Ferguson Structural Engineering Lab Newsletter

THE UNIVERSITY OF TEXAS AT AUSTIN - STRUCTURAL ENGINEERING

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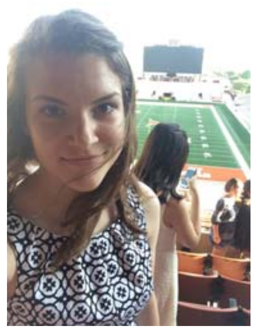
New Faces at FSEL

Graham Hogsett

I am a first year master's student from Kingwood, Texas, a suburb of Houston. I graduated in May of 2015 from Louisiana Tech University with a Bachelor's Degree in Civil Engineering. I have been working under Dr. Ghannoum on two projects involving high strength reinforcing steel. I am looking forward to getting to know everyone here at FSEL throughout the summer.

Ryan Boehm



I grew up in Dripping Springs TX (just west of Austin), and I'm currently a third year architectural engineering undergrad. Outside of studying and working in the lab, I like to spend time with friends and family, watch Netflix, and draw/paint. I'm excited to work with the 0.7" team, as well as help other projects. I look forward to meeting y'all and learning a lot this summer!

Strengthening Continuous Steel Bridges with Post-Installed Shear Connectors – Kerry Kreitman & Amir Reza Ghiami Azad

This research is focused on strengthening existing non-composite steel girder bridges by post-installing adhesive anchor shear connectors to create composite action with the concrete deck, and allowing for inelastic moment redistribution from the interior supports of continuous girders. After a few years of small- and large-scale laboratory testing, this project is wrapping up this summer with the design of a strengthening system for an existing non-composite bridge in East Texas, shown in the figure. Additionally, a pre-strengthening load test will be conducted on this bridge this summer. A future project will monitor the construction process for installing the adhesive anchor connectors and complete a post-strengthening load test on the bridge.

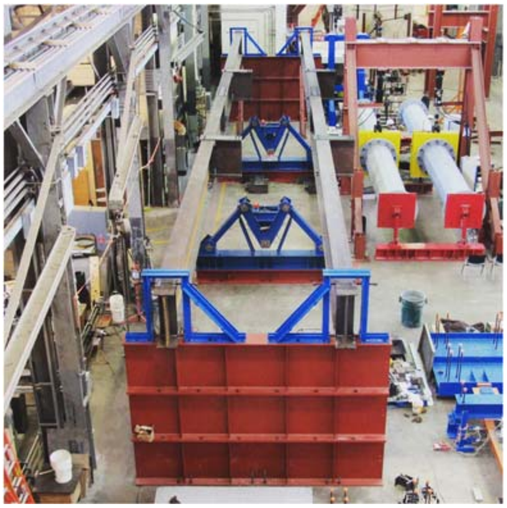
Bridge to be strengthened, after very heavy rains.

Inside this issue:

Special points of interest:

- Ice cream social, July 21, 3pm, Large Conference Room
- FSEL Welcome Party and Open House, September TBD

Partial Depth Precast Concrete Deck Panels on Curved Girders – Paul Biju-Duval, John Kintz & Colter Roskos



Twin I-girder test setup

This research program is investigating the use of prestressed precast concrete panels (PCPs) as bracing elements in curved bridges during the construction phase. Last semester the research team tested several different connection details between the PCPs and the girders with a total of eight PCPs that were produced by a local Texas precaster. Furthermore, the twin I-girder test set-up was fabricated and second-order FEA has been performed to simulate the expected behavior, which will be tested experimentally over the summer. On the programming side, a series of new features have been added to UT Bridge V2.0, which was presented at the Steel Conference in Orlando and will be released to a first group of users in the summer for further improvements.

