### UNIVERSITY: The University of Tennessee

### TITLE OF PROJECT: Integrating Pavement Engineering and Road Geometric Factors into Traffic Safety Management for High Speed Facilities

### FEDERAL FUNDS:
- **Requested Amount:** $50,022
- **Proposed Duration:** 18 months
- **Desired Start Date:** 10/01/2009

### MATCHING FUNDS:
- **Source 1:** TN Dept. of Transportation (TDOT) - $101,111
- **Source 2:**

### DEPARTMENT SUBMITTING PROPOSAL:
- **PI Name/Title:** Dr. Baoshan Huang
- **Address:** 223 Perkins Hall, Dept. of Civil and Env. Eng., University of Tennessee, Knoxville, TN 37996
- **Phone:** 865-974-7713
- **Fax:** 865-974-2669
- **Email:** bhuang@utk.edu

### SUBCONTRACTING INSTITUTION:

### ADMINISTRATIVE REPRESENTATIVE AUTHORIZED TO CONDUCT NEGOTIATIONS:

### ADMINISTRATIVE ORGANIZATION’S REPRESENTATIVE:

### OTHER REQUIRED SIGNATURES:
Southeastern Transportation Center
Proposed Budget for 2009-2011
MRI
Integrating Pavement Engineering and Road Geometric Factors into Traffic Safety Management for High Speed Facilities

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| **Other Direct Costs:**                |               |               |
| Permanent Equipment                    |               |               |
| Expendable Equipment and Supplies      |               |               |
| Computer Costs                         |               |               |
| Education Costs                        |               |               |
| Graduate Student Stipends              |               |               |
| Undergraduate Student Stipends         |               |               |
| Tuition / fees                         |               |               |
| Student health insurance               |               |               |
| Activity fees                          |               |               |
| Other Costs: (specify)                 |               |               |
| Printing / duplication                 |               |               |
| Postal expense                         |               |               |
| Communication                          |               |               |
| Conference Registration / Fees         |               |               |
| Travel                                 |               |               |
| Computer Costs                         |               |               |
| Other miscellaneous costs:             |               |               |
| **Total Other Direct Costs**           | 6,700         | 80,246        |

| Indirect Costs at 26%                  | 10,322        | 20,864        |

| TOTAL COSTS ($)                        | 50,022        | 101,111       |
Integrating Pavement Engineering and Road Geometric Factors into Traffic Safety Management for High Speed Facilities

Problem Statement
High speed facilities include interstates, rural highways and other highway systems. These highways form the networks that provide essential needs and efficiency to our daily life. However, traffic accidents that occurred on these facilities are usually more severe than those on the low-speed facilities (Baruya 1998a,b; Elvik et al. 2004; Aarts and van Schagen 2006). Therefore, keeping the high speed facilities safe is of practical importance in traffic safety management.

Many factors lead to the occurrence of traffic accidents, such as traffic characteristics, speed characteristics, and pavement maintenance conditions (Aarts and van Schagen 2006; Chan et al. 2009; Cooper 1997; Garber and Ehrhart 2000; Kloeden et al. 1997, 2001, 2002; Milton and Mannering 1998; Renski et al. 1999). Speed is an important factor in traffic safety. At high speeds, the driver reaction time to changes in roadway environments is shorter, the vehicle stopping distance is longer, and therefore the maneuverability is reduced. Speed not only affects the severity of a crash, but is also related to the risk of being involved in a crash (Elvik et al. 2004). Garber and Ehrhart (2000) found that the main geometric characteristics that significantly influence safety for two-lane roads are lane width and shoulder width. For interstate highways, crash rate is significantly associated with median type, median width, the number of lanes, shoulder type, and should width, etc (Anastasopoulos et al., 2008). Chan et al. (2009) compared three asphalt pavement distress variables including rut depth (RD), international roughness index (IRI), and present serviceability index (PSI), and found that PSI is more effective in predicting crash frequency than the other two variables. Chan et al. (2009) also suggested that highway safety and pavement condition measurements be integrated into the pavement management system. Incorporating pavement engineering and road geometric factors into the highway safety management process is critical to enhance design and maintenance quality for high speed facilities.

