1. A title page listing the PI and Co-PIs and their affiliation.

Title: **Assessment of Vehicle Performance in Harsh Environments Using Driving Simulator and Numerical Simulations**

Proposal submitted to

Gulf Coast Research Center for Evacuation and Transportation Resiliency

Principal Investigator: **Steve C.S. Cai, Ph.D., PE**

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Associate Professor

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Jan. 2013

Abstract: The present study aims to investigate the safety of vehicles during normal operations as well as emergencies through experimentally and numerically replicating the natural environments. An attempt will be made to simulate the complicated weather, road surface, and driver operational process, such as rain, camber, grade, and acceleration/deceleration as well as steering processes. With the proposed accident assessment framework, the accident-related response is studied and accident risks are assessed for vehicles. The present study may provide a useful basis for traffic designs on highways with complicated topographic and weather conditions and optimization of evacuation routes and strategy that may lead to minimized single-vehicle accident risks.

2. Technical description not to exceed five (5) double spaced pages.

2.1 Background

The negative effects of weather (e.g. strong winds, snow, and icy rain) on the safety of vehicles have been recognized and reported upon for some time worldwide. As an important category of vehicle accidents, the single-vehicle non-collision accidents under adverse environmental and topographic conditions have not been studied sufficiently. In the United States, strong wind, together with other adverse weather and topographic conditions, has been blamed for many single-vehicle accidents every year, especially those involving trucks. Vehicle safety not only threatens people's lives during normal operations, but may even put many people in miserable situations when an emergency evacuation is interrupted by accidents on key routes. As a result, the safety of many people who are stuck in the evacuation routes may be jeopardized. The reasons that cause single-vehicle accidents can be very complicated: from a single primary reason such as a strong gust to the combination of several reasons such as weather conditions, vehicle conditions, road surface conditions, driver operational errors, etc.

The present study aims to investigate the safety of vehicles during normal operations as well as emergencies through experimentally and numerically replicating the natural environments. An attempt will be made to simulate the complicated weather, road surface, and driver operational process, such as rain, camber, grade, and acceleration/deceleration as well as steering processes. With the proposed accident assessment framework, the accident-related response is studied and accident risks are assessed for vehicles. The present study may provide a useful basis for traffic designs on highways with complicated topographic and weather conditions and optimization of evacuation routes and strategy that may lead to minimized single-vehicle accident risks.

2. 2 Specific Objectives/Goals

The main goal of this research study is to lay a foundation for modeling the vehicle performance during harsh conditions that can be used as part of assessments to decide when evacuation routes need to be closed during hurricane and tropical storm events.

1. Investigate how to use the driving simulator to replicate vehicle performance of typical vehicles used by the general public, fire departments, emergency management teams, etc.
2. Study the driver response to different driving conditions (such as windy, wet conditions) and develop the corresponding mathematical model for drivers' response, i.e., steering reaction.
3. Develop an analysis framework and estimate the rollover risk index of vehicles under different combinations of environmental and driver operational conditions;

2. 3. Significance and literature review

Historically, most studies on truck crash risks and injuries in the past were dominantly related to multiple-vehicle crashes focusing on traffic conflicts. Single-vehicle crashes, which were often more often and devastating than multiple-vehicle collision crashes in the United States, can be caused by many reasons, such as adverse environments (e.g. inclement weather and road topographic conditions) and driver's errors due to fatigue and sleepiness, etc. For example, large trucks, as a type of typical high-sided vehicles, are especially vulnerable to rollover crashes when strong wind, slippery road surfaces, slopes, curves, operational errors or mechanical failures (e.g. brake failure) exist. In spite of accounting for about 30% of all crashes involved of large trucks, single-vehicle truck crashes and injuries studies considering adverse environments are very limited.

Compared to multiple-vehicle crashes, large-truck single-vehicle crashes and injuries are more complicated phenomenon resulting from coupled interactions between **people** (e.g. truck drivers), **transportation infrastructures** (e.g. trucks and highways) and **natural environments** (e.g. inclement weather and topographic features) which warrant interdisciplinary research to address the resulting problems. For example, each year more than 1.5 million vehicular crashes is associated with adverse weather, which results in 800,000 injuries and 7,000 fatalities in the country [The National Academies

2006]. Inclement weather, such as strong crosswind gusts, snow, rain, fog and ice, can greatly threaten the stability of large trucks.

