Ferguson Structural Engineering Lab Newsletter

THE UNIVERSITY OF TEXAS AT AUSTIN - STRUCTURAL ENGINEERING

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New Faces at FSEL

Gloriana Arrieta Martinez

I am originally from Costa Rica. There I obtained my BS, worked for a year at a construction company, and then moved to Austin for graduate studies. I graduated from in May 2012 with my MS and I am just starting my PhD. I enjoy outdoor activities (running, biking, hiking, swimming, etc.) and good food as well! I am very excited and grateful for having the opportunity to stay in Austin and at UT for a few more years!

James Felan

I was born in 1982 in San Jose, CA, moved to Austin, TX, in 1996, and went to Del Valle High School. That was followed by attending UT for a BS in Architectural Engineering with electives in Structures. Upon graduation, I obtained a position in Plan Review at TxDOT's Design Division. I married Beatrice in 2006, who works for Hays/San Marcos as a Paramedic. In 2007, we had a son, who we named Matthew James Felan. That same year, I moved on to Fracture Critical Bridge Inspection in TxDOT's Bridge Division. I earned my P.E. license in 2009 and began the grad school application to advance my engineering career for more complex work.

Jongkwon Choi

I was born and raised in South Korea. I received my BS and MS from Seoul National University. After graduation, I worked for Hyundai E&C for 4.5 years. My major tasks varied from assessing cracks to analyzing the hydration of massive structures. In my free time, I enjoy watching movies, playing any kind of sports, and traveling with my beloved wife and 1.5 year-old son.

Lindsay Hull

After growing up in Seattle and doing my undergrad at Tufts University in Boston, I am continuing my tour of the country with a stop in the South! My favorite things about Austin so far are the food and my awesome classmates (in that order), but the heat terrifies me a little bit. I will be spending the summer working hard at FSEL and filling my free time with any and all water-related activities.

Inside this issue:

Corrosion Resistance of New PT Systems - Kevin Moyer & Michael Weyenberg

Well, the beams did not grow any bigger despite loving them continuously for over two years. So in March, the sounds of a concrete saw and a jack-hammer could be heard at the south end of FSEL. This was the sounds of the beginning of the end of Project 0-4562. The innards of the beams were brought into the cleanroom and examined closely for corrosion (rust).

The findings to date are:

- Galvanized ducts do not perform well in a high chloride environment
- Detailing is an important factor in the design process
- Proper grouting procedures are a must for durability
- Proper installation of components helps ensure that the strands will not corrode
- Writing is SOOOOOOO much fun

The project is an accelerated-corrosion study of various components of post-tensioned concrete and different anchorages. Approximately six years ago, beams containing various PT component combinations were constructed according to TxDOT standards and were exposed to a 3.5%-salt solution by a spray system, to simulate the splash zone in a coastal region, and by a wet-dry cycle in basins formed in the tops of the beams, to simulate a corrosive environment that is likely to occur in de-icing operations and/or coastal regions.

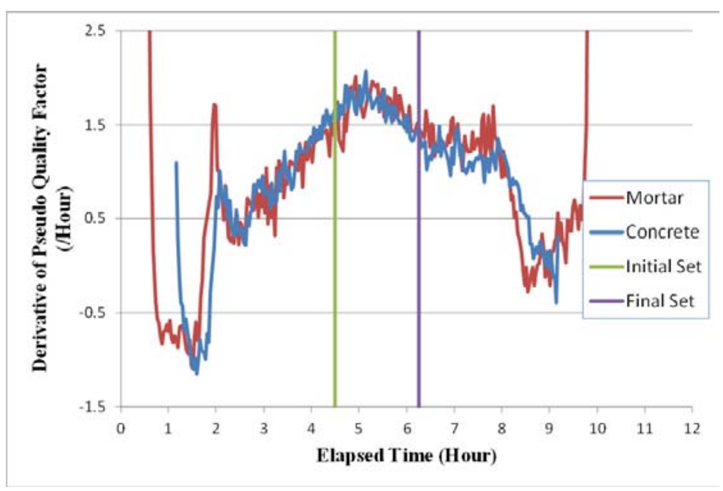
What did you say?? We can't hear you!!!

Galvanized Duct + Chlorides = Corrosion

Passive Wireless Conductivity Sensors - JinYoung Kim

Passive wireless conductivity sensors were designed to monitor variations of conductivity within concrete. The response of the conductivity sensors embedded in fresh concrete was evaluated, with the goal of detecting the setting time of the concrete. Determining the time of setting is not only a considerable value in scheduling concrete construction operations, but also useful in comparing the relative effectiveness of various set-controlling admixtures. The standard test method for time of setting of concrete mixtures was also conducted as a reference.

