Ferguson Structural Engineering Lab Newsletter

THE UNIVERSITY OF TEXAS AT AUSTIN - STRUCTURAL ENGINEERING

Volume 5, Issue 1

March 14, 2013

STEER 2013 - April 4-5

This spring, a **ST**ructural **E**ngineering **E**ducation **R**eunion (STEER) will be held to celebrate Dr. Klingner's career at the University of Texas at Austin. Dr. Klingner has now retired after 36 years at UT, teaching and supervising research at Ferguson Lab.

The STEER event is also a reunion for structural engineering alumni of UT, and a technical conference with speakers who are all UT alums themselves. The event will be held on April 4-5 at the Commons Conference Center at the Pickle Research Campus. Nine sessions of presentations will be spread over two days, with a BBQ at Ferguson Lab on the first evening. Online registration is available on the FSEL website ($40 for current UT graduate students until March 25).

In addition to learning about current advances, big projects, and issues in structural engineering around the world, the conference is a great way to meet and network with past graduates.

Program and Registration:
http://fsel.engr.utexas.edu/about/events/steer_2013/

New Faces at FSEL

Nawaf Kh Alotaibi

I was born in Kuwait, a place where temperatures usually hit 120°F. I completed my B.S. in Civil Engineering from Kuwait University. After 3 years of work experience, I am back to academia once more, and may be for the rest of my life. I joined SEMM last semester and started working at FSEL this spring. When I am not working on assignments or helping out at FSEL, I enjoy my time playing with my lovely one-year-old daughter Munera.

Will Shekarchi

Home is a short hour drive away in San Antonio, Texas. After four years, I graduated from UT Austin with my bachelor's degree in Civil Engineering. Soon after, in spring 2012, I began my MS studies. My hobbies mostly include school; however, when I find a little extra free time I love to fly, shoot guns, and snowboard.

Inside this issue:

More New Faces at FSEL

Amir Reza Ghiami Azad

I was born in Tabriz, Iran and grew up in Tehran, Iran. I got my bachelor's degree from the University of Tehran. I came to Austin in August 2009, got my master's degree in May 2011, and now am working on my PhD. I have four hobbies that I am really passionate about: 1) Teaching the Persian snap. I've taught literally thousands of people how to do the Persian snap; 2) Playing a traditional Iranian instrument called "Santoor"; 3) Going to state parks in Texas. So far I've explored 10 of them. There are still 20 more for me to drive to; 4) Dancing with my students while I'm teaching. You might think I'm silly, but silly people win the outstanding teaching assistant award.

Josh Massey

Hi my name is Josh Massey, and I'm a first semester Master's student. I received my BS here at UT and had so much fun playing in the lab that I decided to stay. I have steel-toed cowboy boots, and my interests include loud music and random lab improvements. For example, I like to build shelves, install surround sound speakers, and decorate with Christmas trees and penguins.

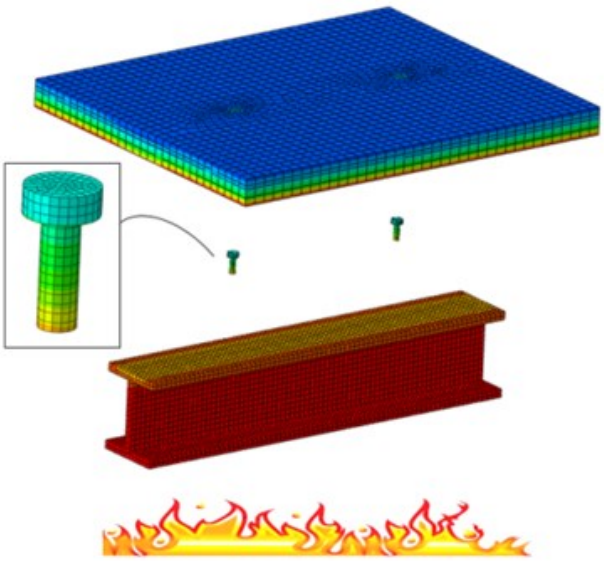
Disclaimer: This summary was not composed by Josh Massey

Congratulations to the 2012 FSEL Fall Graduates!!

