Ferguson Strucural Engineering Lab Newsletter

THE UNIVERSITY OF TEXAS AT AUSTIN - STRUCTURAL ENGINEERING

Volume 6, Issue 3

September 26, 2014

New Faces at FSEL

Anne Hulsey

I was born in New York, raised in Turkey, went to high school in Germany, and came to Austin for college. I got my undergrad in liberal arts, started a master's in engineering, and then added Public Affairs for a dual degree. Apparently I just can't stick to coloring inside the lines. I like playing ping pong, reading, and being outdoors. I've been around ECJ for a while now but I'm looking forward to joining everyone here at FSEL.

Colter Roskos

I was born and raised in the northwest corner of the Treasure State (Montana) just minutes away from beautiful Glacier National Park. Growing up in the Rocky Mountains allowed me to enjoy many activities over the years including skiing, hiking, biking, and hunting to name a few. I obtained my BS and MS in Civil Engineering from Montana State University in 2009 and 2011, respectively. After working for a structural engineering consulting firm for two years, I decided to go back to school and pursue a PhD. My time at FSEL will be spent doing research for Dr. Helwig on the TxDOT Curved Girder project.

Special points of interest:

- FSEL welcome party and open house - Septemeber 26th; 5-8pm
- First years vs. old timers flag football challenge, date TBD
- Tailgating with SEMM! Every home UT football game, 7am to game time at the corner of Dean Keeton and San Jacinto

Cody Lambert

I was born in Houston and grew up in Cypress, Texas. I'm very happy to be back at UT to earn my MS after earning my BS in Arch. E. here last spring. After volunteering at the lab last year, I'm also excited to return and spend time with all the new and familiar faces. In addition to turning wrenches and having fun at FSEL, I enjoy reading, rock-climbing, cooking, tailgating, and playing soccer.

Douglas Pudleiner

I was born and raised in Springfield Virginia, just a few miles south of Washington DC. I completed my BS in Civil Engineering at Virginia Tech in the spring of 2014. Outside of class and the lab, I enjoy doing almost anything outdoors. Biking, hiking, slacklining, soccer, sailing, really I'll try just about anything. Music holds a huge place in my heart which makes me pretty excited for living here in Austin. I am very glad to be working in FSEL and look forward to research and meeting everyone else!

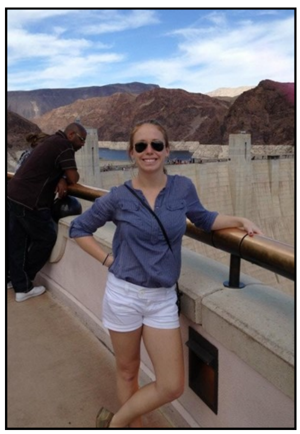
Inside this issue:

More New Faces at FSEL

Jessica Salazar

I am from New Mexico where I grew up primarily in Albuquerque. For my undergraduate I attended New Mexico State University in Las Cruces and received my B.S. in civil engineering. When there is time, I enjoy watching movies, photography, drawing and traveling. I look forward to beginning my next journey at UT and in Austin, with every intent to grow as a person and continue my education. What better opportunity than to become a part of the FSEL community and meeting and working with you all!

Katelyn Beiter



I was born and raised in San Antonio, TX and am a first year master's student. I come from a family of longhorns and always knew I would be a longhorn myself. I received my BS in Architectural Engineering from UT in May and could think of no place better to pursue a master's degree. While not studying, I enjoy hiking and kayaking as well as going to see live music and enjoying the outdoors. I am excited to begin my time at FSEL and look forward to meeting everyone and making great friends.

Roya Abyaneh

I was born and raised in Tehran, the capital city of Iran. Some years later I moved to Dubai, UAE, where I attended high school. Escaping the desert heat, I arrived in Waterloo, Canada, where I completed my BS in Civil Engineering. A couple of

winters later, I joined BakerRisk in San Antonio, where I worked on blast design of buildings. I am excited about being at UT and especially joining FSEL. I enjoy the outdoors, running, TX BBQ ... and trying new foods and cultures.