The rate of change of the pseudo quality factor was used to determine initial and final setting time. As shown, the initial and final set times, determined in accordance with the ASTM guidelines, corresponded to a value of 1.5/hour in the derivative of the pseudo quality factor. The trends were similar for all specimens and the initial and final setting time could be approximated from the pseudo quality factors.



Rate of pseudo quality factor and measured time of setting by the ASTM guideline.

Wireless Fatigue Monitoring - Jeremiah Fasl & Vasilis Samaras

Over the last few months, we have installed WSN strain nodes in three bridges, one in Jackson, MS, and two in Austin. The strain nodes were quick to install and configured with custom firmware that performed a rainflow analysis at the node to reduce the amount of data that needed to be sent back wirelessly. The Jackson installation used three nodes, whereas the Austin installations used between nine and nineteen nodes. Some bugs related to communication in large-network systems were identified and are currently being investigated.

The WSN strain node was used to determine the durability of strain gages. One WSN strain node was placed inside a humidity room and so far the results are great. The performance of the wireless system inside the humidity room is better than the wired system. Regarding the durability tests of gages with different protection levels, we have gotten very interesting results that will help us identify when a gage has deteriorated or become damaged.

On the analysis side, three bridges that have previously instrumented with strain gages and accelerometers have been modeled in SAP2000. The models are simple and use line elements to model all the members of the bridge. The goal of these analyses is to investigate how accurately a simple model can estimate the dynamic response of the bridge due to vehicular-induced vibrations. The analysis results are compared with actual field test data to determine the accuracy.

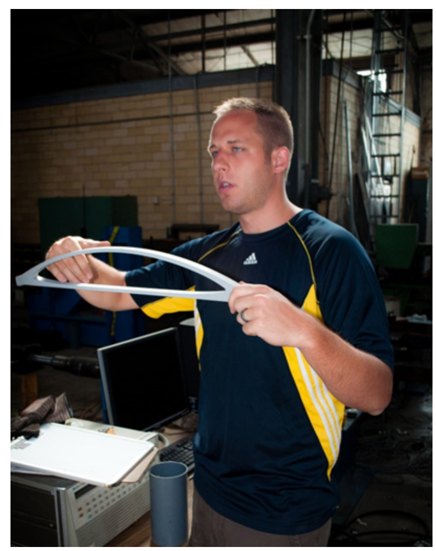
"MOOG" - *def.* moveable platform used to access the bridge girders from the top of the bridge deck

Monitoring Stresses in Prestressed, Precast Concrete Arches - Hossein Yousefpour & Joel Blok

After one year of enthusiastically waiting, we are now getting close to the casting day for the first arch. As such, we spent significant time in the past semester on getting ready for the instrumentation. Once the instrumentation layout was finalized, we assembled our data acquisition boxes and prepared our data logging programs. One significant outcome of our efforts was also to figure out the wireless communication for transferring vibrating wire gage (VWG) data to the data logger in the field. Using wireless communication together with the new programming strategy will increase the scanning speed significantly as compared to the practice currently used in the lab for VWGs.

Another part of our activities regarding the arches was focused on the modulus of elasticity tests on the trial mixes of concrete at different ages. The results will be essential in calculating the stresses during each stage of the arch bridge construction. A total of 80 modulus tests were performed on the trial mixes, and there is more on the way.

On the other hand, experimental studies on slender post tensioned concrete members have been in progress on the lab floor. Comprehensive elastic buckling studies were performed on the second specimen, and the effects of different levels of post-tensioning force and sequences of post tensioning on the behavior of the specimen under external loading were evaluated. After the specimen eventually buckled and cracked, several post-cracking buckling tests were performed to evaluate the effects of post tensioning on the stability of the cracked member.



Explaining how the innovative idea of implementing intentional duct sweep was used in the arch bridge design might be challenging. Joel is doing his best by using the arch model and a lot of math and physics principles, including the right hand rule.

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

Sometimes a "persuasive force" is the answer. Team IIT has found that by really destroying their beams, testing is much more fun.

