

Center for Transportation Infrastructure and Safety (CTIS)

**National University Transportation Center
(NUTC)**

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Center Director

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Kamal H. KHAYAT

Design of advanced cement-based materials for structural applications and rehabilitation of infrastructure and building construction



Genda CHEN

Structural control, structural health monitoring, interface mechanics and deterioration of composite structures, bridge engineering, and multi-hazard effects on civil infrastructure



Ronaldo LUNA

Geotechnical engineering, seismic effects, soil-structure interaction, modulus limit states



John MYERS, Associate Director

Structural behavior of prestressed concrete, including advanced cement-based materials, fiber-reinforced polymers in structural repair and strengthening applications

Outline

- **CTIS Mission and Goals**
- **Examples of R&D Activities**
- **Sample Success Stories**
 - Implementation of Technologies
 - Impact of Collaborative Research
- **Funding and Performance Metrics**
- **Education and Workforce Development**
- **Technology Transfer**

Mission

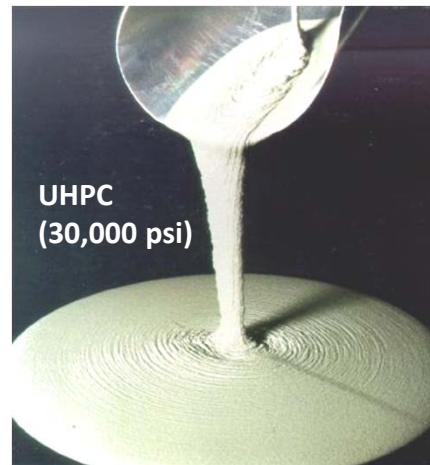
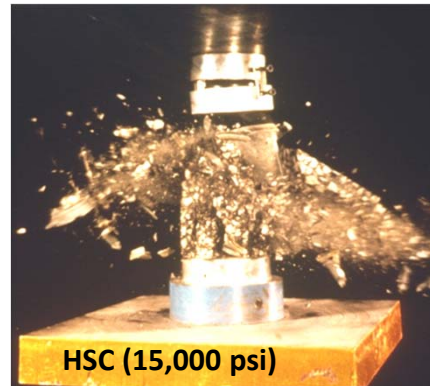
- In operation since 1998
- In 2006, promoted to National UTC (1 of 10)
- Funding Source: US Department of Transportation
- **Mission:** To advance U.S. technology and expertise in various disciplines comprising transportation through the mechanisms of **education**, **research**, and **technology transfer** at a university-based center of excellence

Goals

- Develop advanced construction materials
- Improve structural integrity and reliability of the transportation system
- Develop non-destructive testing, monitoring, and evaluation methods of new and repaired structures
- Develop and deploy infrastructure for safe and sustainable hydrogen economy

Examples of Advanced Construction Materials

- Safer infrastructures (strength, ductility ...)
- Faster construction
- Longer service life
- Cost-effectiveness
- Greater use of recycled materials and lower GHG emissions