Fall 2012

- Farhad Ahmadi (PhD)
- Anthony DeFurio (MS)
- Ki Yeon Kwon (PhD)
- Jinwoo Lee (PhD)
- Whitney Lee (MS)
- David Wald (MS)

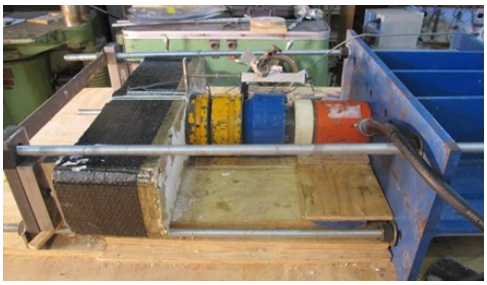
Elevated Temperature Performance of Shear Connectors for Composite Beams - Sepehr Dara



Ongoing activities of this research project are aimed at developing a mechanical spring-like model of a shear stud at elevated temperatures to be used in lieu of geometrically complicated finite element models. The effect of exposure to two fire scenarios is considered: short-hot, which is critical because of different amounts of thermal expansion of steel and concrete, and long-cool, which is critical because of degradation of material properties. Another variable considered is the level of composite interaction between the steel and concrete. Furthermore, the effect of changing the boundary conditions at the end of the beam will be explored. The last variable to be investigated is the effect of insulation applied to the steel beam. Insulation reduces the temperatures in the beam, slowing the degradation of the steel material properties, and affecting the thermal expansion behavior of the composite beam.

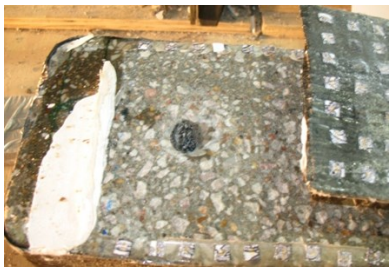
Debonding Mechanism of CFRP - Wei Sun & Will Shekarchi

This project focuses on the failure mechanism of CFRP debonding in repaired or strengthened concrete members. Eight unreinforced 6x6x24-inch concrete beams have been built and strengthened by 4- or 5-inch CFRP sheets to increase their flexural capacity. CFRP anchors have been applied to help the sheets develop their full capacity, instead of debonding before rupture. The debonding process and results are recorded and collected by a visual system, and then compared with numerical results from ANSYS simulations.



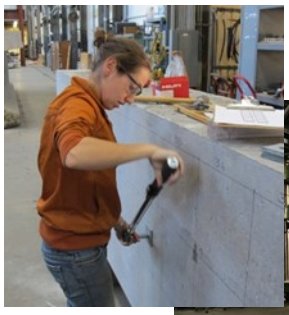
Right: Test setup

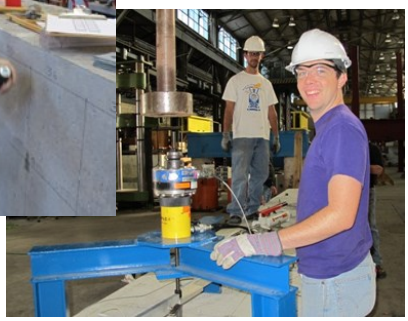
Below : Failure modes - FRP rupture (left) and anchor failure (right)



Anchor Testing in ASR Concrete - Alissa Neuhausen, Anthony DeFurio & Patrick Short

This past fall, the greenhouse was completed, and all of the remaining specimens were cast. Now, the specimens are sitting in the greenhouse where they are periodically watered so that deterioration from alkali-silica reaction (ASR) progresses as quickly as possible. Half of the anchors were installed prior to the onset of deterioration, and the rest will be installed and tested immediately at specified levels of expansion. In addition, the control tests were performed in the fall before any cracking had occurred. For the time being, we are taking lots of pictures and monitoring the slowly growing cracks in hopes that they will grow quicker!

