both for low-density and high-density areas, the Los Angeles MSA yields the highest CO_2 emissions. Higher population densities results to trip origins and destinations that are much closer to each other and thus, shorter trip length on average (TRB, 2009). This supports the findings of earlier studies (Stone et al., 2007; Brownstone, 2009). With respect to vehicle type, for all the MSAs, the recreational vehicles produce more CO_2 emissions compared to vans and more significantly in Los Angeles MSA. This could be due to relatively longer trips made by recreational vehicles compared to automobiles. In addition to this, recreational vehicles also have low fuel efficiency and therefore produce more CO_2 emissions under similar conditions than automobiles.

MODEL SPECIFICATION

The relationship between CO_2 emissions with land use, trip characteristics, demographic and socioeconomic characteristics is evaluated by specifying a multivariate regression model. The endogenous variable is the amount of CO_2 emitted per trip. The model takes the following form:

$$y_i = \alpha + \sum_{k=1}^{K} x_{ik} \beta_k + \varepsilon_i$$

(1)

where:

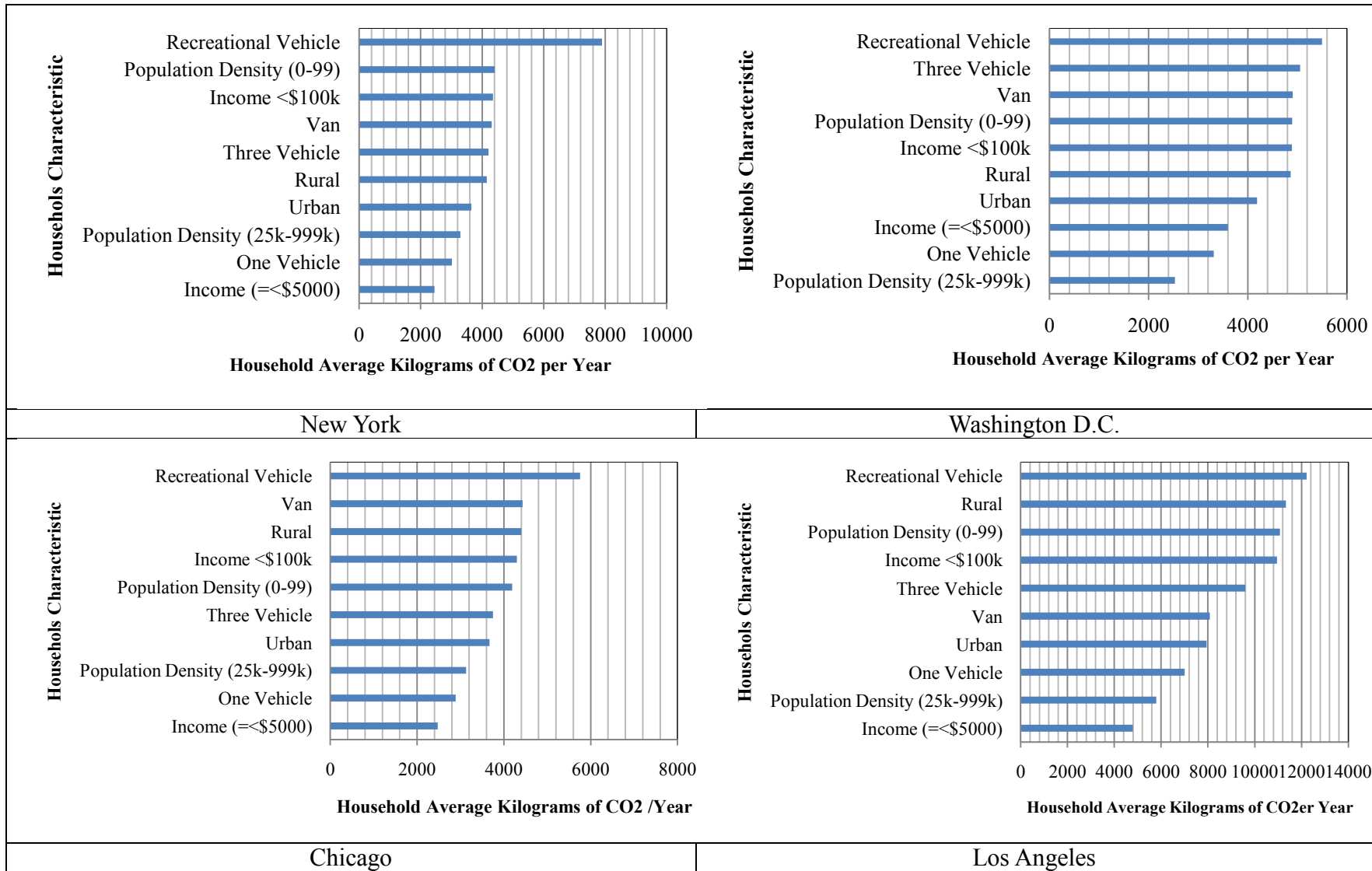i is the indexes trip,
k is the indexes explanatory variable,
x_{ik} is the kth explanatory variable of trip i,
α is the constant term,
β_k is the kth coefficient of the kth explanatory variable,
ε_i is the random term for trip i, and
y_i is the kilograms of CO_2 emitted for trip i,

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Figure 1. Average CO_2 (kg) per year for selected household characteristics

