# Ferguson Structural Engineering Lab Newsletter

THE UNIVERSITY OF TEXAS AT AUSTIN - STRUCTURAL ENGINEERING

Volume 7, Issue 1

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## New Faces at FSEL

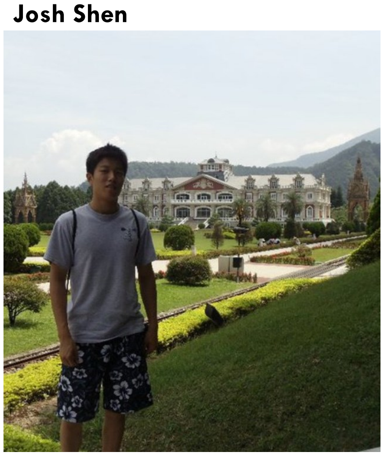
**Stephen Zhao**

I am an international student born and raised in Trondheim, Norway. I came to the United States to attend UT for my BS in Civil Engineering and then decided to continue for my MS. Some of my hobbies include playing the violin, archery, cooking and taking photos. I am excited about getting to know and do research with everyone at FSEL.

**Albert Limantono**


I was born and raised in Surabaya, Indonesia and am a first year masters student. I earned my BS degree in Civil Engineering from Bandung Institute of Technology and then came directly to UT Austin. I am excited to do experimental work at Ferguson Lab with Dr. Ghannoum. When I have free time, I like to play basketball, travel and play computer games. I am looking forward to experiencing the lab and meeting everyone at FSEL!

**Josh Shen**



I was born in Taipei, Taiwan, and moved to Texas when I was ten years old. I discovered my interest in structural engineering half way through my college career; it seemed more tangible to me than the other subjects. Outside of class, my hobbies include playing the piano, playing basketball, and trying new food. I hope my time at FSEL will give me a good grasp of what grad school is like, and I look forward to working with everyone in the lab.

Inside this issue:



Special points of interest:

- SEMM Recruitment, TBD
- Annual Picnic and Softball Game, May 8
- JNT Golf Tournament, May 20

**Congratulations to the 2014 FSEL Fall Graduates!!**

- Xiaowei Dai (PhD)
- Daniel Elizondo (MS)
- Josh Massey (MS)
- Ali Morovat (PhD)
- Drit Sokoli (MS)
- Sara Watts (MS)

## Summaries of Ongoing Research

### Extending Use of Elastomeric Bearings to Higher Demand Applications - Kostas Belivanis

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 the long-term bridge behavior is improved.

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 are being testing in all modes of deformation (compression, shear, rotation), and results are being used for the FEA parametric study.

Bearing tested in shear to evaluate the shear stiffness, friction coefficient, and implications of partial non-contact

The ultimate goal of this study is to provide practicing engineers a tool that will provide them with simple spring element properties for more accurately simulating the support conditions of a long span, stiff bridge.

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

Prestressing bed at Ferguson Lab

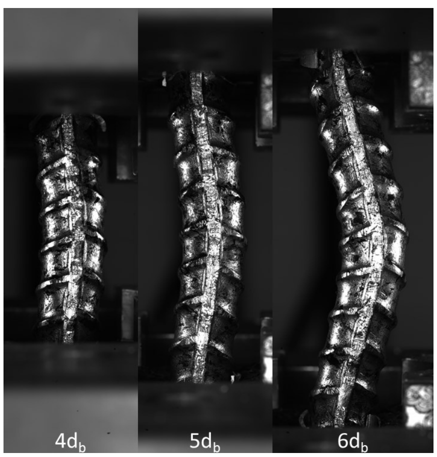
The use of 0.5 and 0.6-inch diameter prestressing strands in TX-girders is common practice today. Increasing strand diameter to 0.7 inches would conceivably result in broad economic gains similar to those associated with the increase in strand diameter from 0.5 to 0.6 inches. Benefits include reduced material and labor costs, beam depth reduction, and the possible elimination of a beam line in a highway bridge. However, current knowledge in prestressed beams is not sufficient to accurately predict the limits of beams utilizing 0.7-inch strands in areas such as release strength and shear strength. Our team's research will quantify limit states associated with the new strand based on existing knowledge applied to strands stressed up to 202.5 ksi on a 2-inch by 2-inch grid. An experimental program consisting of at least six different beams fabricated will begin this semester with the goal of developing a professional set of design codes and fabrication specifications for TX-girders with 0.7-inch diameter strands. Analytical models will also be developed, beginning this semester, to verify experimental results and to detail for end-region stresses under several different configurations.