Lightweight aggregate

Fibers



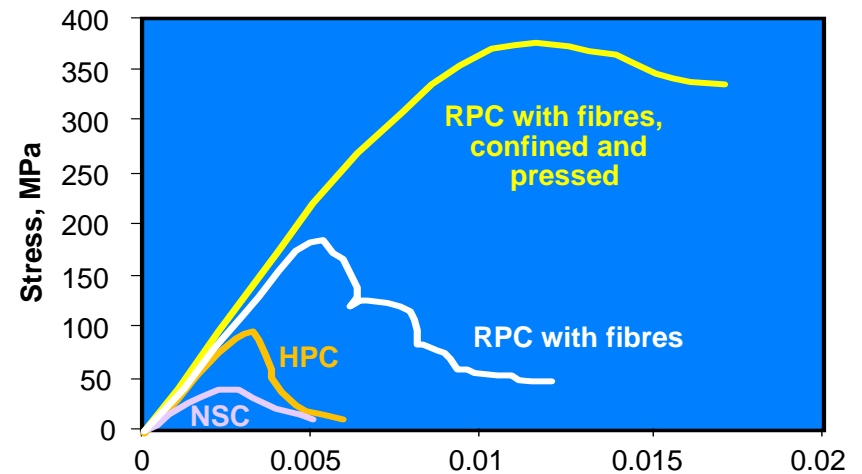
Sustainable HPC infrastructure

Roller-compacted concrete



Design and Implementation of Advanced Construction Materials

- Evaluation of structural behavior
- Monitoring of long-term performance
- Development of design procedures
- Establishment of guidelines and specifications



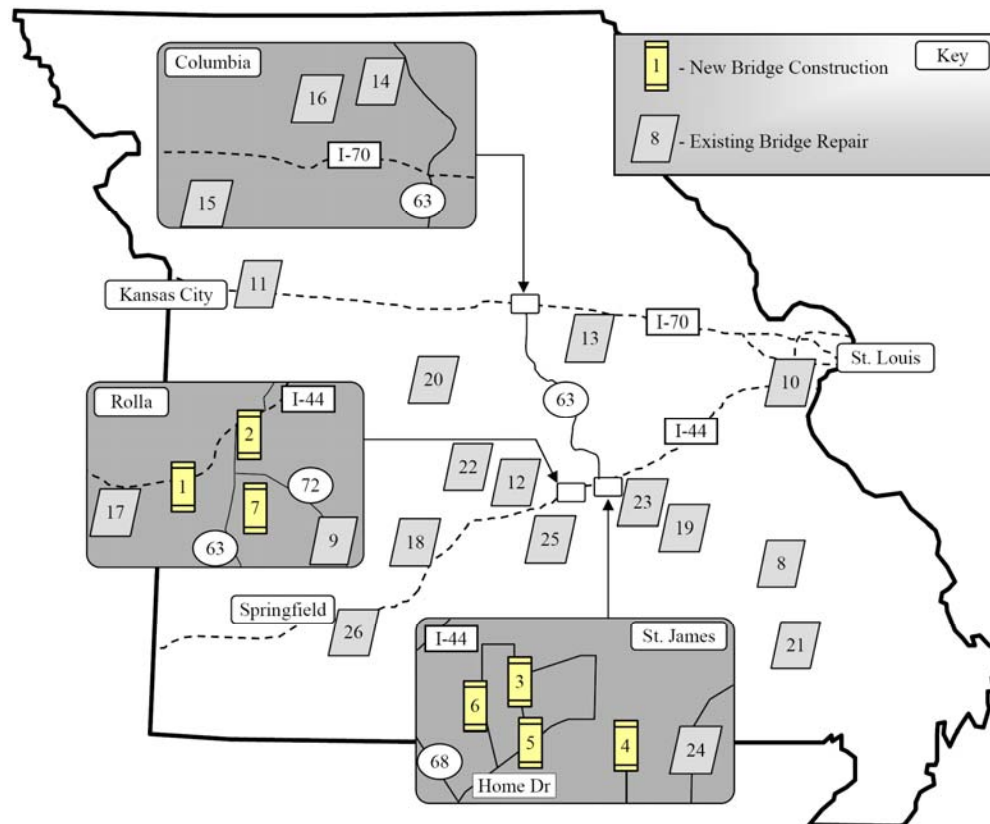
Use of Non-Corrosive Materials (Fiber-Reinforced Polymers, FRP)



Missouri S&T has been a leader in the development and implementation of composite materials in the United States