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The amount of CO_2 emissions produced per trip for gasoline and diesel is computed based on the steps described by EPA (2005). These steps are as follows:

Step 1: **Determining the CO_2 produced per gallon of fuel**

The Code of Federal Regulations, 40 CFR 600.113-78 gives a carbon content value of 2,421 grams and 2,778 grams of carbon per gallon of gasoline and diesel, respectively. The carbon content is then multiplied by the ratio of the molecular weight of CO_2 to the molecular weight of carbon: 44/12, which gives the CO_2 grams per gallon of fuel burned to be:

$$\text{Gasoline: } CO_2(g) = \frac{2,421 * 44}{12} = 8,877 \tag{2}$$

$$\text{Diesel: } CO_2(g) = \frac{2,778 * 44}{12} = 10,186 \tag{3}$$

The CO_2 grams per gallon are then multiplied by an oxidation factor of 0.99, which assumes that 1 percent of the carbon remains un-oxidized (IPCC, 2006). This produces 8.8 kilograms and 10.084 kilograms of CO_2 per gallon of consumed gasoline and diesel, respectively.

Step 2: Estimating the fuel economy of a vehicle

The 2009 NHTS data contain vehicle fuel-economy information from U.S. Energy Information Administration (EIA) and Environmental Protection Agency (EPA). This study uses the EPA estimates of fuel economy since similar values are used in the EPA's MOBILE6 and MOVES models which are widely used by transportation agencies for estimating emissions for emissions inventory and conformity determination.

Step 3: Determining the number of miles driven

The data also has vehicle miles of travel for vehicle trips traveled. Vehicle miles of travel (VMT) and information from Steps 1 and 2 are used to compute kilograms of CO_2 per trip as shown in Step 4**.**

Step 4: Calculating the resulting CO_2 emissions per trip

The input in this step is from the previous three steps and CO_2 emissions in kilograms are computed for gasoline and diesel fuel types as follows:

$$CO_2(kg) = \frac{(CO_2 \text{ per gallon}) \times (\text{Vehicle Miles of Travel})}{\text{Vehicle Fuel Efficiency (mpg)}} \tag{4}$$

The kilogram of CO_2 emissions produced by electric vehicles per trip is computed as:

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$$CO_2(kg) = EF \text{ x } (0.35kWh/mile) \text{ x (vehicle miles of travel)} \tag{5}$$

Where EF is the emission factor, which is 0.442kg/kWh (Brooks, 2005). Typical mid-size cars have power consumption level of 300–400 Wh per mile (Anderman, 2004) which translates to 0.35kWh/mile used in this study. For vehicles using natural gas, the kilogram of CO_2 emissions produced per trip is computed as;

$$CO_2(kg) = \frac{(EF) \times (\text{Vehicle Miles of Travel})}{\text{Vehicle Fuel Efficiency (mpg)}} \tag{6}$$

Where EF is the emission factor 6.89kg of CO_2 per gallon (City of Tallahassee, 2011)

RESULTS

This section presents the model estimation results of each of the MSA considered in this study. In addition, the section presents a description and results of the measures used to assess transferability performance of the models. The performance measures include Transfer Index (TI) and Mean Absolute Error (MAE). Table 1 presents the estimation results for all of the four regions. All the models give the total impact of the exogenous variables on CO_2 emissions per trip. The subsections that follow discuss in detail the implications of various variables representing household, land use, and trip characteristics.

Household Characteristics

Variables representing household characteristics specified in the model include household income, natural log of household size, and lifecycle. As observed from Table 1, consistently across MSA's household income influences CO_2 emissions positively. This confirms the descriptive results presented in Figure 1. In part, this can be explained by the likelihood of affluent households to (1) reside in low-density areas and (2) own less fuel-efficient vehicles, and therefore produce significantly more CO_2 emissions compared to their counterparts. Likewise, household size affects CO_2 emissions positively. This is consistent with the travel demand findings in which households with more people tend to make more trips to cover both personal and family needs and therefore produce more CO_2 emissions. Surprisingly, the coefficient of lifecycle for those with children and without children is statistically equal at 5 percent significant level though the opposite would be expected.

Land Use Characteristics

In this study, land use variables specified in the model include population density per square mile at census block level and urbanism. From Table 1, it is observed that the increase in population density reduces CO_2 emissions per trip. Everything being equal in the variables specified in the model, a trip made in an area where the population density in the range of 0-99 in New York,

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Chicago, and Washington DC would yield around 4kg more CO_2 emissions compared to when the population density is within 1000-1999. Similarly, a trip made in the urban area would yield less CO_2 emissions compared to one made in rural area, *ceteris paribus*. The explanation for the aforementioned observation would be due to highly dense and urban areas tend to have services in a close proximity and thus reducing trip length, which in turn reduces CO_2 emissions. Similar results have been reported in other studies (Brownstone and Golob, 2009; Glaeser and Kahn, 2008).