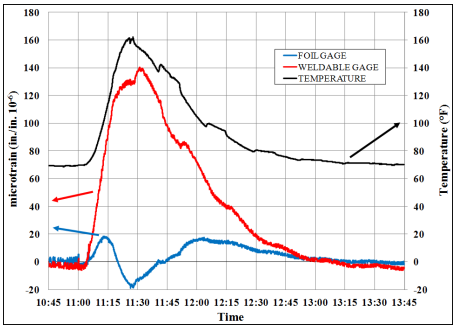




Wireless Fatigue Monitoring - Jeremiah Fasl & Vasilis Samaras

Over the last semester, the wireless monitoring team members have been working on finalizing their dissertations. Jeremiah successfully defended his dissertation this past January, and he is now out in the real world.

In addition to transferring all the information to paper, the gage durability tests continued this past fall. The instrumented specimens were monitored to determine the effects of load and temperature on the strain readings. Very interesting results were obtained regarding the behavior of foil and weldable strain gages during temperature fluctuations. As is shown in the figure, the weldable strain gages output a higher strain than the foil gages under the same temperature change. This is due to the different thermal compensation factors and strain gage technologies. These thermal studies will help us better understand the behavior of the gages and determine the correct strain reading, allowing the rainflow counting process to provide more accurate results.



Variation of strain measurement with temperature for different gage types

Improved Cross Frames - Anthony Battistini & Sean Donahue

Cross frame fatigue setup with X frame

Cycle, cycle, cycle! The fall semester was full of "ups" and "downs" for the cross frame fatigue setups. Between controllers and computers not working, the initial excessive flexibility of the test setup, and hydraulic fittings breaking, it is a wonder that we now have two fully functional fatigue tests running, with 6 tests already completed. We are performing tests on different cross frame layouts, including the commonly used single angle X frames and K frames, as well as proposed Z frames utilizing square HSS tubes or double angles. Due to the eccentric loading condition created by a single angle member welded to a gusset plate, a large amount of bending can be seen at the connection (stop by and check out the tests!). Preliminary results show that the bending reduces the fatigue life of the members. In addition, some problems with the typical connection spacing have been identified.

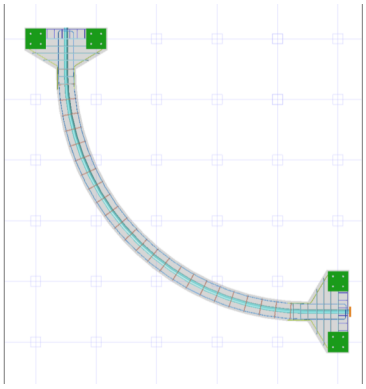
Examples of fatigue cracks in X frame (far left), K frame (center), and Z frame with HSS tubes (right)

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

Failure of control specimen

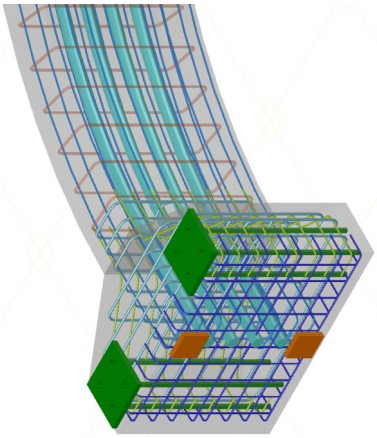
The spliced girder team has been continuing its investigation into the shear performance of post-tensioned bridge girders, with a particular focus on the reduction in shear strength due to the presence of a post-tensioning duct in the web. To explore this effect, a shear test was performed on a control Tx-girder specimen without a post-tensioning duct. The strength of this specimen was compared to the results from the previous shear tests performed on two post-tensioned girders. The shear test of the control specimen resulted in the most dramatic failure to date, as shown in the figure. Additional shear tests on post-tensioned girders will be conducted in the following months. A testing program focused specifically on the details of the splice region of spliced girder bridges will begin later this year.