Structural Mechanics of ASR-Affected Concrete - David Wald & Morgan Allford

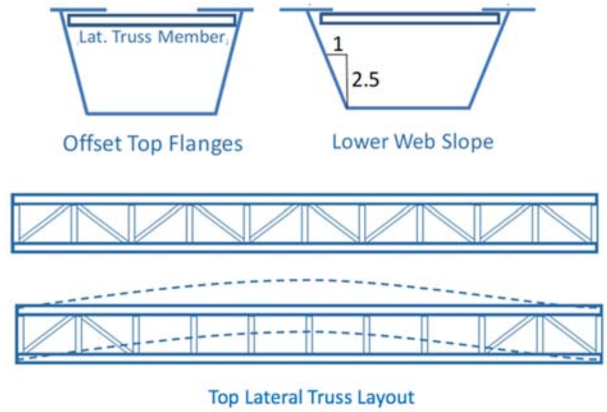
This study aims to better understand the influence of ASR on the structural mechanics of reinforced concrete. Experimental work is currently being conducted to assess two fundamental aspects of ASR-affected concrete behavior: the multi-directional distribution of expansions under passive restraint provided by reinforcement and the degradation of concrete material properties. A number of uniaxially-, biaxially-, and triaxially-reinforced concrete cubes with ASR have been fabricated and are currently being conditioned and monitored to assess expansion behavior under a wide range of restraint conditions. Frequent material testing of companion cylinders serves to provide information on how the compressive and tensile strengths, elastic modulus, and overall stress-strain behavior of concrete with ASR changes with increased expansion.

The experimental results will feed ongoing analytic efforts to model ASR-induced strains and stresses in reinforced concrete elements and subsequently determine changes to capacity and load-deformation response at the element and member levels. Presently, a new methodology to predict ASR expansions is being formulated. This approach may be implemented within the framework of a smeared crack, nonlinear finite element analysis for reinforced concrete structures. Once ASR expansion mechanics are better understood, the mechanics of load transfer in elements with pre-existing strains and stresses will be explored in greater detail.

The cube farm

Improved Tub Girder Details - Yang Wang & Stalin Armijos Moya

This project is focused on studying the impact of modified girder geometry and bracing details on the behavior of steel tub (trapezoidal box) girder. Two major parameters will be investigated in the girder section layout: 1) offsetting the top flange to make more flange width available for the direct connection of top lateral truss members; 2) using a lower web slope than AASHTO specified limit. In regards to the bracing details, the impact of reducing the number of top diagonals on girder torsional stiffness will be investigated. Four specimens with different configurations have been properly designed and the laboratory test will be performed later this year.



Sectional views of the tub girder

High Strength Reinforcing Bars (HSRBs) in Reinforced Concrete Columns - Albert Limantono & Drit Sokoli

This research program was developed to evaluate the seismic performance of concrete columns reinforced with high strength reinforcing bars. At present, the vast majority of reinforcing steel produced and utilized in the United States is Grade 60 (or having specified yield strength of 60 ksi). Economic, environmental, and constructability incentives have been fueling the demand for higher strength reinforcing steel, particularly in highly congested seismic designs. In the last decade, advances in production capabilities have resulted in reinforcing bars of Grade 80 through 120 with a relatively high ductility (>10% fracture strains). However, the steel industry is producing the high-strength steels with varying mechanical properties (i.e. tensile-to-yield strength ratio; fracture elongation).

An experimental program was carried over the past two years and consisted of four large scale columns tested under cyclic quasi static lateral loading. Three of the specimens, namely CH100, CL100 and CM100 were reinforced with Grade 100 steel from different manufacturers and as a result having different mechanical properties. The fourth column, CH60, was reinforced with conventional Grade 60 ASTM A706 bars. These tests were conducted as part of a research effort aimed at setting the minimum acceptable tensile to yield strength ratio (T/Y) in new ASTM specifications for seismic Grade 100 reinforcement. Previous work on the subject (i.e. Machi et. al., 1996; Aoyama, 2001) has shown that a low T/Y ratio of the steel reinforcement can lead to strain concentrations in longitudinal bars of concrete members. In return, Stress concentrations can limit the ductility of these members. Data gathered from the four tests will be used to evaluate the influence of reinforcement with different mechanical properties in the behavior of concrete columns. Conclusions are to be drawn with respect to the effects of higher strength reinforcement on the seismic performance of concrete columns. In addition to the tests performed on large scale concrete columns, low cyclic fatigue tests are to be conducted on bar samples from the same reinforcing steel used in building the specimens. The strain history measured during the quasi-static tests will be simulated on bars in order to evaluate their fatigue life. The goal is to calibrate steel fracture models to predict the cyclic life of reinforcing bars in concrete members subjected to lateral loads.