Team IIT (Inverted-Inverted-T) is busy wrapping up the experimental portion of our project. With help from Mike & Mike, we are constructing and testing our final two beams to reach a total of twenty-one. We have examined the effect of different ledge geometry, number of point loads, shear span, and reinforcement ratio on the shear strength and serviceability of Inverted-T straddle bent caps.

We use strut-and-tie models to design these beams and then compare their predicted capacity to their test performance. Our last two beams will focus on decreasing the size of the critical node located at the load point and examining the effect of the resulting concentrated tensile zone. Soon Lalo and Nancy will be busy writing reports, papers, and dissertations and you will begin to see other, less-exciting projects in our formwork and test-setup.

Anchor Testing in ASR Concrete - Anthony DeFurio, Alissa Neuhausen, Josh Ramirez, & Daniel Sun

…dary. *(continued from Volume 4, Issue 1)*

We recently cast our first set of ASR blocks that are currently undergoing repeated wet and dry cycles. ASR growth will be monitored over the next two months. Several more blocks and beams will be cast over the upcoming semester for the same purpose. These will be cured in a newly constructed appropriate curing facility located east of Building 24. Once desired ASR growth is achieved, we will be testing additional anchors at various embedment depths. The goal is to provide information regarding any strength reduction in anchorage capacity due to cracking provided by ASR.

Seismic Behavior of Steel Beam-Column Connections - Sungyeob Shin

A total of ten cyclic loading tests will be conducted on large-scale specimens at the University of Minnesota. All ten bare steel specimens were designed to simulate interior moment-resisting connections consisting of a column with two beams attached to each flange. During the spring, five specimens were tested successfully and provided a better understanding of the inelastic behavior of the beam-to-column connection region. I expect to return to Austin in the following semester with the eight erector columns used for the lateral support frames.

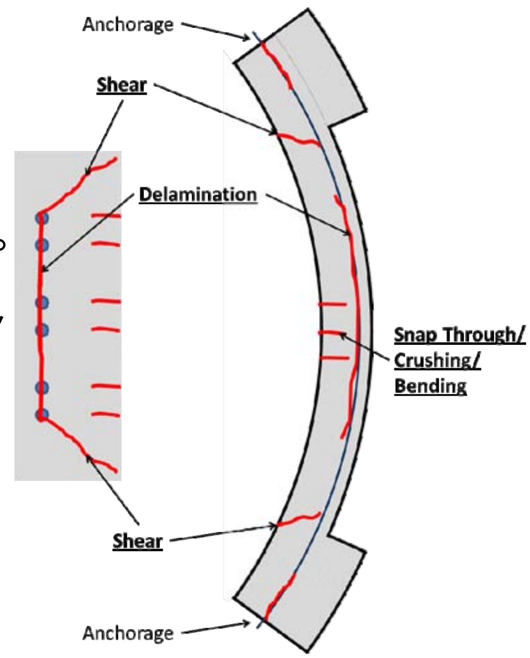
Specimen with a weak panel zone at 7% story drift - MAST Lab (U of M)

Lateral Tendon Breakout - Jongkwon Choi & Patrick Short

The purpose of this research is to verify the size effect of tendon breakout failure in curved prestressed concrete. Horizontally-curved concrete might appear to be subjected to only axial compressive stresses. However, closer examination of the equilibrium reveals that because the inward radial forces induced by the tendons are localized and the outward radial forces of the concrete are distributed, local tensile stresses develop in the concrete. This tension causes vertically-oriented splitting cracks, or delaminations.

This project includes finite element analysis and laboratory testing. Currently, the finite element model is being developed using ABAQUS. After obtaining the simulation results, including deformations and failure loads of test specimens, two curved beams will be cast and tested this summer.

The test results could be applied to the design of curved box girders, circular tanks, nuclear containment buildings, and offshore structures.



Possible failure modes in a curved prestressed concrete beam

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

In TxDOT Project 0-6374, long-term prestress losses in pretensioned concrete beams are being examined experimentally. Sixteen Type C and fourteen Tx46 girders were fabricated at three major precast manufacturers in Texas. Internal instrumentation was installed in select beams to monitor the internal state of strain (and corresponding prestress losses) over time. The beams feature full-scale cross-sections, yet are small enough to be transported into the lab for testing at the service load.

In the past few months, all 30 of the fabricated girders were service-load tested.

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 will be used to support future recommendations for prestress loss estimation.