Vehicle performance in harsh windy environments, especially during dynamic, gusty, intermittent wind loadings experienced during hurricane events, is an extremely important safety consideration and should be considered in any route closure assessment. Few and limited studies have been carried out in terms of vehicle safety in a windy environment. Baker (1991) made exploratory studies on the performance of high-sided vehicles in crosswinds on roads. Coleman and Baker (1990) investigated wind tunnel tests on several particular vehicle models to identify the wind loadings on vehicles. Saiidi and Maragakis (1995) investigated minimum wind speeds to overturn common motor vehicles. Pinelli et al. (2003) studied wind effects on emergency trucks in a static equilibrium approach. None of these studies utilized the dynamic, gusty and intermittent wind loadings experienced with hurricane winds. The closest studies was undertaken by Schmidlin et al. (2002) where they investigated the possibility of vehicles overturning in stationary conditions during hurricane winds. However, long before the stability of a vehicle (to overturn) becomes a factor, the ability of a vehicle to retain a relatively straight path forward becomes an issue. It is worthwhile to determine when vehicles will begin to find it difficult to remain in their lanes due to dynamic, gusty and intermittent hurricane winds. This study explores reproducing sample hurricane winds in two dimensions, side thrusts and longitudinal loadings, by utilizing a driving simulator to mimic real life situations. Future research will build on the findings of this study to investigate vehicle performance subject to harsh hurricane wind conditions.

2.4 Methods and Data Analysis

Task 1: Simulation Using Driving Simulator

Figure 1 below shows snapshots of the LSU driving simulator which will be used for this study.

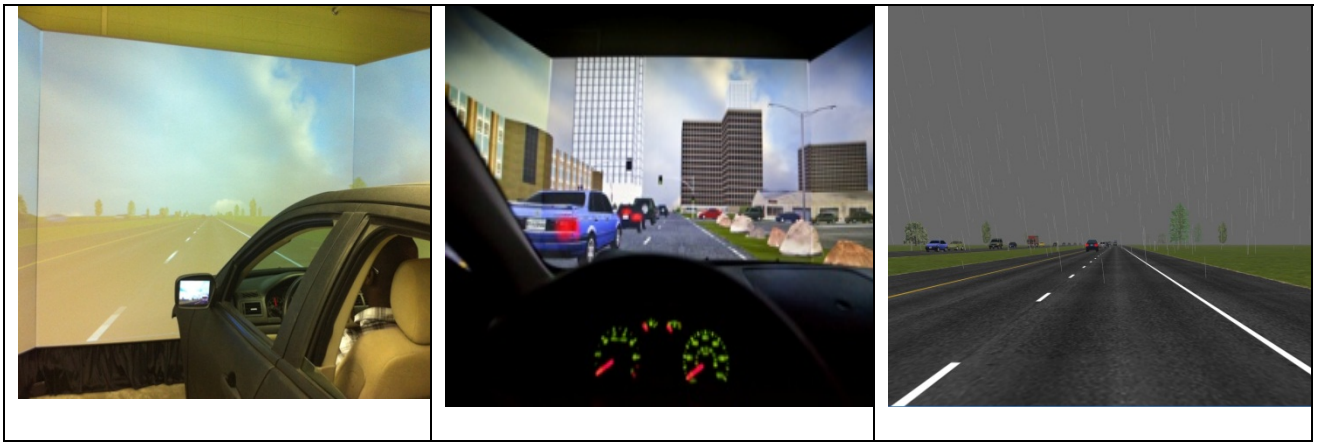

Figure 1: A side view of the LSU driving simulator with simulated environments

The driving simulator provides multi-channel audio/visual systems with 180˚ display, full-width automobile cab including windshield, driver and passenger seats, center console and dash, full instrumentation, control loaded steering, braking and acceleration, mini-LCD rear-view mirrors plus real-time one degree of freedom motion simulation. This driving simulator has a library of residential, urban, rural, commercial, industrial, highway, intersection and traffic signal control; autonomous, interactive ambient traffic; extensive, interactive scripted vehicle activity; variable roadway friction and weather effects; and data collection definition. Its flexible scenario creation interface and customizable highway system design tools will enable the research team build the various virtual simulation networks that will be used for this study.

