

PREEMINENT



ENGINEERING PROGRAM

A Division of Resilient and Sustainable Coastal Infrastructure Group at FIU




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BRIDGE ENGINEERING AT FIU

A DIVISION OF RESILIENT AND SUSTAINABLE COASTAL INFRASTRUCTURE GROUP



Our infrastructure includes roadways and bridges, waterways and ports, sewers and electrical grids, telecommunications and so much more that makes daily life possible and keeps the economy running. **The American Society of Civil Engineers gives a grade of D to our infrastructure and estimates that it will require \$3.6 trillion to address the nation's substandard infrastructure. There is an urgent need to develop resilient and sustainable solutions.** This work demands collaboration among scientists, engineers, architects, economists, social scientists, policy makers, journalists and experts from other disciplines. **The Division of the Resilient and Sustainable Coastal Infrastructure Group at Florida International University (FIU)** is the university's response to the need to develop engineering solutions for resilient and sustainable coastal infrastructure.

FIU has built one of the best bridge engineering programs in the country. Recognizing the national impact of its research and the wide reach of its technology transfer activities, the university in 2016 designated it a Preeminent Program, the only one in the College of Engineering & Computing. The influence of the Bridge Engineering Program at FIU was validated again, in December of 2016, when the U.S. Department of Transportation for a second time funded the Accelerated Bridge Construction University Transportation Center at FIU (ABC-UTC). The ABC-UTC was established in October of 2013 for three years, and the 2016 grant allowed FIU to continue serving the bridge profession for an additional five. The combined grants and associated matching funds have provided FIU with almost \$20 million to deepen its commitment to research, education and workforce development, and technology transfer.

The success of the Bridge Engineering Program stands on the shoulders of its world-class faculty, who collectively hold expertise in every aspect of bridge engineering. Likewise, the unwavering support of FIU's administration has contributed to making FIU the best place for young people to study bridge engineering as they take advantage of high-quality academic instruction in combination with hands-on experience in well-appointed campus labs. Finally, important relationships continue to elevate the program while highlighting its relevance, with FIU working closely with the Federal Highway Administration, the American Association of State Highways and Transportation Officials and State Department of Transportation across the country, as well as with consultants and others in the industry. These stakeholders figure into the selection, implementation and monitoring of key research projects.

Making its case as a national leader even stronger, the Bridge Engineering Program has established an unparalleled reputation within the industry as a source of continuing education and technology transfer. The monthly ABC-UTC webinars attract more than 4,000 bridge professionals from nearly every state DOT. The ABC-UTC National Conference brings together more than 700 bridge professionals to share the latest findings and innovations. These activities also provide opportunities for graduate students to get a jump on their careers as they gain firsthand access to authorities in the field as we educate the transportation workforce of tomorrow.

Prospective graduate students: You will not find a better university in United States at which to study bridge engineering than FIU. Join us and enjoy the opportunity to work closely with experts in the field and alongside top researchers in the lab. FIU's bridge engineering graduates are highly sought after and find responsible and challenging positions across the country. Both master of science and doctoral degrees are offered.

Bridge owners, consultants and other stakeholders: Look no further for help in solving your bridge engineering challenges. FIU faculty and affiliates bring an unmatched level of experience and knowledge to finding effective and economically sound solutions. We can partner with you to organize workshops, conduct short courses at your location, provide expert witness services, conduct field tests and joint research, evaluate new products, provide service-life design for long-span bridges and more.

Alumni: Your work makes us proud. We invite you to stay connected to your alma mater and to help us further develop FIU's Preeminent Bridge Engineering Program. We are in the process of building a state-of-the-art testing facility and we need your help. For more information, please contact Susan Jay (jays@fiu.edu), who is leading the effort. Please continue to keep us abreast of your work and feel free to visit us at the Engineering Center for a look at the many ways in which we are upgrading our facilities.

Atorod Azizinamini, Ph.D., P.E.

Vasant H. Surti Professor Civil Engineering
Director, Accelerated Bridge Construction University
Transportation Center
Chairperson, Department of Civil and Environmental Engineering
College of Engineering & Computing
Florida International University
Miami, Florida, April 2017

TEAM



MEET THE **BRIDGE ENGINEERING TEAM** AT FIU

We are proud to work with some of the brightest and innovative minds in the industry!



Atorod Azizinamini, Ph.D., P.E.

Professor of Civil Engineering; Chair, Department of Civil and Environmental Engineering; Director, ABC-UTC; Coordinator of U.S. DOT's Beyond Traffic Innovation

Dr. Atorod Azizinamini has devoted his career to developing solutions for the challenges facing the nation's transportation infrastructure. As the principal investigator of the Transportation Research Board of the National Academy of Science Foundation project, SHRP2 R19A, he led the development of the first and most comprehensive manual worldwide — "Design Guide for Bridges for Service Life" — that offers a systematic framework to design new and existing bridges with durability and sustainability in mind. He is also the developer of the revolutionary Folded Steel Plate Girder Bridge System that is now being used across the U.S. to replace sub-standard short span bridges. He is the recipient of numerous awards for his many contributions to bridge engineering and was recognized in October of 2015 by the White House as a White House Champion of Change: Transportation Innovator.



Armin Mehrabi, Ph.D., P.E.

Associate Professor, Department of Civil and Environmental Engineering; Director of Research, ABC-UTC

Dr. Armin Mehrabi is a seasoned engineering and research services leader with more than 20 years of experience in bridge engineering activities, including advanced modeling and analysis, evaluation and health monitoring, inspection, NDT, laboratory and field testing, vibration and wind effect evaluation, life-cycle-cost analysis and more. He received his Ph.D. from the University of Colorado at Boulder and is the co-inventor of a laser-based cable monitoring system, for which he was awarded "One of Top 25 Newsmakers of the Year" in 1997 by Engineering News Record. His thesis on Seismic Behavior of Masonry Infilled RC Frames won the Most Outstanding Thesis Award by The Masonry Society in 1997.



David Garber, Ph.D., P.E.

Assistant Professor, Department of Civil and Environmental Engineering; Director, Education and Workforce Development, ABC-UTC

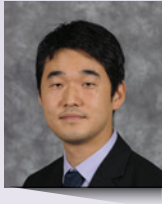
Dr. David Garber has led a number of research efforts involving large-scale testing and analytic work in the areas of reinforced and prestressed concrete and accelerated bridge construction. He has also been involved in the development of recommendations and code specifications that are being considered for implementation into the AASHTO Bridge Design Specification. He received his Ph.D. from the University of Texas at Austin in civil engineering. Dr. Garber is an active member of the American Concrete Institute (ACI), the Precast/Prestressed Concrete Institute (PCI) and the Transportation Research Board (TRB).



Kinglsey Lau, Ph.D.

Assistant Professor and Graduate Program Director, Department of Civil and Environmental Engineering

Dr. Kingsley Lau has more than 10 years of experience in corrosion research, particularly for civil infrastructure. He received his Ph.D. in civil engineering from the University of South Florida and worked as a research scientist at the Florida Department of Transportation State Materials Office Corrosion Laboratory, which provided him with close insight and an understanding of the research needs of the FDOT. His research interests include the corrosion of engineering materials and the durability of reinforced and prestressed concrete. He has more than 50 publications on corrosion materials durability of civil infrastructure.

**Seung Jae Lee, Ph.D.**

Ralph E. Powe Junior Faculty; Assistant Professor, Civil and Environmental Engineering

Dr. Seung Jae Lee works in the area of computational discrete mechanics at the interface of structural, geotechnical and computational engineering, and conducts major research to tackle the underlying mechanisms behind the complex behavior of discrete systems and materials. He extended the limits of length and time scales in discrete mechanical simulation by two orders of magnitude in his career and received several awards from civil engineering research communities including ASCE EMI. He was recognized in 2016 as one of 35 Ralph E. Powe Junior Faculty Enhancement awardees nationwide, an award given to young faculty to promote game-changing research.

**Pezhman Mardanpour, Ph.D.**

Assistant Professor, Department of Mechanical and Material Engineering; Director, Fluid-Structure Interaction Lab

Dr. Pezhman Mardanpour received his Ph.D. and M.S. from the School of Aerospace Engineering at the Georgia Institute of Technology. He then joined UCLA as a post-doctoral fellow to serve as the assistant director of the Flutter System Research Center. Prior to coming to the United States, he received a master's degree from Sharif University of Technology in Tehran, Iran. In addition, he worked as a research scientist at the Institute of Aeroelasticity at the German Aerospace Center in Göttingen, Germany, where he focused on the experimental aeroelasticity of high-aspect-ratio wings, and Unmanned Aerial Vehicles (UAVs). A regular contributor to the American Institute of Aeronautics and Astronautics Journal, the Journal of Aircraft, the Journal of Fluids and Structures, the Journal of Nonlinear Dynamics, and the Journal of Vibration, Sound and Control, Prof. Mardanpour is a professional member of American Institute of Aeronautics and Astronautics (AIAA), the American Society of Mechanical Engineering (ASME), and the American Physics Society (APS).

**Mohammed Hadi, Ph.D., P.E.**

Professor, Department of Civil & Environmental Engineering

Dr. Mohammed Hadi's received his Ph.D. in transportation engineering from the University of Florida. His experience covers a wide variety of transportation engineering areas with emphasis on system management and operations, intelligent transportation systems (ITS), simulation and DTA, data analytics, performance measurements, planning for operations and connected vehicles. He is the chair of the Transportation Research Board (TRB) Joint Simulation Subcommittee and a member and the research coordinator of the TRB Traffic Flow Theory and Characteristics Committee and the TRB ITS Committee. He serves on the ITS Florida Board of Directors.

**Wallied Orabi, Ph.D.**

Assistant Professor, Department of Construction Management

Dr. Wallied Orabi's research is focused on optimization and decision making for resilient and sustainable infrastructure systems. He received his Ph.D. in civil engineering from the University of Illinois at Urbana-Champaign and developed innovative models to accelerate post-disaster reconstruction of highway systems and to minimize service disruption to motorists from highway rehabilitation projects. Dr. Orabi also analyzed the effectiveness of alternative contracting methods in motivating contractors to accelerate highway construction projects and examined the cost-effectiveness of accelerated bridge construction methods.

**Ton-Lo Wang, Ph.D., P.E.**

Professor and Associate Chair, Structural of Engineering

Dr. Ton-Lo Wang specializes in railway and highway bridge vibration, impact, reliability, load distribution, load rating and fatigue damage analyses. He has authored and co-authored numerous refereed journal papers, conference papers and technical reports. In addition, since 1969, he has been the principal investigator or co-principal investigator of many research projects on highway bridge vibration, impact, and reliability analyses for the Florida Department of Transportation (FDOT). In 1992 and in 2000, Dr. Wang was a recipient of the prestigious FIU Faculty Awards for Excellence in Research. In 2003, he received the FIU Faculty Award for Excellence in Teaching.

**Hesham Ali, Ph.D., P.E., C.P.M.**

Green Paving Professor of Practice, Department of Civil & Environmental Engineering

Dr. Hesham Ali is a globally recognized highway infrastructure expert. He has 25 years of experience in highway and pavement design, construction, quality assurance, testing, inspection, preservation and research. His work spanned three continents — North America, Asia and Africa. Nationally, he was involved in projects in New York, New Jersey, Georgia, Texas and Florida. In Florida, he was responsible for the delivery of \$3B of highway projects. He served as a PI in \$1.5M worth of research projects for federal, state and private entities and authored more than 35 publications.

**Arindam Gan Chowdhury, Ph.D.**

Director, Lab. Wind Engineering Research, International Hurricane Research Center; Associate Professor, Department of Civil and Environmental Engineering

Dr. Arindam Gan Chowdhury is director of the Wall of Wind (WoW) facility under FIU's International Hurricane Research Center. The National Science Foundation (NSF) designated WoW as one of the nation's major experimental facilities focusing on hazard mitigation. Under his direction, the WoW research team has had a significant impact in mitigating hurricane damage by enhancing building codes and validating innovative mitigation technologies. He received his Ph.D. in engineering mechanics from Iowa State University and is the recipient of the National Science Foundation CAREER Award and FIU's President's Council Worlds Ahead Faculty Award.

**Ioannis Zisis, Ph.D.**

Assistant Professor, Department of Civil and Environmental Engineering

Dr. Ioannis Zisis holds a Ph.D. in building engineering from Concordia University. His research activity is focused on structural and environmental wind engineering as part of the general civil and building engineering disciplines. Of particular interest are wind-structure interaction and experimental wind engineering methods. He has been studying the effects of wind to the built environment by using field observations, model and full-scale experimental approaches and numerical simulation techniques. Dr. Zisis has been carrying out research specific to infrastructure systems, such as traffic management systems, wind-induced vibration of stay cables and complex aerodynamic behavior.

**Peter A. Irwin, Ph.D., P.Eng**

Wall of Wind (WoW) Professor of Practice, Department of Civil and Environmental Engineering

Dr. Peter Irwin is an international authority on the effects of high winds on structures. After graduating from McGill University in Canada with his Ph.D. in mechanical engineering, he worked for the National Research Council of Canada. He then became a wind consultant at the well-known firm RWDI, where he was responsible for the wind engineering of numerous major bridge projects, including the Ravenel Bridge near Charleston, the Tappan Zee twin cable stayed bridges in New York and the Tacoma Narrows bridge. He is the recipient of many awards, including the Jack Cermak Medal, the Alan Davenport Medal, and the Fazlur Khan Medal for his contributions to the field of wind engineering.

**Arvind Agarwal, Ph.D., FASM**

Associate Dean, Research for the College of Engineering & Computing; Professor, Department of Mechanical and Materials Engineering
Director, Advanced Materials Engineering Research Institute (AMERI)

Dr. Arvind Agarwal serves as the director of the Advanced Materials Engineering Research Institute (AMERI), a facility for materials characterization and nanofabrication. His research over the last two decades focuses on developing advanced materials, coating and nanocomposites for corrosion, wear, aerospace and biomedical applications. He received his Ph.D. in materials science and engineering from the University of Tennessee, Knoxville. Dr. Agarwal has received the National Science Foundation's prestigious CAREER award, FIU President's Council Outstanding Worlds Ahead Faculty Award and was inducted as a Fellow of the American Society of Materials (ASM). He has established several laboratories at FIU, including the Plasma Forming Laboratory.