Lateral Tendon Breakout - Jongkwon Choi



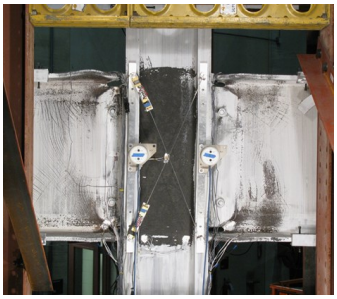
Top view of wall specimen

The purpose of this research is to explore tendon breakout failures in large-scale, curved prestressed concrete walls. Delamination, local shear, and buckling are all potential failure mechanisms for such walls. Assuming elastic behavior, two specimens are being designed for experimental testing so that delamination is the controlling mode of failure, followed by shear and finally buckling. The wall specimens will be 8 to 16 inches thick, and will have a 16-foot radius of curvature. Detailing of the walls is currently in progress, and the experimental stage will soon follow.



Anchorage detail

Seismic Behavior of Steel Beam-Column Connections - Sungyeob Shin

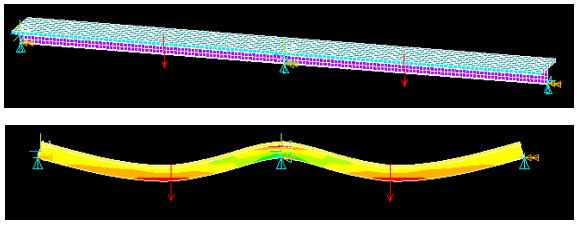


Above: Specimen with weak panel zone after testing

Left: Specimen with strong panel zone after testing

The main objective of this research is to investigate the effect of panel zone strength on the seismic performance of beam-to-column moment connections. Ten large-scale interior moment connection specimens with a full range of panel zone strengths were subjected to slowly applied cyclic loads up to failure. Nine of ten specimens satisfied the qualifying drift angle criteria for special moment resisting frames (SMFs) required in the current US Seismic Provisions (AISC 341-10), meaning they achieved at least 0.04 radians of story drift angle prior to failure without significant strength degradation. Specimens with weak panel zones generally exhibited larger story drift angles and less beam instability than specimens with strong panel zones. Test results may support a relaxation of the required panel zone shear strength in AISC 341-10.

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



Finite element model of a two-span composite beam

The goal of this project is to strengthen older non-composite steel girder bridges by creating composite action between the steel and the concrete deck using three types of post-installed shear connectors: two high-strength bolted connections and one adhesive anchor. For the past few months, we have continued our small-scale fatigue testing on the adhesive anchor. The setup consists of a concrete slab (representing the bridge deck) with a steel plate sitting on top (representing the girder flange), attached by a single shear connector. Load is applied to the steel plate to induce a shear force in the connector. In the next couple of months, we plan to complete these tests and to develop a large-scale, two-span composite beam test setup. The large-scale setup will accommodate both cyclic loading to evaluate fatigue life, and static loading to evaluate ultimate strength.

Monitoring Stresses in Prestressed, Precast Concrete Arches - Hossein Yousefpour

Upward jacking on one of the arches

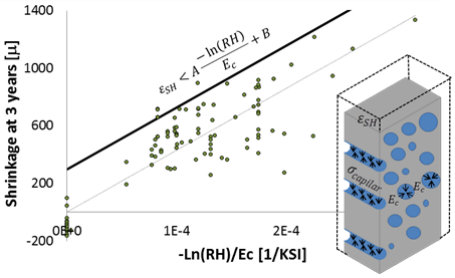
After 6 months of sleepless nights and thousands of miles driven in 33 trips to Fort Worth, installation of the sensors finally came to an end in February. Thanks to help from José, Ali, Kostas, David, Vasilis, and Hemal, a total of 224 vibrating wire gages were successfully installed in 12 arches. All of the arches are being monitored to evaluate their structural behavior during construction, and the prestress loss over time. As of now, the construction process - which consists of concrete casting, stressing, rotation, destressing, sweep control, upward jacking, and grouting - is finished for the first 4 arches and is in progress for the remaining arches. By mid-April, the 300 ton precast arches will be transported to the bridge site and installed in place. Until then, there is plenty of opportunity to further analyze the data and compare the observed behavior with FEM results.