Trip Characteristics

The results show that vehicle choice has influence on CO_2 emissions. As observed, consistently for all the MSA's, CO_2 emissions increases from motorcycles and golf carts (reference group) in the following passenger cars, vans, sport utility vehicles, pickup trucks, other trucks, to recreational vehicles. This is consistent with the fuel economy of such vehicles as reported elsewhere (Mwakalonge and Perkins, 2011). As expected, travel time influences CO_2 emission positively. One-minute increase in travel time produces nearly 227g, 293g, 217g, and 264g more of CO_2 emissions for Chicago, Los Angeles, New York, and Washington DC, respectively. This imply that encouraging and/or educating drivers to avoid making discretionary trips such as shopping, recreation during relatively congested traffic conditions have significant impact on CO_2 emissions. In addition, improving roadway efficiency could help to relief CO_2 emissions produced specifically due to traffic related congestion.

With respect to models' ability to explain CO_2 emission variability at trip level, the Washington DC models yield superior explanatory power followed by Chicago model. The Los Angeles model yields the lowest explanatory power.

Transferability Performance

As mentioned earlier, the models' transferability performance were evaluated based on transfer index and the mean absolute error. The Transfer Index (TI), which is the ratio of the Transfer R-squared to the R-squared of a locally estimated model in the application context, is used to measure model transfer performance relative to the application context model. The upper bound value for TI can be greater than one, which occurs when a transferred model outperforms the locally estimated model in the application context. Its lower bound value is zero, which occurs when the transferred model is not able to explain at all any of the variation in household-trips in the application context.

Mathematically TI is expressed as (Koppelman and Wilmot, 1982)

$$TI = \frac{R^2_{transferred}}{R^2_{local}} \qquad (7)$$

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Table 1. Model Estimation Results

Variable	Chicago		Los Angeles		New York		Washington DC	
	Coef.	t-Stat.	Coef.	t-Stat.	Coef.	t-Stat.	Coef.	t-Stat.
Household Income	0.0039	2.21	0.0030	2.82	0.0017	1.94	0.0020	1.48
Loghhsize	0.1373	1.35	0.1890	2.97				
Adults, no Child					0.2145	3.53		
Adults with Children					0.1929	3.34	0.1292	1.74
Vehicle Type Car=1 0=otherwise	5.1026	4.82	1.6829	3.56	1.4838	3.16	2.8459	4.84
Vehicle Type Van=1 0=otherwise	6.0211	5.65	2.4743	5.12	2.1940	4.62	3.6673	6.17
Vehicle Type SUV=1 0=otherwise	6.0868	5.73	2.7238	5.73	2.4698	5.24	4.0433	6.84
Vehicle Type PUT=1 0=otherwise	6.9424	6.48	3.0176	6.28	3.0712	6.41	4.4136	7.42
Vehicle Type Other Truck=1 0=otherwise	14.0917	6.28	33.8175	27.99				
Vehicle Type Recreational=1 0=otherwise			73.4113	48.8				
Travel Time (min)	0.2269	106.66	0.2932	201.33	0.2176	234.02	0.2639	202.44
Population Density	-0.00006	-6.78	-4.6E-05	-9.86	-5.9E-05	-20.36	-5.1E-05	-5.84
Urban=1 0=otherwise					-0.1124	-2.13	-0.3511	-4.1
Constant	-7.1165	-6.67	-4.5829	-9.49	-2.8176	-5.9	-5.1202	-8.61
R-Squared	0.7531		0.6073		0.6758		0.7879	
Number of Observations	3863		30152		26944		11351	

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Table 2 presents TI values resulting from application of models estimated with data from the four MSAs. As observed, the application of a Washington DC model to predict CO_2 emission in Chicago, Los Angeles, New York yield superior results for New York and Chicago but marginally lower for Los Angeles. This implies that, CO_2 emission levels for New York, Chicago, and Washington DC are more comparable compared to Los Angeles. Likewise, the New York and Chicago models' yields superior TI values when applied to each other and to Washington DC but not to Los Angeles. However, the Los Angeles model explains more than 99 percent of the CO_2 emission variability in New York, Chicago, and Washington DC relative to the local models in the respective MSAs.

Table 2. Transfer Index Values

Estimation MSA	Application MSA			
	DC	NY	LA	Chicago
DC	-	0.9988	0.9182	0.9952
NY	0.9995	-	0.9190	0.9955
LA	0.9987	0.9913	-	0.9903
Chicago	0.9981	0.9997	0.9216	-

Further, the models' prediction performance was evaluated using Mean Absolute Error (MAE) measure. Mathematically, the MAE measure is presented as:

$$MAE = \frac{\sum_{i=1}^{N}|y_i - \hat{y}_i|}{N}$$

(8)

Where:

y is the observed values of CO_2 emissions for a given region

$\hat{y}$ is the predicted values of CO_2 emissions for a given region

N is the total number of trips

Figure 2 shows MAE results obtained for the four metropolitan areas. From the figure, the MAE values are larger for Los Angeles MSA and small for New York and Chicago MSAs. The application of the Washington D.C. model to other MSAs yields a low MAE value for New York and Chicago compared to Los Angeles MSA. The application of the New York model to other MSAs yields a low MAE value for Chicago and Los Angeles compared to Washington DC MSA. The Los Angeles model gives the highest error values for all applications. In part, this may be explained by the low explanatory power that the model exhibits compared to other models.