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

Installing the adhesive anchors: Drilling holes (left) and inserting the threaded rod (right)

The goal of this project is to investigate the feasibility of strengthening older continuous steel bridges by making them composite with the concrete deck using post-installed shear connectors. The shear connectors are adhesive anchors consisting of high strength threaded rods to connect the two materials together.

The current focus of this research is conducting large-scale tests in the laboratory on a 85-foot long continuous two-span girder consisting of a W30x90 steel beam with a 6.5-foot wide concrete deck, strengthened with adhesive anchor shear connectors. Loading cycles have been applied that simulate the effects of increasingly heavier trucks crossing a bridge, and very good performance has been observed well into the inelastic range. This semester, fatigue testing will be conducted on the same specimen, followed by the construction and testing of a second girder.




Maximum lateral buckling of #8 bars

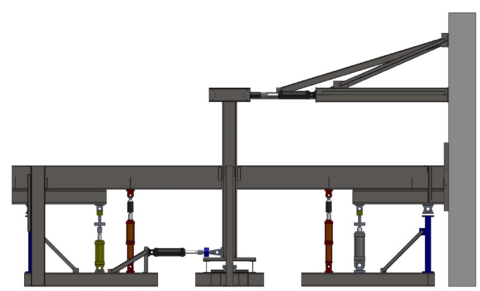
## Low-Cycle Fatigue of High Strength Reinforcing Steel – Chase Slavin & Stephen Zhao

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 intends to study the differences in fatigue behavior of grade 60, grade 80, and grade 100 bars under cyclic loading at high inelastic strains.

One potential weakness of high strength reinforcing steel is the typically lower ratio of tensile to yield (T/Y) strength. To assess the effect of this variable, test specimens include bars from 2 different manufacturers, which represent different T/Y ratios. In addition, the amount of buckling which occurs has a large effect on the fatigue life of reinforcing steel so the unbraced length is modified to control the amount of buckling. Preliminary tests indicate that the grade 100 bars behave comparably to grade 60 A706 bars.

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

Typical seismic design for steel structures assumes all of 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. Given the large number of gravity connections present in most buildings, this stiffness has the potential to contribute significantly to the seismic strength of a structure. However, their behavior is not sufficiently understood to allow engineers to count on this capacity. This research hopes to simulate the response of such connections under earthquake loads, so that the contribution of such connections can be modeled and used in future structures. Testing will also identify the potential weaknesses in the response of gravity connections, so new details with improved seismic performance can be designed.



Proposed test setup for experiments (slab not shown)

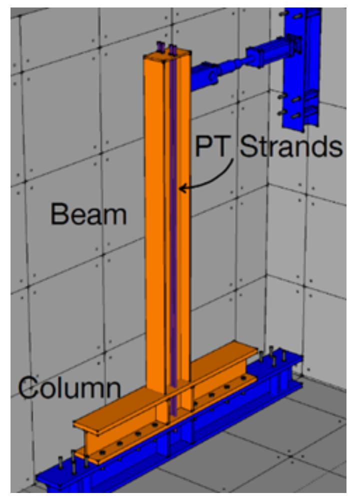
## Spliced Prestressed Concrete I-Girders – Chris Williams & Dhiaa Al-Tarafany

Spliced girder test specimen after failure

The spliced girder team is currently conducting tests to study the performance of the cast-in-place (CIP) post-tensioned splice regions of spliced girder bridges. Each of the test specimens consists of two pre-tensioned girder segments spliced together at a 2-foot long splice region. The first test on a large-scale spliced girder was completed last semester (see figure). The second girder contains different reinforcement details within the splice region and will soon be tested, wrapping-up the experimental program. The test results will be used to develop design and detailing recommendations for CIP splice regions. In addition to the girder tests, push-off shear tests were conducted last fall to study the strength of the interface between the precast girders of spliced girder bridges and the CIP splice regions. The tests revealed that varying the interface details and applied post-tensioning force had a significant impact on the shear behavior of the specimens.