**Laird Kramer, Ph.D.**

Founding Director, STEM Transformation Institute; Professor, Department of Physics, College of Arts, Sciences & Education

Dr. Laird Kramer's work focuses on facilitating institutional change through implementation of, and research on, evidence-based educational practices. His unique work led the transformation of the undergraduate physics and STEM experience at FIU, situating the university as a STEM education laboratory to develop inclusive models to meet the national need for qualified STEM professionals, including teachers. He received his Ph.D. from Duke University, and he has over 250 publications and numerous active STEM education research grants. In 2015, he received FIU's Outstanding Faculty Award.

**John L. Volakis, Ph.D.**

Dean, College of Engineering & Computing

John L. Volakis has 35 years of experience in sensors and sensing, wireless/Radio Frequency (RF) communications, antennas, transceivers, energy harvesting, RFIDs and more recently in textile electronics. He has international recognition for significant impact in radars and RF communications antennas and RF front-ends for the wireless industry, wearable electronics, RFIDs, flexible textile electronics and medical sensors. He has written 8 books, co-authored more than 400 journal papers and over 750 conference papers in these areas, and graduated nearly 90 Ph.D. students. Dr. Volakis develops and provides research and expertise in sensors and sensing to evaluate bridge integrity (vibration, pressure, movement/stretching), traffic information and material composition along with information gathering.

ABC-UTC

ACCELERATED BRIDGE CONSTRUCTION

UNIVERSITY TRANSPORTATION CENTER (ABC-UTC)

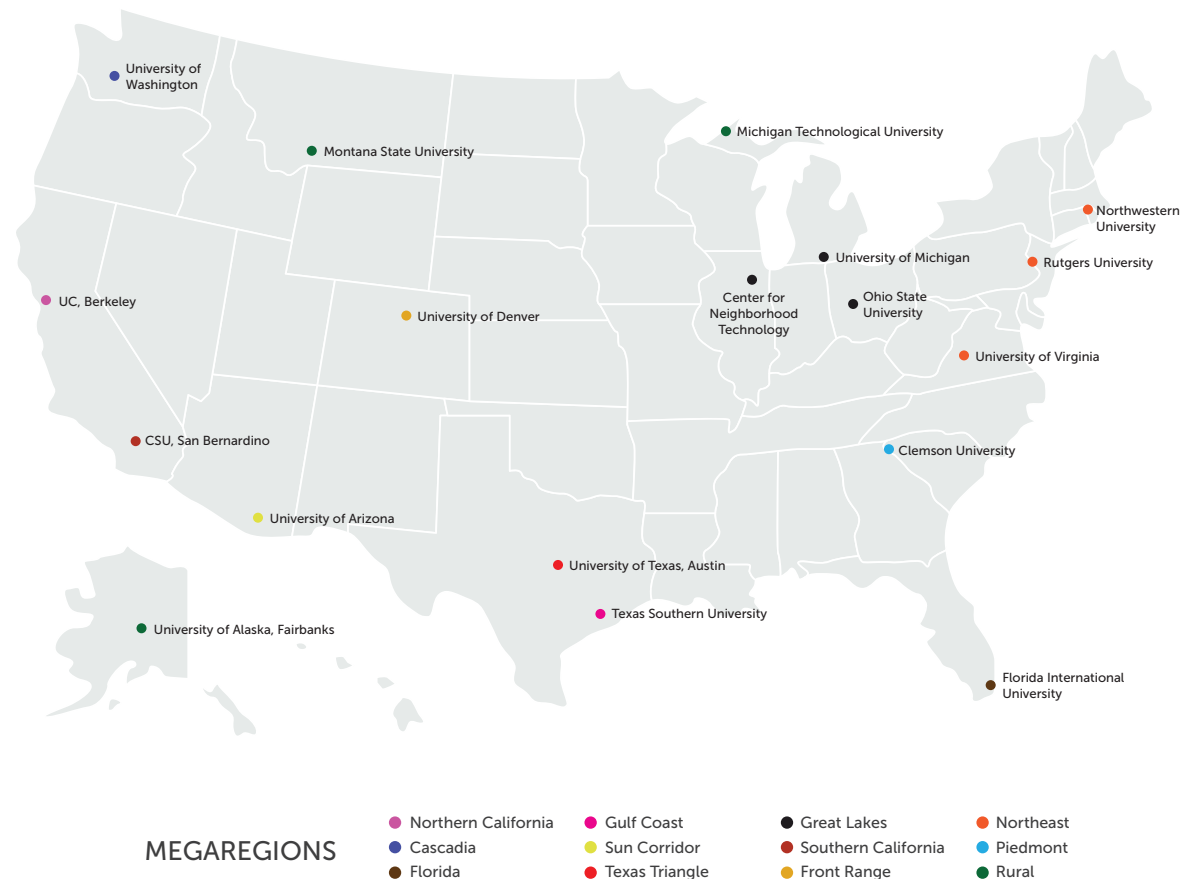
An important element of the Preeminent Bridge Engineering Program at FIU is the establishment of the Tier One, U.S. DOT Accelerated Bridge Construction University Transportation Center (ABC-UTC) (www.abc-utc.fiu.edu) with FIU as the lead institution.

ABC-UTC was first established during a 2013 UTC competition with Florida International University (FIU) as the lead and Iowa State University (ISU) and the University of Nevada-Reno (UNR) as partner universities. During the very competitive 2016 UTC competition, FIU was successful in receiving the Tier One U.S. DOT, UTC with focus on ABC for the period of 2016 through 2022. The 2016 coalition consisted of FIU as lead institution and Iowa State University (ISU), University of Nevada, Reno (UNR), University of Washington (UW), in Seattle, Washington, and University of Oklahoma (OU), in Norman, Oklahoma as partner universities.

The objectives of the Tier I ABC-UTC is to advance ABC; develop new ABC knowledge; effectively transfer state-of-the-art ABC knowledge to the profession; develop a next-generation ABC work force; and collaborate among industry partners which include, but are not limited to the Federal Highway Administration (FHWA), the American Association of State Highway and Transportation Officials (AASHTO), State Departments of Transportation (DOTs), other UTCs, industry, and the transportation profession to establish ABC as the best solution for the nation's aging bridge infrastructure in line with the U.S. DOT's Draft 2045 Beyond Traffic: Trends and Choices and State of Good Repair.

FIU's Preeminent Bridge Engineering Program in December of 2016, in response to a call by Secretary of Transportation, Anthony Foxx, prepared and submitted a proposal to be designated as U.S. DOT Beyond Traffic Innovation Center. In January of 2017, U.S. DOT announced the list of universities, receiving such designation. The U.S. DOT in its January 2017 announcement, named 18 colleges and universities to address America's growing transportation needs, identified in DOT's report, entitled, Beyond Traffic 2045, that outlines America's growing need for improvements to its transportation system.

As shown on the map, U.S. DOT identified 11 "mega regions" in the United States that require particular attention. At least one college or university in each mega region will serve as the designated Innovation Center in that mega region. FIU will be working closely with U.S. DOT and all stakeholders and concentrate on developing transportation solutions for South East Region of U.S.



MEGAREGIONS

<https://www.transportation.gov/BeyondTraffic>

ABC-UTC ORGANIZATION

As the lead university within the ABC-UTC, FIU works closely with its partner universities and board to assist faculty and graduate students. The ABC-UTC Advisory Board brings together renowned members of the bridge engineering profession to assist in ABC-UTC related activities in the areas of research, education and workforce development, and technology transfer.



Dr. Armin Mehrabi
Director of Research

Dr. Atorod Azizinamini
Director of ABC-UTC

Dr. David Garber
Director of Workforce Development

Mary Lou Ralls
Director of Technology

OUR PARTNERS



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Director

IOWA STATE UNIVERSITY

Dr. Terry Wipf
Co-Director

Dr. Brent Phares



Dr. Musharrat Zaman
Co-Director



Dr. John Stanton
Co-Director

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RIST — South Korea

Taek-Ryong Seong
RIST — South Korea



RESEARCH

RESEARCH PROJECTS SPOTLIGHT

Research is leading to exciting advances that are rapidly improving our nation's aging bridge system. These are just a few examples of ongoing or completed ABC-UTC-sponsored research projects.

Extending Application of SDCL to ABC

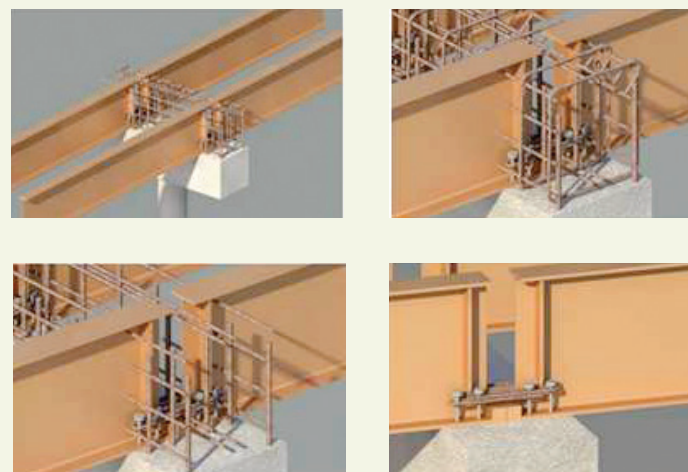
Led by **Dr. Atorod Azizinamini, FIU**

The steel bridge system, referred to as **"Simple for Dead Load and Continuous for Live Load" (SDCL)** has gained popularity in non-seismic areas of the country. Research conducted over the past 10 years has resulted in the development of complete design and detailing provisions for this new system for non-seismic applications. Results of this work are summarized in five journal papers published in the second and third quarters of 2014 issues of the AISC Engineering Journal.

In the SDCL bridge system there are no bolts or expansion joints, resulting in higher service life in addition to many other advantages. The system can significantly accelerate the construction process, and is ideal for building individual spans off site, transporting them to the final location and then joining them over the middle piers to create continuity for live load.

The research project, a joint effort between FIU and UNR, is being conducted in three phases. Phase I is complete and Phases II and III are ongoing. The connection detail suitable for seismic application of the system was developed at FIU during Phase I of the project. Phase II consists of component testing and verifying the merits of the detail, before being implemented in the shake table test, which will be conducted at UNR in Phase III of the project.

The following figures show schematically the detail over the pier that can be used to extend the application of SDCL to high seismic areas.



Schematic of seismic SDCL detail developed at FIU during Phase I of the project.

IMPACT

"Our State DOT has used the 'Simple for Dead and Continuous for Live' concept for many years in precast concrete girder designs and in a few cases for steel girder designs, where it provided significant advantages in durability, due to removal of deck joints, and in design efficiency. We are very interested to see this concept extended to ABC applications, due to its inherent advantages."

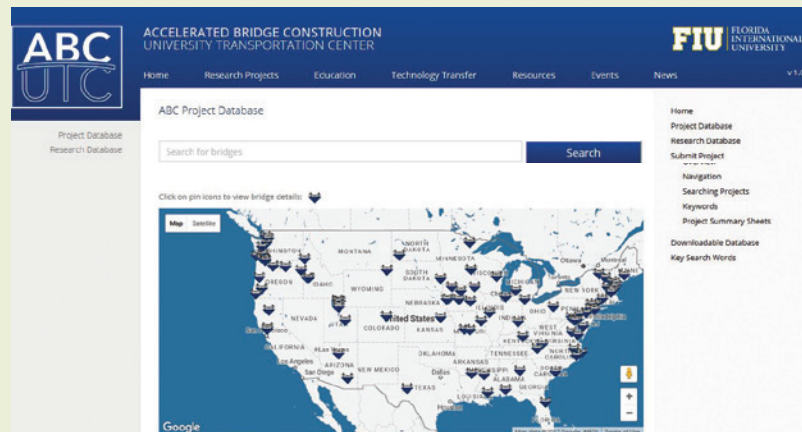
— Bruce Johnson, State Bridge Engineer, Oregon DOT

ABC Project and Research Database

Led by **Dr. David Garber, FIU**

The nation's infrastructure is aging and in desperate need of repair, retrofit or replacement. Accelerated bridge construction (ABC) and accelerated retrofit procedures are being utilized more by bridge owners, designers, contractors, and fabricators to minimize traffic impacts and costs and improve safety. Additionally, since ABC is a relatively new technique, there is a significant amount of new and ongoing research being undertaken to test concepts or validate design philosophies.

The main objective of this project was to create a resource to give any interested party easy access to information on completed bridge construction projects involving some aspect of ABC and to research efforts investigating a technique or technology impacting ABC. An online database and user interfaces were created to allow for easy searching, viewing and submission of completed ABC projects and research efforts (utcdb.fiu.edu). Detailed information is provided for each of the bridge construction and research projects. The ABC Project and Research Database is the location where designers, contractors, owners, researchers and other interested parties can turn for details on all different types of ABC projects and research efforts. In addition, it is a place where they can promote their own efforts.



IMPACT

"The sharing of information is a critical aspect of the deployment of new technologies. Through this database, owners and designers can build on past successful projects leading to continuous improvement in the technology."

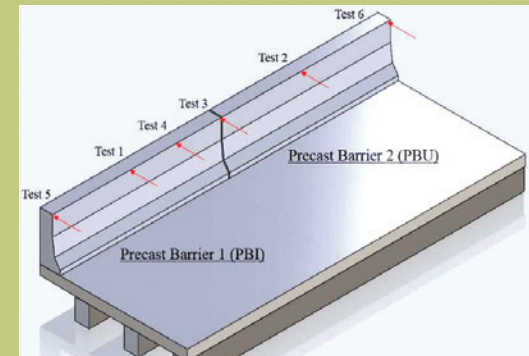
— Carmen Swanwick, Chief Structural Engineer, Utah DOT

Development of Prefabricated Bridge Railings

Led by **Dr. Teri Wipf and Dr. Sri Sritharan, ISU**

The overall objective of this research is to develop crash-tested prefabricated concrete bridge railings that have durable anchorage details. They are expected to be attached to a bridge superstructure with durable connections that satisfy the MASH 2009 Specification. The end products will be crash-tested prefabricated bridge railings with recommended durable anchorage systems and details that meet design test level TL-4 in accordance with MASH and LRFD Bridge Design Specifications.