The dynamics of the driving simulator can be modified within the SimCreator proprietary software tool which is a graphical simulation and modeling system. At its top level, it represents a graphical user interface that allows placement and connection of various components including extensive, scripted vehicle activity in C/C++ code components. Relevant components will be explored and modified to allow the driving simulator to behave (vehicle component loadings) as a sedan, SUV, minivan, fire truck, mass transportation bus and a commercial truck.

Task 2: Simulation of Vehicle Performance and Data Analysis

This task involves observing the effect of wind forces and other harsh conditions such as wet road surface on test subjects. A selection of sample of students will be used as test subjects to experiment with

the driving simulator. The purpose of this is to make a preliminary observation of the effect of the harsh conditions on different driving behaviors/ styles. For each simulation scenario, data will be collected throughout the experiment to measure how each human subject reacted and responded to the different wind forces and vehicle type. Data will be collected in two ways: through the monitoring software tools provided by the proprietary SimObserver and Data Distillery software and secondly by interviewing the test subjects.

Task 3: Assessment of Vehicle Performance

The PI's group has developed a general truck rollover crash risk estimation model, which can consider the adverse weather, topographic and driver operational conditions [Chen and Cai 2004, Chen et al. 2009]. The driver operational condition is quantified with vehicle speed and reaction time under different vigilant level (e.g. good, average or poor). The information of the drivers' behavior from Task 2 will be incorporated in the analysis. A rollover risk index (an indicator of rollover risks, from 0-1) will be assigned to each type of vehicles under different combinations of weather conditions (e.g. wind, rain, ice or snow), topographic conditions (e.g. grades, curves and camber) and driver operational condition (e.g. vehicle driving speeds and vigilant level). This information will be useful for evacuation planning and transportation management.

Task 4: Final Report

A final report documenting the entire research effort, including the methodology used in the research, conclusions drawn from the research, and recommendations for future research and implementation plan will be submitted.

2.5. Future Direction

The PI has worked on vehicle single–vehicle crash and interactions with transportation infrastructures (bridges and highways) for many years with many publications. Besides, the co-PI has been working on drivers' behavior using the driving simulator. It is obvious that although the proposed pilot study is only for demonstrative purpose, the whole study can be expanded to study vehicle safety of any major interstate around the nation. Through working on this proposed pilot study, the PIs have envisioned for future research through seeking supports from other federal agencies.

References

Chen, S.R. and Cai, C.S. (2004). "Accident assessment of vehicles on long-span bridges in windy environments." Journal of Wind Engineering and Industrial Aerodynamics, 92(12), 991-1024.

S. R. Chen, C. S. Cai and B. Wolshon (2009). "From normal operation to evacuation: single-vehicle safety under adverse weather, topographic and operational conditions", Natural Hazards Review, ASCE (in press)

The National Academies (2006). "Where the weather meets the road- a research agenda for improving road weather system", Report in Brief, The National Academies.

Baker, C.J. (1991) "Ground vehicles in high cross winds part II: Unsteady aerodynamic forces" Journal of Fluids and Structures, Vol.5, Issue 1, 91-111.

Coleman, S.A. and Baker, C.J. (1990) "High sided road vehicles in cross winds" Journal of Wind Engineering and Industrial Aerodynamics, 36: 1383-92.

Saiidi, M. and Maragakis, E. (1995) "Indentification of trigger wind velocities to cause vehicle instability: final report to the Nevada Department of Transportation"

Pinelli, J. P. and Subramanian, C. (2003) "Wind Effects on Emergency Vehicles." Final Report to Florida Department of Community Affairs

Schmidlin, T.W., B. Hammer, P. King, Y. Ono, L.S. Miller,G. Thumann. 2002. "Unsafe at any (wind) speed? Testing the stability of motor vehicles in severe winds" *Bulletin of the American Meteorological Society* 83:1821-1830.

3. A description of recent activities carried out by the PI and/or the Co-PIs relevant to the proposed topic including papers published, research contracts, presentations, Master Degree theses, and Ph.D. Dissertations. This summary should not exceed two pages.