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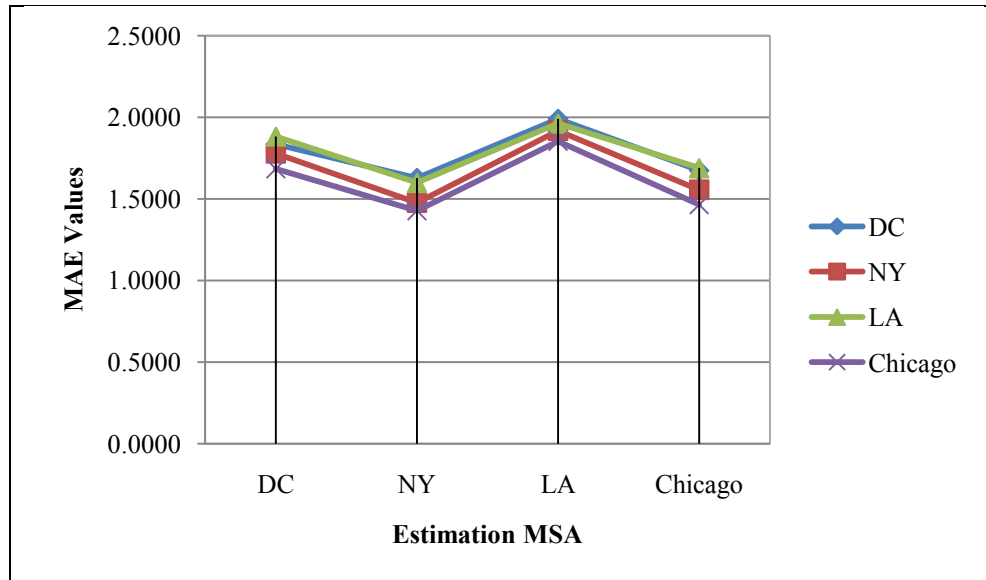
Figure 2. Estimation and Transfer MAE Values

CONCLUSIONS

The study investigated the spatial transferability of CO_2 emissions models incorporating land use, socioeconomic, and trip characteristics using the 2009 National Household Survey (NHTS) conducted by the U.S. Department of Transportation. The study evaluated transferability of four MSAs namely; Chicago, Los Angeles, New York, and Washington D.C. From the analysis presented the following conclusions are made:

- Choice of vehicle influences CO_2 emissions positively. Of all the vehicle types evaluated recreational vehicles were found to have higher impact on CO_2 emissions followed by trucks compared to other vehicle types. On the other hand, automobile/car/station wagon was found to have the lowest effect on CO_2 emissions than other vehicle types.
- Land use variables were found to have influence on the amount of CO_2 emissions produced per trip for all regions. Specifically, urban and population density were found to influence CO_2 emissions negatively. Everything being equal, a trip made in an area with population density of 0-99 in New York, Chicago, and Washington D.C. would yield comparatively more CO_2 emissions compared to areas with population density of 1000-1999. Additionally, a trip made in urban area in New York and Washington D.C. would produce 112g and 351g less amount of CO_2 emissions, respectively.
- Household characteristics like income, life cycle, and logarithm of household size were found to affect CO_2 emissions positively. Thus, the affluence households, on average, generate more CO_2 from driving compared to their counterparts. This is in line with travel behavior theory where households with high-income and more number of vehicles make more trips than other household types, hence, emitting more CO_2 emission. The affluence people in Chicago emit more compared to other MSAs.
- The results show that regions with similar characteristics yield superior transferability performance compared to regions with relatively less comparable characteristics. This confirms the counterintuitive expectations that transferability between regions with

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similar characteristics yields superior transferability performance.

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Web-Based Project Management Action Research for Highway Projects Under $10 Million

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ABSTRACT

The Iowa Department of Transportation's (DOT) desires a web-based project management system (WPMS) for smaller highway project (< $10 million). In 2008, the Iowa DOT was undergoing a construction period that included several complex bridge projects (>$10 million). They sought a WPMS that was able to ease the document management of requests for information (RFIs) and shop drawings for these projects. After having implemented the WPMS solution for complex projects, they are looking for a simpler WPMS that can be implemented in smaller highway projects (under $10 million), with capabilities of expanding its usage to additional Iowa DOT projects. This paper reports on the process of identifying and testing WPMSs for the aforementioned projects.

Action research, an iterative process of continuous improvement, was the methodology used to identify and test WPMSs that met the Iowa DOT's needs. Through this process the research team, alongside a technical advisory committee (TAC), evaluated the effectiveness of possible WPMS solutions.

This paper describes the process of identifying a WPMS for smaller highway projects. This process involved the development of the workflow for the Iowa DOT's document management. The workflow that was created corresponded to sign truss projects; this helped the researchers understand the document management of smaller DOT highway projects. Subsequently, several WPMSs were studied and were compared to the workflow. From these, SharePoint was selected as a possible solution for implementation. Currently, further studies and tests are being performed to SharePoint before being pilot tested.

Key Words: Action Research – document management – electronic collaboration – Web-based Project Management Systems

INTRODUCTION

The Iowa Department of Transportation (Iowa DOT) began a phase of complex bridge construction projects in 2008. Having realized that the management of construction documents, such as requests for information (RFIs) and shop drawings, was consuming more time than traditional bridge projects, they approached the research team to help identify and implement a Web-Based Project Management System (WPMS) that could ease the management of such documents. For the first three phases of the project, the research team underwent the task of identifying and implementing different WPMS for complex bridge projects. For the current project phase, the research team was assigned the task to identify a WPMS for smaller highway projects.