A two-step research process was adopted; (1) development and laboratory testing of prototype concepts, and (2) crash-testing of promising concepts. The scope of work for the current project will be limited to item (1). Based upon the results of the literature search and nationally conducted survey, and for the purpose of laboratory testing, the research team selected one railing shape (F-shape) and developed two conceptual connection designs for connecting railing to deck and to each other. Nevertheless, the ultimate goal is to develop a system that can be adopted for multiple railing shapes. The construction of the deck slab and the loading block were done in the Iowa State University Structures Lab, and the barrier rails were fabricated by a precast plant in Omaha. The barrier segments were tested individually to test the barrier to deck connection. Then they were connected and tested again. It was concluded that the two precast barrier systems did not have any construction challenges in the assembly. The construction of the inclined connection required minimal access to install the connection reinforcement. The u-bar connection required access from under the bridge overhang to install the u-shaped connection reinforcement. Based on the results of testing, the final report will recommend barrier railing systems to undergo full-scale crash testing.



IMPACT

"A prefabricated bridge railing system will be a great addition to the ABC tool box."

— Ahmad Abu-Hawash, Chief Structural Engineer, Iowa DOT

Development and Seismic Evaluation of Pier Systems w/ Pocket Connections and Square PT/UHPC Columns

Led by **Dr. Saiid Saiidi, UNR**

Accelerated bridge construction relies heavily on prefabricated reinforced concrete members. Connections of prefabricated members are particularly critical in moderate and high seismic zones because earthquake forces place high demand on nonlinear deformation capacity of adjoining members. Various connections have been explored in the past few years. These connections may be placed in two categories — coupler or pocket connections. Promising results have been obtained for different versions of both categories, although much research and development have to be done before reliable and proven design methods of the type used in practice can be recommended.

With a few exceptions, past research on seismic response of ABC connections has focused on conventional reinforcing steel and concrete materials. Standard cast-in-place (CIP) bridges are designed to undergo large inelastic deformations to dissipate earthquake energy, but must not collapse. It is understood that these bridges would need to be decommissioned for major repair or replacement at a time they are needed the most for emergency response vehicles — after an earthquake. A new paradigm is being promoted and embraced by leading bridge engineers to utilize advanced materials. Research has been conducted to demonstrate the feasibility and merit of advanced materials for CIP construction. Specifically, advanced materials and methods are intended to minimize damage to plastic hinges and permanent drift of the bridge.

Despite numerous advantages of ABC, states in moderate and high seismic zones have not been able to embrace ABC because of insufficient research results and guidelines for seismic design of prefabricated members and connections.

The overall objective of the proposed study is to develop and evaluate resilient bridge piers consisting of prefabricated columns and cap beams subjected to simulated earthquake loading on shake tables. The study will focus on precast columns that are post-tensioned with unbonded carbon fiber reinforced polymer (CFRP) tendons and are connected to the footings and the cap beam using pocket connections.

IMPACT

“Combining prefabricated bridge elements with high performance materials will produce resilient bridge substructure components that are rapidly constructed and will provide enhanced seismic performance and post event serviceability.”

— Tom Ostrom, Acting State Bridge Engineer, Caltrans



Figure 1. Insertion of precast column into the precast footing



Figure 2. Inserting cap beam on top of columns

OTHER BRIDGE RESEARCH PROJECTS AT FIU

Bridge engineering team at FIU are also conducting research studies sponsored by various agencies outside of ABC-UTC. What follows are examples of ongoing or completed projects.

Design Guide for Bridges for Service Life

Led by **Dr. Atorod Azizinamini, FIU**

The main product developed by the Second Strategic Research Program (SHRP2), R19A, is the Design Guide for Bridges for Service Life, completed in 2014. It became the first and most comprehensive manual worldwide devoted to the subject. The first application of this document was the general framework for the design of the Tappan Zee Bridge over the Hudson River in New York. The document is now being used across the U.S. Following is an excerpt from an article by FHWA on the document developed, its impact and importance.

CHALLENGE

Because of deterioration, individual bridge components and systems such as bearings, decks, joints, columns, and girders require frequent and costly inspections, maintenance, and repairs that are often difficult to conduct. These activities cause lane closures that create congestion and impact safety for road workers and motorists. Bridge engineers need improved design options so they can deliver bridges that are operational for 100 years or more.

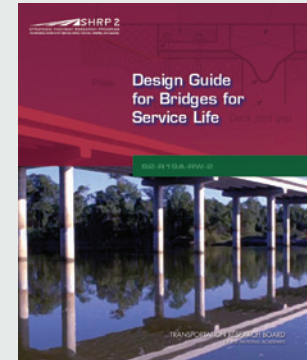
SOLUTION

The Service Life Design Guide for Bridges is a comprehensive reference document that complements AASHTO specifications and equips bridge engineers with the tools to develop specific solutions for given conditions and constraints. It represents a new approach to designing for service life that results in longer-lasting bridge components and systems that are both easier to inspect and better suited to their environments. The guide focuses on typical bridges with one or multiple spans and a maximum single span length of 300 feet. It addresses design, fabrication, construction, operation, maintenance, repair, and replacement issues applicable to both new and existing bridges. It includes standard plans, model specifications for design and construction, and fault tree flow charts.

BENEFITS

The Service Life Design Guide for Bridges may be utilized to provide longer service life by design through durable and state-of-the-art materials, construction techniques, and utilization of emerging technologies that are ideally suited for the bridge. The guide addresses service life issues at the design stage; which is significantly less costly than taking maintenance and preservation actions while the bridge is in service. It also provides engineers with tools to select and design for longer-lasting bridge systems and subsystems for the appropriate environment.

Original post: www.fhwa.dot.gov



Condition Assessment of Cable-Stayed Bridges

Led by **Dr. Armin Mehrabi, FIU**

The past decade has seen a significant increase in construction of cable-stayed bridges. As it is often the case, when designing bridges, engineers are usually so focused on solving the intricate problems and issues related to design and construction that they inadvertently tend to overlook potential effects of their design and detailing choices on the durability, maintenance needs, and long-term behavior of structural elements and details. This necessitates development and implementation of new evaluation approaches and methods applicable to stay cable systems that are undoubtedly the most critical elements of a cable-stayed bridge. A FHWA-sponsored research project, No. DTFH61-96-R-00029, for Condition Assessment of Cable-Stayed Bridges attempted to establish the approach and set direction for further investigation.

This project, for which Dr. Mehrabi served as co-investigator, was the first comprehensive research project in the US in relation with newer generation of mid- to long-span cable-stayed bridges. The outcome of this project can be summarized as:

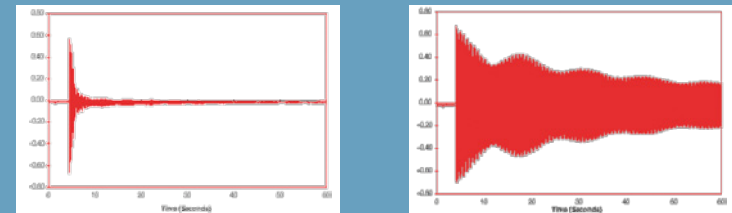
- Compilation of data for existing bridges and statistical analysis of data.
- Development of NDT method for vibration measurement of cables.
- FD and FE analysis of cable dynamic behavior.
- Development of new formulation for force estimation of cables.
- Development of damper design formulation and charts.
- Development of damage detection concept using cable forces.

The project was very successful in producing results that went to practice even before the final report for the project was issued. For his contribution to development of a new non-destructive laser-based condition assessment method for cable-stayed bridges in this project, Dr. Mehrabi was awarded by Engineering News Record as One of Top 25 Newsmakers of the Year, 1997. Later, Dr. Mehrabi served as PI and Co-PI for two NCHRP IDEA (#50 and #71) related to this project in relation with vibration suppression methods and co-invented a new Tuned-Impact damper for stay cables.

The practical evaluation techniques and design methods developed as a result of this research have been applied to several actual bridge structures, including 25 major cable supported bridges in the US and abroad. The research work continues toward development and refinement of a unified approach for condition assessment of cable-supported bridges, life-cycle-cost analysis, and repair/rehabilitation methodologies.



Special Inspection of Stay Cable Anchorages



Vibration Suppression Measures help Mitigating Stay Cable Vulnerability to Wind-Induced Oscillations



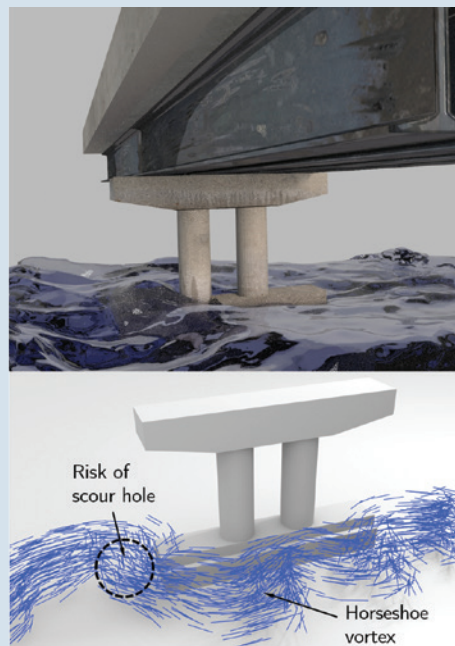
Non-contact, Non-Destructive, Laser-Based Technique for Force and Damping Measurement of Slender Tension Elements

Holistic Bridge Scour Vulnerability Evaluation

Led by **Dr. Seung Jae Lee, FIU**

It has been reported that about 60% of bridge failures in the United States since 1960 were caused by scour. In spite of recent advances in testing and measurement methods, their applications are mostly limited to the estimation of the soil erosion potential, and are missing the capability to predict the failure of bridges caused by soil erosion. There are many scour-related engineering issues remain to be better answered to robustly estimate, e.g. remaining safety margins before a bridge topples, accelerated soil erosion rate possibly caused by storm surge or sea level rise and its effect on bridge stability.

The research team makes a systematic approach to enable holistic bridge scour vulnerability evaluation by leveraging simulation-based methods that can consider the fully coupled interactions between soil particles, water flow and bridge piles that may lead to the failure. This ongoing research will (1) provide an effective simulation-based framework that can consider the fully coupled multi-physics phenomena to holistically assess the scour vulnerability of existing bridges, (2) develop and evaluate an in-situ bridge scour sensing system that can diagnose the existing scour depth of existing bridges, and (3) develop a seamlessly integrated framework based on the simulation method and the sensing system to predict the scour-induced failure that may possibly occur.



Numerical modeling for bridge scour vulnerability estimation (Modeled turbulence flow around bridge pier)

Redundancy of Bridges with Fracture Critical Element

Led by **Dr. Atorod Azizinamini, FIU**

A survey found that **approximately 11% of steel bridges in the U.S. contain members that are "fracture critical."** A significant number of these are box girder bridges. "Fracture critical" is a formal designation based on design characteristics, making such bridges subject to regular, detailed, and expensive inspections. However, some bridges have been noted to have cracks in some parts of the box girder and yet remain in service with no indication of failure. This suggests that the stability of these bridges is not always linked to fracture critical members and that engineers need a deeper understanding of how these bridges carry loads, possibly changing the formal definition of "fracture critical."

Florida International University, under the direction of Dr. Azizinamini has been researching the possibility of removing twin steel box-girder bridges from the list of fracture critical structures. The study has focused on two steel box girder bridges and has developed a tool to quantify the redundancy level of these bridges in the event that one girder is completely fractured. The effect of cross-frames, both within



and between the girders, was also studied. In the first part of the project, a comprehensive set of experiments was performed on a small-scale twin box girder bridge section approximately 9 feet wide, 40 feet long, and 2 feet high. It consisted of a reinforced concrete deck supported by two steel box girders. The model was thoroughly instrumented. Investigations were conducted on the intact structure; under a simulated catastrophic failure with specific damage to the girders; and in ultimate load tests which loaded the structure to the failure point. Extensive finite element modeling was conducted to analyze the distribution of loads in the structures and modes of failure in the laboratory model. Two steel box girder bridges were also tested in the field. A general framework for investigating the redundancy of the two steel box girder bridges has been developed and step-by-step procedures are envisioned for DOT engineers to assess the redundancy of two steel box girder bridges and remove them from "fracture critical" lists where appropriate.



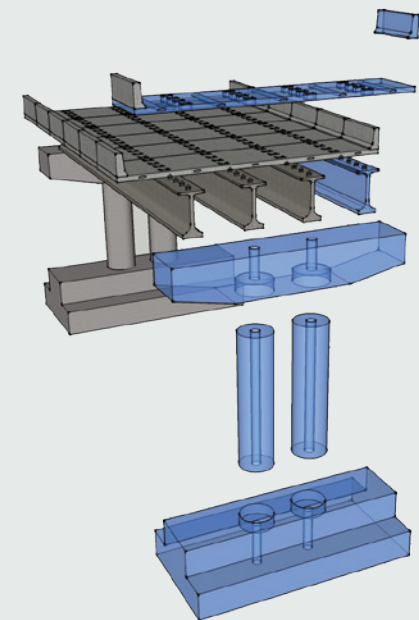
3D Printed Accelerated Bridge Construction (ABC)

Led by **Dr. Seung Jae Lee & Dr. David Garber, FIU**

There are a wide variety of prefabricated bridge elements and systems used in ABC. These elements can be used for all components of bridge construction from sub-structure to super-structure. Some common prefabricated elements include parapets, bridge decks, girders, column caps, columns and footings or pile caps.

In recent decades, 3D printing has gained in popularity. 3D printing is a process for making a physical object from a three-dimensional digital model, typically by laying down many successive thin layers of a material.

A number of engineering areas have started adopting the 3D printing technique to help bring their ideas into the real world. An Accelerated Bridge Construction — University Transportation Center (ABC-UTC) research team recently used 3D printers to perform "physical" modeling of ABC. Using 3D printing technology, the team was also able to provide more hands-on opportunities for students to study ABC without resorting to "computer" simulation. Currently, the research team is investigating ways to create an entire bridge using a 3D printer on a small-scale by exploring different connection options. The goal of this research is to determine if 3D printers could be used for prefabricating bridge elements and checking specialized connections prior to any field construction.



Prefabricated bridge elements that can be 3D printed for ABC study

Local and Global Strain-Based Corrosion Detection Using Available Sensors

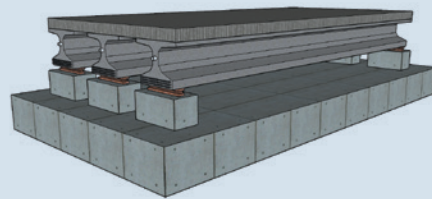
Led by **Dr. David Garber and Dr. Kingsley Lau, FIU**

Corrosion of steel rebar in reinforced concrete structures is a major concern for highway bridge owners, as reinforced concrete and prestressed concrete bridges make up over half of the bridges in the U.S. Reinforced concrete in severe environments with exposure to chloride ions and carbon dioxide can result in corrosion deterioration that leads to structurally deficient behavior and increased maintenance costs. Corrosion monitoring of steel-reinforced concrete structures with embedded sensors can be used to complement common corrosion inspection methods. These monitoring techniques will require sensors that operate over several decades.

