Ferguson Structural Engineering Lab Newsletter

THE UNIVERSITY OF TEXAS AT AUSTIN - STRUCTURAL ENGINEERING

Volume 4, Issue 3

September 20, 2012

UT Students win PCI 2012 Big Beam Contest

UT students placed very well in the 2012 Big Beam Contest, with one team earning first place in the Zone 2 and national competitions. The Big Beam Contest is organized by the Precast/ Prestressed Concrete Institute's (PCI) Student Education Committee, and sponsored by Sika Corp. The contest consists of a zone competition and a national competition. First place winners of each zone, along with the winner of the international entries move on to the national competition to determine the national champion.

This competition requires a team of students to design, analyze, fabricate, and test a precast, prestressed concrete beam under the guidance of local PCI producer members. PCI's Student Education Judging Committee is responsible for selecting the winners. Prizes are awarded based on the most efficient design, highest load capacity, and best report, among multiple categories.

A total of twenty-four UT students, forming three teams of eight, participated in this year's competition. Dr. Michael Brown served as the Faculty Advisor, while Coreslab Structures Inc. in Cedar Park, Texas served as the sponsor. The UT teams are listed below.

UT Austin Teams

Zone 2 Competition: 1st place
National Competition: 1st place
Frederico Aguyao, Kostas Belivanis, Trey Dondrea, James Felan, Candice Kou, Scott McCord, Hemal Patel, & Vasilis Samaras

Zone 2 Competition: 2nd place
Daryl Barone, Nick Dassow, Samuel Gold, Lindsay Hull, Jeff Krummel, Whitney Lee, Alissa Neuhausen, & Jose Zuniga

Zone 2 Competition: 3rd place
Ariel Creagh, Mitchell Domak, Reid Markus, Phu Nguyen, Eugene Polenclo, Omid Razars, Evan Reschreiter, & William Shekarchi

"Big Beam" being tested at FSEL

Inside this issue:

New Faces at FSEL

Jinhan Kwon

I was born and raised in Busan, Korea. It is the biggest harbor city in my country. I got my BS degrees from there. I attended Stanford University for my MS before I got here in Austin. Both cities were places that I could get delicious seafood at a low price. If you know any special places in Austin with good seafood, please help me out!!!

Andrew Kilduff

Originally from San Francisco, I made the short 10-mile trip to UC Berkeley as an undergraduate before coming to Austin last year. After months of sticking around campus, my classmates have exposed me to the outdoor wonders Austin has to offer. My personal favorites have been Hamilton Pool and early morning trips to Zilker Park with my girlfriend's puppy. I enjoyed playing intramural soccer last year and look forward to another season. I am also a huge fan of Arsenal FC, a soccer team based in London, and can be found cheering them on every weekend.

Liwei Han

My name sounds like 'leeway' in English. I was born and grew up in east China. I came here for my PhD study. Yes I do enjoy the clement weather in Texas (compared with the Siberian winter winds and summer typhoons in my hometown). My hobbies include tennis, hiking, camping, travelling, etc. I am looking forward to meeting new friends here.

Nick Dassow

I was born and raised in Waco, Texas, where I attended community college before transferring to UT and completing my BS in Architectural Engineering last May. When I am not studying or at the lab, I enjoy fishing, golfing, and playing racquetball. I am looking forward to continuing my education in graduate school and getting to know all of you here at FSEL!

Dhiaa Al-Tarafany

I am from Iraq. I was born and raised in Baghdad, close to the first civilization on earth. I attended what is now called Nahrain University where I got my BS in Civil Engineering and MS in Structural Engineering. I have worked as an assistant instructor at the same institution for four years. At the same time, I have worked as a structural engineer at the Engineering Consultancy Bureau / Nahrain University. In 2011, UT accepted me as one of its PhD students, which gave me the chance to fulfill my desire of doing more in-depth studies. I like reading and sports, especially soccer.