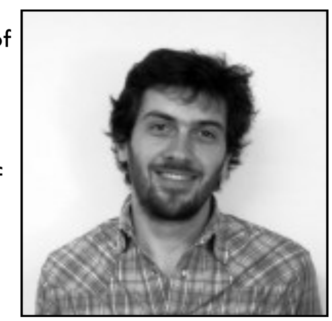
Gabriel Polo

I was born and raised in the capital city of Panama, in Central America. I earned my BS degree in Civil Engineering, and my MS degree in Structural Engineering, from the Technological University of Panama. I was offered the opportunity of studying abroad to pursue a PhD degree, and chose UT for all the

excellent reviews about the Structural Engineering program and the friendliness of the people in Austin. Besides working and studying structures, in my free time, I like soccer and football, outdoor activities and traveling. I'm looking forward to enjoying the next few years here.

Mario Glikman

I am from Argentina. After completing my undergraduate studies in Civil Engineering at UCA (Universidad Católica Argentina) and some years of work experience in a structural engineering consulting firm, I decided it was time to achieve one of my biggest goals, studying abroad. One year later, I am starting my MS studies at UT where I am happy to be a part of FSEL. When I am not in class, I enjoy spending time outside with friends, listening to music, and playing the drums.



Stalin Armijos

I was born and raised in Quito, Ecuador. After completing my undergraduate studies in Civil Engineering at the Army's Polytechnic School of Ecuador, I worked for three years in the industry as structural designer. I really love everything related to soccer which is one of my passions. Additionally, I enjoy listening to music, traveling, meeting new people and learning new things. I am excited about working at FSEL to learn as much as I can, collaborate with you all, and make new friends.

Morgan Allford

I was born and raised in Houston, TX. I graduated from UT with my BS in Architectural Engineering last May. Outside of class and the lab, I like to run, read and wander around Austin. I am looking forward to getting to work with and learn from everyone at the lab.

Victoria McCammon

I was born and raised in central Texas. I received my B.S. in Civil Engineering from UT in 2005. I have been working in the industry and I am now I am a Master's student. In my free time I enjoy baking and hanging out with my dog. I look forward to meeting everyone at FSEL.

Paul Biju-Duval

I was born in Paris and studied at the Ecole des Mines. After a Master's Degree at Georgia Tech and several years of working in industry overseas, I am back at school pursuing a PhD. This is my second year at UT. I enjoy running by Lady Bird Lake and cycling in the Hill Country.

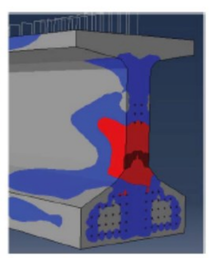
Alex Katz

I was born Fort Worth, TX, and raised just north of the Ballpark in Arlington. I recently completed my BS in Civil Engineering at the University of Virginia, where you couldn't watch a Rangers game if you wanted to. As a first year Master's student at UT Austin, I am looking forward to settling back into Texas for a great education with a side of barbeque, music, swimming holes, and baseball. I hope to meet everyone soon, and can't wait to get started at FSEL!

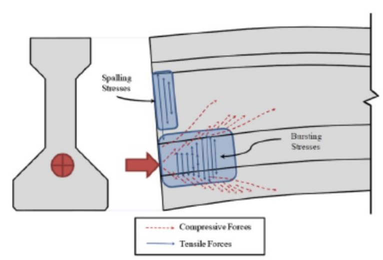
Summaries of Ongoing Research

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

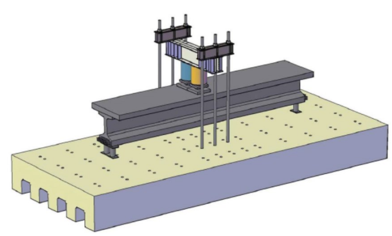
The use of 0.5 and 0.6- inch diameter prestressing strands in TX girders is common practice today. Future implementation of 0.7- inch diameter prestressing strands may reduce fabrication costs and extend the working range of pretensioned concrete beams; however, the limits of its application have yet to be defined. The larger diameter of 0.7- inch diameter strands would reduce the number of required strands in a beam and consequently reduce labor costs. On the other hand, the increased diameter of the strands in a standard (2-inch by 2-inch) grid would increase the end region stresses in concrete beams. It is expected that high stress levels would have a dramatic effect on the performance of current end region details. In addition, these unique stresses may influence the failure mode and ultimate strength of shear-dominated TX girders.