The objective of this project is to evaluate the feasibility of using currently available local and global sensor technologies to monitor corrosion deterioration in bridge structures. This work will be used to connect corrosion rates and percent mass loss to sensor readings and, finally, to the overall member performance and residual strength. The project includes long-term experimental testing and finite element modeling of the bridge system.



(a) Small-scale post-tensioned specimens instrumented with VWGs



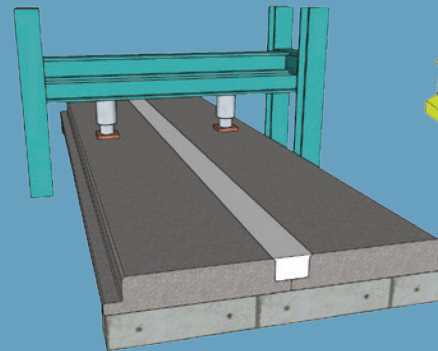
(b) Mock-ups of large-scale specimen to be constructed during project

Florida Slab Beam Bridge with Ultra-High Performance Concrete Joint Connections

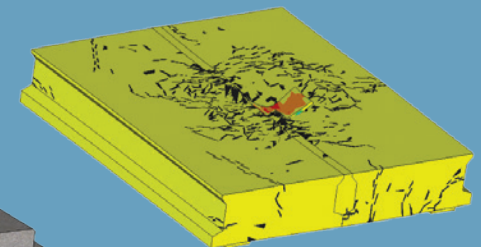
Led by **Dr. David Garber, FIU**

The availability of new materials and techniques is allowing for accelerated construction and increased durability of bridge structures. One innovation that is receiving national attention for its exceptional structural properties is ultra-high performance concrete (UHPC). The Florida Department of Transportation (FDOT) is interested in creating a modified prestressed concrete section shape for short- to medium-span bridges. The desired section will utilize UHPC joints to connect adjacent members and not require a cast-in-place composite deck to accelerate construction and improve long-term performance.

The objective of this research is to develop a suitable cross-section design and joint detail for use in short- to medium-span bridges with accelerated construction. The project involves finite element modeling and full-scale structural testing of the joints and beams.



(a) Mock-up of full-scale beams to be constructed



(b) Initial analysis results of behavior of developed joint

Accelerated Bridge Construction Drone (ABCD)

Led by **Dr. Pezhman Mardanpour, FIU**

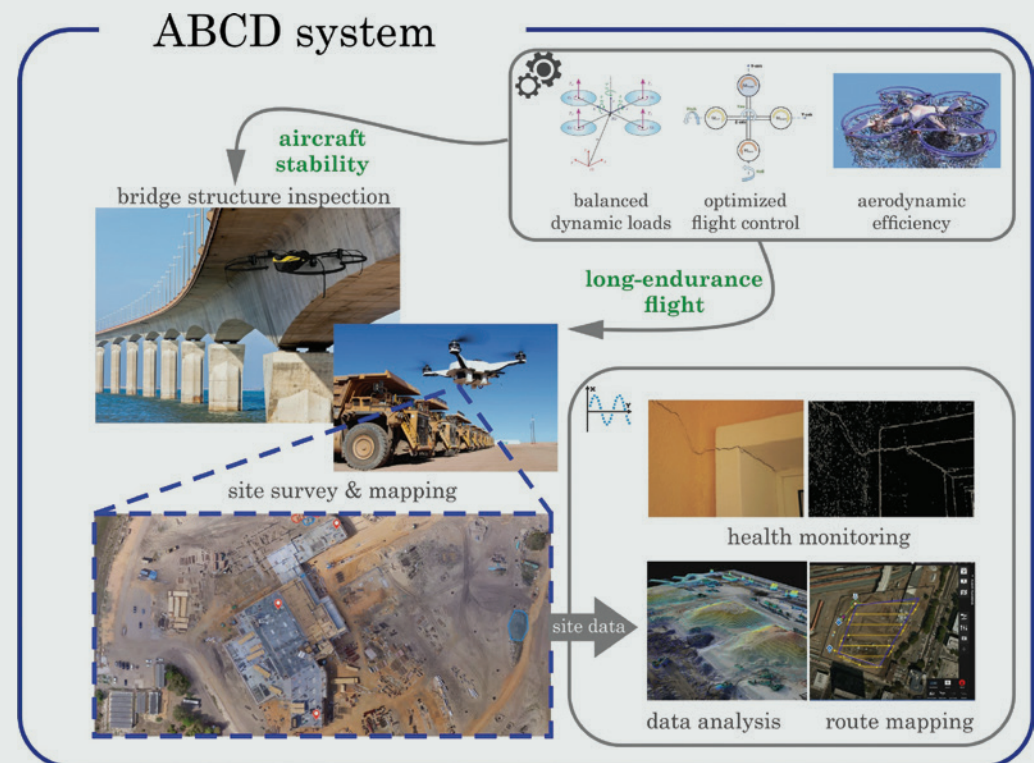
Over the next decades, automation will be at the center stage of many advances within different disciplines of engineering. Recent advances in drone-related technologies allows better construction management, quality control, inspection and maintenance of bridges.

Drones have many applications in bridge engineering. Following are a few examples.

A challenging task during bridge construction is the control of geometry. In Accelerated Bridge Construction, it is not unusual to have two or three separate entities verify survey results. Misalignment is a costly construction mistake that can easily result in major lawsuits and construction delays. In ABC systems, drones can be used for on-site mapping and surveying of existing supports and off-site mapping of prefabricated elements. This will then allow for tolerances to be verified and appropriate corrections made before shipping the bridge elements to the site.

Another major application of drones in bridge engineering is the automation of bridge inspection. According to law, every bridge needs to be inspected once every two years and DOTs are required to report the inspection results to FHWA. Inspection using drones also enhances driver safety, and more importantly, significantly minimizes interruption to traffic. In addition, drones can be automated and controlled remotely from the design office. Such capabilities also allow the bridge owner to inspect critical parts of bridges on a demand basis, from the office, when data is urgently needed.

Currently, the use of drones in bridge engineering is limited to commercially available drones to carry out different tasks. By developing specialized drones that are better suited for bridge engineering applications, their optimum use can be achieved. FIU researchers at the Fluid-Structure Interaction Laboratory and their collaborators in civil engineering possess a comprehensive and up-to-date knowledge of drone technology that is essential in developing Accelerated Bridge Construction Drone systems. Fundamental work is being carried out to develop the next generation of drones with applications in bridge engineering.



Accelerated Bridge Construction Drones

TECH TRANSFER



TECHNOLOGY TRANSFER

The majority of FIU's bridge engineering ventures are developed, organized and carried out through ABC-UTC activities. FIU's bridge engineering group is in continuous communication with various segments of the industry and is able to effectively transfer cutting-edge knowledge to bridge professionals.

In-Depth Web Training

Building upon the monthly webinar series, an annual in-depth web training program was initiated in 2014 to provide more detailed coverage of select projects and topics related to ABC. Each four-hour training session consists of six, 30-minute modules that include a presentation by an expert in the focus area. It is followed by a 10-minute Q&A session. The ABC-UTC website's in-depth web archives document the training.



GUEST SPEAKERS:

Wayne Seger, P.E.
Director, Division of Structures
Tennessee DOT

Lia Obaid, P.E.
Assistant Director, Construction
Tennessee DOT

Terry Mackie
Project Manager, Jones Bros., Inc.

Ted Kniazewycz, P.E., F.ASCE
Senior Associate with Gresham,
Smith and Partners

Past Webinars

October 4, 2016 —

Tennessee DOT's "Fast Fix 8"
Project in Downtown Nashville

November 10, 2015 —

Milton-Madison Bridge Replacement:
The Mega-Lateral Slide

November 4, 2014 —

MassDOT's 93FAST14 Project

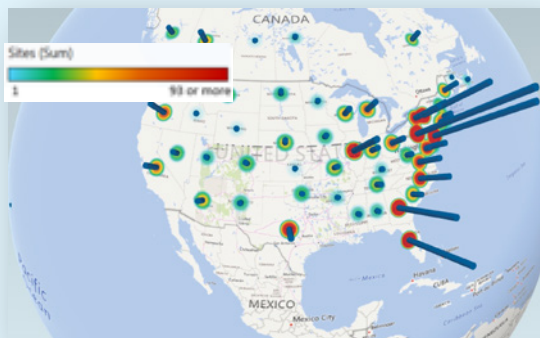
Map showing over **283 sites nationwide** that registered for the October 2016 in-depth web training — Tennessee DOT's "Fast Fix 8" project in Downtown Nashville.

Monthly Webinars

On average, more than 800 sites register for each webinar. At most sites, more than one individual listens to the webinars, and at DOT offices, many bridge professionals gather in one room to take part. About 4,000 bridge professionals participate each month in these webinars, providing an excellent platform for communicating the latest developments in the ABC area. The maps below show the locations of registered sites for the March and April 2017 webinars. ABC-UTC, on a monthly basis, offers a one-hour, free webinar that features an expert speaker and provides up-to-date information related to ABC. To date, 72 monthly webinars have been produced and are recorded and archived under the “Webinar Archive” section of the ABC-UTC website. They are available free.

MARCH 2017

Georgia's Rapid Replacement Utilizing Full-Depth Precast Deck Panels with UHPC Closure Joints



SPEAKERS:
Bill DuVall, P.E.
State Bridge Engineer,
Georgia Department
of Transportation

Dexter Whaley, P.E.
Bridge Design Group
Manager, GDOT

Map of over **1073 registered sites** by state that attended the March 2017 Webinar.

APRIL 2017

PennDOT's Rapid Bridge Replacement Project Utilizing Folded Steel Plate Girder Bridge



SPEAKERS:
Tom Maciocce, P.E.
Chief Bridge Engineer,
Pennsylvania Department
of Transportation

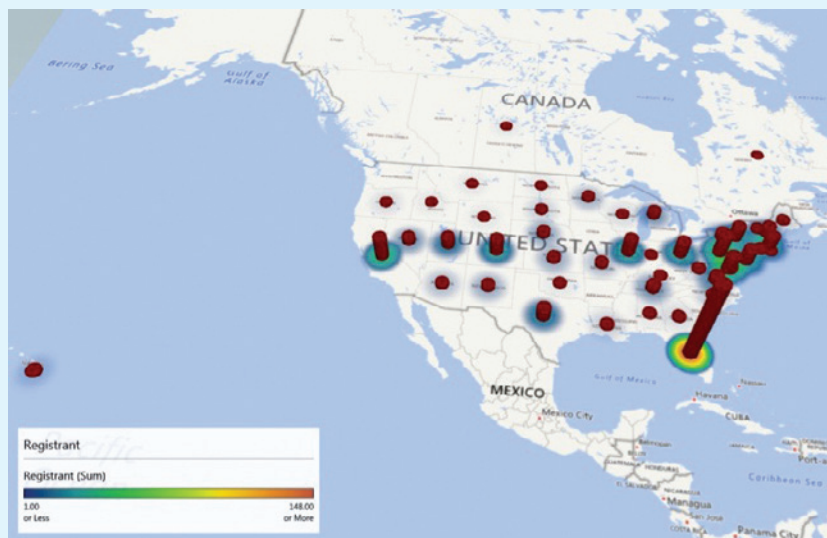
Charles Zugell, P.E.
Design Build Coordinator
Walsh/Granite JV

Curt Beveridge
Project Manager,
Walsh/Granite JV

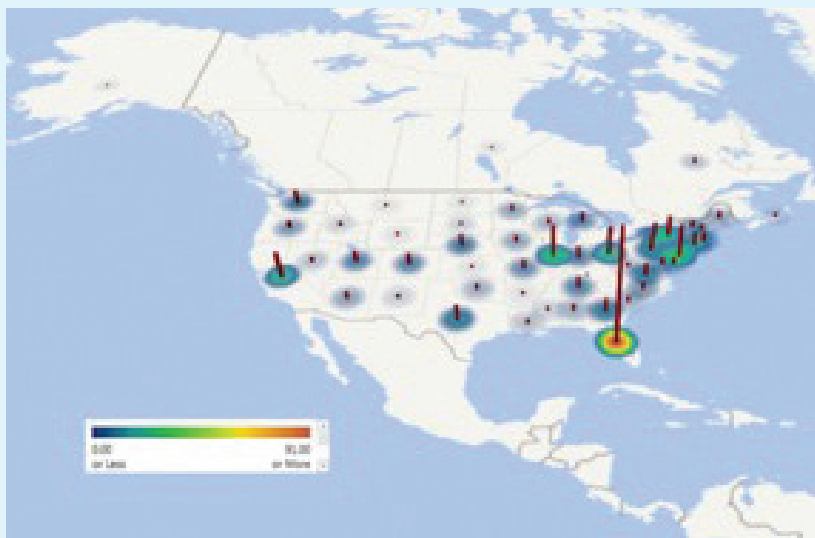
Map of over **1100 registered sites** by state that attended the April 2017 Webinar.

National ABC Conferences

ABC-UTC organizes and conducts national or international ABC conferences annually or every other year. They are considered to be the premier bridge engineering conferences and are co-sponsored by State DOTs and the Federal Highway Administration. In 2014 and 2015, ABC-UTC organized and conducted two national ABC conferences. The next conference, 2017 National ABC Conference, is scheduled for December of 2017.



This map shows where about **750 attendees** of 2014 National ABC conference organized by ABC-UTC came from, including almost every state and a few from other countries.

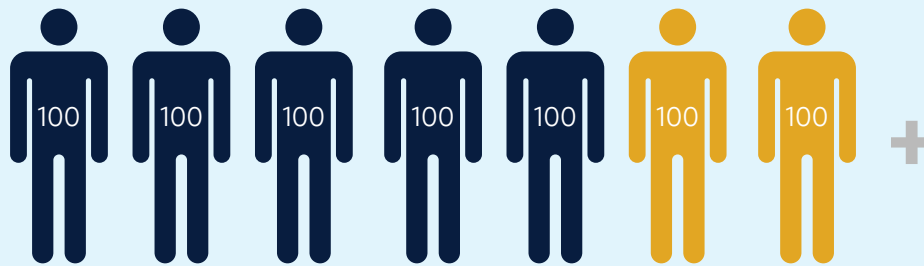


This map shows where about **700 attendees** of 2015 National ABC conference organized by ABC-UTC came from, including almost every state and a few from other countries.