Widespread Implementation of FRP in Missouri



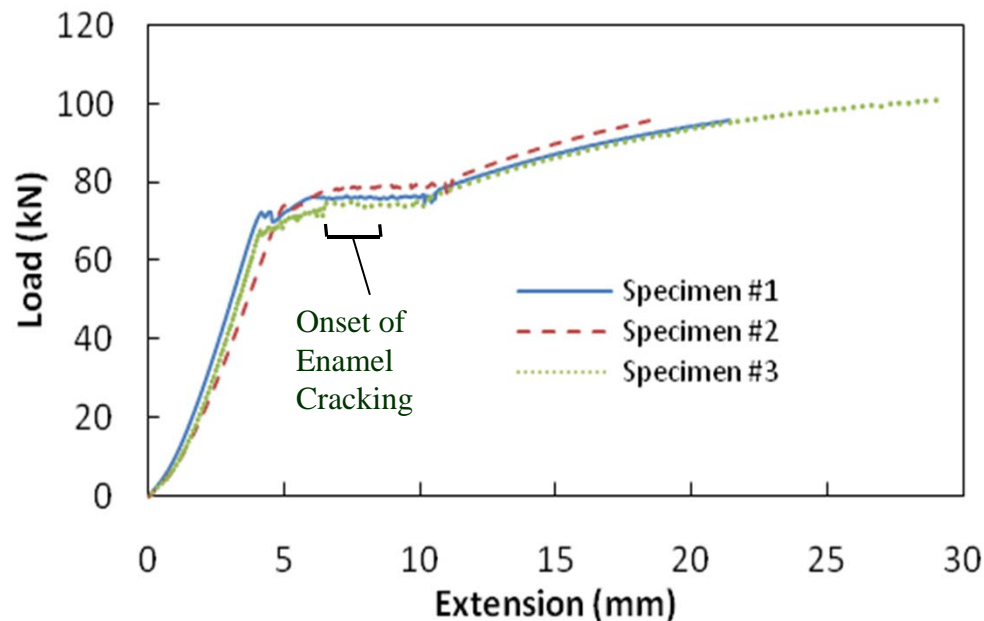
- **More than 30** new and repaired bridges in Missouri over the past decade have been built or repaired to today's standard in Missouri
- Work has led to implementation and advancement in codes and standards (ACI, AASHTO, ...)

(Green County bridge construction)

Infrastructure Challenges Addressed

Enamel Coating on Steel Rebar

- Societal Needs
 - Corrosion - #1 reason for bridge rehabilitation and replacement
 - Bond strength – main reason for rebar congestion in joint structures
- Manufacture
 - Pro-Perma Engineered Coatings, Rolla, MO
- Deformability



Blast Testing of Full-Size RC Wall Barriers

After 30 lbs (back face)



