Ferguson Structural Engineering Lab Newsletter

THE UNIVERSITY OF TEXAS AT AUSTIN - STRUCTURAL ENGINEERING

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New Faces at FSEL

Heather Wilson

I am a first year master's student from Sacramento, California. I earned my bachelor's degree in Civil Engineering at the University of Alabama before moving to Austin. Some of my interests include exploring and traveling, playing sports, hanging out with friends, and reading. I hope to use my engineering degree to work internationally with emerging countries. I am excited to be working on the MPR project with Dr. Bayrak. I look forward to working with and getting to know everyone at FSEL.

Cem Yesilyurt

I was born in Oregon and raised in San Jose, California. I earned my Bachelor's at UCLA and came directly to UT Austin to work on my Master's. I have just completed my first year. I am excited to be working with Dr. Hrynyk, Gabriel, and Mario on the flat plate, inclined shear reinforcement project. Outside of class my hobbies include reading, listening to music, and playing Lego's with my siblings. I have met great people at FSEL and look forward to working with them.

Inside this issue:

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

The goal of this research is to investigate a method to strengthen existing non-composite steel girder bridges by "post-installing" adhesive anchor shear connectors. By creating a mechanical connection between the existing steel girders and concrete deck, an increase in strength and stiffness on the order of 50% and 100%, respectively, can be achieved in regions of the girder dominated by positive bending. Regions of the girder dominated by negative bending will be "strengthened" by allowing inelastic moment redistribution to the adjacent spans per the current AASHTO LRFD specifications.

The experimental phase of this research is in full swing with another large-scale girder being constructed and tested this summer and into the fall semester. The previous test specimen performed very well under elastic loading, repeated large loads, fatigue loading, and monotonic testing to failure, and showed a high level of resilience and ductility. Design recommendations for strengthening existing bridges are also in development this summer.

First girder specimen after completion of all testing

Special points of interest:

- Ice cream social, July 29, 3pm, Large conference room
- FSEL Welcome BBQ, September TBD

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

First panel test

This research program is investigating the use of prestressed precast concrete panels as bracing elements in curved bridges during the construction phase. Last semester the team completed the fabrication of the test setup for measuring the strength and stiffness of the precast concrete panels, and tested two panel specimens – each with different panel-to-beam connection details. The team is also updating UT Bridge, a bridge analysis software. A revised version of the program is about to be released, which will give more accurate results for the eigenvalue buckling of curved steel bridges during erection. In parallel, an entirely new version is being developed, with improved geometry definition, a new quadratic shell element, improved stiffener modeling, and updated solver and eigensolver algorithms. The long-term goal for the program is to include the ability to perform a second-order analysis. This semester the team will test more panels with different connection details, design the next test set-up which will consist of two large girders connected with panels and loaded eccentrically to simulate the torsion seen by curved girders, and continue improving UT Bridge.

Second panel test

Effects of ASR on Reinforced Concrete Walls without Transverse Reinforcement - Gloriana Arrieta, Katelyn Beiter, Joseph Klein, Alistair Longshaw, Heather Wilson, Beth Zetzman

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. The research team continues to make significant progress in each of the key subject areas.

§ Shear Strength - A total of 10 specimen placements and 12 shear tests (4 controls, 6 at moderate levels of ASR, and 2 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. Testing at high and medium levels of ASR damage will take place through the summer and next fall. We hope to be running our last structural test next November!

§ Reinforcement Anchorage - A total of 9 specimen placements and 4 reinforcement anchorage tests (1 control, 2 at moderate levels of ASR and 1 at high level of ASR) have been completed to date. As for the Shear Strength specimens, we hope to be wrapping up our structural testing efforts by next fall!

§ Out-of-Plane Expansion Monitoring - The research team has been monitoring the out-of-plane expansions of a 5-foot-tall wall segment fabricated in-house last summer using three different commercial instruments. Monitoring efforts will continue through this summer, when a decision will be made on which of the instruments performed the best.

§ Performance of Post-Installed Anchor Bolts - The research team continues to monitor ASR-related expansions within the existing inventory of anchor specimens. This summer, the team will be post-installing anchors to complete testing on the effects of high levels of ASR damage on anchor strength.

Finally, we would like to welcome our new team members, Alistair and Heather, to the FSEL family!

Getting ready to test our 48-in. deep shear specimen

The Role of Gravity Framing in Seismic Response of Structures—Sean Donahue, Stalin Moya, Dan Coleman

Typical seismic design for steel structures assumes all the lateral strength of a building is provided by the few moment-resisting frames or braced walls placed throughout the building, with the remaining gravity connections contributing nothing to the building's lateral resistance. However, those gravity connections do possess rotational stiffness, particularly when paired with a composite slab, which could contribute significantly to the seismic strength of a structure. This research will simulate the response of typical gravity connections under earthquake loads, so that the contribution of such connections can be modeled and used in future structures. A first test on a clip angle connection without a floor slab has been conducted. While the connection has high ductility, reaching .09 drift before fracture, the strength of the connection is limited, reaching approximately 12% of the beam's plastic moment capacity. Future tests with a floor slab will hopefully provide an enhancement in moment capacity.