Testing at the service load of an 0-6374 beam

Cracked Panels - Kiyeon Kwon, Aaron Woods, Umid Azimov

Three experts in the field

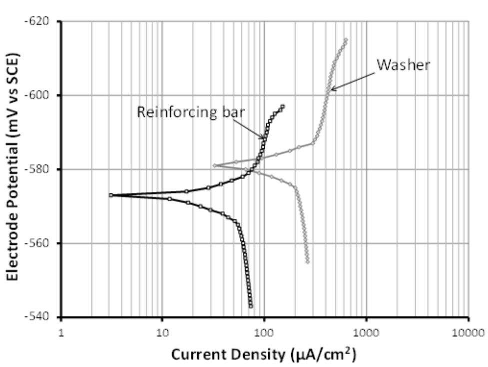
Lunch party after the instrumentation

During the spring semester, we concentrated our efforts on carrying out a field instrumentation in order to determine the optimized top-mat reinforcement by monitoring the behavior of the bridge deck. The bridge is the second one of the project and is located in Belton. The first bridge of the project is located in Houston and we instrumented the bridge last summer.

For the instrumentation, Dr. Chao and his students of UT Arlington helped us. At the second bridge, the reduced welded wire reinforcement was applied which was not applied in the first bridge of the project; we hope that by monitoring the second bridge, we will be able to estimate the possibility of the application of welded wire reinforcement.

We are continuing to monitor long-term prestress losses of precast, prestressed concrete panels and strain changes of top-mat reinforcement of the first bridge in Houston.

Passive Wireless Corrosion Sensors - Ali Abu Yousef



Potentiodynamic test results

The design of the corrosion sensor 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, they 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.

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

The spliced-girder team has wrapped up its testing of panel specimens meant to model the webs of prestressed I-girders with post-tensioning ducts. David Wald is currently analyzing the results from the one-hundred panel tests performed at FSEL and will be including them in his thesis.

The team has moved on to large-scale girder specimens. The first of which was a 30-foot-long Tx46 prestressed girder with a post-tensioning duct in the web that was recently tested on the elevated slab. Preparations are currently being made for the fabrication and shear tests of the first 50-foot-long Tx62 girder specimen. Each of the Tx62 girders will include 7.5-foot-long end-blocks to accommodate the post-tensioning anchorages. The specimens will be fabricated off-site and post-tensioned in the lab before testing.

Retrofit, Retrofit, Retrofit - Guillermo Huaco

The most common location of damage to columns occurs where flexural hinges develop. Masonry walls are often damaged by the development of shear hinges where diagonal ties are formed or by sliding at the bottom. Column sections often suffer considerable loss of concrete in the hinging region and severe distortion of the longitudinal reinforcement. For masonry walls, sliding occurs due to friction loss in the lower course of brick, and shear failure is apparent from the diagonal cracks.

In this project, carbon fiber reinforced polymers (CFRP) are being used to jacket columns that have not been damaged too severely, and as diagonal ties for the masonry walls. Mechanical couplers are being used to replace severely bent bars or to replace lap splices that cannot develop the full strength of the reinforcing bar. An additional concrete ring cast around the two lower courses of brick is applied to repair the sliding failure of the walls.

The research in progress indicates that the use of these innovative materials and retrofit techniques results in performance that is likely to be equal to or better than that of a repair using more conventional techniques. The feasibility of using such techniques depends on the degree of damage, the cost of replacement, and the performance required.

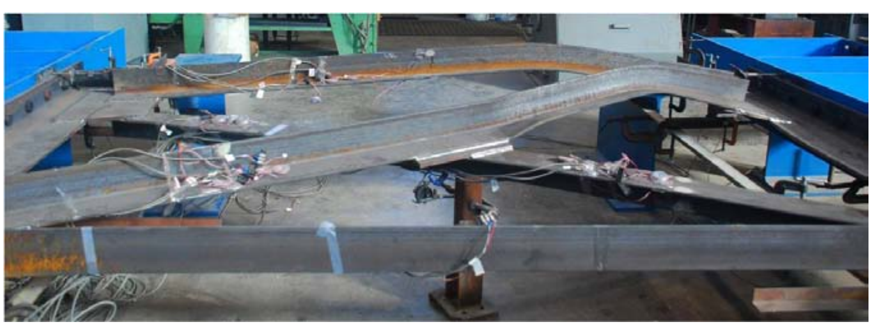
Partially-retrofitted masonry wall showing the concrete ring around the lower two courses of brick

Retrofit of a concrete column using CFRP (top left) and mechanical splices (bottom left)

