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CENTER FOR INFRASTRUCTURE ENGINEERING STUDIES

Enhancing Student Awareness and Faculty Capabilities in Transportation

by

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16. Abstract The Civil, Architectural, and Environmental Engineering (CArEE) Department requests support from the MST UTC to fund activities related to enhancing student awareness of transportation issues and faculty capabilities in select areas of transportation research and education. Activities to be undertaken by a team of faculty members in the Department.			
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FINAL REPORT

Enhancing Student Awareness and Faculty Capabilities in Transportation

The Civil, Architectural, and Environmental Engineering (CArEE) Department at the University of Missouri-Rolla (UMR) received support from the UMR UTC to fund activities related to enhancing student awareness of transportation issues and faculty capabilities in select areas of transportation research and education. The following paragraphs summarize the teaching and research activities performed by a team of faculty members in the Department during the first two years of the project (the academic years 2004/05 and 2005/06). Through these activities, the education of our students now included additional content related to transportation engineering. In addition, faculty have expanded breadth and depth their research programs by addressing several key issues pertaining to the transportation infrastructure in Missouri and in the United States.

Teaching:

- Students were introduced to the concept of influence lines for live load analysis of bridges in CE217 (Structural Analysis I). This concept is used in developing load rating factors for bridge structures. Students were assigned a live load analysis exercise for bridge girders under AASHTO HS20 truck loads and to compute corresponding values of absolute maximum bending moments and shear forces (Dr. Ayoub).
- The application of reinforced and prestressed concrete design principles to bridge design was discussed in CE327 and CE419 (Dr. Belarbi).
- Students were introduced to real-world design issues in CE217 such as the 22 January 2003 strut failure of the Paseo suspension bridge in Kansas to emphasize the importance of understanding structural behavior under a variety of loading conditions. The purpose of these discussions was to let students know about the importance of various aspects of structural analysis, particularly the calculation of support reactions, under changing loading conditions, and the effect of changing load conditions on the function and criticality of structural members. (Dr. Chen).
- Transportation structures were emphasized in discussions of the application of design methodologies covered in CE221 (Steel Design). Although AISC design specifications have been developed for buildings, students are shown how they can be applied to bridges as well. In CE326, the design of plate girders and composite design are also presented and applied to bridges as well as buildings (Dr. LaBoube).
- A student team for PCI's Big Beam Competition was formed to provide the students with the experience of designing, manufacturing, and testing a PC girder, an experience usually not available in a traditional classroom setting. The team finished 2nd out of 15 entries in our region. (Dr. Myers). Dr. Myers also attended a training course on Principles and Practices of Load Resistance factor Design (LRFD).
- A new module was implemented in CE374 (Infrastructure Strengthening with Composites) to cover strengthening of concrete bridges based on the design and construction experience developed at UMR in conjunction with projects funded by the Missouri Department of Transportation (Dr. Nanni).

Research:

- A proposal was submitted to the California DOT to support the development of a computational platform for time-dependent analysis of segmentally-erected prestressed bridge structures. Another proposal was submitted to the Florida DOT to support the development of new software for time-dependent analysis of segmental bridges used by over-weight trucks (Dr. Ayoub).
- A proposal was submitted to the Missouri DOT to support research in the strengthening and rehabilitation of existing transportation structures. Another proposal was submitted to the NCHRP on the shear strengthening of bridge girders using FRP materials (Dr. Belarbi).
- A proposal was submitted to the National Science Foundation to develop new tools and methods for short- and long-term monitoring of transportation systems as a means to significantly reducing the maintenance and operation cost of bridge structures (Dr. Chen).
- A study was performed regarding the use of thin sheet reinforcement for bridge piers (LaBoube).
- An NCHRP research proposal was submitted to study the durability of FRP systems (Dr. Myers).

In the final third year of the project, Dr. Ayoub was supported by the UTC as well as the department to establish and grow a research and teaching program in structural engineering, with a component related to transportation infrastructure engineering. The following paragraphs summarize the accomplishments of Dr. Ayoub during this time.