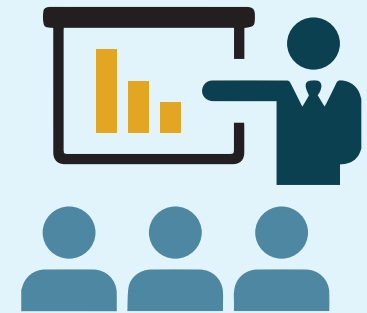
HIGHLIGHTS OF **2014** AND **2015** CONFERENCES

The 2014 and 2015 National ABC Conferences were each attended by more than 700 bridge professionals, including more than 200 state DOT bridge engineers and professionals. During the 2014 and 2015 National ABC Conferences, a total of 275 technical presentations were made, 18 full- and half-day workshops were conducted, and 95 companies exhibited their services. Mr. Gregory C. Nadeau, administrator of the Federal Highway Administration, was the keynote speaker during the 2014 and 2015 conferences. The conferences, through scholarship development, assisted with travel expenses for a number of state bridge professionals attending the conference. **The 2017 National ABC Conference will be held December 6-8 at the Hyatt Regency Miami.**

attendance at each conference



700+ bridge professionals, including more than **200** state DOT bridge engineers and professionals.



275+
technical presentations

total of
18
workshop



95
companies exhibited



For highlights of the 2014/2015 Conference, visit:
abc-utc.fiu.edu/technology-transfer/conferences/

The **2017 National ABC Conference** **December 6-8** at the Hyatt Regency Miami.



To register online visit: abc-utc.fiu.edu/conference/registration/

EDUCATION AND WORKFORCE DEVELOPMENT

TRAINING AND SHORT COURSES

Through research and educational activities, FIU's bridge engineering faculty are in the forefront at the national and international levels and provide short courses on various topics related to bridge engineering. These courses range from half a day to one week long, depending on needs and can be delivered at your site during the week or on weekends. They fulfill the requirements by many states for professional license renewals and provide continuing education credit. The class lectures reflect practical and useful design and construction tips. Attendees receive complete copies of the materials to be covered in the workshop in advance, allowing them to better prepare.

- Introduction to Bridge Engineering
- Design Steel Bridges Using Latest AASHTO LRFD Bridge Design Specification
- Introduction to Corrosion Engineering
- Refined Methods of Analysis
- Prestressed Concrete Design
- Inspection and Evaluation of Cable-Stayed Bridges (Emphasis: Stay Cables)



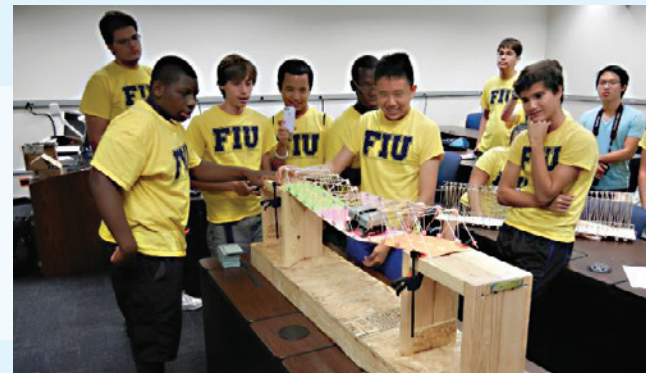
On December 2016, Atorod Azizinamini, director of ABC-UTC, taught a one-day executive education bridge design course titled "**Design of Steel Bridges.**" The course, co-sponsored by the American Institute of Steel Construction (AISC) and the National Steel Bridge Alliance (NSBA), was attended by a diverse group of professionals and graduate students from around the country — including engineers, consultants and Department of Transportation representatives from various states.

SUMMER CAMP PROGRAMS THROUGH ABC-UTC

At the K-12 level, the ABC-UTC implements annual summer camp programs, including academic enrichment programs and teacher training workshops.

FIU's Summer Transportation Camp, 2015

One of the focal points of FIU's Summer Transportation Camp, initiated in summer 2015, was ABC. Eighteen Miami-area inner city high school students ranging from sophomores to seniors attended the camp. Students were introduced to ABC techniques through a series of lessons and then were given the opportunity to explore their use in a balsa wood bridge project. Student teams were required to prefabricate their bridges in three pieces and transport them to the bridge site. They then had 30 minutes to construct their final bridge. Each team tested the capacity of their small scale model bridges by driving a remote-controlled toy truck over them.



FIU's Bridge and Wind Engineering Teacher Workshop, 2016

In the summer of 2016, the ABC-UTC sponsored a K-12 teacher training workshop that introduced Miami-area teachers to structural, bridge, wind and corrosion engineering, and (most importantly) Accelerated Bridge Construction, which spans numerous disciplines within engineering.

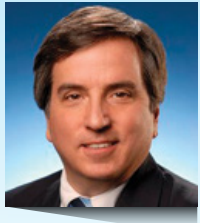
The workshop educated inner city teachers how to better prepare their students to learn about ABC through various classroom activities.

The workshop focused on introducing the teachers to the state-of-the-art in each field and working with them to develop educational modules for use in the classroom and in after-school programs. All the materials from the developed modules are available for free on the ABC-UTC website.



MENTORSHIP PROGRAM THROUGH ABC-UTC

Graduate students engaged with ABC-UTC are provided with opportunities to be mentored by professional bridge engineers currently in practice. The primary goal of the mentorship program is to help ABC-UTC students best prepare for the workforce.



Mike Culmo, P.E.

Mr. Culmo serves as the vice president of CME Associates, Inc., and has more than 25 years of experience in structural engineering. He is considered an expert in the field of bridge design and innovative construction strategies. He possesses a wealth of experience in traffic engineering and materials specification and is a nationally-recognized expert in Accelerated Bridge Construction practices. He has authored numerous papers, articles and manuals in the field of bridge engineering design methods and construction techniques. Mr. Culmo has also worked on several high-profile projects including Massachusetts' Fast 14 Bridge Replacement and has helped Departments of Transportation in Utah, Connecticut and Rhode Island in the development and furtherance of pilot projects and standards using ABC methods. He serves on numerous industry committees and groups, including the National Steel Bridge Alliance, the High Performance Steel Design Advisory Committee for the American Iron and Steel Institute, and the Transportation Research Board. He is the recipient of the 2014 American Institute of Steel Construction's (AISC) Special Achievement Award.



Reza Farimani, Ph.D., P.E.

Dr. Farimani joined Thornton Tomasetti in 2006, where he is a vice president. He has experience in the structural analysis and design of steel and concrete structures including high-rise, commercial, education, residential, sports and mixed-use developments. He is responsible for the analysis, design and preparation of drawings and coordination and communication with outside consultants. In addition, he performs investigations and condition assessments worldwide, most notably the I-35W bridge collapse in Minneapolis. Dr. Farimani is an avid researcher and analyst, publishing his findings in numerous professional journals.



Jawad Gull, Ph.D.

Dr. Gull is a bridge designer at HDR and has nine years of experience in research and structural engineering. He has expertise in cable structures and steel bridges, and has worked on diverse engineering projects in the United States, Japan and Pakistan. Dr. Gull obtained his doctorate degree from Florida International University. He worked on several research projects and successfully addressed issues related to construction, inspection and rehabilitation of bridges. He served as the assistant director of the ABC-UTC at FIU. He earned his master's degree from Saitama University, Japan. He and his research team worked in collaboration with the Tokyo Electric Power Company and addressed several issues related to wind-induced vibrations of cable structures. He also has been involved in several destructive and nondestructive tests of structures and materials in Pakistan.



Finn Hubbard, P.E.

Mr. Hubbard joined Fish & Associates, Inc. in November 2012 with over 30 years of structural design, construction, maintenance, policy and management experience. He has been involved in a variety of structural design and construction projects within the transportation industry and has extensive experience with simple and complex multi-phase, multi-year projects. He has personally designed and overseen the production of thousands of bridge plans and projects. Mr. Hubbard started his career with the Wisconsin Department of Transportation in 1985 and advanced through the ranks to become State Bridge Engineer for Wisconsin. He also served on the American Association of State Highway and Transportation Officials (AASHTO) Subcommittee on Bridges and Structures as Wisconsin's primary representative working directly with the other 49 DOTs on national bridge-related policies for seven years. Mr. Hubbard led the stabilization and reconstruction efforts for the Hoan Bridge failure in Milwaukee, Wisconsin, in December 2000.



Michael LaViolette, P.E.

Mr. LaViolette joined HDR following many years as a senior bridge manager at HNTB and as a bridge research specialist at the Iowa State University Bridge Engineering Center. His unique combination of 15 years of practical bridge design and construction experience along with academic research with proven results was applied to work in developing useful plans and specifications suited for simplified deck panel systems. Mr. LaViolette is currently serving as the principal investigator on several projects. He is an active member of Transportation Research Board Committee AFH40 (Construction of Bridges and Structures). He is also an active member of the Precast/Prestressed Concrete Institute Committee on Bridges as well as its Subcommittee on Accelerated Bridge Construction.



Francesco Russo, Ph.D., P.E.

Mr. Russo is a senior structural engineer and technical and project manager at Michael Baker Corp. His experience includes all phases of engineering practice, including project engineering; staff, scheduling and financial management; construction support services; forensic investigations and report writing. He has design-build experience on multiple projects, including serving as part of design teams, as an owner's advisor, and directing design quality control efforts for a multi-billion dollar design-build project.



Ardalan Sherafati, Ph.D., P.E.

Dr. Sherafati is a structural project engineer at BlueScope Construction Inc. As a structural engineer he has been involved in the analysis and design of stadiums, office buildings, parking structures, underground structures and industrial buildings. For his Ph.D. dissertation, he was involved in the SHRP2-R19A project, where he proposed and successfully tested a pile/cap connection detail that is proven to significantly increase the length of jointless bridges. He has extensive experience in nonlinear finite element analysis as well as computer programming. He has developed several structural design and analysis tools.

INNOVATION



INNOVATIVE BRIDGE ENGINEERING PRODUCTS AND SOLUTIONS

An important part of the Bridge Engineering Program at FIU is the development, patenting and marketing of new and innovative products and bridge systems that address problems faced by bridge professionals in dealing with existing and new bridges.

These products provide an opportunity for venture capitalists and other stakeholders.

As an example, the Folded Steel Plate Girder Bridge System (FSPGBS) developed by Dr. Azizinamini was recognized by AISC Modern Steel Construction Magazine (Jan 2011) as a concept that can revolutionize the steel bridge industry. The concept was developed over seven years of research while Dr. Azizinamini was on the faculty at University of Nebraska-Lincoln. The current system is best suitable for short span bridges up to 60 ft. Currently, Dr. Azizinamini is engaged in the development of the next version of the FSPGBS that is extending the maximum length of the system to more than 100 ft. The FSPGBS has been used by several states. As an example, the Walsh Group, contractors, constructed two FSPGBS bridges in 2016 as part of Pennsylvania's Private, Public Partnership Bridge initiative, with five more scheduled for summer of 2017. Other states that have used FSPGBS, include Massachusetts and Nebraska. FSPGBS is best suited for ABC application and is proving to be very cost effective, demonstrated by its selection over alternatives by contractors. Dr. Azizinamini was recognized by the White House in October of 2015 as a White House Champion of Change: Transportation Innovator, partially because of the development of FSPGBS.

For other available patented bridge engineering technologies and more information, please contact Dr. Azizinamini at aazizina@fiu.edu or 402-770-6210.



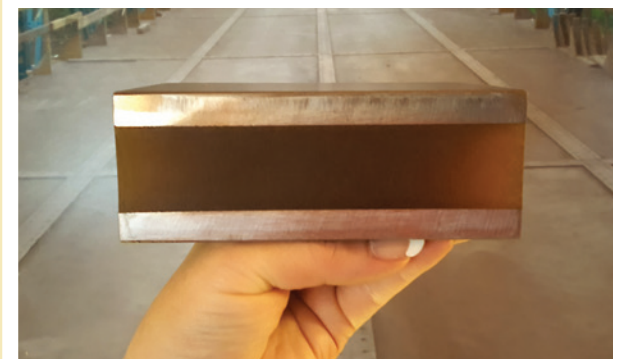
CLEARINGHOUSE FOR INNOVATIVE BRIDGE ENGINEERING PRODUCTS AND SOLUTIONS



Structural Lightweight Concrete



Hillman Composite Beams (HCB)



Sandwich Plate System (SPS)

To address the significant number of substandard bridges among the nation's bridge inventory, development and implementation of innovative and cost effective products and solutions are a must. A major obstacle in implementing new bridge engineering products and solutions is providing bridge owners with confidence in these new products and solutions. To address this challenge, ABC-UTC has undertaken an initiative to assist inventors to introduce their product into the market by providing dedicated resources. In addition, ABC-UTC through its vast resources and facilities has the full capability of independently testing and verifying merits of new bridge engineering products and solutions. Such independent evaluation provides bridge owners with confidence in utilizing these new products and solutions.



The Folded Steel Plate Girder, or FSPG



Hillman Composite Beams (HCB)



Press-Brake-Formed Tub Girders

SERVICES

SERVICES AND TESTING CAPABILITIES

The bridge engineering research team at FIU, has also developed effective methodologies and testing solutions for many complex challenges that bridge owners and engineers face. Here are examples of services that FIU's bridge engineering team has provided to bridge owners and engineers.

Special Inspection, Non-destructive Testing, Cable Vibration Measurement and Mitigation, Health Monitoring, Evaluation and Rehabilitation of Cable Supported Bridges Led by **Armin Mehrabi, FIU**

Research by FIU Engineering faculty has contributed to development of a unified approach for condition assessment of cable-supported bridges from inspection to rehabilitation.