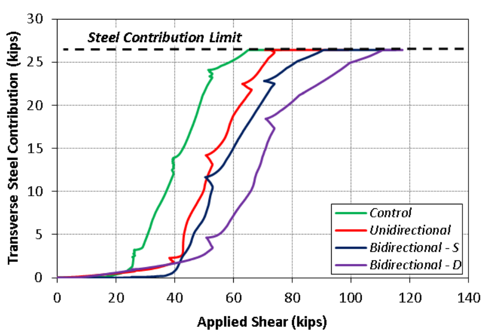
## Limit States for Post-tensioned Beam-to-Column Connections in Self-centering Moment-resisting Frames – Anne Hulsey

In self-centering moment-resisting frames, post-tensioned (PT) steel strands run along the length of the beams. They are connected to the exterior columns as a way of providing a restoring force when lateral sway under earthquake loading rocks open the beam-column connections. 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 is designed to investigate how design parameters such as flange reinforcement details, initial PT force, and beam size affect the beam buckling limit state and the post-limit state cyclic strength degrading response.




3D drawing of a post-tensioned beam-to-column connection

## Bi-Directional Application of CFRP for Shear Strengthening - Nawaf Alotaibi, Douglas Pudleiner & Will Shekarchi




Steel Contribution to Shear Capacity

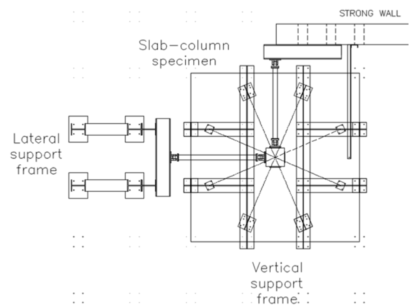
The effectiveness of bi-directional application of CFRP on the shear capacity of RC beams was demonstrated through eight tests conducted previously on four 24-in. deep T-beams. A shear strength gain up to 62% was achieved when applying CFRP strips bi-directionally where a shear strength gain of 43% was achieved when CFRP strips were applied uni-directionally.

The effectiveness of bi-directional application of CFRP on the shear capacity of 48-in. deep T-beams is currently being investigated. Shear tests will be conducted on beams with different transverse reinforcement ratios to investigate the interaction between transverse steel and CFRP strips. These tests will provide a better understanding on the combined interaction between the shear contributions of concrete, steel and CFRP to the shear capacity of RC beams strengthened bi-directionally with CFRP strips and anchors.

During this spring, efforts will be concentrated on constructing first set of specimens with transverse steel spaced at 18-in. on center.

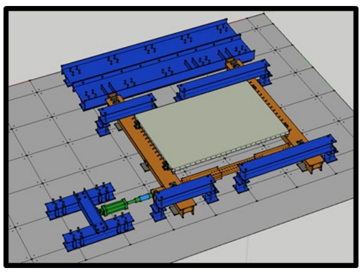
## Behavior of Inclined Reinforcement in Flat Plate Slab-Column Connections under Concentric Shear Loading Conditions– Gabriel Polo & Mario Glikman

This research is focused on 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. Testing of the three large-scale slabs comprising this first stage of the experimental program is expected to commence mid-Spring and to be completed this Summer. The connection assemblies will be subjected to concentrated vertical loading applied at the base of the column forming the connection, and will be restrained vertically by eight support points circumferentially located around the column. These tests aim to study the influence of the inclined shear reinforcement system on the conical punching shear failure region developed under concentric shear loading conditions and on the ability of the novel slab shear reinforcing system to improve system performance.




Test setup plan view

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



Sketch of test frame

This research is investigating the use of prestressed precast concrete panels as bracing elements in curved bridges.

Last semester the team designed and fabricated most of the test setup for measuring the strength and stiffness of the precast concrete panels. The team fabricated a sample panel that will be used to try out the constructability of different connection designs. The team is also updating UTBridge, a bridge analysis software published by the University of Texas, to change to a more precise and robust eigensolver. Changing the eigensolver requires migrating platforms and updating many of the program subroutines. This semester the team will finish assembling the test setup, test some panels in the test frame, and continue improving UTBridge (by modifying the finite element modelling).

