Model of Demonstration Bridge for Classroom and Laboratory Teaching

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PROJECT SUMMARY

The project developed a smart composite mini-bridge for educational and demonstration purposes. The smart mini-bridge was 9 ft. x 18. in. x 9 in. and will be similar to the campus pedestrian smart bridge. It will be a "smart" structure featuring integral fiber optic strain sensors. The completed structure and an associated educational video will be used as a classroom demonstration. The project goal is to create interest in optical engineering, instrumentation, and FRP composites among students. It is a complementary activity to the development of the campus smart composite bridge, to the laboratory component of the smart materials and sensors course, and

BRIDGE DESCRIPTION

<u>Composite Construction Project</u>

The minibridge construction consists of one layer of glass FRP (fiber-reinforced polymer) tubes and a end supports made using the same tubes. It is instrumented with two fiber-optic sensors to measure the mid-span flexure strain. It was designed to give about 50 microstrain measurements for pedestrian loads.

<u>Associated Course</u>

An interdisciplinary course was developed at the senior-elective and introductory graduate level. The topical area was smart structures which involves the intelligent monitoring and control of structures using permanent sensors, actuators, and processors. It crosses traditional boundaries by combining materials, manufacturing, sensing, signal processing, structural analysis, etc.

The course entitled "Smart Materials and Sensors" was co-listed in the electrical engineering, mechanical engineering, aerospace engineering and civil engineering departments. The course was approved by the UMR curriculum committee and given a permanent number in all co-listed departments in 2001. It was taught in the Fall semester of 1999 to five electrical engineering students, eight mechanical engineering students, and one civil engineering student. It was taught in the Fall semester of 2000 to five electrical engineering students, six mechanical engineering students, two aerospace engineering students, and two civil engineering student. The topical content in the first half semester was strain sensing (including sensing theory, electrical resistance gages, linear variable differential transformers, and fiber optic sensors) and materials (including material properties, anisotropic behavior, and fiber reinforce polymer composites). The second half semester covered application technologies including sensor networking, composite fabrication, and the demonstration bridge. New developments were emphasized and how they relate to established technologies.

The learning objectives of this interdisciplinary course were (1) to integrate cross-disciplinary knowledge, (2) to build interdisciplinary collaborative skills, and (3) to gain related applied experience. Instructional delivery was tailored to the desired learning objectives of the course and the student diversity through a structured combination of preliminary tutorials, Socratic lectures, group collaboration on progressively more complex projects, and active laboratory experiences including a large-scale smart bridge. The minibridge served as laboratory experiment for the students and as an introduction to the field demonstration of the full-scale bridge.

Associated Full-Scale Smart Composite Bridge

An instrumented all-composite bridge was a field laboratory for the course and provided a field demonstration of composite and sensing technologies. This bridge was designed, analyzed, and manufactured as a companion project to the course and installed on the UMR campus. The development was a cooperative effort which was led by UMR with industry and government partners and which included substantial student involvement. The prototype structure, the first all-composite bridge in Missouri, is designed for an AASHTO H20 highway load rating and features a novel composite-tube approach to short-span bridges and an embedded fiber-optic-sensor network for measurement of temperature, flexure strain, and shear strain. The rating was confirmed with a destructive laboratory test of a full-scale test article and a near-rating load test of the installed bridge. The bridge development and testing was fully documented with technical specifications, finite element simulations, laboratory testing, manufacturing and installation procedures, cost analysis, and load test history. The students in the course devoted one week to the bridge project as a case study which was supplemented by video documentary of the bridge manufacture, installation, and load testing and by a laboratory exercise of the sensing network monitoring a live load test. A supplementary structure was placed in the sidewalk adjoining the bridge. This structure was identical to the Minibridge and is sensitive to pedestrian traffic. It will serve as a testbed for future course laboratory activities.