The construction industry's document management is based in traditional communication methods. The communication method and document exchange, in its majority, consists of hard-copy paper documents transmittal and approval. This can result in wasted time and money due to a poor document management and coordination (R. Stewart, et al 2004). Because of this, the information that is being exchanged within the industry can be classified, in some cases, as "difficult-to-access", outdated, or incomplete (R. Stewart, et al 2004). Web-based project management systems try to mitigate some of the problems caused by this traditional information exchange system and provide additional benefits. The benefits are: coordination with other email or collaborative solutions, decrease of problems related to communication, improvement of the project's processes, ability to track the project's process and information through the internet (M. Alshawi, et al 2003), increased coordination between the project team members (M. Alshawi, et al 2003 & Nitithamyong, et al 2004), increase in work speed and document quality, decrease in documentation error, and provide easier and faster access to project information (Nitithamyong, et al 2004).

METHODOLOGY

This research project involved the use of action research. Action research is an iterative approach of identifying a problem or requests that need to be addressed and solved (Susman et al. 1978). It is a continuous learning process where the lessons learned from previous iterations are applied to subsequent project iteration. The steps involved in the action research process are the following:

- Diagnosing: The problems are identified and defined.
- Action Planning: The actions required to solve the problem are determined.
- Action Taking: The plan is implemented.
- Evaluation: The implementation is reviewed and the consequences are measured.
- Specifying Learning: The lessons learned from the evaluation are recorded and used for future iterations. (Susman et al. 1978).

After a cycle is completed, the iteration is completed. The lessons learned from the Specifying Learning are used as part of the Diagnosing stage of the next of iteration. This process is depicted in Figure 1. The action research stages are represented in the cycle and the different iterations are identified in the arrow placed after the Specifying Learning stage.

The first iteration for the smaller highway projects used the lessons learned from the previous iterations performed on the identification and implementation of WPMS for complex bridge projects. Using Susman's action research approach, several iterations to find a WPMS solution for smaller highway projects, specifically sign truss projects, were performed. Recommendations were presented to the Iowa DOT with the findings and suggested solutions. A Technical Advisory Committee (TAC) was created to provide input and make recommendations during the entire iterative cycles. This TAC is primarily

composed of engineers and information technology (IT) specialists from the Iowa DOT as well as researchers from Iowa State University.
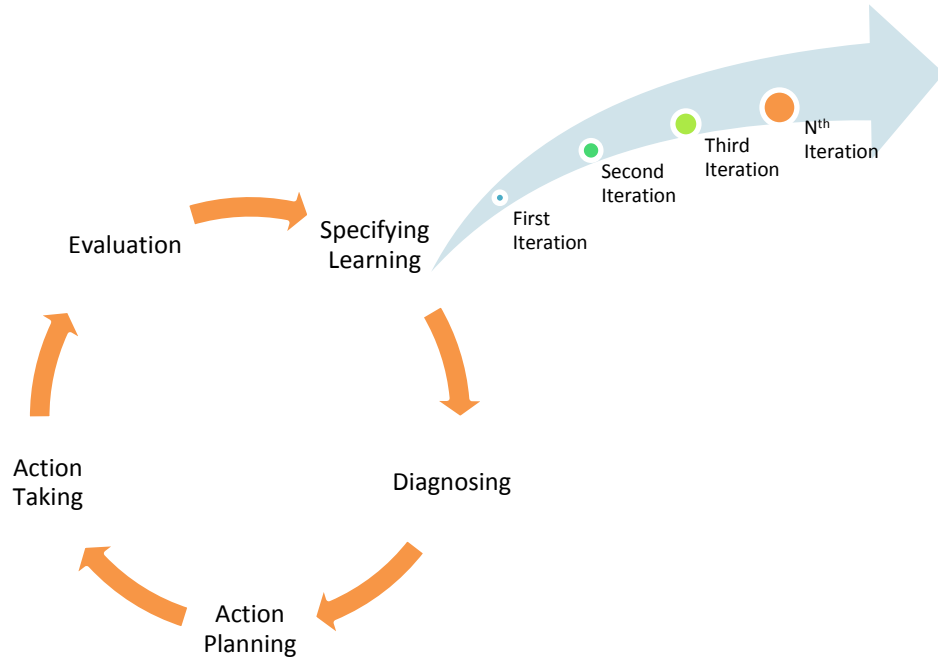