Casting a sample panel

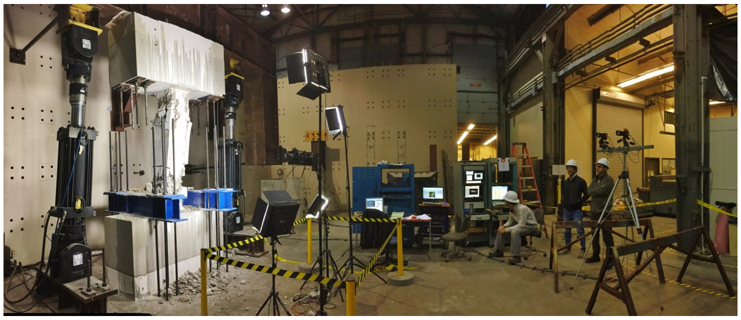
## Fatigue Resistance and Reliability of High Mast Illumination Poles (HMIPs) with Pre-existing Cracks - Ying-Chuan Chen & Ali Morovat

High Mast Illumination Poles (HMIPs) are used throughout Texas and the U.S. to provide lighting along highways and at interchanges. Texas currently has about 5000 HMIPs, varying in height from 100 to 175 ft. In recent years, a number of HMIP collapses have been reported in other states. These collapses have been attributed to fatigue failures at the HMIP shaft-to-base plate connection.

In this TxDOT sponsored project, laboratory fatigue tests will be conducted on pre-cracked galvanized HMIPs. In addition, field data will be collected and additional analyses will be conducted to characterize the wind response of Texas HMIPs. Field and laboratory studies will be supplemented by finite element studies simulating the global and local response of pre-cracked HMIPs. The results of the laboratory data, field studies, and analytical studies will be combined in a reliability-based framework to provide a probabilistic assessment of the fatigue life of in-service pre-cracked HMIPs, and to develop options for mitigating risk associated with cracked HMIPs, such as increased inspection and monitoring, repair techniques, and methods to reduce vortex shedding.

Portal loading frame used in previous fatigue studies in HMIPs at Ferguson Lab

## Seismic Application of High-Strength Steel Bars in Reinforced Concrete Columns – Drit Sokoli & Albert Limantono



Test setup and CS100 specimen at the end of the test.

The demand for higher strength reinforcing steel in concrete construction is rapidly increasing in the U.S. and worldwide. Yet, current code limits on the strength of reinforcing steel, combined with a lack of understanding of the effects of higher strength steel on the performance of the concrete members, are hindering progress in structural design. As part of the first series of tests, three columns satisfying most of the provisions of ACI 318-11 for Special Moment Resisting Frames were tested under constant axial load and cyclic lateral loading until major softening of the lateral load carrying capacity occurred. 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 behavioral implications of using higher strength reinforcement on the seismic behavior of concrete columns. 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 while maintaining the initial axial load and undergoing relatively low softening due to secon order effects. The third column reinforced with Grade 100 steel showed signs of debonding between the steel 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. Further investigation and data analysis is required to shed light on this anticipated issue with high strength steel usage.

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

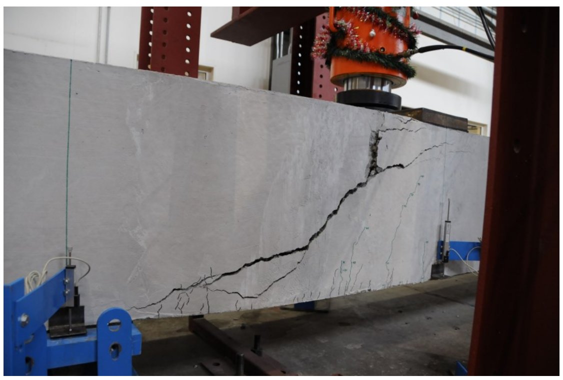
The response of alkali-silica reaction (ASR) induced expansions on the structural behavior of reinforced concrete elements is not very well understood, nor has it been quantified via a complete and comprehensive analysis methodology. It has been repeatedly shown that ASR results in the degradation of mechanical properties (strength and stiffness) of plain concrete used in member design. However, reinforced members with ASR distress do not generally exhibit as severe a reduction (if any) in capacity or stiffness as might be anticipated. The presence of reinforcement serves to restrain expansion and leads to a form of internal prestressing of surrounding concrete that curbs deleterious behavior.