Wireless mechanical monitoring device (wax box) showing one week of recorded data

Extending Use of Elastomeric Bearing Pads to Higher Demand Applications - Kostas Belivanis, Liwei Han & Daniel Sun

Steel girders are often used in Texas for moderate- to long-span bridge applications. Often, these bridges have skewed supports and/or horizontally curved geometry, which place significant demands on the support bearings to accommodate rotations and complex bridge movements from both thermal loads and daily truck traffic. The elastomeric bearing pads that are routinely used in medium-demand systems generally provide reliable means of accommodating translations and are significantly cheaper than pot bearings. The use of elastomeric bearing pads in steel bridge applications results in systems that 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. At this phase of the study, a bridge is being instrumented electronically and mechanically, and test setups for material and specimen testing are being designed.

New Prestress Loss Provisions - José Gallardo & David Garber



got data?

Since the last newsletter edition, the research team has completed the first version of the final project report and conducted further refinement of prestress loss provisions; way to go team! After achieving our initial goals, we could not resist looking into the underlying mechanisms driving concrete shrinkage. We found it convenient to translate this phenomenon into the more familiar language of "Mechanics of Materials." A fraction of shrinkage (strain) is dependent on the capillary tension (stress) and the modulus of elasticity (stiffness). These classifications allowed us to study shrinkage under the light of simplified stress-strain behavior of concrete. To link the equations with experimental results, an existing database of shrinkage testing was expanded to contain data from 640 specimens from the literature. This database will assist in the calibration of a simple expression that will be recommended to conservatively estimate shrinkage.

Progressive Collapse Capacity of Composite Floor Systems - Michalis Hadjioannou, Sean Donahue, Lindsay Hull, Georgios Moutsanidis & Umit Can Oksuz

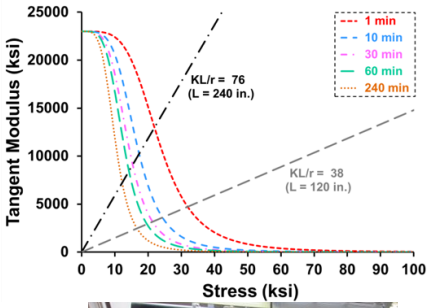
The floor slab at the moment of collapse

A large-scale composite steel floor section was tested last summer under a scenario in which the central column was lost. Although the test was conducted under static conditions, the load imposed on top of the slab was amplified to account for dynamic loading effects. The floor section survived under the design load for progressive collapse, and no significant damage was observed. Because the test setup did not permit application of additional load, bolts and nuts from the beam connections were removed to weaken the specimen, simulating failure of these components. Computational studies indicate that failure of these connections may occur prior to collapse of the structure. The testing approach allowed the critical load transfer mechanisms in the slab to be observed, and results suggest that traditionally constructed steel-framed structures have significant resiliency. Furthermore, by improving several details, the performance can be enhanced.

The creepiest yet hottest thing ever to happen at FSEL is about to take off!