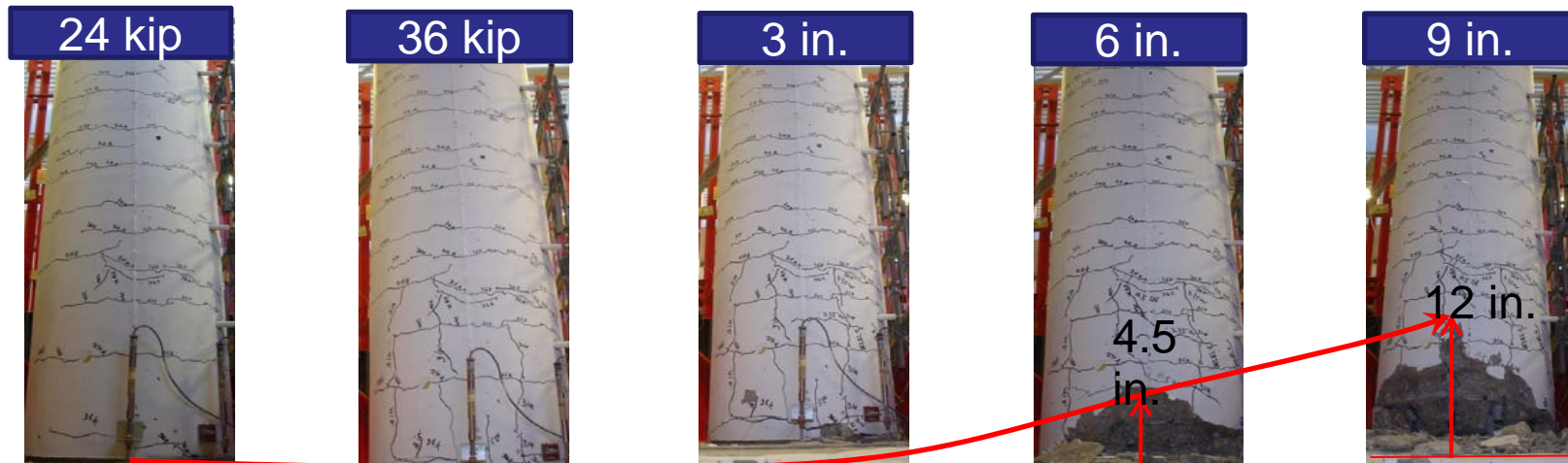
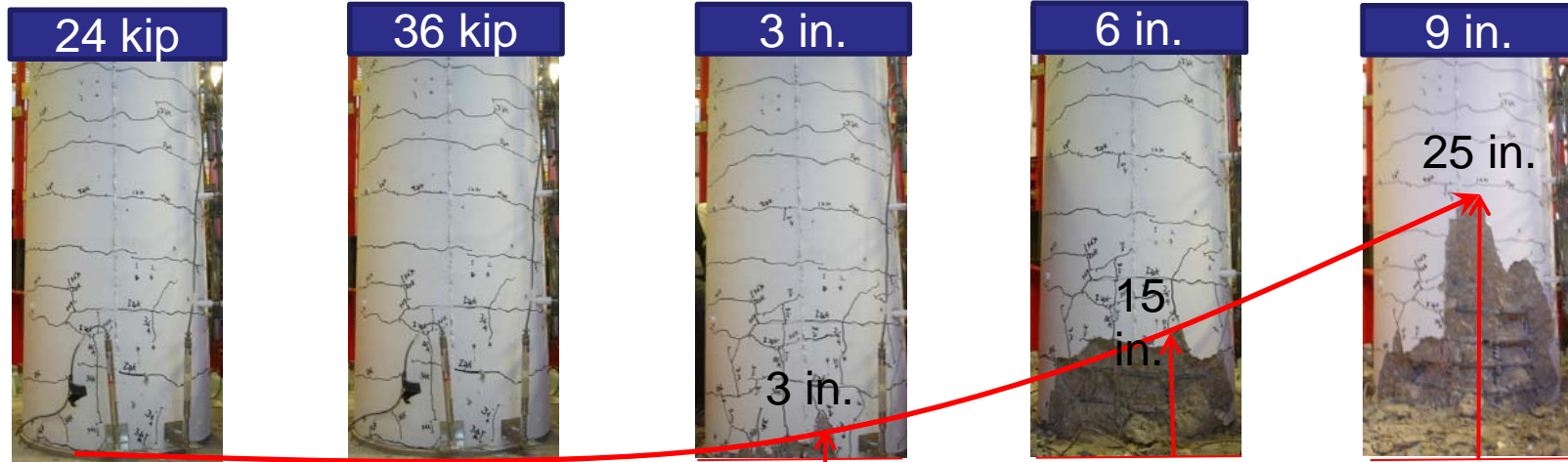
(a) Uncoated rebar



(b) Enamel-coated rebar

After 45 lbs

Earthquake Testing of Large-Scale RC Columns



Impact to State of Missouri

- Address state and nation's needs
- Impact MoDOT practice in bridge design, construction, and maintenance
- Foster intercampus collaboration (Missouri S&T/UMC/UMKC)
- Rally interdisciplinary research between several engineering and science disciplines (12 faculty members in total)
- Engage Missouri-based small business in R&D
- Establish national leadership (enamel coating ...)

