Ferguson Structural Engineering Lab Newsletter

THE UNIVERSITY OF TEXAS AT AUSTIN - STRUCTURAL ENGINEERING

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New Faces at FSEL

Andy Potter

I grew up in a small town in the mountains of Western North Carolina. I attended North Carolina State University, where I received a bachelors degree in Civil Engineering. In my spare time I love to travel, hike, bike, camp, and pretty much anything else where I can be active and enjoy the outdoors. I am excited to be working with Dr's Clayton, Williamson, and Ghanoum, and Slav on the TxDot project, where we will be assessing the seismic vulnerability of bridges in Texas. I am looking forward to getting around the FSEL and meeting everyone as the semester progresses.

Jarrod Zaborac

I began my master's last semester after graduating from Kansas State University last spring with a bachelor's degree in Architectural Engineering. My undergraduate experience was very design/consulting oriented, so I am very excited to be involved with research and explore a different side of structural engineering. I am looking forward to working with Dr. Hrynyk on the TXDOT structural cracking project and getting to know everyone else at FSEL.

Mark Eason

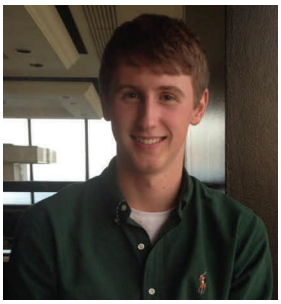
I am a first year master's student from Merritt Island, Florida. I graduated from the University of Florida in May 2015 with a bachelor's degree in civil engineering and moved to Austin shortly after. I've been working on the HMIP project with Dr. Engelhardt, Ali, and Ying Chuan since September. Outside of the lab I spend a lot of time running, hiking, and reading. Don't be surprised if you see me running around the Pickle Campus after work! I've had a great time working at the lab and look forward to continue getting to know everyone at FSEL.

Brennan Dubuc

I am a student in the nondestructive testing part of the lab at the FSEL. I am focusing on using guided ultrasonic waves to locate damage in structures like pipelines and steel reinforcing bars. Outside of this I enjoy playing tennis and golf. I have met some great people here already, and hope to get to know more in the future.

Inside this issue:

John Kintz



I am a first year master's student from the Chicago suburbs, working on the steel trapezoidal box girder project. I earned my B.S.E. in Civil Engineering from the University of Iowa in Spring 2015, and some of my personal hobbies include playing sports and spending time with friends. I have met some great people in my short time at FSEL, and look forward to getting to know many more during my time here.

Vyacheslav Prakhov

I am a second year masters student holding a Bachelor's degree from New Mexico State University. I will be working on a computational study involving seismic evaluation of Texas bridges with Dr. Clayton, Dr. Williamson, and Dr. Ghannoum for the course of 2016. Besides structural engineering I enjoy skiing, playing guitar (poorly), travel, technology, and watching F1 racing. Don't get scared by my name, I go by

Ongoing Research at FSEL

Effects of ASR on Reinforced Concrete Walls without Transverse Reinforcement - Gloriana Arrieta, Heather Wilson

The development of alkali-silica reaction (ASR) in concrete results in the expansion and potentially deleterious cracking of structural members. The broad objectives of this research program are to: (a) examine ASR's structural implications in reinforced concrete walls without transverse reinforcement, and (b) develop the knowledge, tools and techniques necessary to complete in-situ assessments of such structures. After about 3.5 years of hard work, the research team has successfully completed the experimental portion of this project, which included the following activities:

§ Shear Strength - A total of 10 specimen placements and 20 shear tests (4 controls, 4 at moderate levels of ASR, and 12 at high levels) have been completed to date. In addition, a large specimen (twice the width of our typical specimens) was fabricated and tested; with this we were able to verify the importance of size effect on shear strength of reinforced concrete.

§ Reinforcement Anchorage - A total of 9 specimen placements and 9 reinforcement anchorage tests (1 control, 3 at moderate levels of ASR and 5 at high level of ASR) have been completed to date.

§ Out-of-Plane Expansion Monitoring - The research team monitored the out-of-plane expansions of a 5-foot -tall wall segment fabricated in-house last summer for one year, using three different commercial instruments. Monitoring efforts are now complete! A decision was made on which of the instruments performed the best.

§ Performance of Post-Installed Anchor Bolts - All testing has been completed for this portion of the project. Data collected through this effort was analyzed to determine the effect of different levels of ASR damage on the pull-out strength of different types of post -installed anchors.

Now that the structural testing efforts have been wrapped up, all that is left is some data analysis. So, be on the lookout for the main conclusions from this project in the Summer edition of the newsletter!

Our team would like to congratulate our former team members Katelyn Beiter and Joseph Klein for obtaining their Master's degree this past December. They will be missed!