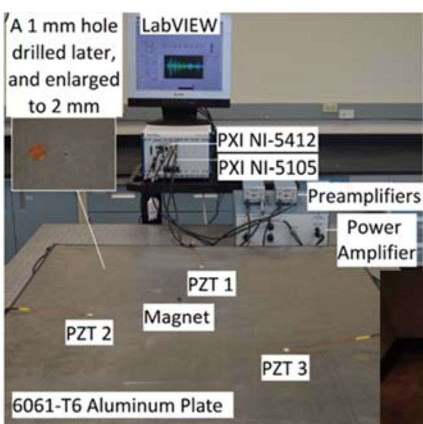
Test setup as pictured at the end of a test

End-Region Behavior of Pretensioned Concrete Beams with 0.7-inch Prestressing Strands - Roya Abyneh, Jessica Salaza, Alex Katz, Dennis Kim & Ryan Boehm

While the use of 0.5 and 0.6-inch diameter prestressing strands is common practice in precast bridge girders, engineers have interest in the use of 0.7-inch diameter strands due to perceived physical and economic benefits. However, the implications on design and fabrication standards pertaining to the larger strands have not been sufficiently studied. Our team will quantify various physical and economic benefits through a broad parametric study, and explore girder end-region detailing modifications through analytical modelling. Finally, an experimental program will provide crucial data on the behavior of Tx-girders with unique strand patterns and release strengths for future field implementation. The team has conducted a parametric study by exploring potential span length gains using 0.7-inch strands, and developed a refined finite element model that captures the release and failure of pretensioned girders. Three release and three shear tests have already been performed on the first three specimens. Based on the three specimens that have been tested, the release tests have shown that the use of 0.7-inch girders at a standard grid do not require modifications to the end-region reinforcement. The shear tests demonstrated atypical failure modes which were conservatively estimated using current standards. The conclusions made to date are preliminary and subject to change based on future tests. The team plans to investigate the implications of 0.7-inch strands with large prestressing forces and greater release strengths to evaluate the potential benefits of using larger strands. The team is preparing to fabricate the fourth specimen this semester.

The team pictured with the third specimen before the test

Damage Localization in Metallic Plate Structures using Edge-Reflected Lamb Waves - Arvin Ebrahimkhanlou & Brennan Dubuc

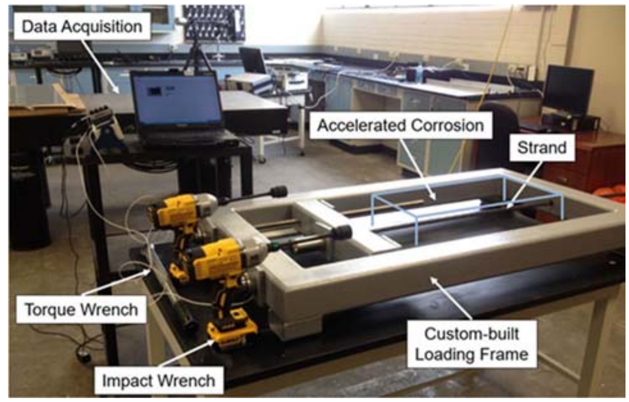


Test setup

Plate-like component are widely used in civil, naval, and aerospace applications. The goal of this research is to monitor and localize corrosion, fatigue cracks, and impact dents on plate structures. The number of sensors is minimized, because one challenge for the structural health monitoring techniques is the number of sensors, costly data acquisition channels, and size of the acquired data. The idea is to efficiently process the data and minimize the redundant data collection. To minimize the number of the sensors the novel idea of leveraging ultrasonic reflections from edges is under investigation. These reflections are traditionally considered as noise and a challenge for most damage localization algorithms. However, the reflections carry useful information that can be leveraged with proper signal processing techniques. The extracted information help reduce the number of sensors and improve the localization accuracy. The results for the active ultrasonic mode has recently been accepted for publication, and the results for the passive acoustic emission mode is under preparation.

