Replacement Pedestrian Bridge
UMR-UTC Research Project
Final Report

Identification Number: R-5-38018

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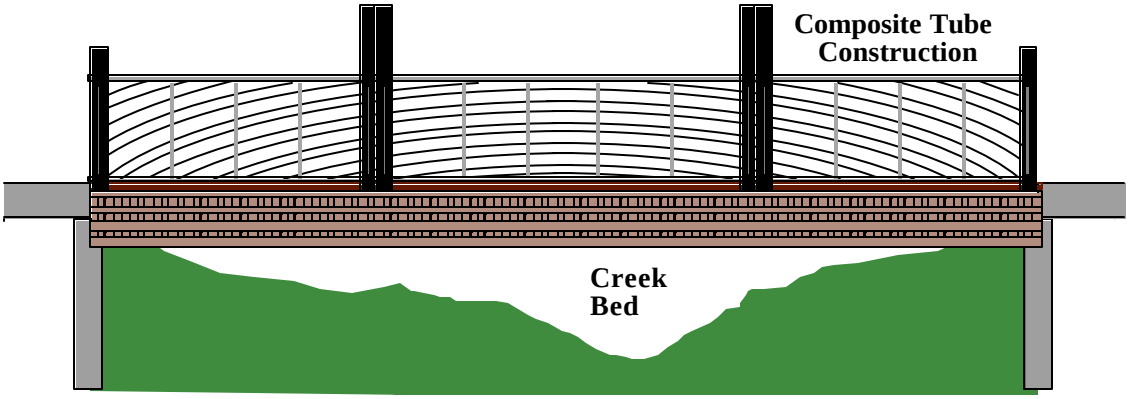
Project Objective: Create a field laboratory and technology demonstration

Project Abstract: A pedestrian bridge is being designed and built for the UMR campus. This project demonstrates the use of composite materials for new civil construction and the use of fiber optic sensors for structural monitoring. In particular, a composite tube system is developed featuring flexible and economical design. The bridge will be a point of interest for the campus, a field laboratory for two interdisciplinary courses, and the subject of a web site for technology transfer. It is designed and fabricated in cooperation with industrial, no-profit, government partners. The project includes finite element analysis, laboratory component testing, fabrication protocols, sensor integration, load testing, and multimedia documentation.

Task Description: Design a structure that is user friendly, professional-looking and practical for the users, development of a process to collect and prepare material for web presentation, collection of that material and development of the web site with the appropriate content.
Bridge Design and Finite Element Analysis, Composite Tube Pultrusion, Component Testing, Full Scale I-Beam Failure and Fatigue Testing, Site Preparation, Bridge Assembly, Installation, Field Testing, and Web Site Documentation.

Milestones: Project Start Date 03/01/99
Project End Date 06/30/00



UMR Smart Composite Bridge

Student Involvement:

Graduate Research Assistants:

Prakash Kumar, MS Student, UMR, Mechanical Eng. Dept. (Laboratory Testing)

Minjie Xu, MS Student, UMR, Mechanical Eng. Dept. (Finite Element Analysis)

Martha Phariss, MS Student, UMR, Electrical and Computer Eng. Dept. (Smart Instrumentation)

Vicki Eller, MS Student, UMR, Electrical and Computer Eng. Dept. (Web Site)

Other Student Projects – Senior Design Projects in Electrical Engineering, Surveying Special Project in Civil Engineering, Project Management Case Study in Engineering Management, and Image Processing Project in Electrical Engineering.

UMR Undergraduate Winners of Bridge Railing Design Competition:

Wesley E. Tull, Jr. and Matthew J. Snader, Civil Eng. (Selected by UMR Faculty Committee)

Technology Transfer Activities: A web site www.umr.edu/~smarteng/bridge documents all aspects of the bridge design, assembly, and testing. The project was featured on an August newscast by KSDK Channel 5-St. Louis.

Potential Benefits of the Project: Promotes acceptance of smart fiber-optic sensors and composite materials in civil engineering structures.

Transportation Research Board Keywords: Demonstration Bridge, Smart Composite Tube System

Summary:

A smart composite bridge for highway applications was built. This short-span structure is nine meters in length and is designed for an AASHTO H20 load rating. The prototype bridge, the first full-composite bridge in Missouri, was designed, analyzed, and manufactured as a cooperative product-development by the University of Missouri-Rolla, Composite Products Inc., and the Navy Center of Excellence for Composites

Manufacturing Technology (CECMT) at the Lemay Center for Composites Technology. It was installed on the campus of the University of Missouri-Rolla as a field laboratory for smart structures courses and a working demonstration of composites technology. Although rated for highway applications, the normal usage is by pedestrians and light vehicles. The smart instrumentation is remotely monitored via a dedicated fiber-optic data line.

The bridge features include an all-composite design and an integral sensor network. It has a modular construction based on a pultruded 76-mm square tube. The cross section of the overall structural element is an I-beam formed by seven layers of bonded tubes. The top and bottom layers are carbon/vinyl-ester tubes for strength and the other layers are glass/vinyl-ester tubes for economy. Extrinsic Fabry-Perot interferometric (EFPI) fiber-optic sensors were embedded throughout to measure temperature, flexure strain, and shear strain. Also, radio-frequency identification tags were co-located with fiber-optic sensors to aid in determining load placement during field tests. The laboratory tests of the test article show that the bridge exceeds the required vehicle load rating. The participates are listed.

Project Faculty Team:

Dr. Steve E. Watkins, University of Missouri-Rolla (UMR), Electrical and Computer Eng. Dept. (contact 573-341-6321 or watkins@umr.edu)
Dr. Antonio Nanni, UMR, Civil Eng. Dept.
Dr. K. Chandrashekhara, UMR, Mechanical Eng. Dept.
Dr. Abdeldjelil Belarbi, UMR, Civil Eng. Dept.
Dr. Richard Hall, UMR, Psychology Dept.

Industry Partner: Composite Products Inc., Missouri (John F. Unser, President)

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Project Supporters include

Luna Innovations, Inc., Blacksburg, VA (suppliers of fiber optic strain instrumentation)
John Belk (donation of Radio Frequency Identification Tags – RFID tags)
Boeing, St. Louis, MO (loan of RFID tag reader)
International Association of Bridge, Structural, Ornamental, and Reinforcing Ironworkers, Local Union #396, St. Louis, MO (labor for site preparation and installation)
Missouri Soybean Merchandising Council (soybean-based resin for surface and railing rods)
Zoltek, St. Louis, MO (donation of carbon for tubes and rods)
Dow Chemicals (donation of resin for carbon tubes)
Fiber Glass Industries (donation of fiberglass mat for carbon tubes)
Albemarle Corporation (donation of flame retardant for carbon tubes)
Vetrotex America (donation of fiberglass roving for glass tubes)

Interplastic Corporation (donation of vinyl ester resin)
Dexter (donation of adhesive for bonding tubes)

Assembled Smart Composite Bridge