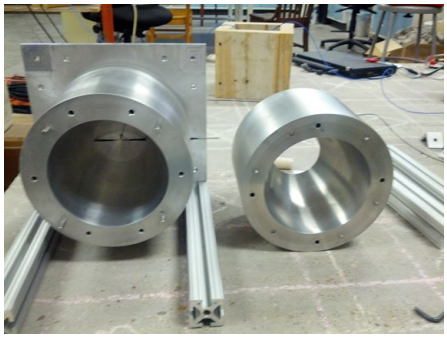
Creep Buckling Due to Fire - Ali Morovat

The objective of this research is to develop an improved understanding of creep buckling of ASTM A992 steel columns subjected to fire. Analytical, computational and experimental studies of the material creep and creep buckling phenomena at elevated temperatures are being conducted. Analytical solutions have been developed to model the creep buckling behavior of steel columns using the concept of a time-dependent tangent modulus. Creep buckling simulations have also been carried out using the finite element program Abaqus. On the experimental side, material characterization tests have been conducted at temperatures up to 1000°C to evaluate tensile and creep properties of ASTM A992 steel at elevated temperatures. W4×13 wide flange columns will be tested under pin-ended conditions, using knife-edges made of tool steel with high yield strength and high hardness properties. The column test setup has been designed and fabricated, and the creep column tests are scheduled to be started this spring.



Air-Coupled NDT Methods - Xiaowei Dai & Yi-Te Tsai

The goal of our project is to develop a noncontact air-coupled nondestructive testing (NDT) system employing the impact-echo method (IE) to locate defects in concrete bridge decks. Previously, we were able to effectively excite stress waves in concrete using an ellipsoidal reflector with a spark source located at its focal point. However, since the amplitude of the spark-induced noise is much higher than that of the useful impact-echo signal, extensive effort is required to separate the IE signal from the noise. To resolve this issue, we are focusing on optimizing the geometry of the ellipsoidal reflector and on developing an acoustic muffler for decreasing the emitted noise. Numerical simulation indicates that the pressure amplitude of the focused sound beam can be doubled when an ellipsoidal reflector having an eccentricity of 0.395 is used. In addition, simulation results show that the pressure amplitude of the emitted noise can be decreased by half if the proposed acoustic muffler is attached. The newly designed ellipsoidal reflector and acoustic muffler will be manufactured and tested in the near future.



The cannon (ellipsoidal reflector) for nondestructive testing

ASR Affected Walls - Gloriana Arrieta, David Wald, Nick Dassow & Trey Dondrea

The goal of this project is to investigate the effect of ASR (alkali-silica reaction) on concrete shear strength and reinforcement anchorage. While there has been a moderate amount of research concerning the effect of ASR on transversely reinforced sections, this project will focus on sections without transverse (i.e. through-thickness) reinforcement. At this stage, the vast majority of the work completed on this project has been preparatory. Our team - with the help of others - has built the 100-foot long greenhouse which occupies the old asphalt testing facility to the east of the lab. The high humidity and temperature provided within the greenhouse will accelerate the development of ASR within our specimens. The freshly painted test frames in the center of the lab, as well as near the south end, are prepped to test splice and shear strength, respectively. We recently began ordering construction materials en-masse and look forward to casting our first test specimens shortly!

Info-only anchorage testing: Dramatic failure of a non-code compliant splice at a devastating 30 kips

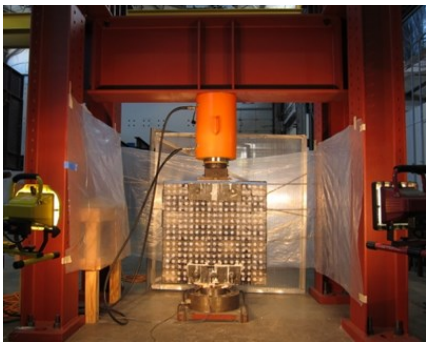
Passive Wireless Corrosion Sensors - Ali Abu Yousef

The physical autopsy was conducted using a Scarifier (aka the loud dust-maker)

The passive sensor platform developed at FSEL enables early detection of corrosion within concrete members. The sensors rely on a sacrificial corroding element (a washer) that corrodes gradually in the presence of chlorides, altering the response of the sensor. In the past few months, extensive electrochemical testing was conducted to examine the corrosion tendencies of the sacrificial element and the reinforcing steel. The tests were conducted in simulated concrete and carbonated concrete solutions. The results indicate that the washer exhibits similar electrochemical properties as the reinforcing steel. However, due to the lower chromium and nickel composition, the washers tend to have higher corrosion rates under any environment.