Figure 1. Action research flow

FIRST ITERATION

Diagnosing

It was established by the TAC to implement the WPMS solution first sign truss projects. The researchers went ahead to establish the required tasks and actions that the solution had to offer for this type of project. For this, the researchers met with the engineers from Traffic and Safety division and Bridges and Structures division from the Iowa DOT, to identify the steps and workflow of the review process for the shop drawings submittals in sign truss projects. The established workflow can be seen in Figure 2. The workflow involves different Iowa DOT departments, depending on the type of shop drawing sent for review. It is important the WPMS solution has the capacity of sending automatic notifications to the corresponding parties involved in the process. The WPMS should also have a log-in requirement, where user access to the site is restricted and a username and password is required to access the page. Also, another requirement to satisfy the workflow is that the WPMS must keep track of the different document versions, especially when the shop drawing has to be resubmitted. Lastly, the WPMS should have the capacity to have an approval option or a comment section where the documents can be categorized as "No Exceptions Taken" or "Make Corrections Noted" (documents do not need to be resubmitted) or as "Revise and Resubmit" (were the documents need to go through the workflow process again). These categories are the Iowa DOT's response and evaluation to the shop drawings submitted by the prime contractors.
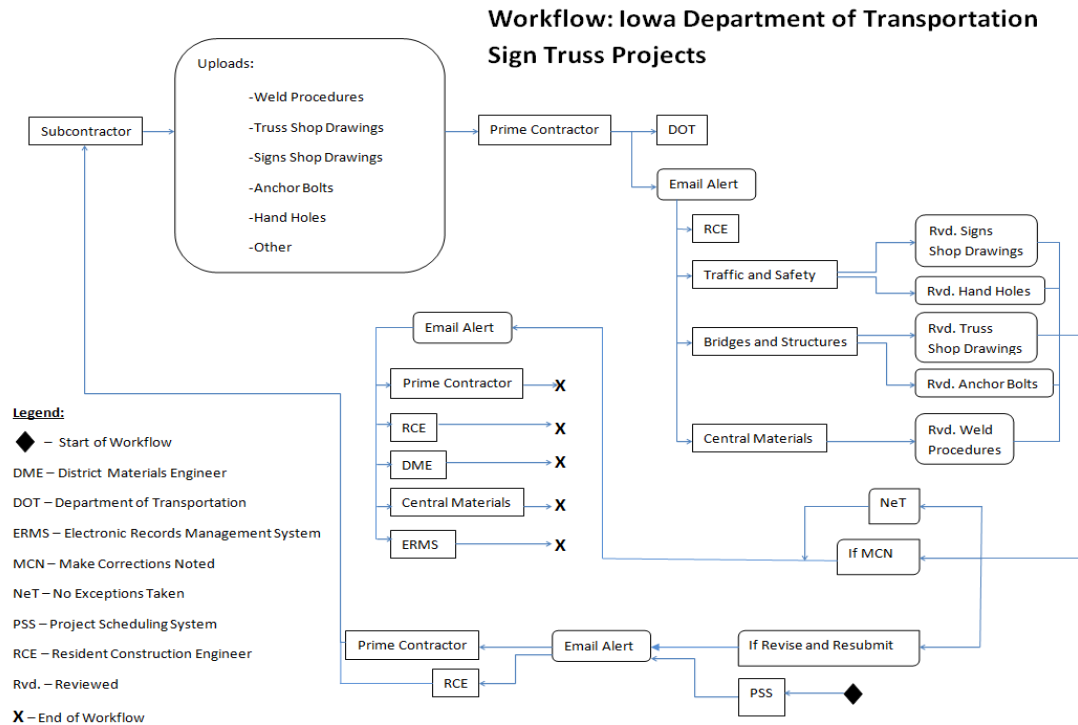
Figure 2. Sign truss shop drawing workflow

Action Planning

Having established the needs and requirements of the WPMS, a plan was developed in order to identify the different existing solutions available. The basic strategy was to find existing online solutions that focused mostly on document management and file sharing. The evaluation criteria in which all the identified WPMS were going to be tested was established. The criteria used for each of the WPMS evaluation are the following:

- project capacity
- storage capacity
- document tracking history
- accessibility
- notification
- approval option
- price
- capacity to recreate the workflow and requirements provided by the Iowa DOT

Action Taking

The researchers sought commercial WPMSs that met the requirements established by Iowa DOT engineers. The researchers began identifying solutions with an interface familiar to the end user: the DOT staff and project team members. For this reason, the researchers studied social and professional

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connection websites and used these as a backbone for identifying the different WPMS solutions for the sign truss projects.

The WPMS identified were Huddle, Google Applications, TeamWork Live, TeamWork Project Management, and Sosius. Each one of these web-based project management systems were tested by creating different e-mail accounts, representing different parties that are identified in the workflow for the sign truss shop drawing approval process. These emails were set up as different user accounts for each of the solutions being tested. The restrictions on the WPMS were set based on the established workflow and the requirements presented by the Iowa DOT.

Evaluation

After all the possible solutions were tested, each of them were compared and evaluated based on the evaluation criteria established in the action planning stage. A matrix was developed to make the comparison of the WPMS easier. Table 1 shows how each solution performed against the evaluation criteria.

Table 1. Evaluation of first iteration solutions

	Huddle	Google Applications	TeamWork Live	TeamWork Project Management	Sosius
Project Capacity	25 Projects	Unlimited	Unlimited	35 Projects	Unlimited
Member Capacity	Unlimited	Unlimited	25	Unlimited	Unlimited
Managers	1	Unlimited	1	1	1
Storage Capacity (Group)	25 Gb	100 Mb	50 GB	10 Gb	25 Gb
Storage Capacity (Personal)	NA	NA	NA	NA	250 Mb
Document Tracking History	Yes	No	Yes	Yes	Yes
Ease of Accessability to the Site	Yes	No	Yes	Yes	No
Document Approval Option	Yes	No	Yes	No	No
Email Notification	Yes	Only for folder created	Yes	Yes	Yes
Calendar Option	Yes	Yes	Yes	Yes	No
Price	$200/month	Free	$149/month	$49/month	$100/month
Capacity to Reproduce DOT Workflow	Yes	No	Yes	Yes	No

From these, the one that was chosen for further testing in the next iteration was Huddle, a collaboration and content management solution. Huddle had the most user friendly interface, was the easiest to learn how to use as well of having all the requirements presented in the sign truss workflow. Even though the sign truss shop drawing approval workflow could be recreated in this solution, it lacked the capacity of being fully customizable. This reduces the capability of having other uses and applications in other projects and integration with other communication systems, such as email.