However, there is a gap in the safety evaluation process between pavement management and highway design groups. Traditionally, skid resistance and surface texture, roughness (e.g., IRI), pavement friction and surface conditions (ruts, faults, potholes, cracks, spalls, etc.) related to different paving materials and types are the most common pavement engineering indicators of safety problems. While these pavement engineering factors are important for pavement design and maintenance, they are not utilized for traffic safety considerations by highway design and planning groups. In fact, these pavement engineering factors are complexly correlated with highway design factors, such as highway type, profile, alignment, the number of lanes, lane width, shoulder types, median types, traffic characteristic, etc. For example, curve segments have a higher demand for surface friction to reduce lane-departure crash rates. Therefore, there is a need for integrating pavement engineering and road geometric factors into traffic safety management for high speed facilities. This proposed study will focus on traffic crash modeling analyses using existing databases, the Tennessee Roadway Information Management System (TRIMS) and Pavement Management System (PMS). The process and methodology of this study is illustrated in the following diagram.
Research Objective
The objective of this proposed research is to integrate pavement engineering and road geometric factors into traffic safety management for high speed facilities with the currently available databases in the state of Tennessee, the Tennessee Roadway Information Management System (TRIMS) and Pavement Management System (PMS). The relationship between traffic accident data and pavement engineering as well as road geometric factors will be systematically and statistically analyzed. The guideline and strategy will be established for improving the safety of high speed facilities based on their conditions and for the optimal timing maintenance and management of the facilities based on the traffic safety data and the geometric characteristics.

Research Significance
The proposed research will be the first time to explore the large-scale use of existing databases (such as TRIMS and PMS) for high speed facilities safety. The advantages and potential deficiencies of the databases will be identified and summarized. Especially, the robust statistical methodology will be applied for integrating high speed facility crash history with pavement engineering and road geometric factors as an overall highway safety management, planning, and decision system. This proposed research will bring a significant influence on existing database application, high speed facility safety management, pavement engineering, road geometric factors, and high speed facility maintenance method and strategy.

Research Approach
The research approach used in the proposed study will include
- Analysis and categorization of high speed facility conditions and geometric characteristics
- Analysis and categorization of traffic accident data by accident type, severity, damage, etc.
• Statistical modeling and analyses of the relationship between high speed facility conditions, geometric characteristics, and traffic accidents
• Recommendation of the strategy for high speed facility traffic safety management.

In this proposed study, the research approach will be divided into the following tasks using appropriate research methods corresponding to different research stages:

**Task 1: Literature Review**
This task will involve an extensive literature search of published materials and on-going research projects to obtain the latest information on high speed facilities safety. Databases of TRB, TRIS, COMPENDIX AND UMI THESIS AND DISSERTATIONS will be searched.

**Task 2: Evaluation of Databases (TRIMS and PMS) and Data Preparation**
The Tennessee Roadway Information Management System (TRIMS) and Pavement Management System (PMS) of the Tennessee Department of Transportation (TDOT) will be accessed and evaluated. The relevant data will be retrieved from the TRIMS and PMS databases and prepared for statistical analysis.

**Task 3: Identifying Crash Factors and High Speed Facility Conditions**
In this task, the retrieved data from TRIMS and PMS will be processed and categorized before the statistical analysis is made. The factors contributing to the occurrence of traffic accident will be identified and categorized. The high speed facility conditions will be analyzed and categorized according to distress type, geometric characteristics, roughness, and rideability.

**Task 4: Statistical Modeling Analysis**
Advanced statistical modeling techniques, will be used for the analysis of crash data, such as the count data regression models (zero-inflated count model, the Poisson model, the Negative Binomial model, etc), categorical data regression models (logistic regressions, probit model, etc), and nonparametric regress models (hierarchical tree-based regression, neural network, etc). Corresponding to the data properties, the proper models will be applied to identify the quantitative relationships between crash frequency and severity and factors of pavement engineering and road geometric.

**Task 5: Establishing Guideline for High Speed Facilities Safety**
Based on the results from the statistical analysis, the strategy will be developed for improving the safety of high speed facilities based on their geometric characteristics and pavement engineering conditions. The findings from the proposed study will also provide a basis for optimizing the timing of maintenance for high speed facilities based on their traffic safety data.

**Task 6: Final Research Report**
A final report will be drafted upon the completion of statistical analyses. The report will include literature survey, the research methodology, findings of this project, and the recommended strategy for high speed facility maintenance from the standpoint of highway safety management.

**Research Duration and Cost**
The proposed period for this research project will be 18 months after receiving the fully executed contract or a letter authorizing the starting data. The time period will include the final review and approval of the final report. The total cost of this project is estimated to be $49,998. Detailed information about the schedule and the budget can be found in the schedule/timeline and budget forms.