On a second front, the long-term accelerated corrosion test conducted on reinforced concrete beams with embedded passive sensors was recently concluded (meaning there is now ample space in the back building for storage). The physical autopsy is currently underway, and the initial findings confirm the reliability of the passive sensor.

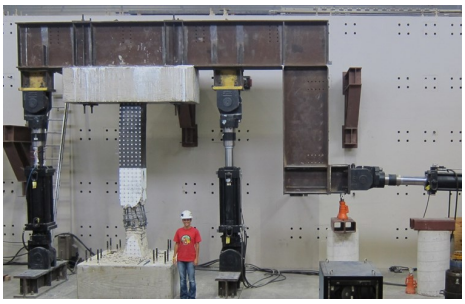
Bi-Directional Application of CFRP - Changhyuk Kim



Test setup showing a panel with CFRP

The objective of this study is to demonstrate the feasibility of using bi-directional CFRP for shear strengthening of large I- and U-shaped bridge girders. Tests of "deep beam" panels with both uni-directional and bi-directional CFRP strips indicate that the use of bi-directional strips leads to significantly greater increases in shear capacity. So far, a total of twelve panels with and without CFRP anchors have been tested under compressive forces. Such loading generates a bottle-shaped compressive strut between the load and reaction points. Subsequent panel tests will be focused on targeting the most influential parameters, such as the amount of CFRP, strip inclination, and anchorage. We are using a visual system to determine strain distributions and principal stresses. From the test results, we can verify the consistency of strains from the visual system and the strain gages.

Seismic Rehabilitation of RC Structures - Guillermo Huaco



Repaired RC column after lateral cyclic and vertical load tests

Reinforced concrete columns and a masonry wall were initially tested under axial load and cyclic lateral load, causing severe damage. New procedures of retrofitting using innovative materials such as carbon fiber reinforced polymer (CFRP) and mechanical rebar splices were applied to the damaged concrete members. The performance of the repaired RC columns and masonry wall under a similar pattern of cyclic loads was satisfactory, indicating an increased shear capacity and larger ductility for lateral deformations. The backbone curves from each member were used to construct behavioral models for further structural analysis. The research is aimed toward calculating the seismic vulnerability of structures through analysis using the proposed models.

Behavioral models of the new retrofit procedures will be proposed for the current Performance Based Seismic Design procedure (ASCE 41) to strengthen existing structures and repair damaged buildings. In addition, the models will be used to perform a nonlinear static analysis of a simple moment frame structure, in which the columns have been repaired using either mechanical splices or CFRP. The objective of this non-linear static analysis is to provide sample calculations to demonstrate how these retrofit methods can be used in design.

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

JNT Golf Tournament - May 15

BASTROP, TX Have you started looking at possible summer plans once finals are over? Well, wait to leave until after May 15th so you can participate in the annual structural engineering department golf tournament. The 20th Annual J. Neils Thompson Golf Tournament will be held at the Pine Forest Golf Course in Bastrop on the Wednesday immediately following finals, May 15th. 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). Eighty students, professors, staff, and industry representatives have participated in each of the past four tournaments. The tournament format is a "shotgun start, four-person best ball scramble." With such a scramble, all four players hit from the same spot and use the best shot of the group for their next shot (i.e. three players pick up their ball and shoot from the "best ball"). Thus, anyone has the chance to make a difference.

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

Special points of interest:

- Recruitment Weekend, February 28 - March 1
- STEER 2013, April 4-5
- Annual Picnic and Softball Game, May TBD
- JNT Golf Tournament, May 15

2012 Winning Team
Anthony Bentivegna
Brian Hanson
Karla Kruse
Aaron Sterns

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 2013, nineteen 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
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