The PI (Cai) received a NSF grant (CMS-0301696, 07/01/2003–06/30/2006, $311,565) titled "*Investigation of Large Coastal Bridge Performance in Hurricane Environment*". This project focuses on wind sensitive long-span bridges and their interaction with traffic loads in extreme cases of hurricane evacuation. The objective of the research is to investigate the effect of the traffic on bridge aerodynamic behavior and then to predict the maximum wind velocity that is safe for the vehicles and the bridge. Meanwhile, it is to develop a movable tuned mass damper (TMD) for vibration control in extreme winds to ensure the bridge safety and extend the amount of time the bridge can remain open for evacuating traffic. In the last few years this research has been extended to study traffic performance on highways, which has resulted in many related publications and presentations, and laid a good foundation for the proposed pilot study.

Published papers etc:

Han, Yan, C. S. Cai, Zhengqing Chen, Jiexuan Hu, Chunguang Li (2012) "Aerodynamic Forces of Vehicles on the Bridge under Crosswinds,", the International Conference on Advances of Civil Infrastructures, Changsha, China, Sept. 14-16. (also presented)

Han, Yan, C. S. Cai, Zhengqing Chen, Jiexuan Hu, Chunguang Li (2012) "Wind tunnel measurements of aerodynamic forces on vehicles and Bridges under Crosswinds," Proceeding of the 12th International symposium on structural engineering, pp 658-672, Science Press, Beijing, China, on Nov. 17-19, 2012, Wuhan, China (also presented).

Han, Yan, C. S. Cai, Zhengqing Chen, Jiexuan Hu, Chunguang Li (2012) "Wind tunnel measurements of aerodynamic forces on vehicles and bridges under crosswinds" The Seventh International Colloquium on Bluff Body Aerodynamics and Applications (BBAA7), Shanghai, China; September 2-6, 2012. (also presented)

C.S. Cai, Wei Zhang, Xianzhi Liu, Wei Peng, S. R. Chen, Yan Han, and Jiexuan Hu (2012) "Framework of Wind-Vehicle-Bridge Interaction Analysis and its Applications" , Proceeding of the 12th International Symposium on Structural Engineering, pp 36-52, Science Press, Beijing, China, on Nov. 17-19, 2012, Wuhan, China (keynote presentation).

S. R. Chen, C. S. Cai and B. Wolshon (2009). "From normal operation to evacuation: single-vehicle safety under adverse weather, topographic and operational conditions", Natural Hazards Review, ASCE (in press)

Cai, C. S., X. Z. Liu, and Chen, S. R. (2008) "Investigation of Wind Effects on Coastal Long-span Bridges and Vehicles." Proceedings of 2008 NSF Engineering Research and Innovation Conference, Knoxville, Tennessee (also poster-presented).

Cai, C.S. Suren Chen and Xianzhi Liu (2008) "Wind Effects on Bridges and Traffic along Coastal Transportation Infrastructure Lines" The 10th International Symposium on Structural Engineering for Young Experts, Oct. 19-21 2008, Changsha, China. (also presented). pp 24-28, published by Science Press, China.

Liu, X. Z., Cai, C. S., Levitan, M. and Nikitopoulos, D. (2007). "Wind tunnel test for mean wind loads on road vehicles" 12th International Conference on Wind Engineering Cairns, Australia, July 2-6, 2007. (also presented)

Chen, S.R. and Cai, C.S. (2004). "Accident assessment of vehicles on long-span bridges in windy environments." Journal of Wind Engineering and Industrial Aerodynamics, 92(12), 991-1024.

Chen, S.R. (2004). "*Dynamic performance of bridges and vehicles under strong wind", Ph. D. dissertation, Louisiana State University.*

The study team also involves Dr. Ishak (co-PI), who is the manager of the LSU driving simulator facility and has research experience in several and diversified topics in transportation engineering including traffic simulation, data collection technologies, traffic operations, traffic safety, Intelligent Transportation Systems applications, and artificial intelligence. Project management skills as a result of managing and directing as a PI and Co-PI several research projects. Some related previous and current research projects are:

- S. Ishak (PI), "Distracted Driving and Associated Crash Risk", Gulf Coast Research Center for Evacuation and Transportation Resiliency/USDOT/ Louisiana Transportation Research Center, $117,175 (2012-2013).
- F. Aghazadeh (PI), L. Ikuma (Co-PI), and S. Ishak (Co-PI), "Effect of Changing Driving Conditions on Driver Behavior towards Design of a Safe and Efficient Traffic System", Gulf Coast Research Center for Evacuation and Transportation Resiliency/USDOT, $82,143 (2012-2013).
- H. Shin (PI) and S. Ishak (Co-PI), "History of Road Design Standards in Louisiana DOTD", Louisiana Transportation Research Center, $149,999 (2012-2013).
- S. Ishak (PI), "Modeling the effect of gusty hurricane wind force on vehicles using LSU driving simulator", Louisiana Transportation Research Center, $30,000 (2012-2013).
- S. Ishak (PI), "Measuring Effectiveness of Ramp Metering Strategies on I-12", Louisiana Department of Transportation and Development / Louisiana Transportation Research Center, $99,999 (2011-2012).

Most Recent Refereed Journal Publications

- Cheng, D. and S. Ishak. A Dynamic Feedback-Control Toll Pricing Methodology for Revenue Maximization: A Case Study on I-95 Managed Lanes, accepted for publication in the Journal of Transportation Research Board, 2013.
- Qi, Y.* and S. Ishak. Stochastic Approach for Short-Term Freeway Traffic Prediction for Peak Periods, the IEEE Transactions on Intelligent Transportation Systems, accepted for publication, in press.
- Alecsandru, C.*, S. Ishak, J. Stanley*, and Y. Qi*. (2012) Passenger Car Equivalents of Trucks on Four-Lane Rural Freeways under Lane Restriction and Different Traffic Conditions, accepted for publication in the Canadian Journal of Civil Engineering, in press.

- Rayaprolu, P.*, S. Ishak, Y. Qi*, and B. Wolshon. (2012) Operational Assessment of Joint and Conventional Lane Merge Configurations for Freeway Work Zones, accepted for publication in the Journal of Intelligent Transportation Systems, in press.
- Ishak, S., Y. Qi*, and P. Rayaprolu*. (2012) Crash Analysis and Safety Evaluation of Joint and Conventional Lane Merge Configurations for Freeway Work Zones, Journal of Traffic Injury Prevention, Vol. 12 (2).
- Qi, Y.*, S. Ishak, B. Wolshon, and C. Alecsandru*. (2012) Traffic Behavior and Compliance to Truck-Restriction Policies on Four-Lane Rural Freeways, Journal of Transportation Safety and Security, Vol. 4(2).
- Korkut, M.*, S. Ishak, and B. Wolshon. (2010) Freeway Truck Lane Restriction and Differential Speed Limits: Crash Analysis and Traffic Characteristics, Transportation Research Record, Journal of the Transportation Research Board, No. 2194, 11-20.

4. Potential Benefits of the Project (including potential to use as a basis to attract future external funding), Relationship to Recently Completed, On-going, or Proposed Research Projects, Contribution to the field of Evacuation or Transportation Resilience

Very limited studies have been carried out in the US in terms of vehicle safety in a windy environment. All the previous studies focused on parked vehicles and did not consider the driver behavior, vehicle dynamics, driving condition, road surface conditions, and many other important factors. These results, while providing information for stationary (or parked) vehicles, cannot be reliably applied to moving vehicles on the roads. For example, a 40 mph wind may not pose any risk on a vehicle in the parking lot. However, it may cause a vehicle accident on the highway. *A more general and more realistic accident analysis model that can be used for vehicles on roads is desirable for transportation planning and management, as well as for hazard mitigation.*

In his endeavor to deal with these issues, the PI submitted a proposal to NSF (Proposal No. 0600470). The review comments are very encouraging with a recommendation of “Fund If Possible”. The complete, unedited panel review summary is attached.

The PI’s potential to attract federal funding in the proposed research area is indicated with those comments and panel recommendation. The proposal will be modified and resubmitted to secure NSF and/or other federal funds. The proposed pilot study will help strengthen the PIs’ research and help achieve the funding goals. Given the fact that hurricane-related issues are becoming more important after the disaster

caused by Hurricane Katrina, the federal funding picture is most likely to change in the near future. For this purpose, the seed support is very important to initiate and promote the research, and eventually for LSU to excel in competing for federal research funding. Moreover, the understanding of transportation behavior in strong winds and the corresponding advancement of the related basic science will have broad impact to transportation engineering community. This impact will be national and international in scope.