**Qualifications of Research Team**

Dr. Baoshan Huang will be serving as the PI for the proposed research. Dr. Huang is an associate professor in civil engineering at the University of Tennessee. He has recently finished a research study on the effects of asphalt pavement conditions on traffic accidents in Tennessee utilizing Pavement Management System (PMS). He has been involved in pavement research for over fourteen years. His past research has been focused on various aspects of asphalt pavements. He has published more than twenty peer reviewed journal papers for his research in pavement engineering. A detailed curriculum vita is attached as an appendix to this proposal.

Drs. Stephen Richards and Xuedong Yan will both serve as the Co-PI for the proposed research. Dr. Stephen Richards currently serves as the director of the Southeastern Transportation Center and an associate professor in civil engineering at UT. Dr. Richards is a nationally-known expert in several important areas of traffic safety and operations, including: accident data analysis, congestion management, construction zone safety, level of service, human factors involving motorists, traffic control devices, ITS applications, pedestrian/bicycle facilities and issues, railroad-highway grade crossings, roadside design, traffic models, traffic software, and truck safety.

The other Co-PI of this proposed project, Dr. Xuedong Yan, currently serves as the transportation safety research director at the Southeastern Transportation Center and a research assistant professor at The University of Tennessee (UT). His areas of expertise include: driving simulator, human factors, database analysis, statistical modeling, highway design, and intelligent transportation systems. He has published more than 60 technical articles and reports in the field of traffic safety and operation.

The PI and Co-PIs have been involved in teaching and conducting research in traffic safety and operations, highway design, and highway pavement related topics for many years. Their most recent journal publications (2008-2009) relevant to this proposed project are listed in the following:


**Student Involvement**

Two graduate students will be involved in this proposed project to learn the GES database, assist in data preparation, and practice statistical techniques in traffic crash data analyses. The proposed research study could be developed into a master thesis or even a dissertation topic.

**Technology Transfer**

In addition to publishing the research findings in peer reviewed research journals (such as STC safety journal, TRR, AAP, or JST), the research team plans to organize a workshop or seminar to TDOT and TDOS professionals to help improve their individual traffic and decide on the appropriate pavement maintenance strategy.

**References**

Cooper, P.J., 1997. The relationship between speeding behavior (as measured by violation convictions) and crash involvement. Journal of Safety Research, 28(2), 83–95.


### STC Research Schedule/Timeline

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<tr>
<th>Task / Month</th>
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<td>Task 3: Identifying Crash Factors and High Speed Facility Conditions</td>
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Appendix A: Curriculum Vita of Principal Investigator

Baoshan Huang, Ph.D., P.E.
Associate Professor
Department of Civil and Environmental Engineering
The University of Tennessee
Knoxville, TN 37996
Tel: (865) 974-7713, Fax: (865) 974-2669, Email: bhuang@utk.edu

SUMMARY:
Baoshan Huang joined the faculty of the Department of Civil and Environmental Engineering at the University of Tennessee in January 2002. He received his Ph.D. degree in civil engineering from the Louisiana State University, his M.S. and B.S. degrees from Tongji University in Shanghai, China. Prior joining to the University of Tennessee, he was a senior asphalt research engineer at the Louisiana Department of Transportation and Development (LADOTD). His professional career includes over 20 years of experience in pavement and geotechnical engineering with academia, industry and government agencies. He is registered as a professional engineer in Louisiana.

RESEARCH INTERESTS:

Pavement Engineering – Pavement Design and Testing, Construction Quality Control (QC) and Quality Assurance (QA), and Pavement Management System (PMS).


EDUCATION:
- Louisiana State University, Ph.D. in Civil Engineering, 1994 – 2000
  Dissertation Title: Fundamental Characterization and Numerical Simulation of Large Stone Asphalt Mixtures
- Tongji University, China, M.S. in Civil (Geotechnical) Engineering, 1985 – 1988
  Thesis Title: Random Field Application on Engineering Geological Mapping
- Tongji University, China, B.S. in Civil (Geotechnical) Engineering, 1980 – 1984

Profession Registration:
Louisiana P.E. Registration No. 27660 (Since Jan., 1998)

Funded Research (at UTK):
- Principal Investigator, Georgia DOT, “Laboratory Evaluation of Polymer-Modified Pervious Concrete (PMPC),” Georgia Department of Transportation, 2008 – 2009, $68,302


Funded Research (Prior Joining UTK):


Principal Investigator, China National Key Research Project, “Engineering Geological Mapping & Geotechnical Information System of Shanghai Pudong New Area,” 1990 – 1994, Budget: RMB ¥1,000,000 (Approx. $120,000)