Transportation Geotechnics

MoDOT Project provided Engineering Policy Guidelines (EPG) for bridge foundations and slopes

Objective: Develop cost-effective solutions to geotechnical problems (foundations/slopes) along Missouri Highways



Deep Foundation Load Tests

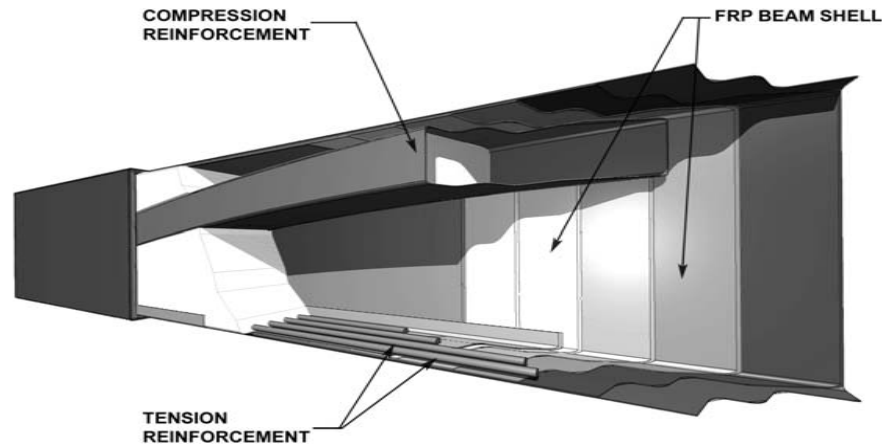
- Drilled Shafts (2010)
- Micropiles (2011)
- Driven Piles (2012)



Impact to State of Missouri

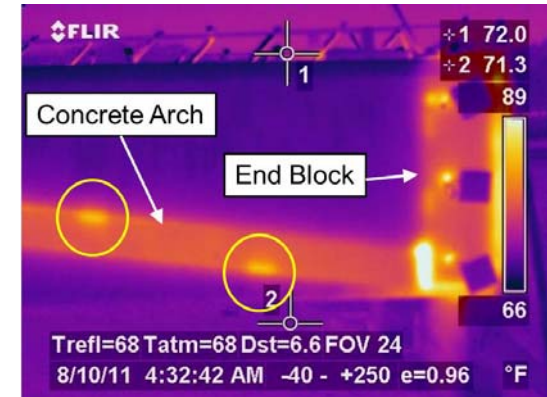
- Cost savings on the length of foundation elements
- Enables MoDOT to meet FHWA national guidelines to use LRFD
- State has led in developing new guidelines and has invited collaboration with neighboring state DOTs (e.g., Kansas, Iowa, Arkansas...)

Representative Collaborative Projects



Fragmentary perspective of Hybrid-Composite Beam

Overall study involves the construction of 3 new HC-beam bridges in MO as part of the States 802 Bridge Program