Organization: Louisiana State University & Agricultural and Mechanical College

Panel Summary #1

Proposal Number: 0600470

Panel Summary:
Panel Summary

The proposed scope of work addresses a new problem by looking into the performance of highway systems, including bridges, highways and vehicles under hurricane-induced harsh environments. The investigator is highly qualified to conduct the study based on past achievements and current resources. However, the proposal addresses problems unique to New Orleans and neglects to mention probable extensions to other geographical areas. The proposer should address the ways in which their project results would deviate from those achieved in recent work by Schmidlin and colleagues. The vehicle types selected for study should be more representative of those expected for use by the general public and not just emergency personel under hurricane conditions. The broader impacts of the proposed study are not well articulated. The proposal should specify how the study findings would directly impact on evacuation planning.

Panel Recommendation: Fund If Possible

Back to Proposal Status Detail

Steve C. S. Cai, Ph.D., PE - BIOGRAPHICAL SKETCH

A. EDUCATION AND HONORS

1993 Ph.D. in Civil/Structural Engineering, University of Maryland, College Park
1987 M.S. in Civil/Structural Engineering, Tsinghua University, Beijing, China
1983 B.S. in Civil/Structural Engineering, Zhejiang University, Hangzhou, China
1993 Best Student Paper Award, 10th International Bridge Conference, Pittsburgh
1993 Merit Award, James F. Lincoln ARC Welding Foundation
1991-1993 Dwight D. Eisenhower Fellowship, NHI/FHWA, McLean, Virginia
1990-1992 Graduate School Fellowship, University of Maryland, College Park
2006 Achievement Awards, Department of CEE, LSU
2008 Best paper award, ASCE Earth and Space Conference, Long Beach, CA
2008 Top 100 outstanding research and creative faculty- Rainmakers Award, LSU
2008 Roy Paul Daniels Distinguished Professor, LSU (yearly renewable)
2009 Top 100 outstanding research and creative faculty- Rainmakers Award, LSU
2009 Co-author of a journal paper awarded "Collingwood Prize", ASCE
2010 Elected ASCE Fellow
2010 Awarded the Edwin B. and Norma S. McNeil Distinguished Professorship
2011 Achievement Awards, Department of CEE, LSU
2011 Outstanding Young Researcher Award, Louisiana Transportation Research Center Foundation. In recognition of his accomplishments in the field of transportation
2012 Leslie D. Martin Award of Merit for the Outstanding Technical Publication"Bridge Design Manual, Third Edition", Precast/Prestressed Concrete Institute
2012 Certificate of Appreciation for the Outstanding Lecture at the 2012 New Millennium Yuelu International Forum on Advanced Construction Technology, Hunan University, China

B. PROFESSIONAL POSITIONS HELD

Aug. 2010 - present Professor, Department of Civil and Environmental Engineering, Louisiana State University, Baton Rouge
Aug. 2001 - 2010 Assistant/Associate Professor, Department of Civil and Environmental Engineering, Louisiana State University, Baton Rouge
Aug. 2000 – Aug. 2001 Assistant Professor, Department of Civil Engineering, Kansas State University, Manhattan, Kansas
June 1996 - Jul. 2000 Senior Structural Engineer, Structures Research Center, Florida Department of Transportation, Tallahassee, FL
Aug. 1993 -May 1996 Project Engineer, Michael Baker Jr., Inc., Pittsburgh, PA

C. SELECTED PUBLICATIONS (totally over 100 journal papers)

i) Five publications most closely related to the proposed project:

1 Chen, S.R., and **Cai, C. S.** (2006) **"**Unified approach to predict the dynamic performance of transportation system considering wind effects" Structural Engineering and Mechanics, An International Journal, 23(3), 279-292.
2 **Cai, C. S.**, Chen, S. R. (2004) "Wind Vibration Mitigation of Long-span Bridges in Hurricanes", Journal of Sound and Vibration, Elsevier, 274 (1-2), 421-432.
3 Chen, S. R. and **Cai, C. S.** (2004) "Coupled Vibration Control with Tuned Mass Damper for Long-Span Bridges ", Journal of Sound and Vibration, Elsevier, 278(1-2), 449-459.
4 **Cai, C. S.** and Chen, S. R. (2004) "Framework of vehicle-bridge-wind dynamic analysis ", J. of Wind Engineering and Industrial Aerodynamics, Elsevier, 92 (7-8), 579-607.