30th

Strengthening Continuous Steel Bridge Girders with Post-Installed Shear Connectors - Kerry Kreitman and Amir Reza Ghiami Azad

This research is focused on strengthening existing non-composite steel girder bridges by post-installing adhesive anchor shear connectors (Figure 1) to create composite action with the concrete deck, and allowing for inelastic moment redistribution from the interior supports of continuous girders. Laboratory testing of two girder specimens (85 and 105 feet long) was recently completed and indicated that strengthened girders perform well under both fatigue and strength limit states. Design recommendations were developed for implementing this strengthening method for existing bridges

This semester, the research team is focusing on extending the laboratory work to field applications. Evaluation and design of a strengthening scheme is underway for an existing non-composite bridge in East Texas constructed in the early 1940s (Figure 2). Additionally, a load test will be conducted on the bridge to evaluate the behavior prior to strengthening. A future project will complete the implementation work by monitoring the construction process and conducting a second load test on the strengthened bridge.

Figure 1: Post-installed connectors

Figure 2: Bridge to be strengthened (with record high river levels flowing beneath

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

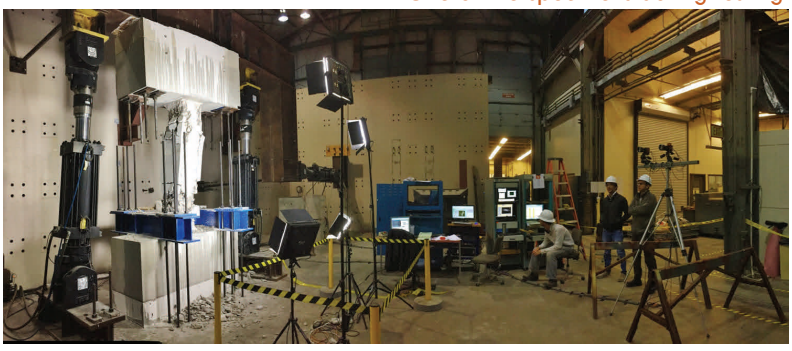
Part of this project is the testing of four reinforced concrete columns. The tests were designed to explore the effects of the tensile to yield strength ratio and ultimate elongations on plasticity spread and deformation capacity of concrete columns. Three columns were reinforced with Grade 100 reinforcement from different production techniques which led to different mechanical properties. The fourth column was reinforced with Grade 60 A706 steel.

Two columns reinforced with Grade 100 reinforcing bars were tested during summer 2015. The two types of steel used represented the upper bound of the achievable T/Y from different manufacturing techniques. The first column, with relatively high tensile to yield ratio of 1.27, lost lateral load carrying capacity at the end of the second cycle towards -5.5% drift due to fracture of one of the longitudinal bars. The response of the second column, with relatively low tensile to yield ratio of 1.16, remained stable and maintained axial load carrying capacity past the two cycles of 5.5% drift. First bar fracture occured at a drift ratio of +4.8% as the column was being pushed towards its first cycle to +7.0% and followed by two more bars fractured.

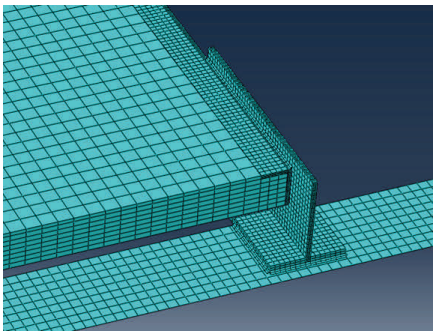
The test was stopped after a fourth bar fractured at drift ratio of +8.0%.

The last two columns are to be tested in the following months.

One of the specimens during testing



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



PCP Finite element mesh

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 team produced a 3D finite element model of the shear test frame that showed similar stiffness and strength for the PCPs compared to the laboratory tests. An equivalent truss model was also produced. The connection detail between the PCPs and the steel girders was validated by TxDOT, and contact was made with the precasters. Another connection detail is also being tested in parallel. Next semester the team will test actual prestressed PCPs and fabricate the twin girder test set-up. UT Bridge V1.6.1 was published, correcting a bug encountered in V1.6, while UT Bridge V2.0 is planned to be uploaded to the FSEL website around summer.

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 placed throughout the building, with the remaining gravity connections contributing nothing to the building's lateral resistance. Although composite 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 modeled in future analysis. Testing of composite clip angles has shown the connection has very high strength (reaching approximately 50% of Mp of the beam) and ductility, reaching 9% inter-story drift without failure. The initial stiffness of the connection is low, so the contribution in a small earthquake is likely minimal. The large number of connections could play a significant role in preventing collapse in a high strength earthquake.

