Ferguson Structural Engineering Lab Newsletter

THE UNIVERSITY OF TEXAS AT AUSTIN - STRUCTURAL ENGINEERING

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Welcome to New Faculty Member!

As of Fall 2015, we are excited to welcome Salvatore Salamone as a new faculty member joining us at FSEL.

Dr. Salamone comes to us from the University of Buffalo, where he was an Associate Professor. He received both his MS and PhD degrees at the University of Palermo, and worked as a post-doc at the University of California - San Diego. His research interests include structural health monitoring and non-destructive evaluation, focusing in ultrasonic sensing methods for smart structures and digital signal processing and pattern recognition.

We look forward to learning more about his research in future editions of the newsletter!

Salvatore Salamone, our new faculty member at FSEL

New Faces at FSEL

Arvin Ebrahimkhanlou

I started my PhD two years ago with Dr. Salamone in the area of Nondestructive Testing (NDT). My background is civil-structural engineering, and my research bridges between recent advancements in computer science and structural nondestructive evaluation. We have recently moved our NDT lab from University at Buffalo to Ferguson lab, and I look forward to know and collaborate with everyone at FSEL.

Patrick Alrassy

I am a first year master's student from Lebanon. I earned my bachelor's degree in Civil Engineering at the American University of Beirut. My main interest outside class is playing sports and mainly swimming, gymnasium and jogging. I am excited to be working on the high strength reinforcing steel project with Dr. Ghannoum, Drit and Albert. I look forward to working with and getting to know everyone else at FSEL.

Congratulations to the 2015 FSEL Summer Graduates!!

- Chase Slavin (MS)
- Hossein Yousefpour (PhD)

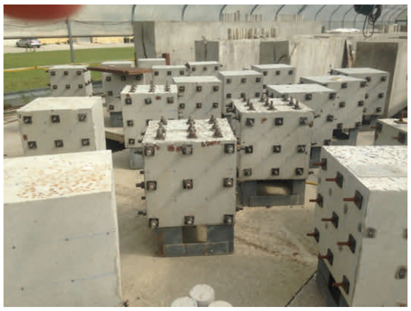
Inside this issue:

Special points of interest:

- FSEL WELCOME PARTY AND OPEN HOUSE, October 2; 5-8 PM
- FIRST YEARS VS. OLD TIMERS FLAG FOOTBALL CHALLENGE, DATE TBD
- Tailgating with SEMM! Every home UT football game, at the corner of Dean Keeton and San Jacinto, from 7am to start of the game

Ongoing Research at FSEL

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.

Effects of ASR on RC Walls without Transverse Reinforcement - Gloriana Arrieta, Katelyn Beiter, Joseph Klein & Heather Wilson

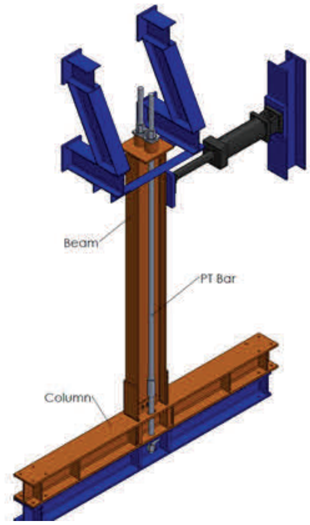
An example of the damage that ASR can cause - Condition of the 5-foot-tall wall segment after completion of the out-of-plane monitoring efforts

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 16 shear tests (4 controls, 4 at moderate levels of ASR, and 8 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. Four more structural tests at high levels of ASR damage will take place next October.
- Reinforcement Anchorage - A total of 9 specimen placements and 7 reinforcement anchorage tests (1 control, 3 at moderate levels of ASR and 3 at high level of ASR) have been completed to date. We hope to be wrapping up our structural testing efforts by the first week of November!
- 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 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 will now be analyzed to determine the effect of different levels of ASR damage on the pull-out strength of different types of post-installed anchors.

Limit States 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.