These include special inspection, cable vibration evaluation and mitigation, cable force measurement, health monitoring, rehabilitation design and QC/QA. The bridge evaluation results are presented in a manner that are applicable to bridge condition rating. The practical evaluation techniques and design methods developed as a result of this research have been applied to several actual bridge structures, including 25 major cable supported bridges in the US and abroad. These include among others; evaluation of post-tensioning external tendons in the Second Vivekananda Bridge in India, instrumentation, testing, and fatigue/failure analysis of the Bosphorus Bridge in Turkey, vibration, force measurement, and integrity analysis of stay cables of QEII Bridge in London, UK, and more recently, inspection, evaluation, rehabilitation design and construction support for the complete cable replacement of the Luling Bridge in LA, the first of its kind in North America.

Dr. Mehrabi has also served as consultant and complex bridge specialist for Florida State Department of Transportation Districts to identify and implement applicable evaluation, inspection, health monitoring and non-destructive testing to address their concern on structural safety and integrity of the Sunshine Skyway and Dames Point Cable-Stayed Bridges.

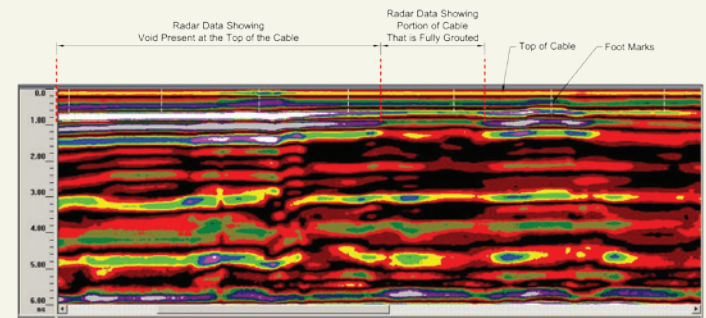
FIU Bridge Engineering team can provide similar services to bridge owners through FIU. For more information please contact Dr. Atorod Azizinamini at aazizina@fiu.edu or 402-770-6210.



Hale-Boggs (Luling) Cable-Stayed Bridge in Louisiana was evaluated for corrosion and all stay cables were recently replaced



Digitized tap testing for NDE of corrosion protection of stay cables and post-tensioning tendons



Impulse Radar (or GPR) NDT method for stay cable cover-pipe and grouting evaluation

Sample Radar Scan

Impulse Response (IR)

Led by **Dr. Atorod Azizinamini, FIU**

The IR test is a simple yet powerful non-destructive testing method that allows assessment of a given structure for onset and progress of damage or anomalies. It can be applied to a variety of bridge structures, in the following ways:

1. It provides a record or signature of the structure at a given time. By conducting the same test, after say two years, one could evaluate the changes the structure experienced over time
2. The IR test can be used to compare the relative condition of one part of the structure to other portions and thereby detect the problem areas
3. IR tests can identify damaged areas of structures due to a variety of reasons

IR testing is conducted by drawing a grid over the region of the structure to be studied. The testing apparatus consists of a hammer attached to a load cell capable of generating small force, as an example, at a point in the deck. The other element of the testing device is a transducer that measures the response of the structure in terms of velocity.

The velocity transducer is placed at every grid point, and the hammer is used to impart a strain. The data is collected and stored in the computer in the form of time versus velocity and time versus force. The information is then converted to frequency domain by using Fast Fourier Transform (FFT).

The resulting velocity spectrum is then divided by the force spectrum to obtain a transfer function, referred to as the mobility of the element under the test. Mobility is an index that allows the engineer to quickly assess the condition of one part of the structure relative to other parts.

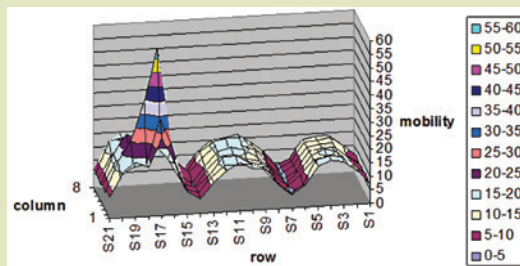


Hammer, Load cell and Velocity Transducer



Data Collection and Processing

The figures below show results of IR tests carried out by FIU bridge engineering faculty on the segment of a bridge that included a failed splice.



(a) IR Test Results of Failed deck Section, along the traffic. High pick correspond to failed splice device

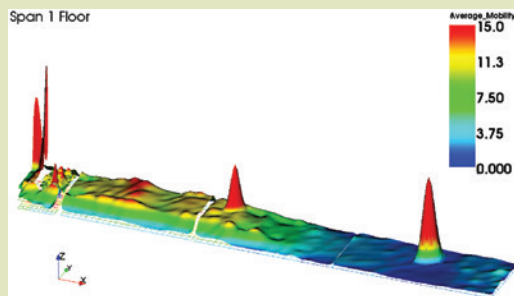


(b) Failed Splice because of lack of good workmanship and corrosion



(c) Section of Failed Deck, in a phase constructed bridge after removing concrete and exposing failed splice devices (splice devices already cut and removed)

The axis defined as Row in **(a)** is along the bridge width and the axis defined as column is along the traffic. The vertical axis is mobility, which is an index to assess the bridge condition. In simple terms, the higher the mobility, the higher the tendencies of the structure at that location to move (higher mobility). The higher mobility could be caused by damage or just being in a portion of the structure with relatively smaller stiffness. For instance in **(a)**, the lines along rows 1, 7, 14 and 21 coincide with bridge girders. At these locations the mobility would be relatively lower than the mobility of the slab between the girders. In the case of this particular bridge, between girders 14 and 21, mechanical devices were used for splicing the reinforcing bars. These mechanical devices were corroded and had failed (see **b** and **c**). As a result, one could note a relatively high mobility for the portion of the slab between girder 14 and 21.



To the left here, is another application of IR used by FIU bridge engineering faculty to identify the delaminated areas in bottom flange of a long span segmental concrete bridge. High picks correspond to areas with delaminated concrete

Another application of IR is to assess the effectiveness of retrofit by conducting an IR test before and after or to monitor behavior of bridge segments over time. FIU has a complete array of equipment and expertise to carry out IR testing and provide bridge owners with recommendations.

Load Testing Bridges

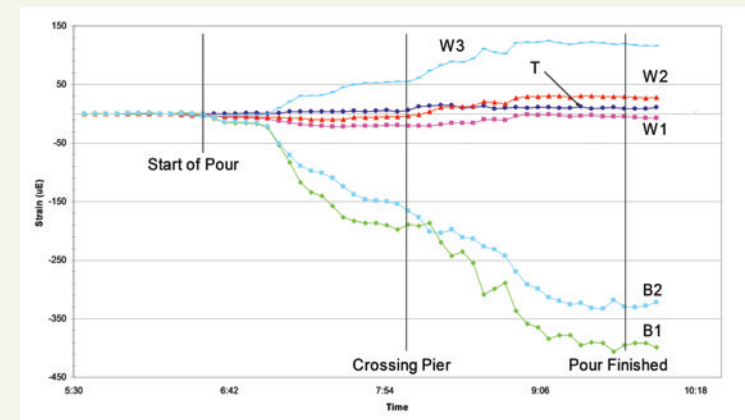
Led by **Dr. Atorod Azizinamini, FIU**

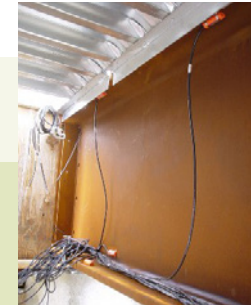
FIU Bridge Engineering faculty members have gained significant knowledge for in-service behavior of various bridge types through research and field testing. These projects cover concrete slab, steel girder, prestressed concrete, segmental concrete and steel truss bridges. These experiences also include testing bridges to collapse in the laboratory and in the field. The results provide the FIU bridge engineering team with unique and unparalleled capabilities and knowledge to evaluate bridges.

Load testing bridges can be carried out to achieve different objectives. These include field testing to load rate bridges, evaluating the effectiveness of new design or particular retrofit procedures, collecting data for taking timely actions for maintenance purposes, and complementary service design of bridges, especially signature and long span bridges or for monitoring critical regions of bridges demonstrating distress. Our team has a full line of equipment, coupled with the expertise and staff to provide bridge owners and consultants with state-of-the-art bridge load testing services. Below are some cases when FIU bridge engineering team members have provided field testing services to bridge owners.



Through field testing the load posting of the historic steel truss bridge was increased from existing 4 ton to 14 ton with minimal member upgrades.





RETROFITTING HISTORIC STEEL TRUSS BRIDGE

A historic steel truss bridge, shown left, was load posted for only 4 Ton and severely limited the passage of emergency vehicles. The alternate route for emergency vehicles was not a viable option. The owner wished to preserve the historic features of the bridge while increasing the load carrying capacity to about 14 Ton.

Budgetary limitations prevented the owner from spending the funds needed to significantly improve the load carrying capacity of the bridge. Instead, the objective was to economically increase the load posting to 14 Ton while completely saving the bridge's historical features. Dr. Azizinamini, director of ABC-UTC at FIU, developed a plan and associated cost that was accepted by the owner for retrofitting the bridge. It included the review of existing rating documents, available plans, an initial field visit to verify the available information and initial field testing of the bridge to develop a full understanding of the condition and behavior of the bridge in as-built condition. This information, together with the detail analysis that was carried out, was used to develop a cost effective retrofitting solution. The elements of the retrofitting procedure consisted of replacing certain members of the bridge, strategically. Some of the retrofitting steps used information that was developed through previous research. The retrofitting procedure, based on analysis, increased the load posting to 14 Ton while preserving historical features of the bridge. Through the bidding process, a contractor was identified, and under the supervision of Dr. Azizinamini's team, the retrofitting was completed.

Construction engineering services were provided to ensure that the contractor followed the specified retrofitting procedure. Before opening the bridge to traffic, a final load test was conducted to verify the new 14 Ton load carrying capacity. Load testing indicated that load posting could actually be increased to about 20 Ton. However, the decision was made to use 14 Ton load posting.

VERIFYING VALIDITY OF NEW DESIGN PROVISION

Through several years of research studies, a new steel bridge system referred to as simple for dead load and continuous for live load was developed. Three bridges were instrumented and short- and long-term monitoring of the three bridge was conducted to verify the merits of the recommended design and construction.

One bridge, shown above, was instrumented and its behavior continuously monitored from construction time until five years after completion. Appropriate instrumentation, data acquisition system and data collection procedures were utilized to ensure the accuracy of data for the duration of monitoring. Data was used to make corrections in predicting long-term behavior of the critical details associated with the new system. Additionally, two other bridges were instrumented and short-term field tests using loaded trucks were carried out.

All three bridges were monitored from the beginning of construction. Information during the construction phase provided valuable data that led to changes in the recommended design and construction. All three bridges were also field tested using loaded trucks. Data from these load tests were used to provide the owner with rating information. Testing procedures were based on Chapter 8 of the AASHTO Manual for bridge evaluation, which govern bridge load rating using field testing.

Magnetic Flux Leakage (MFL)

Led by **Dr. Atorod Azizinamini, FIU**

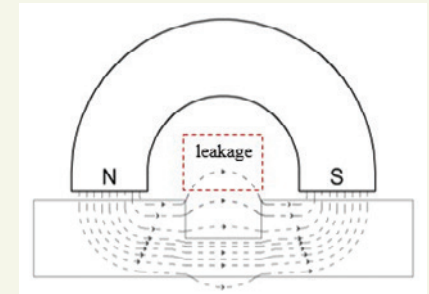
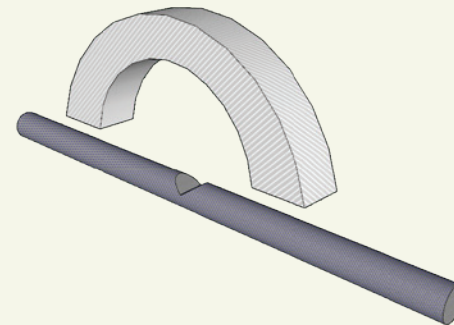
Ongoing research activities by FIU bridge engineering faculty have resulted in the advancement of MFL non-destructive methods of testing to identify corrosion within steel elements in different concrete bridge types, such as steel strands in steel ducts embedded in segmental concrete bridges. Further, recent agreements with researchers in Germany have resulted in creating unparalleled worldwide expertise to conduct our MFL tests to identify corrosion in complex structures, including segmental concrete bridges.

The MFL method is a magneto-static measurement technique and is based on the application of an external magnetic field in the vicinity of a ferromagnetic (steel) material to create magnetic flux lines that pass through the steel. The application of MFL to concrete structures is possible since concrete medium does not affect the measurements unless ferromagnetic impurities are present in the concrete. The MFL method works by magnetizing a strand under an existing magnetic field and the magnetic flux predominantly remains within the strand. In the presence of a geometric discontinuity, such as a part of a corroded strand with loss of cross-section, the magnetic flux is deviated (leakage) and can be detected by magnetic sensors such as Hall Effect (HE) sensors (see **a**).

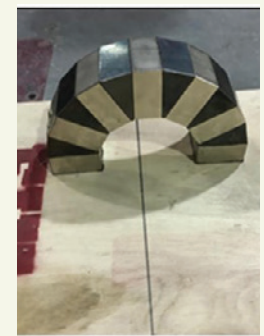
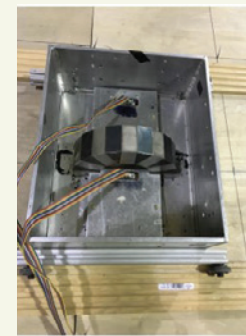
(b) Shows example of elements of a simple MFL device used by FIU bridge engineering faculty to identify corrosion in steel strands embedded in segmental concrete bridges. Elements consists of permanent or electro magnet, carriage, and array of Hall Effect sensors.

(c) Shows typical MFL signals for a steel strand with corrosion activities. These signals can be masked in the presence of other mild reinforcement. Years of research by FIU bridge engineering faculty members have provided us with the ability and methods to analyze the signals, similar to physicians with expertise reading X-Rays.