Test setup at 9% inter-story drift

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

As part of the research program investigating the use of high strength reinforcing bars (HSRB) in concrete columns, three series of tests had to be performed. The first series of tests included three columns and was concluded last Fall. Each column was reinforced with different grades of steel for both longitudinal and transverse reinforcement: Grade 60, 80 and 100. The goal of these tests was to assess the integrity of shear transfer mechanism of columns with HSRB under high shear stresses. The first two columns reinforced with grade 60 and 80 ASTM A706 bars, respectively, showed comparable behavior and exceeded minimum performance objectives by a substantial margin, going past 5.5% drift ratio while maintaining the initial axial load and undergoing relatively low softening due to second order effects. The third column reinforced with Grade 100 steel showed signs of debonding between the corner longitudinal bars and the surrounding concrete starting at 1.5% drift. After completing the 3.0% drift cycles debonding had taken place along the whole height of the member. High bond demands in columns with HSRB remains one of the main concerns regarding the topic.

The second series of tests consists of two column reinforced with Grade 100 bars from two different manufacturers, each having a different tensile to yield strength ratio. The goal of this series was to investigate the implications of the low and high ends of this ratio in the behavior of concrete columns. The first column, with relatively high tensile to yield ratio of 1.27 was tested the second week of June 2015. The lateral load carrying capacity of the specimen dropped at the end of the second cycle towards -5.5% drift due to fracture of longitudinal bar. While going to the previous half-cycle, +5.5%, the response softened by 12% as most of the bars buckled. The second series will be concluded in the next weeks with the test of the column reinforced with Grade 100 bars having a tensile to yield ratio of 1.16. Based on these results, the scope of the third series is to be determined.

Test setup and specimen

Extended Use of Elastomeric Bearings to Higher Demand Applications - Kostas Belivanis and Liwei Han

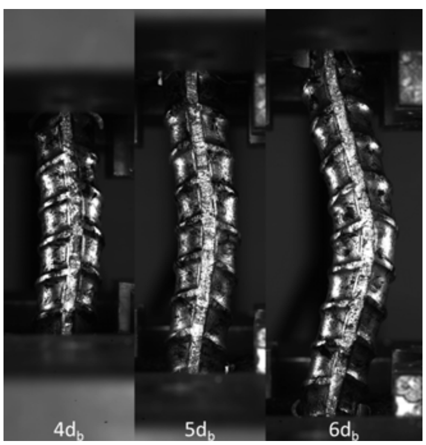
Bearing tested under axial load and rotation

The use of elastomeric bearings in steel bridge applications provides an economic and reliable means of accommodating the superstructure movement. In addition, systems are easier to fabricate, erect, and maintain while also improving the long-term bridge behavior.

Results from this research study will provide valuable insight into the behavior of large elastomeric bearing pads for use in high demand applications. As design procedures in AASHTO are developed after numerical and experimental research on smaller bearings there are concerns regarding the applicability of those procedures for larger sized bearings. The main goal of this study is to verify those design procedures and develop suggestions for corrections where needed.

At this phase of the study, bearings have been tested in all modes of deformation (compression, shear, rotation), and results are being used for the FEA parametric study. The ultimate goal of this study is to provide practicing engineers a simple, yet safe, design approach for elastomeric bearings regarding higher demand application.

Low-Cycle Fatigue of High Strength Reinforcing Bars – Chase Slavin & Stephen Zhao



Maximum lateral buckling of #8 bars

In order to enable the use of high strength reinforcing steel in concrete members subjected to seismic loading, the behavior of the bars under low-cycle fatigue must be identified. This research has studied the differences in fatigue behavior of grade 60, grade 80, and grade 100 bars under cyclic loading at high inelastic strains. In addition to testing steels with different yield strengths, the effect of unbraced length, total strain amplitude, bar size, and manufacturing process are assessed.

The results of these tests have identified certain types of steel which perform similarly to the commonly used grade 60 A706 and others which would require additional specifications to limit their use in seismic regions or modifications of their chemistry and/or microstructure.

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

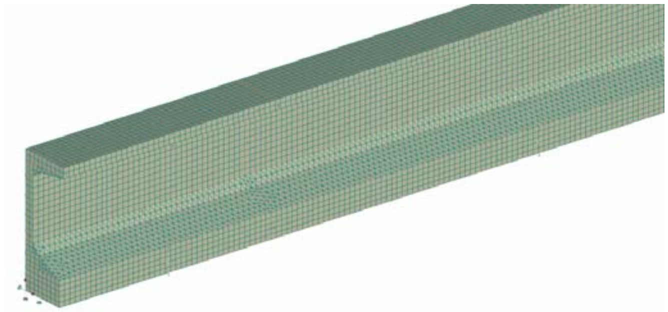
First specimen on test frame

This research is focused toward investigating the performance characteristics and punching resistances of reinforced concrete slab-column connections employing a novel shear reinforcement system consisting of inclined deformed steel reinforcing bars. The first specimens have been fabricated, and the test frame has been assembled. The tests aim to study the influence of inclined shear reinforcement on slab punching shear performance. The behavior of the specimens will be assessed on the basis of reinforcing bars strains, slab displacements measured using linear potentiometer and a visual tracking system, and visual damage assessed on the basis of crack patterns and widths.