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Specifying Learning

From this iteration several lessons learned can be identified:

- Establishing the workflow with the necessary functions and requirements before identifying solutions or alternatives proves to be the most efficient way of selecting a WPMS. The workflow not only establishes the requirements needed but it distinguishes the relationships between the document management and the different parties involved in the project.
- Most of the commercial WPMS solutions available have established tasks, interfaces, and workflows.
- Several commercial WPMS solutions meet the sign truss workflow requirements. Huddle meets these requirements. This WPMS has an already established workflow and allows little to no room of adjusting it in order to provide a customizable solution to the end users. A solution that has the option of allowing the creation of customized workflows could be more beneficial for the Iowa DOT since it can be implemented in other Iowa DOT projects.

SECOND ITERATION

Diagnosing

Using the lessons learned from the first iteration, the researchers sought a solution that was more customizable and allowed for workflows. This enables the research team and the Iowa DOT to implement the WPMS solution effectively, not only on sign truss projects, but if decided in the future, in other types of projects. Also, as established in the first iteration, an automated solution that has the capacity of sending email notifications to the respective party reviewing the shop drawings was still of importance for this iteration.

Action Planning

The researchers will compare Huddle, the WPMS from the first iteration, to Microsoft SharePoint, a web-content management system, based on the requirements of sign truss projects. The evaluation criteria for this iteration are the same as those in the first iteration.

SharePoint can be integrated with other personal content management systems and email services, such as Microsoft Outlook. Also a SharePoint expert can customize workflows in a SharePoint Depending on the Microsoft license, user access can be restricted. If the license owner has the internal license, only users who are in the internal network and have permission can access the SharePoint page. However, with an additional fee, the external license can be acquired and allows external users into the system.

Action Taking

A SharePoint page was developed by the research team using the SharePoint server space provided by the College of Engineering at Iowa State University. Based on of the sign truss shop drawing review process workflow developed in the first iteration, the SharePoint page, the document libraries, and restrictions were established. Since the SharePoint page is limited to users within the University network, the external email accounts developed in the first iterations could not be used. University email accounts were created to be used as project users within the SharePoint page. The researchers then sought a solution to grant external users access to SharePoint or provide them with an option to at least export and import documents to and from, respectively, the SharePoint project page.

Microsoft Outlook and an FTP website were considered as possible solutions. Each of them were evaluated and proposed to the TAC so a decision could be made for the third iteration. Interest was placed in developing an alternate way for external users to access the information within SharePoint, because the current license that the Iowa DOT holds does not allow granting permission to users outside of their network. Given the scope of this iteration was to only find a customizable solution and compare it to the first iteration, the decision regarding the alternative for external user access is considered as part of the third iteration.

Evaluation

As done in the previous iteration, the Microsoft SharePoint page developed was evaluated and compared with Huddle, the first iteration solution. The SharePoint solution was able to provide the opportunity of the development of the exact workflow established in the first iteration in a successful manner. Table 2 summarizes the evaluation process and comparison with Huddle.

Table 2. Evaluation of second iteration solution and comparison with huddle

	Huddle	Microsoft SharePoint
Project Capacity	25 Projects	Depends on server space
Member Capacity	Unlimited	Unlimited- Approved by Adm.
Managers	1	1
Storage Capacity (Group)	25 Gb	Depends on server space
Storage Capacity (Personal)	NA	NA
Document Tracking History	Yes	Yes
Ease of Accessability to the Site	Yes	Yes
Document Approval Option	Yes	Yes
Email Notification	Yes	Yes
Calendar Option	Yes	Yes
Price	$200/month	Depends on License
Capacity to Reproduce DOT Workflow	Yes	Yes

As it can be seen in Table 2, the performance of the two solutions is very similar with the only difference being the price of the solution. From these two, the one selected for further research and study was Microsoft SharePoint. The main decisive element was the ability of creating the customized workflow, document library and folders as well as having the option of implementing Iowa DOT terminology into the system. This WPMS allows the page developer to set all the requirements and page restrictions which can enhance the implementation of this solution to not only sign truss projects, but other Iowa DOT projects.

Specifying Learning

For this iteration, as it was in the first iteration, there were some lessons learned that are worth noting:

- A WPMS that enables the creation of customized workflows instead of a solution with an already established workflow has a better capability of reproducing the specifications of the users and the project. Since the web-page developer or administrator can create different functions and restrictions to meet the project needs, each page can be developed for particular needs.
- The solution selected, Microsoft SharePoint, can cause some difficulties, depending on the license restrictions, when it comes incorporating people outside of the server's network into the WPMS system. For this reason, a way to mitigate this situation should be addressed in order to provide to all project team members the benefits of a WPMS.

THIRD ITERATION

Diagnosing

Microsoft SharePoint proved to be a good solution for sign truss projects and other small (less than $10 Million) highway construction projects. Some difficulties that have to be overcome involve allowing external project team members access to the SharePoint page. This access allows them to upload and access shop drawings.