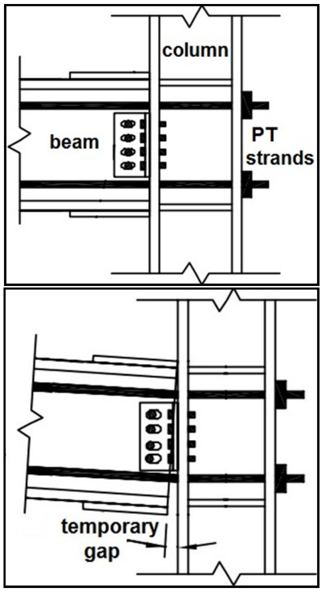


Due to lack of knowledge and code specifications for larger diameter prestressing strands, it is of interest to implement and evaluate the behavior of 0.7-inch prestressing strands in pretensioned TX girders. This project will combine experimental evaluation with analytical modeling in an effort to develop practical modifications to the end region reinforcement schemes in order to obtain serviceable behavior.



Beam stress distribution (above, left)
Sketch of test setup (below)

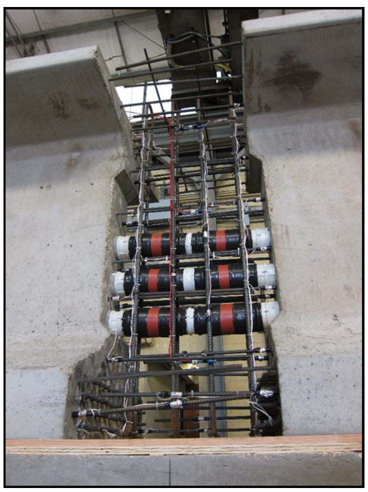




Limit States for Post-tensioned Beam-to-Column Connections in Self-centering Moment-resisting Frames – Anne Hulsey

Self-centering moment-resisting frames employ post-tensioned beam-to-column connections that allow beams to rock about their flanges under lateral sway during an earthquake. As the connection rocks open, the post-tensioned (PT) steel strands that run horizontally along the length of the beam elongate, developing restoring forces that re-center the frame. At present, there is little information on the strength degrading response of these systems after potential limit states, such as beam buckling. Understanding this post-limit state response in the PT connection is critical in understanding the collapse risk of self-centering systems due to extreme seismic events. This research focuses on the beam local buckling limit state to develop a model for PT connection strength after the beam has shortened due to buckling. The study will include both experimental testing and numerical modeling using ABAQUS.

Detail of a post-tensioned beam-to-column connection



Spliced Prestressed Concrete I-Girders – Chris Williams, Dhiaa Al-Tarafany & Josh Massey

The spliced girder team is in the final stages in the preparation of the first girder specimen used to study the performance of the cast-in-place (CIP) post-tensioned splice regions of spliced girder bridges. Over the summer, two pre-tensioned girder segments were spliced together with a 2-foot long splice region (see figure). The upcoming tests will be used to guide the development of details for CIP splice regions. In addition to the girder tests, push-off shear tests are being conducted to study the strength of the interface between the precast girders of spliced girder bridges and the CIP splice regions. Several tests with various interface details and post-tensioning forces will be tested during the fall semester.

Splice region of test girder

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

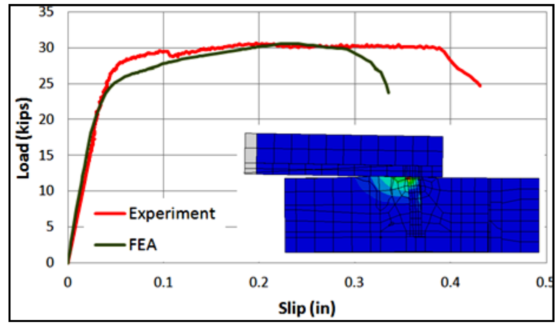
Portal loading frame used in previous fatigue studies in HMIPs at Ferguson Lab

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.