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

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 suficiently 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 at least 6 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. Modifications to the prestressing bed are nearly complete and assembly of the rebar cage for the first specimen is underway. The team plans to cast and test the first girder later this month.

Test setup



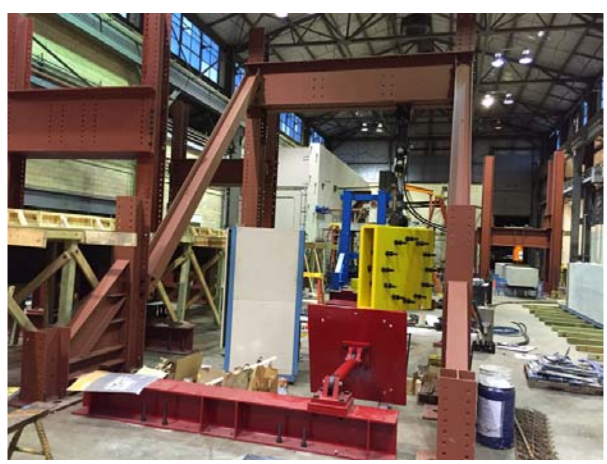
Finite element mesh of a Tx-46 girder in Atena 3D

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

Ultrasonic test conducted to characterize the weld cracks in the shaft-to-base plate connection

The objective of this TXDOT sponsored project is to examine the remaining fatigue life of High Mast Illumination Poles (HMIPs) with pre-existing cracks in the weld at their shaft-to-base plate connection. As a major step to fulfill this objective, laboratory fatigue tests will be conducted on pre-cracked galvanized HMIPs. Since the goal of experiments is to study how pre-existing cracks grow due to fatigue, the length and depth of cracks need to be evaluated prior the fatigue tests. A non-destructive method called ultrasonic test (UT) is conducted to characterize the cracks (Figure 1). Additionally, fatigue tests will be conducted at stress ranges in the order of 1 to 6 ksi. These stresses are selected to represent those that might be experienced by an in-service HMIP due to wind.

Test setup to accommodate four HMIP specimens in fatigue studies at Ferguson Lab



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

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

Figure 1: Cracked specimen 1 after the test

The goal of this project is to gain a better understanding of the behavior of curve post-tensioned concrete structures. In the past, there have been several analytical studies on the radial stress distribution, but no experimental verification has followed. This research will provide the necessary experimental data in order to model the effect of localized tensile stress and delamination of curved post-tensioned structures.

Our team finished first test on last April. The specimen failed at a higher load than the expected failure load.

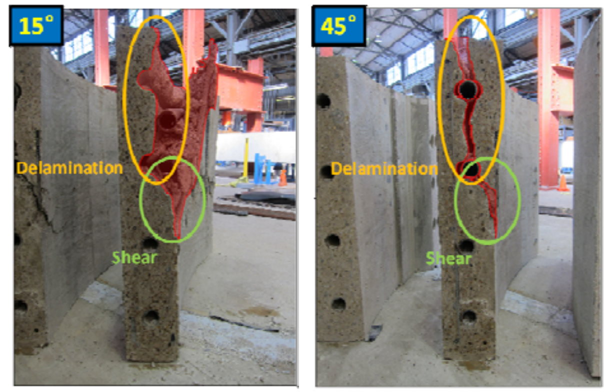


Figure 2: Crack patterns at the 15° and 45° sections

The final failure was a combination of delamination and shear failure (Figure 1 and 2). After the test, we spent a month to interpret the test data. As expected, the delamination failure is highly dependent on the direct tensile strength of concrete. The second specimen was designed based on the first test results. As shown in the Figure 3, the second specimen will be twice larger than first specimen.

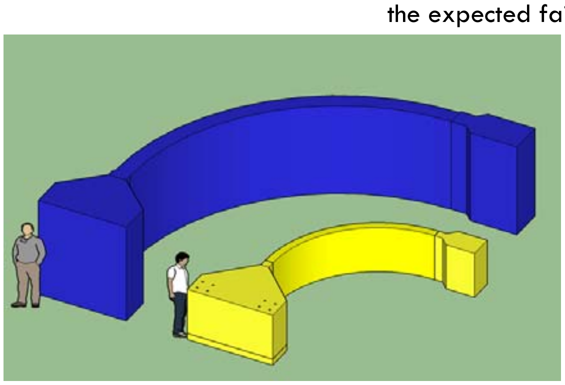


Figure 3: Size comparison of specimen 1 (blue) and specimen 2 (yellow)

Congratulations to the 2015 FSEL Spring Graduates!

- Stalin Armillos (MS)
- Michalis Hadjioannou (PhD)
- Beth Zetzman (BS)

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 2015, eleven 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 Kerry Kreitman or Drit Sokoli
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