Employment History:

- Associate Professor, The University of Tennessee, 2008 - present
- Assistant Professor, The University of Tennessee, 2002 – 2008
- Sr. Research Engineer, Louisiana Transportation Research Center, 2001 – 2002
- Research Associate, Louisiana Transportation Research Center, 1997 – 2001
- Graduate Assistant, Louisiana State University, 1994 – 1997
- Research Engineer, Shanghai Institute of Geotechnical Investigation and Design, 1988 – 1994
- Assistant Engineer, Shanghai Institute of Geotechnical Investigation and Design, 1984 – 1985

Journal Publications:

Published


• Huang, B., J. Xu, “Urban Geotechnical Information System,” Urban Investigation, No.2, 1992, Beijing, China


Patent (Non-Provisional):
• **Huang, B.** J. Cao and X. Shu, Recycling Industrial Waste through Development of Chemically Active Coating by Coupling Agent, (filed through The University of Tennessee Research Foundation)

• **Huang, B.** X. Shu and Hao Wu, A Novel Testing and Analysis System for Loaded Wheel Tester (LWT), Invention Disclosure Filed to The University of Tennessee Research Foundation.

**Conference Papers:**


• **Huang, B.** X. Shu, “Development of Three-Layered HMA Composite,” International Conference on Asphalt Pavements, August 12 – 17, 2006, Quebec City, Canada.


• Huang, B., G. Li and X. Shu, “Three-Layered Composite HMA,” ICCE/12, Twelfth International Conference of Composite/Nano Engineering, Tenerife, Spain, August 1 – 6, 2005.


Technical Reports:


Presentations:


- Huang, B., “Development of Polymer Modified Pervious Concrete,” Invited Presentation to Pavement Faculty and Graduate Students at Changsha University of Science and Technology, October 28, 2008.


- Huang, B., “Materials Science Applications in Asphalt Paving Materials,” Invited Presentation to Faculty and Graduate Students at Tongji University, October 24, 2008.


- Huang, B., “Pavement Research Program at the University of Tennessee – Effects of Coarse Aggregate Angularity on Rutting Performance of HMA,” Invited Lecture at the Changsha University of Science and Technology, Changsha, China, September 18, 2007.


Huang, B., “Improve the Properties of Rubber-Modified Cement-Based Composite with Coupling Agent,” ICCE-14, Fourteenth International Conference of Composite/Nano Engineering, July 2 – 8, 2006, Boulder, CO.

Huang, B., “Geotechnical Investigation for Highway Engineering,” Invited Lecture at the Shanghai Geotechnical Investigation and Design Institute, Shanghai, China, June 22, 2006.


Huang, B., “Fatigue Properties of HMA Mixtures Containing RAP,” Invited Lecture at the Jiangsu Transportation Research Institute, Nanjing, China, June 20, 2006.


Huang, B., “Recent Development of HMA Technology in USA,” Invited Lecture at Shanghai University, Shanghai, China, June 9, 2006.


- **Huang, B.** “Experimental Study on Properties of Portland Cement Concrete Containing Recycled Asphalt Pavements,” 8th International Conference on Concrete Pavements, August 13–18, 2005, Colorado Spring, Colorado.


- **Huang, B.** “Laboratory Evaluation of Semi-Circular Bending Tensile Strength Test for HMA Mixtures,” 84th Annual Meeting of the Transportation Research Board, January 9–13, 2005, Washington, DC.

- **Huang, B.** “Laboratory Investigation of Mixing HMA with RAP,” 84th Annual Meeting of the Transportation Research Board, January 9–13, 2005, Washington, DC.


- **Huang, B.** “Development of HMA Pavements in USA,” Invited Lecture at the Guizhou Department of Transportation, Guiyang, Guizhou Province, China, August 12, 2003

- **Huang, B.** “Hot-Mix Asphalt Paving Technology for Racing Tracks,” Invited Speech at the Shanghai Urban Construction Group, Shanghai, China, November 5, 2002

- **Huang, B.** L.N. Mohammad, F.L. Roberts, and H. Qin, “Numerical Validation of Pavement Performance at the Louisiana Accelerated Loading Facility (ALF),” Ninth International Conference on Asphalt Pavements, Copenhagen, Denmark, August 21, 2002

- **Huang, B.** L.N. Mohammad, C. Abadie, “Development of Large Stone Asphalt Mixtures in Louisiana,” 4th International Conference of Pavement and Airfield Technology, Kunming, China, April 25, 2002