Trey Dondrea

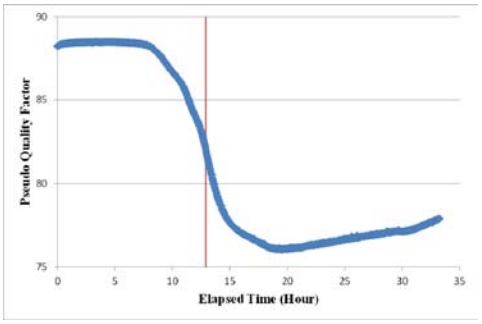
I was born in Freehold, New Jersey, and moved shortly thereafter to Double Oak, a suburb near Dallas, Texas. After graduating high school, I came to Austin and graduated from UT with a BS in Architectural Engineering. When not at Ferguson or ECJ, I enjoy playing guitar and reading (not about engineering...). I am looking forward to research at FSEL and getting to know my fellow students.

Passive Wireless Conductivity Sensors - JinYoung Kim

A passive, wireless, conductivity sensor was designed to monitor the variations of electrical conductivity within concrete by tracking the pseudo quality factor. In the previous newsletter, a possible application of the sensor, detecting the setting time and hydration process of the cementitious materials, was presented.

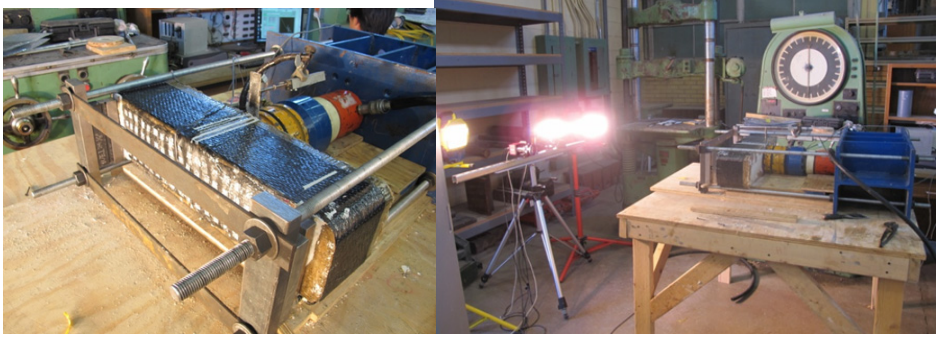
In order to evaluate another possible application for water permeability within concrete, a simple test was conducted. Since the pseudo quality factor tracks the variations in conductivity and is sensitive to changes in moisture content, the water front movement can be detected by monitoring the response of the embedded conductivity sensor.

As the pseudo quality was measured over a period of time, an S-shaped response was obtained. The maximum slope on S-curve is considered to correspond to the moment that the water front passes the level of the conductivity sensor. Using this approach, the time at which the water front passes the sensor can be obtained.



Debonding Mechanism of CFRP - Wei Sun

This program focuses on the debonding mechanism of CFRP with/without anchors. At least nine pure concrete beams with the dimension of 6" X 6" X 24" will be built. Those beams will be strengthened by 4-inch or 5-inch CFRP sheets that are installed to increase their flexural capacity. A new setup will be built to make sure that the vision system can monitor the behavior of the CFRP strips during the tests.



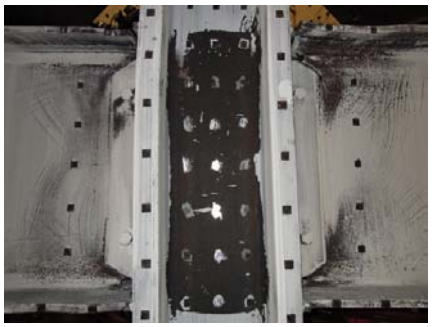
Setup for the test of the FRP-strengthened beam.

Tubular Cross Frames - Anthony Battistini, Weihua Wang, & Sean Donahue

The summer semester was spent finishing the stiffness tests on the full scale cross frame as well as the fatigue tests on the cross frame connections. The research team examined a variety of brace layouts currently used in practice, like the X-type and K-type cross frames with single angle members, as well as some single diagonal Z-type layouts utilizing square HSS tubes or double angles, which have increased compression capacity compared to their single angle counterparts. The fatigue tests verified the double angle and knife-plate tube connections are adequate for use in steel bridge design. However, due to the eccentric connection and subsequent bending of the single angle connection, fatigue tests were not feasible in the MTS machines. Therefore, a new setup will be constructed that will be able to test the entire cross frame in fatigue. Look for the setup to be attached to the strong wall.