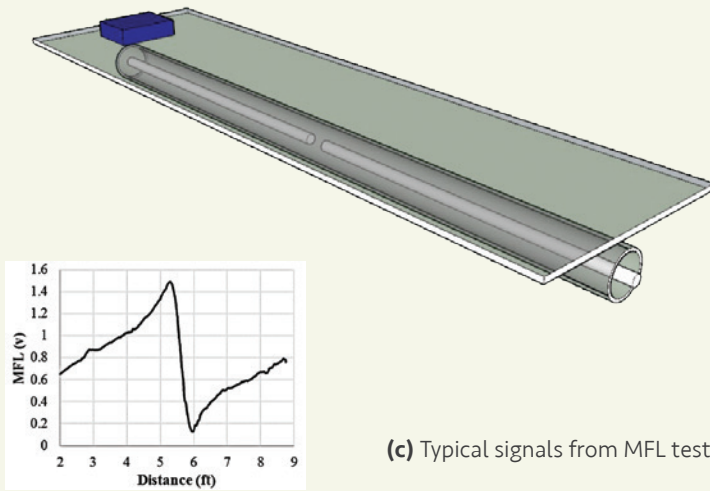
FIU experts couple the MFL testing with powerful numerical methods (see **d**) for customizing the MFL test for given application and analysis of data.



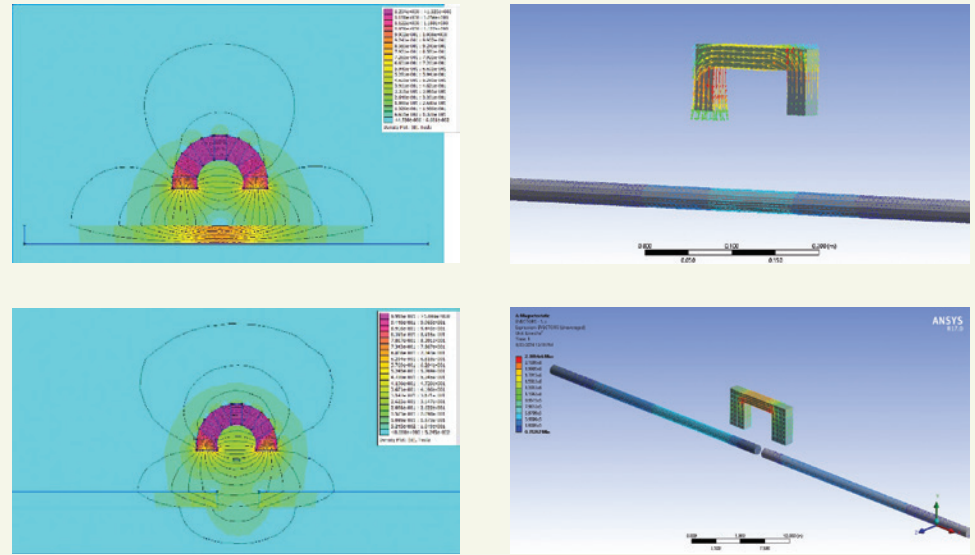
(a) Magnetic flux leakage



(b) Example of Elements of MFL Device- (i) Permanent magnet, (ii) Carriage, (iii) Hall Effect sensor array.

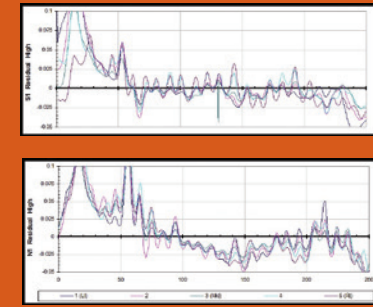


(c) Typical signals from MFL test



(d) Magnetic flux through intact strand (top) and defect induced strand (bottom)

MFL is the only known non-destructive testing capable of identifying corrosion in steel strand embedded in steel ducts and within elements of segmental concrete bridges. FIU bridge engineering faculties have used MFL to inspect multi-span segmental concrete bridges for corrosion activity.



Design Guide for Bridges for Service Life

Led by **Dr. Atorod Azizinamini, FIU**

Limited resources demand that existing and new bridges be designed for an extended service life. As part of the research project entitled Bridges for Service Life Beyond 100 Years: Innovative Systems, Subsystems and Components, supported by SHRP 2 Project R19A, a systematic and general approach to designing for service life has been developed. The major product of this project is the document referred to as the Design Guide for Bridges for Service Life, hereafter referred to as the Guide. It is now available through TRB and AASHTO and is being implemented across the U.S. among State DOTs. The SHRP2 R19A project was led by Dr. Atorod Azizinamini and included more than ten co-principal investigators representing different segments of the bridge profession, from academia to industry to government agencies. The first application of the Guide was at the Tappan Zee Bridge over the Hudson River in New York. Working as a consultant, Dr. Azizinamini provided the New York Thruway Authority with a framework to design the Tappan Zee Bridge for service life. This five-page document was provided by the New York Thruway Authority to short listed consultants as a reference.

The philosophy promoted by the Guide represents a paradigm shift in bridge engineering, and its framework is applicable to any bridge structure. Though most of the data

presented in the Guide focuses on bridges with spans of less than 300 ft., with customization the guidelines can even be used for signature long span bridges, such as the Tappan Zee Bridge. There are number of different ways to use the Guide. With it, agencies can develop guidelines and specifications for different classes of bridges, and to develop service life design plans for short, medium or signature long span bridges. Further, a new concept recently introduced by Dr. Azizinamini, the “Performance Based Service Life Design of Bridges” (PBSLDB), allows customization to meet different performance expectations. Incorporating the PBSLDB into newer editions of the Guide will further facilitate the adaptation of the document by the profession, as it will be more adaptable for a variety of expectations and investment levels.

Traditional approaches for enhancing the service life of bridges, used in various codes and specifications such as AASHTO specs, Eurocodes or British Standards, are mainly in indirect forms, specifying the use of certain details or properties such as cover thickness, maximum crack width, concrete compressive strength, etc. Designing bridges for service life, however, is more than just addressing the service life and durability of concrete. One of the missing elements for designing bridges for service life is the framework that would approach the problem in a systematic manner and provide a complete solution in a format that could ensure long-lasting bridges. It must be approached in a systematic, all-inclusive manner, rather than as a series of isolated tasks. The interaction between strategies for enhancing the service life of different bridge elements, components and subsystems must be given critical consideration. In addition, a maintenance program, retrofit or replacement options, and a management plan should all be part of the design approach. In summary, at the design stage, the owner must be provided with a comprehensive plan that gives a complete picture of what will be necessary to achieve the bridge’s specified service life. The plan must be transparent and identify the challenges ahead so that the owner encounters no surprises.

For general application, the Guide is not intended to dictate a unique solution for any specific service life problem or identify the “best and only” solution unless it is used to establish a plan for the service life design of a specific bridge. FIU’s Bridge Engineering Program, with Dr. Azizinamini as a lead, can assist bridge owners in developing a sound approach to design bridges for service life. Because our work in the service life design of bridges continues, we are always adding to the body of knowledge, making our program a leader nationally and internationally.



Corrosion and Infrastructure Materials Durability

Led by **Dr. Kingsley Lau, FIU**

Florida International University's Department of Civil and Environmental Engineering houses the newly created Corrosion and Infrastructure Materials Durability Research Laboratory. The faculty has multidisciplinary expertise to address the rising concerns of corrosion durability of civil infrastructure, including background in applied electrochemistry in corrosion science and engineering, electrochemical diagnostic techniques, structural materials and design, geotechnical engineering, environmental engineering and water quality management and infrastructure systems. Research interests have included service life modeling of steel in reinforced concrete, corrosion durability of polymer coated steel reinforcement, corrosion studies of post-tensioned tendons with deficient grout materials, non-destructive testing and sensor application to identify corrosion in post-tensioned systems, evaluation of novel coating systems to mitigate corrosion of highway bridges, microbiological influenced corrosion of steel elements submerged in water and embedded in soil, chemo-mechanical behavior of metal-contaminated soil, multi-scale and multi-physics corrosion modeling, microbiological influenced deterioration of concrete, and corrosion durability of pipelines. Practical and research experience to assess corrosion of civil infrastructure include field inspection, lab testing, laboratory research, material assessment and corrosion mitigation.



The laboratory houses equipment required for research on corrosion of infrastructure materials. On-going research includes electrochemical testing of steel strand in chemically and physically deficient post-tensioned grout materials to identify the corrosion mechanism in recent tendon failures including to elucidate the role of enhanced sulfate concentrations. Other topics include testing of novel coating systems for highway and marine bridge structures and evaluation of non-destructive technologies for highway bridges with corrosion and material deficiencies.

Highlights include two Gamry Ref 600 potentiostats with an 8 channel electrochemical multiplexer (with Global software with the entire suite of electrochemical techniques), a Nikon inverse-stage metallographic microscope (with high resolution CCD camera), and a wide array of metallographic equipment (including cutters, grinder/polisher and sample preparation). Instruments for analytical chemistry include pH, conductivity, ISE and turbidity meters (with assorted electrodes).

For coatings research, the Corrosion and Infrastructure Materials Durability Laboratory contains an AES MX-9200 series salt fog chamber, DeFelsko coating thickness meter, and DeFelsko coating pull-off adhesion tester. The Corrosion and Infrastructure Materials Durability Laboratory also houses a secured outdoor exposure test rack facility with weather station at the FIU engineering campus in South Florida.



Concrete Material Testing

Led by **Dr. David Garber, FIU**

The Preeminent Bridge Engineering Program (PBEP) at FIU has the capability to conduct concrete materials testing at several different scales. Universal testing machines with 250-kip and 500-kip capacities are available to do any desired compression, stiffness, tension, or flexure testing on cylinders, small beams or small-scale specimens. These machines are calibrated annually and conform to ASTM standards. The PBEP can perform desired testing to qualify specific products and advise on appropriate applications for products in bridge construction or rehabilitation.

The PBEP facilities also feature a high capacity testing frame capable of applying up to 800 kips force to full-scale members. This frame stands over 11 feet tall and can test any specimen up to 4.5 feet wide. This high capacity load frame can be used to test full-scale bridge girders, deck elements or joints, cap beams, inverted tee deep beams, columns, pier caps, or other substructure elements. Results are measured using state of the art sensors and data acquisition systems, which can monitor traditional strain gauges but also feature the ability to monitor vibrating wire gauges dynamically (at rates up to 333 Hz).

Well qualified researchers oversee all testing and will summarize all results and recommendations in an organized and professional manner.

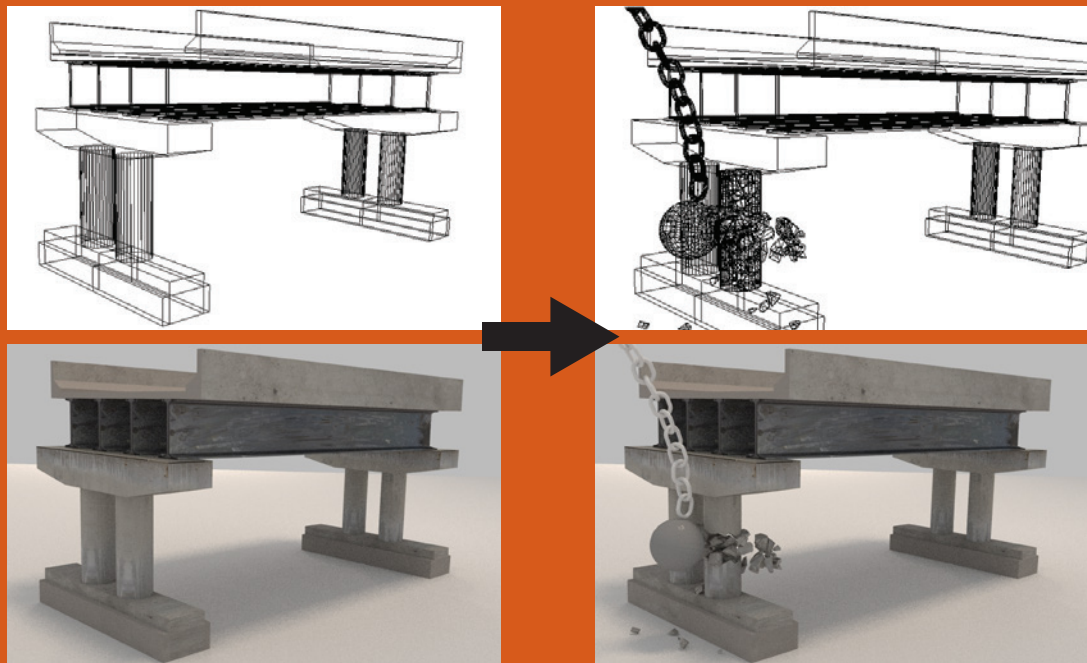


Advanced Numerical Modeling for Proactive Demolition Planning

Led by **Dr. Seung Jae Lee, FIU**

Accelerated Bridge Construction (ABC) is generally used in scenarios where an already existing bridge must be removed and replaced in a short amount of time. While significant effort has gone into techniques to facilitate the design and construction of the new structure, there has been little effort on techniques to remove the existing structure. In spite of the importance of bridge demolition to proceed with the rest of ABC project in a timely manner, there has been difficulty in developing a general guideline/specification for safe and efficient demolition planning due to inherent uncertainty hard to characterize ahead. Therefore, very limited information has been available to guide structural engineers and contractors on how to proceed with demolition, which has often caused unpredictable failures in projects.

The Preeminent Bridge Engineering Program (PBEP) at FIU has the capability to realistically simulate the bridge demolition process to better control and strategically eliminate the potential hazards and inefficiencies associated with the demolition. The research team develops the computational framework that can realistically model, simulate and visualize the bridge demolition process to underpin transparency in the communication between structural engineers, contractors and stakeholders for better and faster decision making. Well qualified simulation engineers will provide all feasible demolition scenarios based on the high-fidelity simulations and recommendations for proactive demolition planning.