Action Planning

One of the main tasks is to meet with TAC to discuss options and identify ways to allow external users to upload and retrieve documents from the Iowa DOT SharePoint page. The easiest way to allow this access would be to acquire the external license. A second option is to develop an FTP site with log-in restrictions that allows external users to upload and access SharePoint. A third option is to develop an email communication system so users could send and receive project documents.

Another main task is to test SharePoint in Iowa DOT sign truss projects, and a final task is to evaluate the effectiveness of SharePoint and identify areas for improvement. Surveys will be used for this evaluation.

Action Taking

This is the current stage of the project. Meetings have been held to identify the best way to allow external users access the documents in SharePoint. Attempts have been made to identify the feasibility of acquiring the external license. Other alternatives have been considered to mitigate the option of not having the external license. The chosen alternative was to develop an FTP website and integrate it with the SharePoint page.   This will provide the external users a central place where the project documents, in this case shop drawings, will be stored. The Iowa DOT staff developed a workflow incorporating the effects of the FTP site with the already established sign truss workflow. The workflow in Figure 2 establishes how the FTP and SharePoint page meet the requirements for the shop drawing review process of sign truss projects.
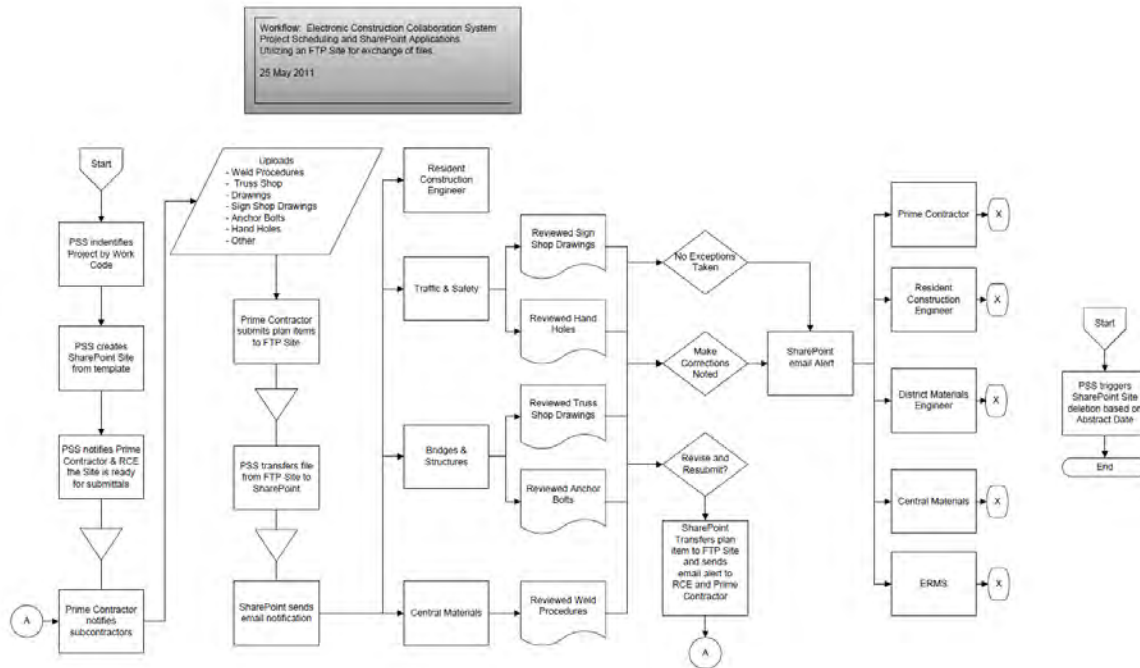
*Workflow courtesy of Karla Hocker, Iowa DOT
Figure 2. Workflow for SharePoint and FTP site implementation on sign truss projects

The SharePoint page for sign truss projects is currently under development. Once that it is developed, meetings with the TAC will be held in order to establish the evaluation criteria for the sign truss project SharePoint page and identify sign truss projects that can benefit from the implementation from a WPMS.

After implementation, surveys will be distributed to both DOT staff and external project team members.

CONCLUSION AND LESSONS LEARNED

- Action Research is an effective method to identify, test, and implement a web-based project management system. This method offers a cycle of continuous improvement that allows research and implementation teams to learn from previous iterations. Those lessons learned are applied in further iterations so a more efficient solution can be tested or implemented.
- Establishing a workflow before identifying solutions helped the researchers identify and test the solutions that met the requirements of the Iowa DOT. The workflows allowed the research team to understand the required tasks and actions that were required for this type of project.
- There are different types of commercial solutions available. The WPMS studied and analyzed by the research team can be categorized into two types of WPMS solutions: one with established workflows that allowed some customization and others with fully customizable workflow capabilities.
- Microsoft SharePoint, a WPMS that allows for workflow customization, was chosen as the solution to be implemented in the Iowa DOT sign truss projects because it could replicate the exact sign truss workflow.
- Having a TAC was an important component when identifying specifications needed in the solution to be implemented. The TAC was also important in testing the different solutions. After implementation and evaluation of the final solution by the researchers, the TAC can still perform

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several iterations, either to apply the solution in other types of projects or make adjustments to the solution workflow.
- Identifying the roles and responsibilities of each project team member at the early stages of the project, helps accelerate the development and implementation process of a WPMS solution.

AWKNOWLEDGEMENTS

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