Fatigue Behavior of HMIPs with Pre-existing Cracks - Mark Eason, Ying-Chuan Chen & Ali Morovat

Figure 1: Fatigue cracks begin to propagate near the extreme tension fiber of specimen

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 cracking. As such, this project aims to quantify the fatigue life of the weld before failure. To do this, specimens are being laboratory tested at stress ranges from 1 to 6 ksi until cracks form, as seen in Figure 1. Additionally, specimens are being instrumented throughout Texas to quantify HMIP response to local wind conditions (Figure 2). Together, the results of the lab tests and field experimentation will be used to estimate the remaining fatigue life of in service HMIPs.

Figure 2: Field Instrumentation of HMIPs

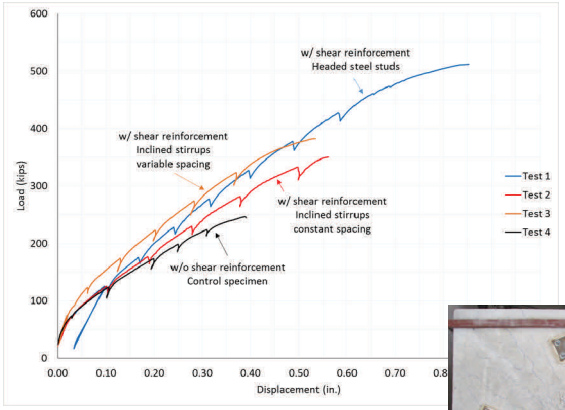
End Region Behavior of Pretensioned Concrete Beams with 0.7-inch Strands - Roya Abyaneh, Jessica Salazar, Alex Katz, & Dennis Kim

While the use of 0.5 and 0.6 -inch diameter prestressing strands is common practice in precast bridge girders, engineers have expressed interest in the use of 0.7-inch diameter strands due to perceived physical and economic benefits. However, these benefits are not well understood, and 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. Currently, the team has begun the parametric study by exploring potential span length gains, and refined analytical modelling capabilities of pretensioned girders by replicating the results of previously tested girders. Two release and two shear tests have already been performed on the first two specimens. So far, the release tests have shown that the use of 0.7-inch girders at a standard grid meets the serviceability requirements of TxDOT. The shear tests demonstrated atypical failure modes which were conservatively estimated using current standards. The team plans to investigate the implications of 0.7-inch strands in larger Tx-girders and is preparing to fabricate the third specimen this semester.

The team pictured with the first specimen after its failure

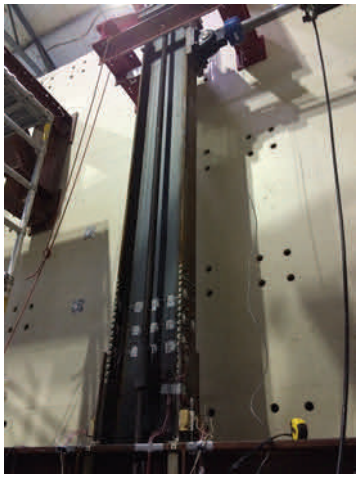
Behavior of Inclined Shear Reinforcement in Flat Plate Slab-Column Connections under Concentric Shear Loading Conditions - Gabriel Polo & Mario Glikman

This research was focused toward investigating the performance characteristics and punching resistance of reinforced concrete slab-column connections employing a novel shear reinforcement system consisting of inclined deformed steel reinforcing bars. Four slab-column connections with varied shear reinforcement were tested: one slab was reinforced with a conventional headed stud system, two of the slabs were reinforced with the novel inclined stirrup assemblies, and one slab was constructed without through-thickness shear reinforcement. The results have shown that the slab-column connections strengthened with the inclined reinforcement assemblies have suffered from premature failure mechanisms attributed to inadequate reinforcement anchorage. A final report has been presented evaluating the merits and limitations associated with employing inclined shear reinforcement as a means of enhancing punching shear strength. Ongoing research is focused on evaluating the punching shear strength of slab-column connections using different headed steel stud rails configurations.



Load-displacement response comparison

Overhead view of the specimen

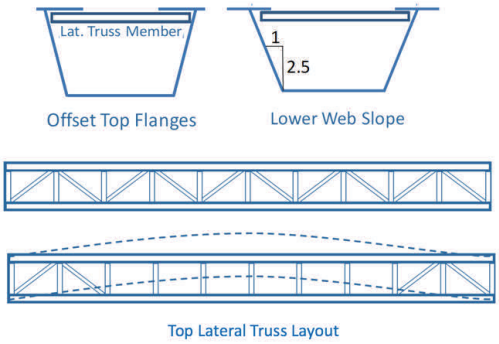


Test setup ready for testing

Limit State for Post-Tensioned Beam-to-Column Connections in Self-centering Moment-Resisting Frames - Anne Hulsey

Self-centering moment-resisting frames employ post-tensioned (PT) steel bars that run along the length of the beams. The PT bars are anchored to the exterior columns, providing a stiff connection under normal conditions but allowing the connection to rock open and develop a restoring force under lateral sway due to earthquake loading. Though this is a proven technology, little is known about the strength degrading response after potential limit states, reducing the understanding of the collapse risk. This test setup investigates how PT area, initial PT force, and the profile of the beam affect the beam buckling limit state and the post-limit state cyclic strength degrading response.