The initial and ongoing challenge within the scope of this research aims to identify how and why various stress and strain states manifest during the course of ASR in a multitude of elements with differing reinforcement orientations and ratios. During this semester a series of uniaxially-, biaxially-, and triaxially-reinforced concrete cubes with ASR will be fabricated, conditioned, and monitored to assess expansion behavior and serve as representative, experimental finite elements. This endeavor will supplement continued efforts at FSEL to decipher the mysteries of ASR, and the data acquired will aid in the computational modelling of expansions and the generation of a robust, finite-element based approach that can be implemented to predict overall structural response.

Sample triaxially-restrained ASR expansion cube

## Effects of ASR in Reinforced Concrete Walls without Transverse Reinforcement – Gloriana Arrieta, Katelyn Beiter, Joseph Klein, 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) establish the structural implications of ASR in reinforced concrete walls without transverse reinforcement, and (b) develop the knowledge base, tools and techniques necessary to complete field assessments of such structures. The research team continues to make significant progress in each of the key subject areas.



'Failing a shear control specimen with holiday cheer!'

*Shear Strength* - A total of 10 specimen placements and 10 shear tests (4 controls and 6 at moderate levels of ASR) have been completed to date. A large specimen (twice the width of our typical specimens) will be fabricated and tested this spring, to evaluate the effect of specimen size on our results. With this our team will be happily concluding the fabrication phase of the project! Testing at high levels of ASR damage will likely take place next fall.

*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.

*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 next 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 with future testing contingent on achieving high levels of expansion.

Sara Watts and Daniel Elizondo have each completed their master's degree this past fall - the research team would like to wish them the best of luck!

## Delamination of Curved Post-Tensioned Structures - Jongkwon Choi

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.

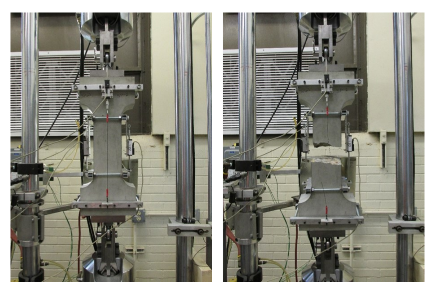
Pilot test specimen after formwork removal

The three dog-bone specimens have been tested last December. We verified the efficiency of the end region of the specimen and figured out the sensitivity of the test results due to the mounting grips and linear potentiometers. For the next direct tension test, we are going to modify the mounting grips and substitute linear potentiometers with LVDTs in order to obtain consistent results.

After we were convinced with the direct tension test, the pilot test specimen had been cast just before the lab closed for winter break and we recently have removed the formwork.  We also conducted material tests including compression, modulus of elasticity and split tensile tests for the 28-day.

Since the delamination failure is highly dependent on the tensile strength of concrete, we will perform modulus of rupture and direct tensile tests. These tests will be conducted around the date we test the pilot specimen, which should be very soon.

Before (left) and after (right) the direct tension test



BUILDING24 COMMITTEE

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

## JNT Golf Tournament - May 20

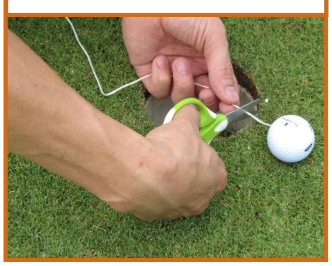
BASTROP, TX  Have you started looking at possible summer plans once finals are over? Well, wait to leave until after May 20th so you can participate in the annual structural engineering department golf tournament. The 22nd Annual J. Neils Thompson Golf Tournament will be held at the Pine Forest Golf Course in Bastrop on the Wednesday immediately following finals, May 20th. 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.

2014 Winning Team
Kaitlin Forke
Ryan Dunbar
Mitch Currah
Beth Anne Feero

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 2015, fifteen 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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