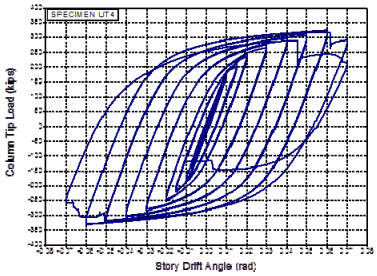
"I'm a cowboy, on a steel horse I ride." Bon Jovi

Seismic Behavior of Steel Beam-Column Connections - Sungyeob Shin



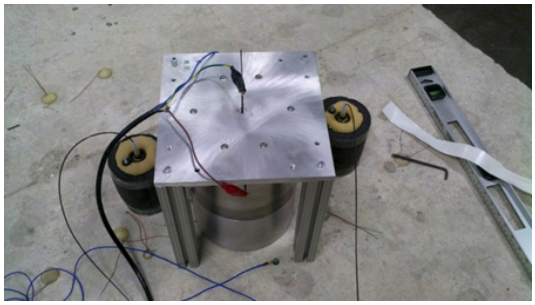
Connection region after testing

A total of 10 large-scale subassemblages were tested to study the cyclic loading behavior of beam-to-column connections in steel moment resisting frames. The main objective of these tests is to evaluate how much shear yielding of panel zones can be permitted in the inelastic seismic response of steel moment resisting frames. Five of the 10 test specimens were designed with weak panel zones to allow most of the yielding within the column panel zone. These specimens showed excellent performance, developing large and stable hysteretic loops without significant strength degradation.



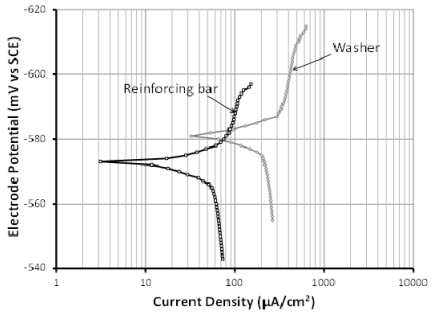
Overall response of specimen with weak-panel zone

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



Recently, we proposed a spark source system by combining an electrical spark generator with an ellipsoidal reflector to generate elastic waves in concrete. The system can provide consistent excitation forces with broad bandwidth spectrum. In our laboratory experiments, Rayleigh wave and impact-echo modes can be generated by the air-coupled spark source. A theoretical model employing the weak shock theory and the KZK equation will be used to predict the reflected pressure response at the focal point of the ellipsoidal reflector and obtain the optimized reflector geometry. For the receiver side, an analytical transient solution has been developed to predict the reflected pressure response along the axis of a parabolic reflector. This analytical solution explains the observed reflected waves and provides a better understanding of the wave propagation of the reflected waves. In addition, we performed a complete analysis using this analytical solution to find the dependence of the signal amplification on the reflector geometry and the frequency of the incident wave. The geometry of parabolic reflector that gives the maximum signal amplification at the focal point was found.

Passive Wireless Corrosion Sensors - Ali Abu Yousef



"The Austin summer heat may annoy some, but it does increase corrosion rates bringing me closer to my degree...Can't wait for the next 100*F days"

The corrosion sensor design relies on a sacrificial element (washer) to indicate the onset of corrosion within concrete. The embedded sensor technology is based on the premise that the sacrificial element and the monitored rebar exhibit similar electrochemical properties, hence, will corrode under the same conditions.

In order to examine the electrochemical properties of the steel washer and reinforcing steel, potentiodynamic tests were conducted. This test is typically used to compare the performance of different materials and their susceptibility to corrosion in certain environments. The test is performed by measuring the electrical current needed to change the corrosion potential of the specimen.

The result of the potentiodynamic test for both specimens is shown. From these early results it was concluded that that the corrosion potential (willingness to corrode) for both specimens is similar and within the experimental bias. However, the corrosion current (rate of corrosion) of the washer element is higher than the steel rebar.

New Prestress Loss Provisions - Dean Deschenes, José Gallardo, & David Garber

In the past few months, thirty specimens were service-load tested at FSEL. The cracking moment of each beam was carefully measured and used to back-calculate the long-term prestress losses. The results from these service-load tests were added to the previously-assembled experimental database. A parametric study was conducted in order to investigate the effect of different design parameters on the loss equations as well as the implications of current and past loss equations on girder design. Results from the parametric study and from analysis of the database are being used to support recommendations for prestress loss estimation.