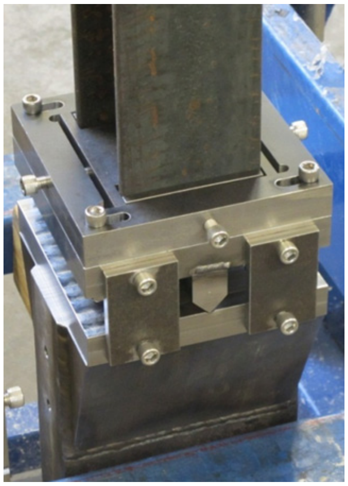
Tubular Cross Frames - Anthony Battistini & Weihua Wang

During the spring semester, multiple tests were performed on the full-scale cross frames using different layouts. The team studied the standard X-type and K-type cross frames currently used in practice, as well as the proposed Z-type cross frame, which utilizes a single diagonal member comprised of a double angle or tubular cross section. The stiffness of the cross frame system and the maximum strength of each brace layout were measured. In addition to the large-scale tests, cyclic fatigue tests on the various members and connections were performed to determine the appropriate rating for the connection for use in steel bridge construction. All the test results have been used to validate finite element models, which are being studied to extend the findings to other geometries.

Right: Fatigue failure of a double angle cross frame - The fatigue tests were all that they were cracked up to be...



Below: Failure of an X-type cross frame



Knife-edge pin at the base of the test setup

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

This research focuses on studying the time-dependent buckling behavior of ASTM A992 steel columns at elevated temperatures. The objective of this project is to better understand the phenomenon of creep buckling and to develop methods to predict creep buckling behavior. Material characterization tests have been conducted at temperatures up to 700 °C to evaluate tensile and creep properties of ASTM A992 steel at elevated temperatures. W4×13 columns will be tested under a pin-ended condition. The knife-edge, being used as a pin, is made out of Viscount 44, a hardened tool steel with high yield strength, so that it can be used for several tests with negligible wear. As seen in one of the pictures, the test setup is ready and the column creep tests are scheduled to start this summer.

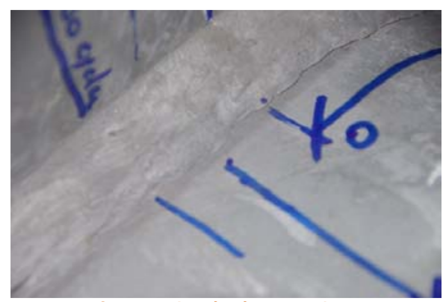
Fatigue Testing of High Mast Illumination Poles - Kostas Belivanis

Repair procedure. Not a scene from Star Wars. Welding stick. Not a light saber.

A high-mast illumination pole from El Paso, TX, was removed from service and sent to FSEL for fatigue testing. Extensive cracking was found along the weld of the shaft-to-base plate connection, and the project sponsor, TxDOT, is interested in an estimate of the remaining fatigue life of the pole.

Cracks were identified using ultrasonic and magnetic particle testing before the fatigue testing started in order to have a reference point. The fatigue test was successfully completed despite a brief break when a seal on the ram broke.

Another pole with cracking has been repaired using the Ultrasonic Impact Treatment (UIT) procedure and is currently being tested at the same time as the El Paso pole (rotated to get another test out of the specimen) to evaluate a repaired pole and a damage pole (El Paso).



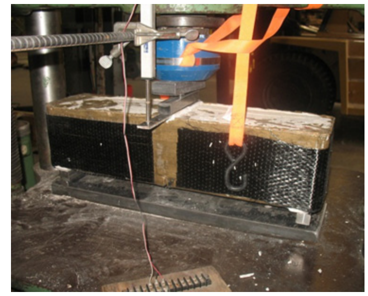
Start is half of everything
-Aristotle

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

It seemed so much smaller before we had to build it...

A test frame able to simulate the boundary conditions present in a collapsing composite floor system has been fully constructed. The first-floor specimen, designed in full compliance with industry standard and practice, is nearly complete. The loading system to simulate collapse conditions is also nearing completion. We plan to be able to run our first test soon, in which we will drive the floor system to complete failure to discover the common weak points in composite floor systems. Using these results, we plan to come up with new details to reinforce those weaknesses and evaluate them in later tests. Hopefully these results will provide a better understanding of the behavior of these floor systems, enabling new buildings to be constructed to better resist disproportionate collapse.