Monitoring Corrosion of Prestressing Strands using Guided Ultrasonic Waves - Brennan & Dubuc Arvin Ebrahimkhanlou

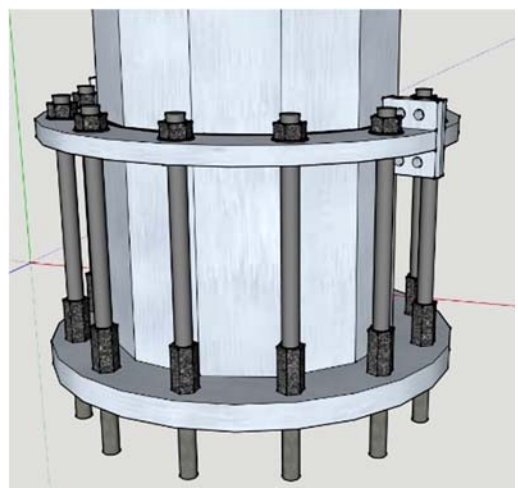
The aim of this project is to examine the suitability of a monitoring system based on guided ultrasonic waves (GUWs) for detecting the initiation and growth of corrosion damage in prestressed concrete beams. The steel reinforcing bars act as a natural waveguide, with the potential for long-range wave propagation within the structure. The sensitivity of guided waves to both the geometry and load level in the reinforcing bars may then be used to infer the corresponding state of corrosion. Accelerated corrosion tests are to be performed on loaded seven-wire strands embedded in a concrete block to experimentally monitor the characteristics of guided wave propagation in the simulated environment.



Experimental setup of the prestressing bed and the data acquisition system

Fatigue Behavior of High Mast Illumination Poles (HMIPs) with Pre-existing Cracks - Mark Eason & Ying-Chuan Chen

High Mast Illumination Poles (HMIPs) are lighting members used to illuminate highways and major intersections. These multi-sided steel poles consist of a lighting fixture and a multi-sided poled that is welded to a baseplate. This welded connection is known to be problematic in that it is susceptible to fatigue crackying. As such, this project aims to quantify the fatigue life of the weld before failure, to create viable retrofits to poles that have been damaged (Figure 1), and to estimate the remaining service life of poles currently in use. To do this, specimens are being laboratory tested at stress ranges from 1 to 6 ksi until cracks form. Thus far, six poles have been tested in the laboratory. Additionally, specimens are being instrumented throughout Texas to quantify HMIP response to local wind conditions (Figure 2). Three of five poles have been instrumented to this date. Together, the results of the lab tests and field experimentation will be used to estimate the remaining fatigue life of in service HMIPs.


A proposed retrofit involves installing post-tensioned rods to alleviate stress at the shafts-to-baseplate weld (Figure 1)


HMIPs are being instrumented with anemometers, accelerometers, and strain gages (not pictured) (Figure 2)

Influence of Shear Stud Configuration on the Performance of Flat Plate Slab - Column Connections - Gabriel Polo

Fabrication of slab-column connection using circumferential stud rail configuration

This research is aimed toward evaluating the punching shear performance of slab-column connections employing different configurations of shear studs rails placement: cruciform (i.e., orthogonally placed, stemming from the column) and circumferential (i.e., uniformly distributed around the slab-column connection). The experimental program will consist of six large-scale slab-column connection specimens: two slabs employing a cruciform shear studs rails configuration, and two slabs employing a circumferential shear studs rail configuration, and two slabs without shear reinforcement serving as control specimens. Slabs will be fabricated with longitudinal reinforcing ratio of 1.4 and 1.0 percent.

The slab-column connection specimens will be subjected to concentrated vertical loading conditions and restrained vertically by eight support points located circumferentially around the column. The results from tests will provide data that is key to examining the influence of the shear studs location on the punching shear performance (e.g., capacity, post-peak load resistance, failure/damage region, etc.).