Instrumented girders being installed at TxDOT bridge construction site

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

The goal of this project is to strengthen older non-composite bridges by creating composite action using three types of post-installed shear connectors (two high-strength bolts and one adhesive anchor). This summer, we got our small-scale fatigue testing up and running. The test consists of a concrete slab (representing the bridge deck) with a steel plate (representing the girder flange) sitting on top, attached by a single shear connector. Load is applied to the steel plate to induce a shear force in the connector. The goal of these tests is to determine if connectors that experience stress reversal have a shorter fatigue life for a given stress range. Later, larger fatigue tests will be conducted on 10-ft long composite beams to investigate fatigue behavior under more realistic circumstances. Additional large-scale, two-span composite beam tests will be conducted a year or two down the road.

The blue channel sections help to minimize uplift of the plate

Failed connectors (adhesive anchor) from the first four tests

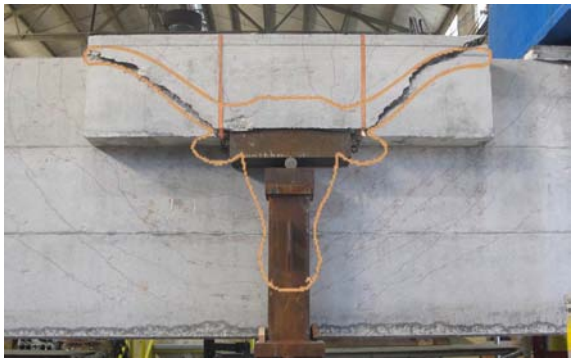
Progressive Collapse Capacity of Composite Floor Systems - Sean Donahue, Michalis Hadjioannou, & Lindsay Hull

Last summer, a composite steel floor section was tested for progressive collapse resistance by simulating a column loss scenario. The floor system exceeded its capacity predicted by current collapse criteria, supporting the full building design load without the central column in place. While the test currently ignores the dynamic effects of collapse scenarios, the results indicate that there is significant residual strength in steel composite buildings that is not currently fully understood.

While this result is promising, there are many aspects of the structure's response that were not observed during the test, due to the minimal damage done to the specimen. The final failure load of the specimen, as well as the behavior under high deflections, has not been observed. Steps are being taken to allow the specimen to be driven to complete failure, in order to study these behaviors, and better understand the response of these systems.

You can note there is a column missing from the middle of the structure. The structure did not seem to mind.

Shear Cracking of Inverted-T Bent Caps - Eulalio Fernandez, Nancy Larson, Mike Carrell, & Michael Weyenberg



"The eyes of Texas are upon you"

Going out in style- Team IIT would like to thank everyone at the lab for all of your help. It was an extensive research project and we could not have built and destroyed these beams without you. In all we tested twenty-two inverted-T beams in shear. By loading these specimens on their ledges, we sought to examine the effects of the resulting tension field on the strength and serviceability behavior of inverted-T bent caps. We found that strut-and-tie modeling provides a useful tool for accurately calculating the strength and failure mode of the specimens. With such a large number of tests we were also able to develop reliable recommendations on sizing structures to limit diagonal cracks and providing web reinforcement to restrain the widths of said cracks. The tests did not always go as planned- but that is research, and we shall continue learning.

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

The spliced girder team has just completed testing the first of eight 62-inch deep TX girder specimens. Each of these full-scale test specimens will contain prestressing strands in the bottom flange as well as a post-tensioning (PT) duct located at the center of the web. The purpose of these tests is to understand the reduction in shear strength caused by the discontinuity in the web introduced by the presence of the PT ducts. The first TX girder specimen (shown in the figure) contained a plastic PT duct along its length. The next TX girder to be tested at the lab will have a steel PT duct and should provide a direct comparison to the first test specimen. An analysis of the results between the two specimens should aid in understanding the shear performance of prestressed concrete girders containing steel ducts versus those with plastic ducts.

Bi-directional Application of CFRP - Changhyuk Kim & Wei Sun

Test setup of the panel with CFRP reinforcement.