Shear Strengthening of Concrete Elements Using CFRP Sheets and Anchors - Changhyuk Kim & Wei Sun



Right: Test setup

Below: Anchor failure (left) and FRP rupture failure (right)

This program focuses on the debonding mechanism of FRP when it is applied to repair or strengthen concrete. Eight concrete beams with the dimensions of 6" x 6" x 24" were built. These beams were then strengthened by 4- or 5-inch CFRP sheets installed on the underside to increase the flexural capacity. CFRP anchors were installed to ensure that the CFRP sheets reach their full capacity, instead of totally debonding before rupture. The debonding process and results will be recorded and collected visually and compared with numerical results from ANSYS simulations.

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

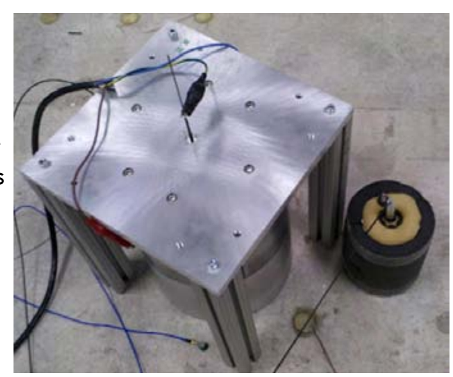
The goal of this project is to increase the load rating of continuous, noncomposite steel girder bridges built around the 1960s by post-installing shear connectors to create composite action. This summer, we will be performing fatigue tests on the three types of shear connectors. Fundamentally, the test setup will include: a shear connector, an A36 steel plate, and a 4'x5' concrete slab anchored to the strong floor. The steel plate and concrete slab represent the flange of a bridge girder and the bridge deck, respectively. The connector will be post-installed into the slab and attached to the steel plate. The steel plate will then be pushed and pulled across the surface of the slab in order to create the horizontal shear force that connectors experience on composite steel bridges. So far, we have installed a small test frame, cast the concrete slabs, and ordered material for the connectors. Testing should begin soon!

Casting the 12 (non-prestressed) slabs in the prestressing bed

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

Air-coupled impact echo testing for inspecting concrete bridge decks has been proven to be feasible through experiments and simulations. FEM models for the air-concrete slab system were developed to visualize the wave field and to better understand the system behavior. In addition, an analytical solution for a parabolic dish (signal amplifier) subjected to an incident plane wave was derived. With this analytical solution, the pressure at the focus of the dish can be predicted. Furthermore, the geometry of the parabolic dish that provides the best signal amplifying effect can be determined.

On the experimental side, we are trying to implement the idea of air-coupled impact source. By not allowing either the source or the sensor to come in contact, the test scanning speed could be significantly increased. The biggest issue in this process is the acoustic noise generated by the source could possibly be captured by the sensor. We are working on this issue to improve the system performance.



Air-coupled test setup

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

Behavioral and Analytical Investigation of Shaking-Table Tests of RC Structures - Jinhan Kwon

Two full-scale four-story RC structures were tested under increasing seismic excitations to near collapse damage levels. The project is focused on conventional RC specimens designed according to the latest Japanese structural design standards. The resulting details of the RC specimen closely match current U.S. seismic design provisions for special moment frames and shear walls. The structure is therefore representative of current U.S. construction in regions of high seismicity.

The shaking table tests produced a wealth of data from which lessons can be learned about our state-of-the-art RC seismic designs, both at the individual component level and the overall structural system level.

The objectives of the project are:

- To assess the validity of current behavioral knowledge and design codes in light of the experimental program.
- To assess the accuracy of current analytical methods for this common type of structure.
- To recommend improvements and ways forward on both behavioral and analytical fronts

During the spring semester, the efforts were focused on shear walls as they did not exhibit the stable hysteretic behavior and high ductilities targeted by design codes. These seeming deficiencies are alarming and require further investigation to uncover their causes so that potential gaps in our fundamental understanding and our design codes can be addressed.

Congratulations to the 2012 FSEL Spring Graduates!!

Spring 2012

- Matt Leborgne (PhD)
- Jose Garcia (MS)
- Jason Golzbein (MS)
- Michalis Hadjioannou (MS)
- Jamie Hernandez (MS)
- David Langefeld (MS)
- Scott McCord (MS)
- Joshua Ramirez (MS)
- Matt Reichenbach (MS)
- Aaron Woods (MS)

Special points of interest:

- Ice Cream Social, July 18, Large conference room
- FSEL Welcome BBQ - Septemeber TBD

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 second issue of 2012, twenty-one 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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