Behavior of Shear Studs in Composite Beams at Elevated Temperatures - Sepehr Dara

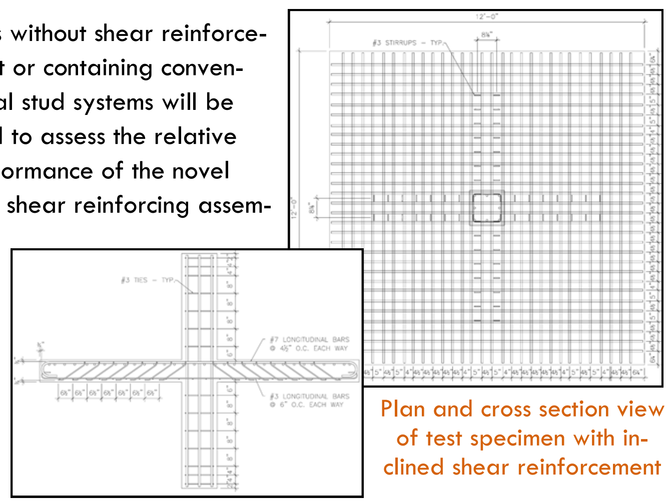
Following the experimental program, Abaqus® finite element software is being used for the on-going analytical part of this research study, which is focused on investigating the behavior of shear studs at elevated temperatures representing fire conditions. Due to the concentration of stresses at the bottom portion of the shear stud and in the adjacent concrete, it is very critical to have proper material models for both the shear stud and the concrete. Tension coupon tests were performed to capture the stress-strain curve of the shear stud which is directly used in the shear stud material model. Compression tests were performed to find the compressive strength of the concrete which is used in developing the Concrete Damage Plasticy model to represent the concrete. Material models at elevated temperatures were developed based on Eurocode 4 recommendations. Considering a proper tensile stress-strain for the concrete was also found to be very important factor both in analysis convergance and accuracy of the load-slip curve as compared to experimental tests.



Experimental and analytical load-slip behavior of shear stud at room temperature

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

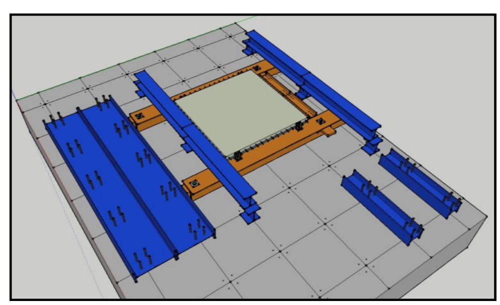
This research is aimed toward determining the characteristics and punching shear performance of reinforced concrete slab-column connections employing a novel shear reinforcement system consisting of inclined deformed steel reinforcing bars. The inclined reinforcing members, which are bent and anchored, will be placed in the vicinity of the column connection where the reinforced concrete slab is most susceptible to shear crack development. The experimental program will consist of three large-scale slab-column test assemblies: one containing the novel inclined shear reinforcement system, one containing conventional headed shear studs that are oriented vertically through the thickness of the slab, and one without any form of through-thickness reinforcement. Slab-column connections without shear reinforcement or containing conventional stud systems will be used to assess the relative performance of the novel slab shear reinforcing assembly.



Plan and cross section view of test specimen with inclined shear reinforcement

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

Lateral-torsional buckling is a failure mode that often controls the design of steel bridges and is a major concern during erection. Horizontally curved girders in particular are prone to buckling due to the torsion induced on the members from the curved geometry. The scope of this research is to investigate the use of prestressed precast concrete panels as possible bracing elements in order to reduce the number of cross-frames in the bridge. The first step of the project is to determine how the precast concrete panels will be attached to the steel girders. Currently, a test set-up is being designed to measure the stiffness and strength of the 8' by 8' panels and their connection to the steel girders.



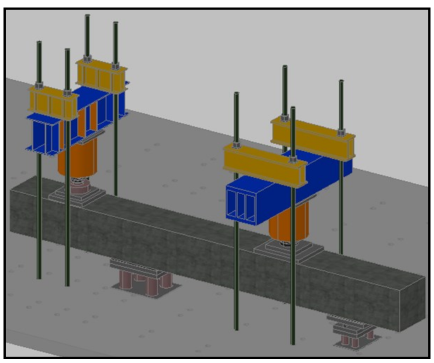
Strengthening Continuous Steel Bridges with Post-Installed Shear Connectors - Kerry Kreitman & Amir Ghiami

First specimen just before testing

The goal of this project is to investigate the feasibility of strengthening older continuous steel bridges by making the steel girders 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. The specimens consist of an 85-foot long, two-span continuous steel I-beam with a 6.5-foot wide concrete deck on top. After conducting elastic testing of the non-composite beam, the shear connectors are installed to create composite action, and further testing is done. The first specimen is focused on the maximum capacity under a loading cycle simulating very large truck traffic. Significant inelastic behavior and moment redistribution is expected to occur during the test. The likely focus of the second specimen is on the fatigue behavior of the post-installed shear connectors under smaller loads.