The objective of the study is to demonstrate the feasibility of using bi-directional CFRP for shear strengthening of large bridge I- and U-beams. Tests of deep beams with both uni-directional and bi-directional CFRP strips indicated that the use of bi-directional strips led to significantly greater increases in shear capacity. So far, six panels without anchors have been tested under compressive forces applied over a restricted area. Such loading will generate a bottle-shaped compressive strut between loading and reaction points. As panel test results become available, we will focus subsequent panel tests to target the most influential parameters such as amount of CFRP, CFRP strip inclination, and CFRP anchorage. We are using the vision system to figure out strain distributions and principal stresses. From the test results, we could verify the consistency of strains from the vision system and strain gages.

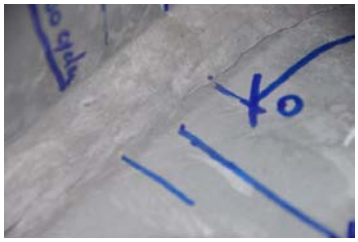
Fatigue Testing of High Mast Illumination Poles - Kostas Belivanis

A high mast illumination pole from El Paso, TX, was removed from service and sent to FSEL for fatigue testing. The decision was made due to the extent of the cracks located along the weld of the shaft to base plate connection. TxDOT wanted to know the estimated remaining fatigue life of the pole.

Cracks were identified using ultrasonic and magnetic particle testing before the fatigue procedure started in order to have a reference point. The first part of the test did not last very before a seal on the ram broke. Finally, the first test was successfully completed. An Ultrasonic Impact Treatment (UIT) procedure was used to repair the test setup pole so it could be evaluated at the same time as the original one (El Paso).

Tests now are done and have validated previous research results conducted at FSEL.

The final part of the project consists of opening the cracks to determine in which phase they have initiated and propagated.



Sometimes prevention is not enough. Remedy is required.

Wireless Fatigue Monitoring - Jeremiah Fasl & Vasilis Samaras

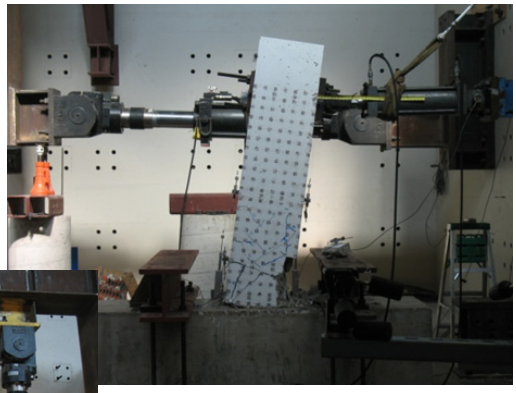
As summer just finished so did the field trips to bridges around Texas for the wireless monitoring team. Thus, this is the point to put all the information together and transfer it to paper. Over the last few months the wireless monitoring team members have been writing chapters of their dissertations. However, some of the analyses and lab tests are continuing. From the analysis standpoint, three bridge models have been completed and analyzed with moving truck loads. The next step is to determine the effect and the sensitivity of the load time step on the acceleration output.

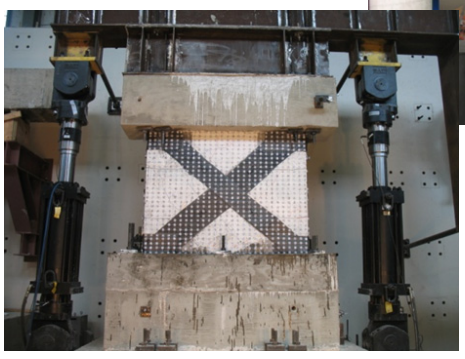
Regarding the gage durability tests, more specimens, which are always loaded, have been placed outside FSEL to determine the load effect on the strain fluctuation due to thermal effects. Utilizing WSN strain nodes to record data simplified the test, because the specimens have to be moved and placed in different environments.

Retrofit, Retrofit, Retrofit - Guillermo Huaco

Reinforced concrete columns and a masonry wall have been retrofitted and tested using Carbon Fiber Reinforced Polymer (CFRP) and mechanical splices. These structural members had severe structural damage; hinges had formed in the columns and sliding failure at the wall. Cycle lateral loads were applied, including axial loads at some tests.

For the columns cases, retrofitting using mechanical splices and CFRP sheets and anchors increased the shear capacity and ductility until fracture occurred. The core between the mechanical splices did not become damaged despite behaving as a plastic hinge. The masonry wall was retrofitted using CFRP sheets placed as diagonal ties and attached by CFRP anchors, allowing it to reach a higher lateral load capacity than prior to damage. However, failure occurred by the top of the wall sliding; installing CFRP anchors resisted this effect.