3D drawing of the test setup

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

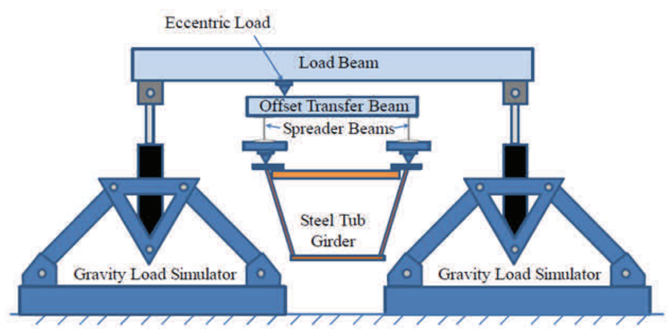
Steel trapezoidal box girders, known as tub girders, are an appealing option to be used in bridges in comparison with other girder types not only for their aesthetics, but also due to several structural advantages. These girders are a popular alternative in systems with large torsional demands, such as horizontal curved bridges, because of the torsional stiffness of their closed section.

Currently, AASHTO possesses a number of requirements to proportion tub girder sections and for bracing details with limited justification about them.

The objective of this research is to enhance the economy and performance of steel tub girders by developing improved details to be applied on the proportioning of tub girder sections and bracing systems. Details of tub girder webs slope, offset of the top flange on the webs, top lateral trusses, and internal cross frames are going to be evaluated.

This research will consist of large-scale laboratory testing as well as parametric finite element analyses.

Tentative loading system for combined bending and torsional load



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

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. Initial tests on clip angle connections without a floor slab have shown that the connection has high ductility, reaching 10% drift while still supporting gravity loads. However, their strength 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 (up)

Tearing of clip angle at high rotation (left)

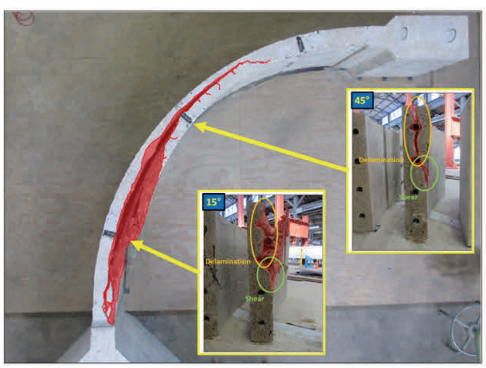
Strengthening Continuous Steel Bridges with Post-installed Shear Connectors - Kerry Kreitman & Amir Ghiami

Figure 1: Post installed connectors

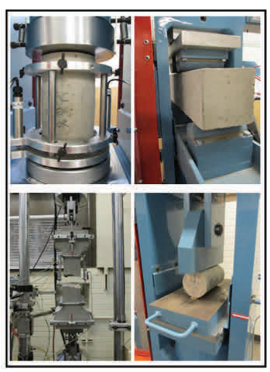
This research is focused on strengthening existing non-composite steel girder bridges by post-installing adhesive anchor shear connectors (Figure 1) to create composite action with the concrete deck and allowing for inelastic moment redistribution from the interior supports of continuous girders. The laboratory testing, which will be completed this fall, incorporates elastic and fatigue loading to simulate typical daily traffic loads, large repeated loads to represent very heavy truck traffic, and monotonic loading to failure. The specimen, shown in Figure 2, is a 104-foot long two-span single girder line with geometry representative of typical existing non-composite bridges in Texas. Results from previous experimental testing and analytical studies indicate that this strengthening method is a feasible and efficient way to increase the load rating of existing non-composite steel girder bridges, which can help avoid load posting, more intensive rehabilitation efforts, or complete replacement of a bridge.

Figure 2: Two-span girder specimen

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



(a) Failure of the first test specimen



(b) Material test

Figure 1: (a) Extent of the failure and cross sections of 15 and 45 degrees at the first specimen, (b) Material tests –compressive strength, modulus of rupture, direct tension, and split tension 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 provided the data necessary to model the effect of the localized tensile stress and concrete delamination in curved post-tensioned structures.

Our team finished the first test last April, and we are now in the process of constructing the second test specimen. The anchor block for the next specimen has already been casted and will soon be moved to the bolt groups near our platform. Next, we will be expanding the wood platform and beginning the fabrication of the curved formwork for the wall.