FIU'S RESEARCH FACILITIES

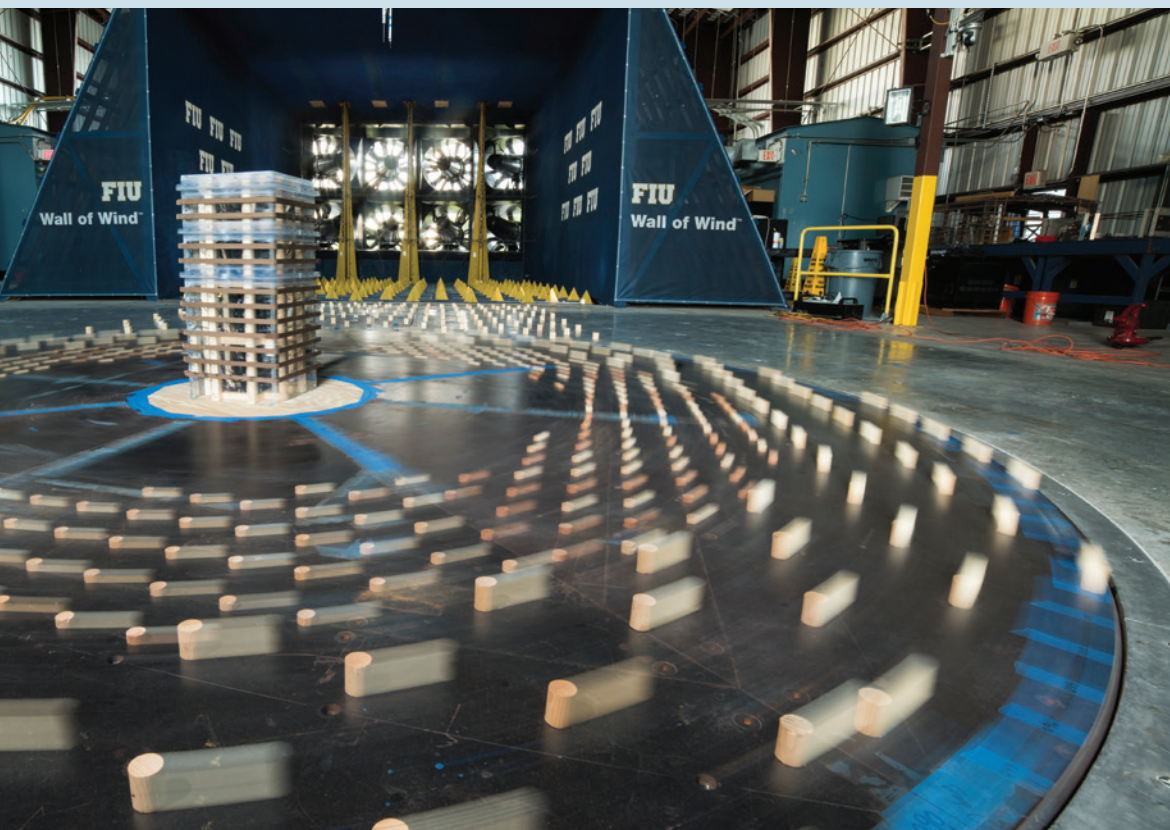
TITAN AMERICA STRUCTURES AND CONSTRUCTION TESTING LABORATORY



Research in Infrastructure and developing resilient and sustainable solutions is a major strategic area of the Engineering College at FIU. In the structural area, the **Titan America Structures and Construction Testing Laboratory** is one of the largest full-scale testing facilities in the State of Florida, with a total area of 6375 ft² of floor space. The Titan America Structures and Construction Testing Laboratory will allow for full scale testing.

WALL OF WIND





FIU's wind testing facility, the **Wall of Wind (WoW)**, is a first-of-its-kind wind testing system designed to generate sustained wind speeds of up to 156 mph.

STRUCTURAL TESTING EQUIPMENT



Titan America Structures Laboratory at FIU is equipped with state of the art MTS equipment, capable of conducting both static, dynamic and fatigue tests. High load capacity and fatigue rated hydraulic rams with 30 inches of strokes allow conducting most challenging structural tests.

RESEARCH FACILITIES AVAILABLE THROUGH ABC-UTC



University of Nevada, Reno



The James E. Rogers and Louis Wiener Large-Scale Structures Laboratory

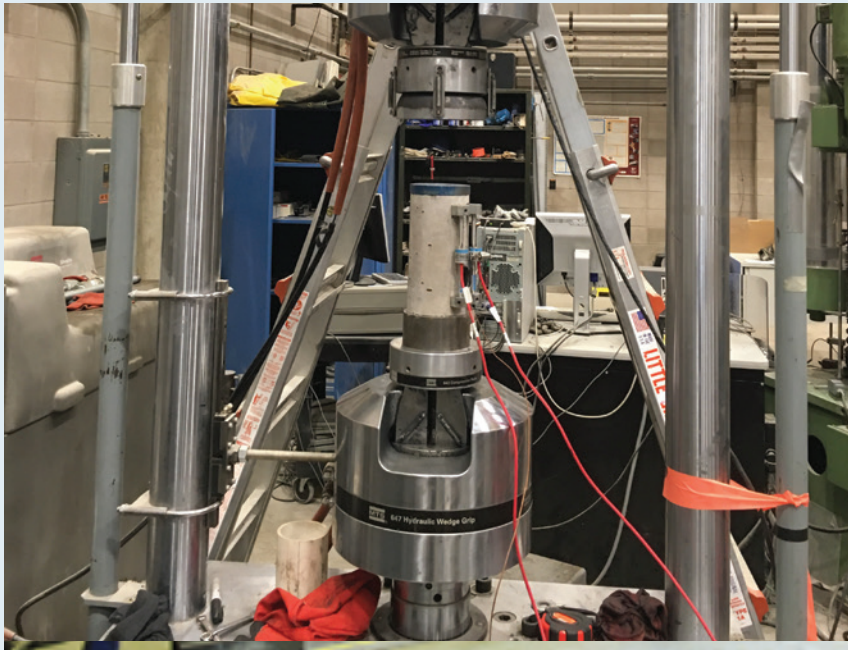
UNR houses some of the most advanced facilities for structural/seismic testing in the country. **The James E. Rogers and Louis Wiener Large-Scale Structures Laboratory** is equipped with four shake tables. This lab received the 2007 Best Experimental Site Innovation Award from the NEES Consortium in recognition of its expertise and innovation in experimental simulation.



Fears Structural Engineering Laboratory

The University of Oklahoma's historic Fears Structural Engineering Laboratory was made possible because of a generous donation from Donald G. Fears. Visionary OU structural engineering professor Tom Murray used this donation to begin the construction of the first research facility on what is now OU's South Research Campus. Murray and his colleagues gathered donations of brick and steel from companies such as Acme Brick and Star Metal Buildings, and eventually assembled all the ingredients that make up this laboratory. Fears Lab now hosts structural engineering and structural mechanics research efforts at OU, as well as some structural engineering faculty and staff.

IOWA STATE UNIVERSITY



Bridge Engineering Center (BEC) & Town Engineering Building Facilities

At ISU, the Bridge Engineering Center (BEC) was established in 1986 with the mission to provide cost-effective bridge engineering solutions to bridge owners at the federal, state and local levels. The BEC is housed within the Institute for Transportation (InTrans). ISU is also home to two world-class structural engineering research laboratories. The BEC manages several million dollars of bridge research per year. The BEC employs 4 full-time staff, several part-time staff, and 7 ISU faculties who manage and perform bridge related research projects along with approximately 15-20 M.S. and Ph.D. graduate students. It is noteworthy that the BEC has field tested over 300 bridges in the past 15 years in Pennsylvania, New York, North Carolina, Alabama, Florida, Texas, Wisconsin, Iowa, Montana, Oregon, and Washington.

W UNIVERSITY of WASHINGTON



University of Washington – Structural Engineering Laboratory

The Structural Research Laboratory (SRL) has a strong floor and reaction wall with a grid of hold-downs at which test specimens and/or actuators can be attached. The laboratory has an extensive hydraulic system, driven by two fixed pumps of 100 gpm each, driving a range of servo-controlled hydraulic actuators, with load capacities of 22 kips to 450 kips, and a one-dimensional shaking table with a payload capacity of 25 kips. The laboratory is also equipped with stand-alone universal testing machines (UTMs) with capacities from 300 to 2400 kips. A National Instruments data acquisition system is used to read from load cells, strain gages, potentiometers, inclinometers and LVDTs, and a dual-camera Optotrak motion capture system and laser extensometer are also available. The SRL possesses a Panel Element Tester; a specially designed rig for testing bridge bearings.

WHY STUDY **BRIDGE** **ENGINEERING** AT FIU?

FIU has fully accredited undergraduate and graduate programs in engineering and has advanced capabilities in various aspects of bridge engineering. The Bridge Engineering program encompasses a wide range of courses, introducing the graduate students to state of the knowledge in bridge engineering.

The bridge engineering research at FIU is conducted in close collaboration with stakeholders such as bridge owners, AASHTO SCOBS and State DOTs. Such approach provides graduate students with an opportunity to develop practical and implementable solutions. In addition, our mentorship and assistantship programs provide outstanding guidance and support as our students continue their professional development journey.





LOCATION

The Bridge Engineering Program is located in the FIU Engineering Center, a major research facility situated a short distance from FIU's Modesto A. Maidique Campus in Miami. One of the most international cities in the hemisphere, Miami is an exciting and dynamic global marketplace and a major gateway to the Americas. The city is a crossroads for trade and travel and a world-class metropolis with rich cultural diversity.

OUR ALUMNI ARE IN HIGH DEMAND!

One of the key performance indicators in measuring our success is the employment rate of our graduates. We are proud to announce our graduates are in high demand. Through our program, graduate students have been exposed to state-of-the-art research, and are currently employed and have successful careers. Some of our graduated students also give back by serving as mentors in the bridge engineering program. Meet a few of our successful students, below.



Jawad Gull, Ph.D.

Dr. Gull is now a bridge designer at HDR and has nine years of experience in research and structural engineering. He has expertise in cable structures and steel bridges and has worked on diverse engineering projects in the United States, Japan and Pakistan. He is currently working on the I-4 Ultimate project that involves the design and construction of over 60 new bridges and the replacement of over 70 existing bridges. Dr. Gull obtained his doctorate degree from Florida International University, where he served as the assistant director of the ABC-UTC. He worked on research projects that successfully addressed issues related to construction, inspection and bridge rehabilitation. He was principal investigator of key ABC-UTC research projects addressing service life and database management of ABC projects. He earned his master's degree from Saitama University, Japan. He and his research team worked in collaboration with the Tokyo Electric Power Company on the wind-induced vibrations of cable structures. He has been involved in several destructive and nondestructive tests of structures and materials in Pakistan. He is an active member of the American Society of Civil Engineers and the American Concrete Institute.



Somaye Fakharian Qom, Ph.D.

Dr. Fakharian Qom graduated with her Doctoral Degree in Civil Engineering from Florida International University (FIU) in the summer of 2016. Thereafter, she joined WSP/Parson Brinckerhoff in September 2016 with a focus in Transportation Engineering. She has conducted Intelligent Transportation Systems (ITS) research projects with a goal of improving the transportation system by providing decision support for transportation planning and traffic operations. Under the supervision of Dr. Mohammed Hadi, her Ph.D. dissertation was about the Multi-Resolution Modeling (MRM) of managed lanes with consideration of autonomous/connected vehicles. Dr. Fakharian Qom was awarded the best Ph.D. graduate from College of Engineering & Computing at FIU in the summer of 2016 and also contributed to the establishment of the Women in Transportation Seminar (WTS) student chapter at FIU.



Arash Tarighi, Ph.D.

Dr. Tarighi received his Ph.D. in civil engineering from Florida International University in 2015. His dissertation, "Dynamic Behavior and Fatigue Life of Highway Bridges Due to Longer Combination Vehicles (LCVs)," studied how the increase in use of LCVs, and their heavier freight capabilities, will impact a bridge's life. Currently, he is a bridge designer for HDR Inc. and he has been involved in "I-4 Ultimate," the largest infrastructure project in Florida history, involving building/replacing more than 100 bridges. His main responsibilities are analyzing, designing and detailing of bridges, performing bridge load ratings and developing bridge plans.



Alireza Mohammadi, Ph.D.

Dr. Mohammadi received his Ph.D. in Structures from Florida International University in 2016. He received his B.S. in 2006 from Tabriz University, Tabriz, Iran and his M.Sc. from Sharif University, Tehran, Iran. He was a structural engineer at Zelzeleh Mohaseb Consulting Engineering Co. for four years before returning to academia. He was involved in several bridge engineering research projects at FIU and assisting with ABC-UTC research and other activities such as organizing monthly webinar and preparing progress reports. His Ph.D. dissertation focused on the dynamic response of high-rise building under wind excitation. He completed his Ph.D. in December 2016 and is currently working at WSP Parsons Brinckerhoff to start his career in the transportation market sector.



Huy V. Pham, Ph.D.

Dr. Pham received his Ph.D. structural engineering at Florida International University in Miami, Florida in 2016. He received both his master's and bachelor's degrees with highest honors in civil engineering from the Georgia Institute of Technology. In his master's research, he utilized a novel material called shape-memory alloy to add a self-centering capacity to steel buckling-restrained braced frames (BRBFs). This capacity was able to fix the problem of large residual deformation/drift in BRBFs. He is currently working as a structural engineer at AECOM.





About Florida International University

Florida International University is classified by Carnegie as a “R1: Doctoral Universities — Highest Research Activity” and recognized as a Carnegie Community Engaged university. It is a public research university with colleges and schools that offers bachelor’s, master’s and doctoral programs in fields such as business engineering, computer science, international relations, architecture, law and medicine. As one of South Florida’s anchor institutions, FIU contributes almost \$9 billion each year to the local economy and is ranked second in Florida in Forbes Magazine’s “America’s Best Employers” list. FIU graduates are consistently among the highest paid college graduates in Florida and are among the leaders of public and private organizations throughout South Florida. FIU is Worlds Ahead in finding solutions to the most challenging problems of our time. FIU emphasizes research as a major component of its mission with multiple state-of-the-art research facilities including the *Wall of Wind Research and Testing Facility*, *FIU’s Medina Aquarius Program* and the *Advanced Materials Engineering Research Institute*. FIU has awarded more than 220,000 degrees and enrolls more than 54,000 students in two campuses and centers including FIU Downtown on Brickell, FIU@I-75, the *Miami Beach Urban Studios*, and *Tianjin, China*. FIU also supports artistic and cultural engagement through its three museums: *Patricia & Phillip Frost Art Museum*, the *Wolfsonian-FIU*, and the *Jewish Museum of Florida-FIU*. FIU is a member of *Conference USA* and more than 400 student-athletes participating in 18 sports. For more information about FIU, visit www.fiu.edu.

About the College of Engineering & Computing

Florida International University’s College of Engineering & Computing is South Florida’s leading engineering education resource. The college offers a complete range of fully accredited engineering baccalaureate, master’s and doctoral degree programs in biomedical, civil and environmental, electrical and computer, and mechanical and materials engineering; construction management; and computing and information sciences. With close to \$20 million of external funding, research is an integral part of the college’s mission and its success. The college is committed to diversity, and is the largest producer of Hispanic engineers, and one of the top producers of African-American engineers and females with doctoral degrees in engineering. For more information about the FIU College of Engineering & Computing, visit cec.fiu.edu.



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