Details of the final condition of the column core with the mechanical splices into it, and the fracture of the CFRP anchor in the masonry wall.

Cracked Panels - Kiyeon Kwon, Aaron Woods, Umid Azimov

Project 0-6348 finished this summer and the key results of are as follows.

In terms of optimization of reinforcement in cast-in-place slabs:

- Current longitudinal reinforcement (No. 4 @ 9 in.) is already optimized
- Current transverse reinforcement (No. 5 @ 6 in.) can be reduced by using a smaller-diameter bar (No. 4 @ 6 in.) or welded-wire reinforcement (D 20 @ 6 in.)

For control of cracking in precast, prestressed concrete panels :

- Initial prestress can be reduced from 189.4 ksi to 169.4 ksi, reducing likelihood of cracking and amount of prestress loss
- Remaining prestress in panels with reduced initial prestress is still above the TxDOT design level for panels with high initial prestess

Double-Punch Test (DPT)

- DPT is reliable for comparing performance of steel FRC for various fiber types at different volume fractions (% fiber)

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

We have been making steady progress on our specimens. In addition to casting beams every two weeks, we have begun installing anchors. These anchors will sit in our beams until the desired level of ASR growth has occurred at which point they will be tested. Additional anchors will be installed and tested immediately at specified cracking points. Currently, our beams can be found east of the lab, covered by burlap and bright orange ratchet straps. They will hopefully be transferred very soon into that shiny new structure that is starting to resemble a greenhouse.

Monitoring Stresses in Prestressed, Precast Concrete Arches - Hossein Yousefpour

First arch being rotated

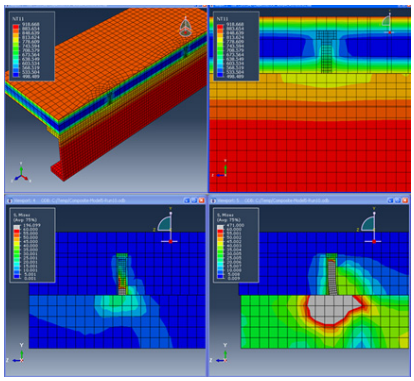
This summer, with substantial help from Jose Gallardo, Ali Morovat, David Garber, Kostas Belivanis, Vasilis Samaras, and Hemal Patel, a total of 108 gages were installed in the first three arches, and continuous monitoring was performed during all the construction stages so far. While valuable data have been collected for research purposes, the instrumentation has been a great assistance to the construction too. It was used not only as a health monitoring tool to prevent cracking in the arches, but also as a key measure to evaluate how realistic the design was, and to justify decisions to modify the construction procedure on several occasions.

The number of gages will be reduced in subsequent arches due to the knowledge of the behavior obtained from the first few arches. Consequently, the total number of gages in the other nine arches will add up to 108.

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

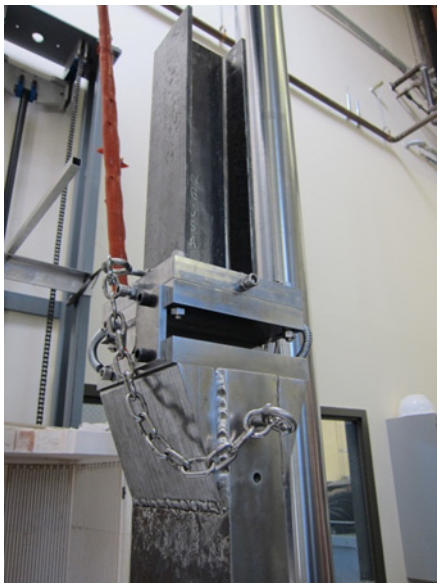
In a heat-transfer analysis, a specimen is exposed to convection and radiation from a defined fire (ASTM E119). The results of the analysis (nodal temperatures) are used as a predefined field in a stress-displacement analysis.