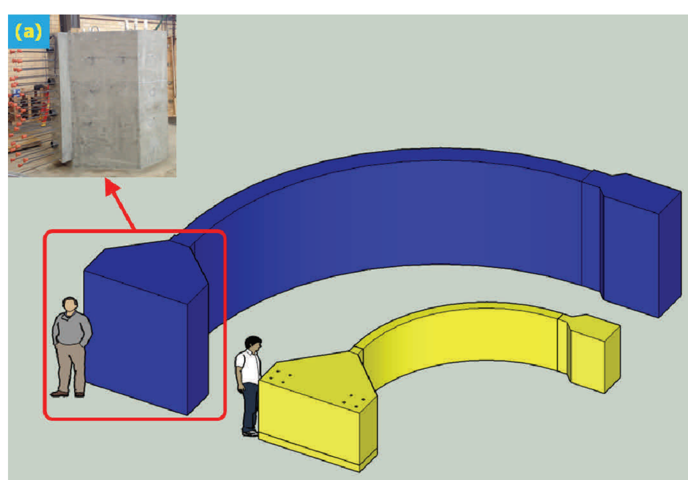


Figure 2: Size comparison of specimen 1 (yellow) and specimen 2 (blue), (a) Anchor block for specimen 2

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 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. An end-region release test has already been performed on the first specimen. The team plans to perform the first shear test and fabricate the second specimen this semester.

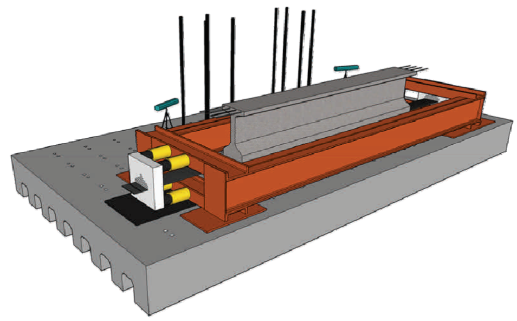


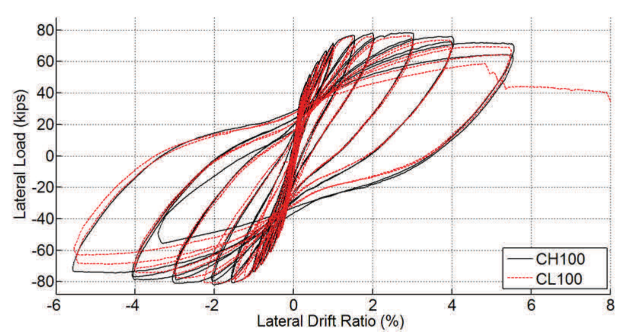
Figure 1: Pre-stress force release test setup

Figure 2: 0.7-inch team casting the deck on the first test specimen

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

The goal of this project is to investigate the implications of the tensile to yield strength ratio (T/Y) of the reinforcing bars to the seismic behavior of concrete columns. To address this topic, two columns reinforced with Grade 100 bars from two different steel manufacturers were recently tested at FSEL. The first column, namely CH100, was reinforced with bars having relatively high T/Y of 1.27. The longitudinal reinforcement in the second column, CL100, had a T/Y of 1.16. Specimens were tested cyclically in double curvature with a constant axial load of 15% of the capacity being applied at all times. Both specimens showed comparable behavior and were loaded past 4.0% drift while maintaining lateral strength and prescribed axial load. The lateral load carrying capacity of CH100 column dropped at the end of the second cycle towards -5.5% drift due to fracture of a longitudinal bar. While the column was being pushed to the previous half-cycle, +5.5%, the response softened by 12% as most of the bars in compression buckled. CL100 remained stable past the two cycles to 5.5% drift. First bar fracture in this specimen was observed 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 bar fractures. Preliminary data analysis showed that CL100 had larger strain concentration at the base of the member, lumping the plasticity over a shorter length as compared to CH100 which distributed the plastic strains to a higher length.

Hysteretic loops from the response of the tested specimens



Quantitative Automated Visual Inspection of Concrete Shear Walls - Arvin Ebrahimkhanlou