5 Chen, S. R. and **Cai, C. S.** (2004). "Accident assessment of vehicles on long-span bridges in windy environments" Journal of Wind Engineering and Industrial Dynamics, Elsevier, 92(12), 991-1024

II) Five other significant publications:

1. Zhang, Y., Cai, C. S., Shi, X. M. and Wang, C. (2006) "Vehicle Induced Dynamic Performance of a FRP Versus Concrete Slab Bridge" J. of Bridge Engineering, ASCE, 11(4), ASCE, 410-419.
2. Cai, C. S., Shahawy, M., and EL-Saad, A. (1999). "Comparison of Bridge Load Rating Based on Analytical and Field Testing Methods." Proceeding of *Nondestructive Evaluation of Bridges and Highways II*, Newport Beach, California, pp. 127-136, Vol. 3587, published by SPIE – the International Society of Optical Engineering (also presented).
3. Shi, X. M., Cai, C. S., and Chen, S. R. (2008) "Vehicle Induced Dynamic Behavior of Short Span Bridges Considering Effect of Approach Span Condition" J. of Bridge Engineering, ASCE, 13(1), 83-92.
4. Shi, X. M., Cai, C. S. (2008) "Suppression of Vehicle Induced Bridge Vibration Using Tuned Mass Damper" Journal of Vibration and Control, 14(7): 1037–1054.
5. Cai, C. S., Nie, J. G. and Shi, X. M. (2007) "Interface slip effect on bonded plate repairs of concrete beams." Engineering Structures, 29(6), 1084-1094.

SYNERGISTIC ACTIVITIES:

- Secretary/Treasurer, American Association for Wind Engineering
- Associate Editor, Journal of Engineering Mechanics, ASCE
- Former Committee Chair, "Experimental Analysis and Instrumentation", EMI, ASCE
- Committee Member of three ASCE committees
- Committee Member of three ACI committees
- Member, AAWE, ASCE, ASEE, ACI, SEI
- Served as faculty advisor of ASCE Concrete Canoe competition team
- Served as regional judger of ASCE Concrete Canoe competition
- Served in many scientific committees of international conferences
- Served as session chairman of many professional conferences
- Technical paper reviewer for ASCE (J. Mech. Eng., J. of Struct. Eng., J. of Bridge Eng., etc.), ACI, PCI, and many other international journals and conferences
- Served as proposal reviewer for NSF panel review and mailing review

E. COLLABORATOR INFORMATION

i) Collaborators in the past 48 months:

Ayman Okeil, Guoping Zhang, George Voyiadjis, Michele Barbato, LSU
Jianguo Nie Dept. of Civil Engineering, Tsinghua University, Beijing, China

ii) Master Thesis and Doctoral Dissertation Advisor

Pedro Albrecht, Department of Civil Engineering, University of Maryland, College Park
Guozhou Wang, Department of Civil Engineering, Tsinghua University, Beijing, China

iii) Students Supervised:

Graduate Students: Suren Chen (Ph.D.), Wenjie Wu (Ph.D.), Xiaomin Shi (Ph.D.), Marcio Araujo (Ph.D.), Xianzhi Liu (Ph.D.), Lu Deng (Ph.D.), Junhui Dong (Ph.D.), Wei Peng (Ph.D.), Archana Nair (Ph.D. and M.S.), Miao Xia (Ph.D.) Anand Chandolu (M.S.), Sadi Torres (M.S.), Stanley Oghumu (M.S.), Bo Kong(Ph.D.), Wei Zhang (Ph.D.), Xuan Kong(Ph.D.), Fang Pan(Ph.D.), Ye Zhang (Ph.D.), Fenghong Fan(Ph.D.), Mott Girouard(M.S.)

Post-Doc /Visiting Professors: Jin Cheng, Shuang Hou, Ziyong Yang, Jianguo Nie, Min Liu, Guohui Shen**,** Wen Xiong

Undergraduate Students: Dishili Davis, Adam Janet, Megan Drewes, Paul Robinson, Alejandro Alvergue