In the stress-displacement analysis, a concrete damage plasticity model was found to be the most appropriate model for concrete. Most of the plasticity in concrete and shear connector occurs at the bottom of the shear connector in the direction of loading. FE analysis was able to capture these plastic actions under shear loading of the composite beam. Even after 15 minutes of fire the shear connector loses around 50% of its capacity. Analysis show that the value of the friction between the steel beam and concrete deck affects the results at low values of slip, however, as the slip increases some separation occurs between the beam and deck and friction does not affect the results significantly.



Creep Buckling Due to Fire - Mohammed Ali Morovat & Will Shekarchi

The objective of this research is to better understand the phenomenon of creep buckling of ASTM A992 steel columns at elevated temperatures and to develop methods to predict creep buckling behavior. 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-end conditions, modeled using knife-edges made of tool steel with high yield strength and high hardness properties. Extra safety measures have also been taken to make sure that the column stays in its position under large lateral displacements. These measures include adding springs to the end fixtures and chaining the column from top and bottom to the end fixtures. As seen in the picture, the test setup is ready and the creep column tests are scheduled to hopefully be started this fall.



The column - the prisoner!

Congratulations to the 2012 FSEL Summer Graduates!!

Summer 2012

- Eulalio "Lalo" Fernandez (PhD)
- Eric Giannini (PhD)
- Saleh Alogla (MS)
- Umid Azimov (MS)
- Joel Blok (MS)
- Kevin Moyer (MS)

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

Breen's Corner: Plain Vanilla can be Enough!

The first research project to utilize the strong floor (in front of Dennis' office) was one that helped birth the development of precast segmental box girders in the USA. In the late 1960s, engineers at TxDOT predicted an increasing demand for bridges in the 130-350 ft range. While structural steel could accommodate the longer spans, the spans were too long for the traditional prestressed concrete girder. Desiring a viable concrete alternative, a state-of-the-art review was conducted and found that precast segmental post-tensioned concrete box girders in Europe could reach the longer spans. As such, Dr. Breen, Dr. Burns, and students from FSEL sought to bring the technology to the USA.

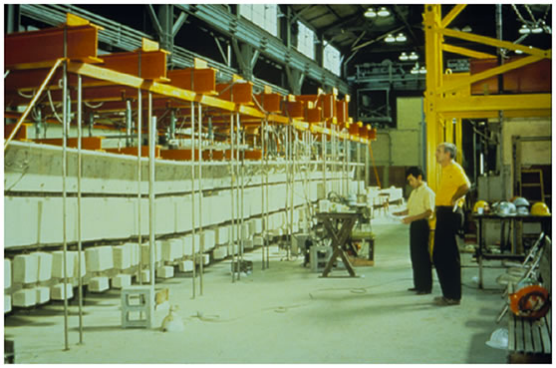
The Intracoastal Waterway at Corpus Christi, TX, was chosen as the pilot location for the new technology. The three-span bridge has a middle span of 200 ft and side spans of 100 ft. Because the 200-ft span had to be constructed without blocking barge access on the canal, cantilever construction from the tall piers was ideal. Match casting and epoxy joints were proposed to connect the precast segments.

To ensure the cantilever construction, match casting, and epoxy joints were suitable for segmental box girders, a model of the bridge was constructed in FSEL at one-sixth scale. Construction of the model with comprehensive documentation of behavior at all stages occupied most of 1971. In early 1972 the thoroughly-instrumented model was load tested under a wide variety of service, overload, factored, and ultimate loading cases. The crack patterns indicated that the final structure was totally unaware of the segmental joints. The structure deflected exactly the same as a traditional post-tensioned girder. The very stiff structure carried far in excess of factored design loads and was totally uncracked at service-load levels. When construction problems were identified in Corpus Christi, the one-sixth model was used to verify a possible solution.

This project ended up being a WIN-WIN for everyone. The foreign technology was transferred and improved upon while completely adapting it to Texas conditions. The key idea in developing the first precast segmental concrete box bridge in the USA was to keep it "plain vanilla." A constant depth of 8 ft was chosen so that the forms could be (and were) later reused for drainage sections. In addition, the engineers and contractors worked together to find solutions for problems.

Bridge under construction in Corpus Christi

Load testing the one-sixth scale bridge at FSEL



Special points of interest:

- FSEL Welcome BBQ, Septemeber 21st; Social hour starts at 5pm and food served at 6pm
- First-years vs. Old-timers Flag Football Challenge, October 26

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 2012, twenty 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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