Improved Tub Girder Details - Yang Wang, Stalin Armijos Moya & John Kintz



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.

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

The cube farm

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.

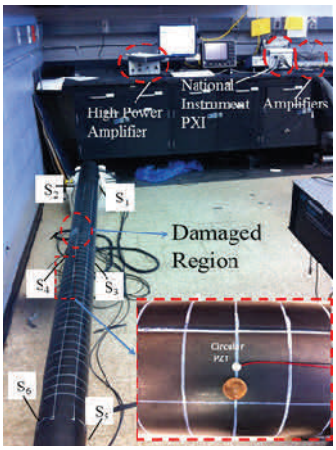
Delamination of Curved Post-Tensioned Structures - Jongkwon Choi & Clint Woods

Figure 1: Cracked specimen 1 after the test

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 finished the concrete casting of the second specimen last December. We also conducted all the material tests including compression, modulus of elasticity, modulus of rupture, split tension, and direct tension tests for 28-day. Based on the material test results and the previous structural test results, the failure load was reevaluated to ensure the design of the test setup. Currently, we are in the process of setting up the instrumentations. Once the load cells and the rams are available, we will finalize the test setup and conduct the test around March.

Structural Health monitoring for Corrosion and Leak Detection in Pipelines - Brennan Dubuc & Arvin Ebrahimkhanlou

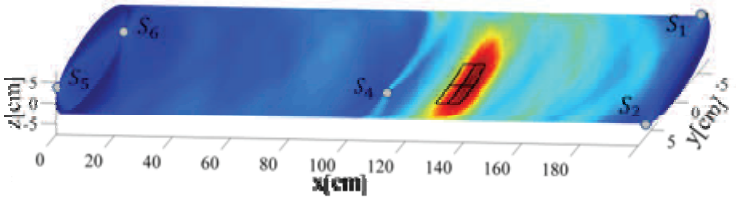


Experimental setup

The team is working to develop a built-in pipeline monitoring system based on permanently installed low profile piezoelectric transducers. Signal processing algorithms, based on probabilistic concepts, will perform the critical tasks of: 1) damage localization (e.g., leaks), and 2) damage characterization (e.g., thickness maps). The main advantage of this approach is that it may take into account uncertainty in sensor measurements to reliably locate and quantify corrosion damage.

The proposed system could operate in two different modes. Under the active mode, the system would be activated for periodically scheduled inspections. Under the passive mode, the system would continuously monitor the progression of damage. It is envisioned that the proposed system will provide an "early warning" of the corrosion process, and allow for the planning and implementation of mitigation strategies, at a point where it is less expensive and invasive than when the structure has been seriously compromised.

Mapping of wall thickness reduction



Congratulations to the 2015 FSEL Fall Graduates!

- Katelyn Beiter (MS)
- Sepehr Dara (PhD)
- Joseph Klein (MS)
- Victoria McCammon (MS)

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

JNT Golf Tournament - TBD

BASTROP, TX Ferguson Lab organizes a golf tournament at the end of every academic year. This event usually takes place the first week after the finals are over. This year we will have the 23rd Annual J. Neils Thompson Golf Tournament. The tournament celebrates the end of the semester and honors J. Neils Thompson, who was the lead developer of UT's civil engineering research program, as well as a scratch golfer.

The format and rules of this tournament create a fun atmosphere for all skill levels (more than 25% of the participants have never played golf before). Around eighty students, professors, staff, and industry representatives have participated in past tournaments. The tournament format is a "shotgun start, four-person best ball scramble." With such a scramble, all four players hit from the same spot and use the best shot of the group for their next shot (i.e. three players pick up their ball and shoot from the "best ball"). Thus, anyone has the chance to make a difference.

The tournament is a lot of fun and more details will be released closer to the tournament. Not only do you get to spend time with your fellow classmates, the tournament offers an opportunity to network with professionals who sponsor the outing to help reduce the cost for students. All skill levels are encouraged to participate and we make sure to add some "special rules" to make the round of 18 enjoyable for everyone. More details will follow during the semester.

Special points of interest:

- Annual Picnic and Softball Game, May TBD
- JNT Golf Tournament, TBD

2015 Winning Team
Aaron Hill
Tim Beckett
Daniel Gretch
Patrick Stewart

Use string to save a stroke

Everyone has a chance to sink the winning putt!

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 first issue of 2016, thirteen 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 to Drit Sokoli
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