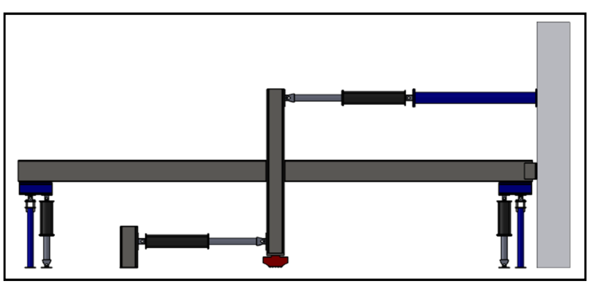
Bi-Directional Application of CFRP for Shear Strengthening - Nawaf Alotaibi, Douglas Pudleiner & Will Shekarchi



Double-curvature test setup

With the 24-in. deep T-beam test series completed, Team CFRP has begun to design 48-in. deep T-beams, order Tx46 I-girders, and construct rectangular bent caps to evaluate the use of bi-directional CFRP strips and CFRP anchors as a shear strengthening technique. The team will use the new beams to investigate the effects of several key variables, such as the CFRP wrapping scheme (uni-directional vs. bi-directional), the interaction between the transverse steel and the CFRP, and the test-setup. Traditional shear tests are conducted by loading a simply supported beam with a single point load, which causes the beam to deform in single curvature. However, recent research has found that loading a beam in double-curvature may result in a reduced shear capacity. Therefore, the majority of the rectangular bent caps will be loaded in double-curvature on the elevated slab.

The Role of Gravity Framing in Seismic Response of Structures - Sean Donahue, Stalin Moya, Nam Ho Kim, Krista Renee

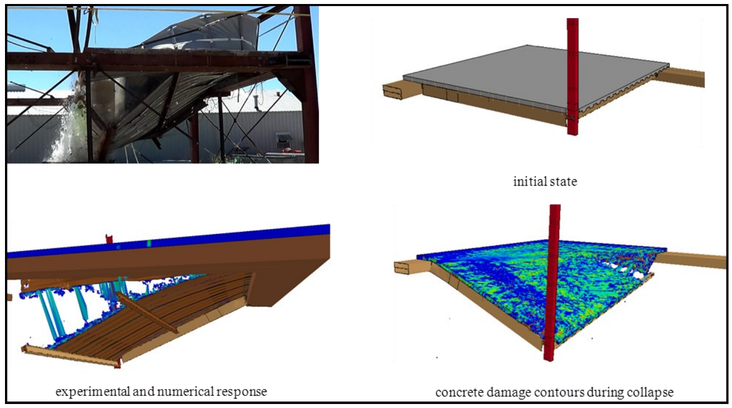


Proposed test setup for experiments (slab not shown)

Typical seismic design for steel structures assumes that all the lateral strength of a building is provided by the few moment-resisting frames or braced walls placed throughout the building. The simple connections used throughout the rest of the building are assumed to behave as perfect pins, contributing nothing to the building's lateral resistance. Despite this assumption, these connections do possess some 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.

Progressive Collapse Capacity of Composite Floor Systems - Michalis Hadjioannou

The response of composite floor slabs with simple shear connections under column loss scenarios has been investigated with large-scale experimental tests. Two tests were conducted, simulating both an interior and an exterior column loss scenario. The ultimate load-carrying capacity for each specimen was measured by testing each specimen until total collapse. The results demonstrate the significant contributions of composite floors in progressive collapse scenarios. Detailed finite element models were developed and validated against the experimental results. The models are capable of capturing the observed response of the physical tests with good accuracy as well as failure modes associated with the collapse of the floor slab when it reaches its maximum load-carrying capacity. The validated finite element models are currently being used to perform parametric studies and to identify influential parameters affecting their performance. Construction details, such as deck splices and non-structural reinforcement commonly used to construct these floor systems, have been found to significantly affect the capacity.