IR thermography to detect defects during fabrication



Field evaluation of H-C girder bridges in MO

Bridge B0439: Missouri's first HC-beam project completed Nov. 2011

Two bridges slated for Spring and Summer 2012 construction

Min. service life of 100 years

Development of NDE technologies for inspection of HC-beam bridges

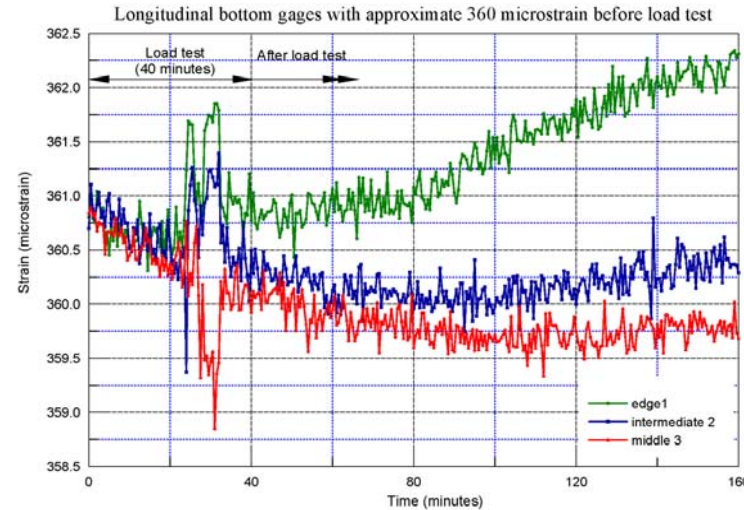
Representative Collaborative Projects



Use and implementation of precast-prestressed panels for bridge approaches

- Speeds-up construction / lower cost
- Improved service life
- Design approach reduces potential for settlement

Field Evaluation of Bridge Approach Slabs



Integrated data acquisition system records strain, thermal, and substrate pressure to validate system in the field



Overall study involves the construction of 5 new bridges in MO as part of the States 802 Bridge Program



Integrated field testing and monitoring

Industry Partnerships



Self-Consolidating Concrete for Infrastructure Element (Missouri S&T/MoDOT)



Optimal Design and Use of Advanced Structural Materials (Missouri S&T)



Sustainable Construction Materials (Missouri S&T/Encore Building Solutions, Inc.)



Funding Agencies

- Industry (material suppliers, designers, manufacturers, ...)
- State Departments of Transportation (MoDot, CalTrans, IDOT, Kdot, KyDot, NYDot, Fdot, ...)
- National Science Foundation (NSF)
- National Cooperative Highway Research Program (NCHRP)
- Federal Highway Administration (FHWA)
- National Institute for Standards and Testing (NIST)
- Military Related Organizations
 - Air Force Research Laboratory (AFRL)
 - Army Research Laboratory (ARL)
 - Leonard Wood Institute (LWI)
 - US Army Corps of Engineers ...

Performance Metrics

Since 2006	
Total CTIS Awarded Proposals	100
Total CTIS Awarded Funds	\$7.5 M
Total Awarded Matching Funds	\$13.8 M
CTIS Award : Match Award Ratio	1 : 1.8

NUTC requires minimum of 1 : 1 match

Education and Workforce Development

During FY06-11:

- Cumulative number of transportation-related courses:
 - **375** (190 undergraduate, 185 graduate)
- Number of students participating in transportation research projects:
 - **953** (736 undergraduate, 217 graduate)
- Number of students enrolled in an advanced transportation-related degree programs:
 - **217** (141 M.S., 69 Ph.D.)

Examples of Technology Transfer Sponsored by CTIS

5th/6th National Seismic Conference on Bridges and Highways (2006, 2007) – **300 attendees**

GeoMo Soil Stabilization: Foundations and Pavements (2004 – ongoing) – **60 attendees**

Structural Materials Technology: NDE/NDT for Highway and Bridges Conference, 2006 – **120 attendees**

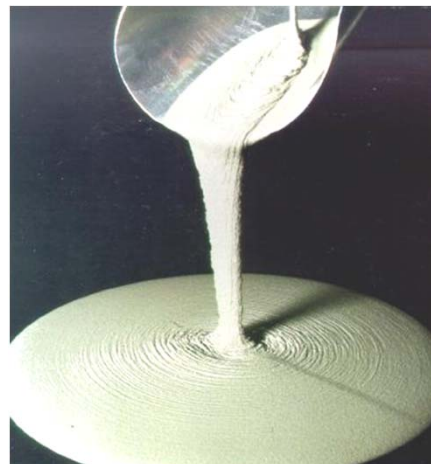
3rd Int. Conference on Electromagnetic Near-Field Characterization and Imaging, 2007 – **46 presentations**

Missouri Local Technical Assistance Program (LTAP) since 2001

- Provide technology transfer to local govt. agencies
- Strong partnership with many state organizations
- Proven & effective process for delivering training & workforce development
- **111 workshops in 2011!**
- Funded by FHWA, MoDOT & CTIS match



Questions?



<http://transportation.mst.edu/>