Courses taught in 06/07

Fall 2006: CivE 217/ArchE 217 Structural Analysis I

Spring 2007: CivE 217/ArchE 217 Structural Analysis I
CivE 319/ArchE 319 Applied Mechanics in Structural Engineering

Graduate students advised in 06/07

Ravi Mullapudi, Ph.D. student
Nathan Newman, M.S. student
Carlos Ortega, M.S. student

Proposals funded in 06/07

“NCHRP 12-75: Design of FRP Systems for Strengthening Concrete Girders in Shear”. Funded by the National Academies through the National Cooperative Highway Research Program (NCHRP).

“NEES-SG: Seismic Simulation and Design of Bridge Columns under Combined Actions, and Implications on System Response”. Funded by the National Science Foundation through a subcontract from the University of Nevada-Reno.

Proposals submitted in 06/07

NEESR-SG: Damping-Enhanced strengthening strategy for optimal design of RC structures under multiple performance objectives.” Submitted to the National Science Foundation.

Journal papers in 06/07

- Lu, F., and Ayoub, A.S., “Effect of bond properties on the behavior of FRP-strengthened reinforced concrete girders subjected to monotonic and cyclic loads”, submitted for publication, ACI special publication, committee ACI-440.
- Mehanny, S., and Ayoub, A.S., “Uncertainty in system parameters and corresponding variability in inelastic displacement demands”, accepted for publication, Journal of Engineering Structures.
- Bae, S.W., LaBoube, R., Belarbi, A., and Ayoub, A.S., “Progressive collapse of cold-formed steel framed structures”, accepted for publication, Journal of Thin-Walled Structures.
- Chenouda, M., and Ayoub, A.S., “Inelastic displacement ratios of degrading systems”, accepted for publication, Journal of Structural Engineering, ASCE.
- Mehrani, E., Ayoub, A.S., and Ayoub, A., “Evaluation of fiber optic sensors for remote health monitoring of bridge structures”, submitted for publication, Journal of Materials and Structures.
- Ayoub, A.S., “Nonlinear analysis of reinforced concrete beam-columns with bond-slip”, Journal of Engineering Mechanics, ASCE, 132(11): 1177-1186, (2006).
- Ayoub, A.S., “Nonlinear Analysis of wood building structures”, Journal of Engineering Structures 29(2): 213-223, (2007).

Conference papers in 06/07

- Lu, F., and Ayoub, A.S., “Analytical evaluation of effect of bond properties on behavior of FRP-strengthened reinforced concrete girders”, Proc. of TRB Annual Conference, Washington, D.C. (2007).
- Belarbi, A., Ayoub, A.S., Greene, G., Shanmugam, S., Mullapudi, R., and Farley, C. “Seismic performance of RC bridge columns subjected to combined loading”, Proc. of Structures Congress, Long Beach, CA (2007).
- Newman, N., Ayoub, A.S., and Belarbi, A. ”Evaluation of bond specifications for development lengths of straight embedded FRP bars”, Proc. FRPRCS-8 Conference, Patras, Greece (2007).
- Chenouda, M., and Ayoub, A.S., “Fragility and incremental dynamic analysis of degrading MDOF structures”, Proc. Of the 8th National Conference in Earthquake Engineering, San Francisco, CA (2006).
- Belarbi, A., Ayoub, A.S., and Bae, S.W., “State of the practice of FRP-strengthened RC girders in shear”, Proc. 3rd International Conference on Composites in Civil Engineering, Miami, FL (2006).
- Newman, N., Ayoub, A.S., and Belarbi, A., ”Evaluation of FRP bond specifications for development lengths”, Proc. 3rd International Conference on Composites in Civil Engineering, Miami, FL (2006).

Professional service activities in 06/07

- Active member, ACI/ASCE Committee 447: “Finite Element Analysis of RC Structures”; Editor of its State-of-the-Art report titled: “Modeling of Modern Concrete Structures for Performance-Based Earthquake Engineering”. A draft of Chapters 2 and 3 were submitted to the committee for review, of which Ayoub was the first author.
- Associate member, ACI Committee 440. Participated in the preparation of a special publication to appear.
- Member, ASCE Methods of Analysis Technical Committee.

- Reviewer for a large number of referred journal articles for the following journals: Journal of Structural Engineering/ASCE ; Journal of Engineering Mechanics/ASCE ; Journal of Earthquake Engineering; Journal of Constructional Steel Research; Journal of Materials and Structures; Journal of Engineering Structures; Journal of Mechanics Research Communications.
- Faculty Advisor for the student chapter of the Structural Engineering Institute (SEI) branch of ASCE