Response of the specimen simulating an exterior column removal

Seismic Application of High-Strength Steel Bars in Reinforced Concrete Columns – Drit Sokoli

The first series of concrete column tests assessing the usage of high strength reinforcement is about to conclude with the testing of the grade 100 specimen. This was a comparative process where three columns were pushed to high shear demands in attempts to highlight the shear and overall behavior of different grades of reinforcement. 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.

A new series of columns will be tested soon at FSEL. The proposed study will explore critical material and structural behaviors at the boundaries of high-strength steel properties that can currently be achieved. Four columns will be constructed using reinforcement of grade 100 steel having different mechanical properties. The main focus is to assess the behavioral implication of the tensile-to-yield ratio and the uniform elongation in reinforced concrete members.


Test setup prior to loading

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. One major issue with high strength reinforcing steel is typically the lower ratio of ultimate to yield strength. To assess the effect of this variable, test specimens include bars from 2 different manufacturers, which represent different ratios. In addition, the amount of buckling which occurs has a large effect on the fatigue life of reinforcing steel, so the span length is modified to control the amount of buckling. Preliminary tests indicate that the higher grade steels behave comparably or only slightly worse than grade 60 bars.

Test setup

Effects of ASR in Reinforced Concrete Walls without Transverse Reinforcement – Gloriana Arrieta, Katelyn Beiter, Daniel Elizondo, Joseph Klein, Cody Lambert, Sara Watts, 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:

Beam before being tested

- Shear Strength - A total of 8 specimen placements and 4 shear tests (all at moderate levels of ASR) have been completed to date. The most recently fabricated specimen will be tested at a low level of ASR shortly. Two control specimens will also be fabricated and tested later this fall.
- Reinforcement Anchorage - A total of 8 specimen placements and 3 reinforcement anchorage tests (1 control and 2 at moderate levels of ASR) have been completed to date. Testing at a high level of ASR is scheduled for October.
- Out-of-Plane Expansion Monitoring - A 5-foot tall wall segment, requiring the in-house production of about 13 cubic yards of concrete, was placed in early July. The research team will use the wall segment as platform to evaluate the use of commercial instruments to monitor out-of-plane expansions due to ASR.
- 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.

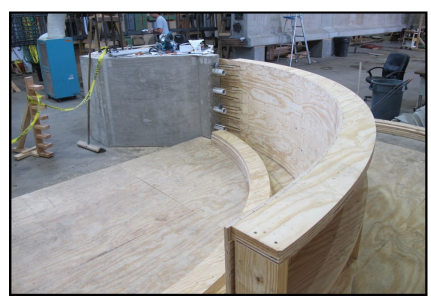
Delamination of Curved Post-Tensioned Structures - Jongkwon Choi

The objective of this research is to better understand the behavior of curved post-tensioned concrete structures. Several analytical studies on the radial stress distribution have been done in the past, but no experimental verification has followed. This research will provide the experimental data necessary to model the effect of localized tensile stress and delamination of curved post-tensioned structures.

We are currently building the pilot test specimen. Due to the curved geometry, some creativity and a significant amount of time was required to construct the wood formwork. Check out our progress in the lab!

Since the delamination failure is highly dependent on the tensile capacity of concrete, we will conduct both direct and indirect tensile material tests. The indirect tests (split-tensile and modulus of rupture) will be conducted according to the respective ASTM standards, but no standardized test method exists for a direct tensile test due to the sensitivity of concrete under tension. We have chosen to use a dog-bone shaped specimen, which is the most widely used shape, and have finished the design of the specimen and test setup.

Outside wall formwork



Congratulations to the 2014 FSEL Summer Graduates!!

- Anthony Battistini (PhD)
- Nick Dassow (MS)
- Trey Dondrea (MS)
- Changhyuk Kim (PhD)
- Alissa Neuhausen (MS)
- Andy Moore (PhD)
- George Moutsanidis (MS)

Feedback to Kerry Kreitman or Drit Sokoli
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drit@utexas.edu