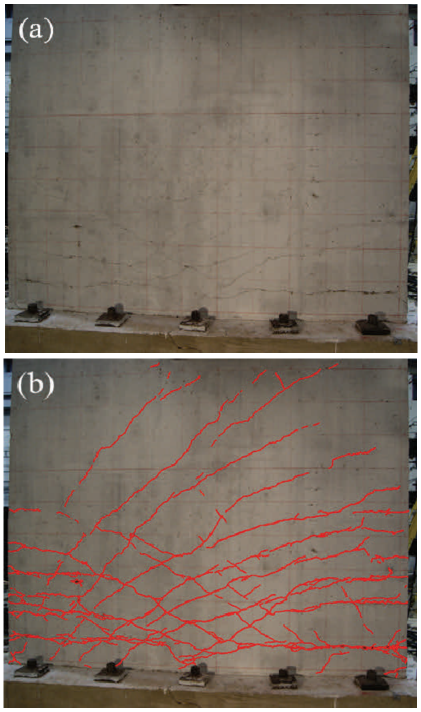


Figure 1: (a) input image, (b) detected cracks overlaid on the original image

The most common assessment technique for reinforced concrete shear walls (RCSW) is currently Visual Inspection (VI). The current practice suffers from its subjective and labor intensive nature as it highly relies on judgment and expertise of the inspectors. In post-earthquake events where urgent and objective decisions are crucial failure of the conventional VI could be catastrophic. Conventional VI is mainly based on the width of residual cracks. Given that cracks could close partially (e.g., due to weight of the structure, behavior of adjacent elastic members, earthquake displacement spectrum, etc.), methods based on crack width analysis may lead to underestimate the state of the damage and eventually an erroneous decision. On the other hand, crack form patterns that change as the damage progresses. The patterns are invariant with respect to the residual displacement which makes them advantageous over crack width. The goal for this NSF founded project is to investigate mathematical and statistical tools like fractal analysis and Bayesian network (BN) reasoning to capture information hidden in the crack patterns and correlate them with the structural damage. The project also aims to automate the extraction of the information from images by using recent advancement in image processing and artificial intelligence (AI).

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

Figure 1: Anemometers and solar panel installed on a mock-up pole

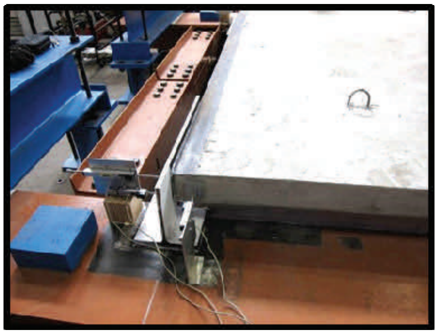
This TxDOT sponsored project focuses on examining the remaining fatigue life of High Mast Illumination Poles (HMIPs) with pre-existing cracks in the weld at their shaft-to-base plate connection. As part of this project field data will be collected to characterize wind response of Texas HMIPs. To evaluate the monitoring system and to practice different methods of installation of sensors, a mock-up pole has been setup outside the Ferguson Lab. As shown in Figure 1, one ultra-sonic anemometer, one propeller anemometer, one accelerometer, and two 90 watts solar panels are mounted on the mock-up pole.

In addition to the field study, laboratory fatigue tests are underway on pre-cracked galvanized HMIPs (Figure 2). Fatigue tests are performed 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.

Figure 2: Test setup and HMIP specimen in fatigue studies at Ferguson Lab

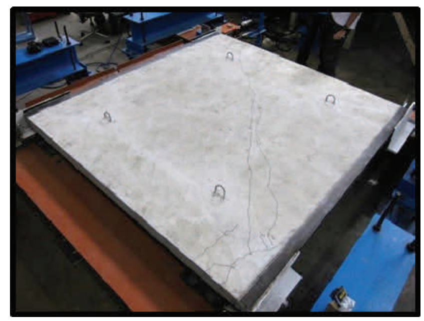
*Committee Vision: Increase **productivity** at Ferguson Laboratory through improved **communication** and **collaboration** of students, staff, and faculty*

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



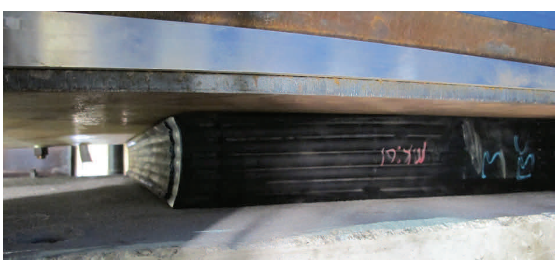
PCP to girder connection

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 an additional three PCPs were tested in the laboratory, with different connection details between the PCPs and the steel girders. The connections show satisfactory stiffness and strength. The team has also been designing the next setup for experimental testing of twin I-girders subjected to flexure and torsion (to mimic the behavior of curved bridges), using FEA to anticipate their behavior. Finally, UT Bridge 1.6 has been created which has provided a fix to many of the bugs see in version 1.5. Next semester the team will contact precasters to test actual PCPs on the test frame, finish designing the twin girder test set-up, and continue working on a new pre-processor and post-processor for UT Bridge 2.0.



Panel at ultimate capacity

Expanding Use of Elastomeric Bearings to Higher Demand Applications - Kostas Belivanis & 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.

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 third issue of 2015, 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.