The Role of Gravity Framing in Seismic Response of Structures - Sean Donahue, Dan Coleman & Cliff Jones

Test setup at 9% inter-story drift

Typical seismic design for steel structures assumes all the lateral strength of a building is provided by the moment-resisting frames or braced frames, with the remaining gravity connections having no effective lateral resistance. Although composite gravity connections are known to have significant flexural strength, the nature of their response is currently not well understood. This research will simulate the response of typical gravity connections under earthquake loads, so the contribution of such connections can be better understood. Testing has shown composite clip angles to have high strength (reaching approximately 50% of Mp of the beam) and ductility, reaching 9% inter-story drift without failure. This strength seems to come primarily from a force couple created by contact between the bottom beam flange and column, and tension in the metal decking. Future tests will further investigate the role of the decking in the response, as well as what parameters control its strength.

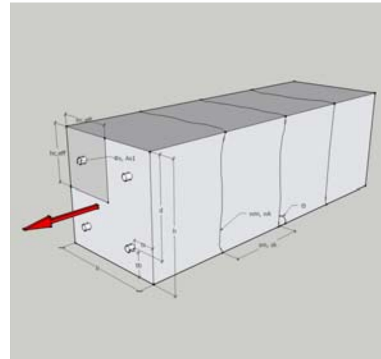
Strength Testing of Vertically Loaded Corbels - Heather Wilson

Test setup and specimen prior to testing

Corbels are commonly used to transfer loads from beams to columns. The goal of this project is to identify the difference, if any, between classical shear design and strut-and-tie design of corbels. To date, one corbel has been constructed and tested. The first test showed that the corbel exceeded its design capacity by over 110%, failing at more than 600 kips distributed over the two corbels. Over the next few months, three more corbels will be constructed and tested with the goal of comparing failure modes, failure loads, and factors of safety.

Evaluation of Structural Cracking in Concrete - Jarrod Zaborac

Interpreting the structural performance implications of concrete cracking in existing reinforced concrete (RC) bridge members can be rather complex. Depending on the nature of the cracks observed and the specific design details pertaining to the RC member, the development of a large number of moderate width cracks may be of limited significance in the context of overall member capacity and, in other cases, the occurrence of only limited relatively small width concrete cracks may greatly impact a member's ability to carry load. This project focuses on the development of mechanics-based procedures that can adequately capture the influences of key parameters that are known to affect the shear resisting performance of diagonally cracked RC bridge members. More specifically, it is envisioned that the mechanics-based procedures developed from this research will be formulated in a manner such that they can incorporate influences associated with member scale, reinforcement details, and loading conditions.



Sketch of axial tension on a concrete member

Delamination of Curved Post-Tensioned Structures - Jongkwon Choi & Clint Woods

The objective of this research is to gain a better understanding of the behavior of curved post-tensioned concrete structures. Analytical studies of radial stress development have been performed in the past; however, no experimental verification has followed. This research will provide the data necessary to model the effect of the localized tensile stress and concrete delamination in curved post-tensioned structures.

Our team tested Specimen 2 successfully on April 27, 2016. The delamination failure started at 15-degrees due to friction loss. This was similar to the failure noted in Specimen 1. From the test data, we could find some meaningful data including size effect, initiation of delamination failure, stress concentration, large friction loss, etc.

After a visual inspection of the failed specimen, we removed it from the platform and started the fabrication of Specimen 3. Specimen 3 will have same dimensions as Specimen 2 but concrete mix design will be changed. If we are not delayed by any unexpected problems, we will cast concrete at the second week of June and will test it around 28 days from the concrete casting.

Video capture of the delamination failure

BUILDING24 COMMITTEE

Committee Vision: Increase ***productivity*** *at Ferguson Laboratory through improved* ***communication*** *and* ***collaboration*** *of students, staff, and faculty*

Information about the Newsletter

The goal of this publication is to keep those working at FSEL aware of the status of ongoing projects around them. In addition to projects, we may also highlight special events, people, or news of interest. The newsletters will come out once a semester, three times a year.

In this second issue of 2016, fourteen research projects at FSEL are summarized. Hopefully you will learn something new about each project so as to initiate more discussions with your fellow researchers.

Feedback
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