Graduate Students Supervised:

Graduated

- Xiang Shu (Ph.D., graduated in August 2007, APPLICATION OF PARTICULATE-FILLED COMPOSITE THEORY TO HOT-MIX ASPHAL MIXTURES)

- Susannah Culbertson (M.S., graduated in May 2003, SENSITIVITY AND STATISTICAL ANALYSES OF VARIABLES INFLUENCING PERMANENT DEFORMATION)

- William Kingery, III (M.S., graduated in May 2004, LABORATORY STUDY OF FATIGUE CHARACTERISTICS OF HMA SURFACE MIXTURES CONTAINING RECYCLED ASPHALT PAVEMENTS (RAP))
• **Dragan Vukosavijevic** (M.S., graduated in August 2006, *LABORATORY STUDY OF FIELD HMA MIXTURES CONTAINING RAP*)

• **Laura Robison** (M.S., graduated in August 2006, *EFFECTS OF COARSE AGGREGATE ANGULARITY TO RUTTING PERFORMANCE OF HMA MIXTURES*)

• **Wenbin He** (M.S., graduated in December 2006, *LABORATORY EVALUATION OF UNBOUND RAP AS A PAVEMENT BASE MATERIAL*)

• **Chun-Yip Chan** (M.S., graduated in December 2008, *CORRELATING PAVEMENT CONDITIONS TO TRAFFIC SAFETY UTILIZING PAVEMENT MANAGEMENT SYSTEM*)

**Current**

• **Qiao Dong** (Ph.D., scheduled to graduate in May 2010, *OPTIMAL TIMING OF PREVENTIVE MAINTENANCE FOR ASPHALT PAVEMENTS*)

• **Hao Wu** (Ph.D., scheduled to graduate in August 2010, *INNOVATIVE STUDY UTILIZING ASPHALT PAVEMENT ANALYZER*)

• **Jingsong Chen** (Ph.D., scheduled to graduate in August 2010, *MICROMECHANICAL ANALYSES OF ASPHALT-AGGREGATE COMPOSITES*)

**Paper Reviewers:**

• Asphalt Paving Technology, Journal of AAPT

• ASCE Journal of Materials in Civil Engineering

• ASCE Journal of Geotechnical and Geoenvironmental Engineering

• ASCE International Journal of Geomechanics

• Composites Part A: Applied Science and Manufacturing

• Composites Par B: Engineering

• International Journal of Pavement Engineering

• International Journal of Road Materials and Pavement Design

• Journal of ASTM International

• Journal of Composite Materials

• Journal of Transportation Research Record

**Editor/Co-Editor:**

• Associate Editor – ASCE Journal of Materials in Civil Engineering

• Editor – Pavement Mechanics and Performance (ASCE Geotechnical Special Publication 154)

**Courses Taught (at UTK):**

• CE321 – Civil Engineering Materials
• CE521 – Pavement Design
• CE522 – Asphalt and Portland Cement Concrete Mixture Design
• CE525 – Advanced Pavement Materials Characterization
• CE691 – Advanced Highway Materials
• CE691 – Pavement Mechanics

Awards and Honors:
• College of Engineering Research Fellow Award, The University of Tennessee in April 2007
• CEE Department Research Recognition Award in April 2006
• College of Engineering Research Fellow Award, The University of Tennessee in March 2005
• CEE Department Scholar Recognition Award, The University of Tennessee in May 2004
• Third Degree National Award in 1992 by the Ministry of Construction, PRC
• Award for Technological Development by the City Commission of Science and Technology of Shanghai in 1992

Professional Membership:
• Active Member (1999 – Present), Association of Asphalt Paving Technologists (AAPT)
• Member (1999 – Present), American Society of Civil Engineers (ASCE)
• Voting Member (2002 – Present), International Society for Asphalt Pavement (ISAP)
• Member, (1999 – 2000) National Society of Professional Engineers
• Member, (2003 – Present) American Society of Testing Materials (ASTM), D04
• Control Member (2000 – Present), ASCE Bituminous Materials Committee (currently vice chairman)
• Steering Member (2003 – Present), ASCE Pavement Engineering Committee
• Committee Member (2003 – Present), TRB AFP60, Committee on Engineering Behavior of Unsaturated Soils
• Committee Member (2004 – Present), TRB AFK30, Committee on Characteristics of Nonbituminous Components of Bituminous Paving Mixtures
• Committee Member (2006 – Present), TRB AFB80, Committee on Strength and Deformation of Pavement Sections