Ferguson Structural Engineering Lab Newsletter

THE UNIVERSITY OF TEXAS AT AUSTIN - STRUCTURAL ENGINEERING

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September 30, 2013

UT Football - Tailgating with SEMM!

Come out and tailgate with your fellow SEMM students before every home UT football game! Our group sets up on the southeast corner of Dean Keeton and San Jacinto (just across from ECJ) bright and early at 7am on game days. Come by and enjoy breakfast tacos in the morning, and bratwurst, burgers and hot dogs fresh off the grill later in the day. Bring a side or dessert to share, and wash down your food with some beer from our keg while getting to know your fellow SEMM grad students!

Contact Walt or Kostas for more details, and make sure to RSVP each week so that there is enough food for everyone!

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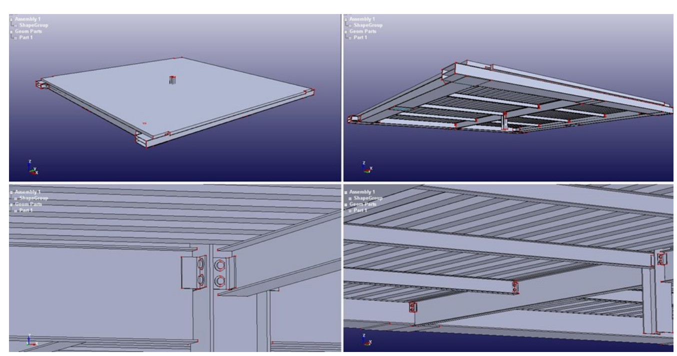
Congratulations to the 2013 FSEL Summer Graduates!!

Summer 2013

- Hemal Patel (MS)
- Vasilis Samaras (PhD)
- Weihua Wang (PhD)

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

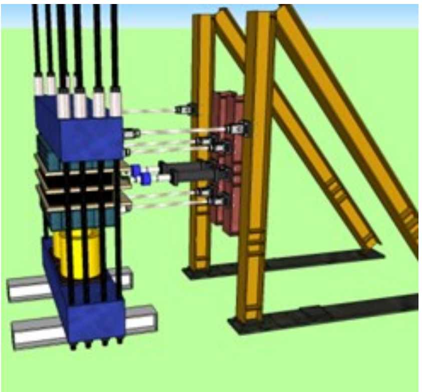
Two large-scale tests have been completed on composite floor systems in prototypical steel framed structures which were loaded to collapse. Both experimental tests confirmed that the floor system contributes significantly in progressive collapse scenarios, exceeding the strength that current guidelines suggest. The research team is now analyzing the data from both tests to identify the primary mechanisms that contribute to the structural resiliency. In addition to the large-scale testing program, significant effort has been given to evaluating the ability of state-of-the-art computer software to predict the response of such structural systems under collapse scenarios. Simplified modeling approaches suitable for use in design practice are also being investigated. The main objective of the computational research program is to develop validated finite element modeling methods that can be used to analyze complex floor geometries and evaluate potential design and construction details to enhance their performance.



High fidelity FE model of the first test specimen

Inside this issue:

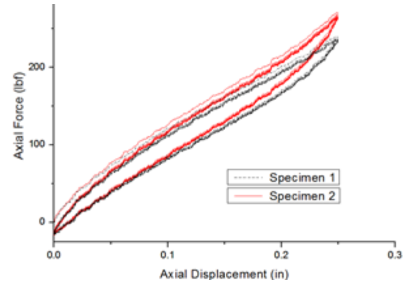
Extending Use of Elastomeric Bearing Pads to Higher Demand Applications - Kostas Belivanis, Liwei Han & Daniel Sun



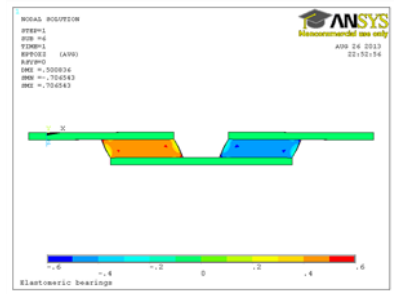
3D rendering of test setup

The elastomeric bearing pads that are routinely used in medium-demand steel bridge systems generally provide a reliable means of accommodating translations, and the pads are significantly cheaper than pot bearings. The use of elastomeric bearings in steel bridge applications will result 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), the test setup for laboratory specimen testing is being built, material directly from the specimens is being tested, and FEA studies are being conducted. In summary, there is a research boom on bearings at FSEL!!!

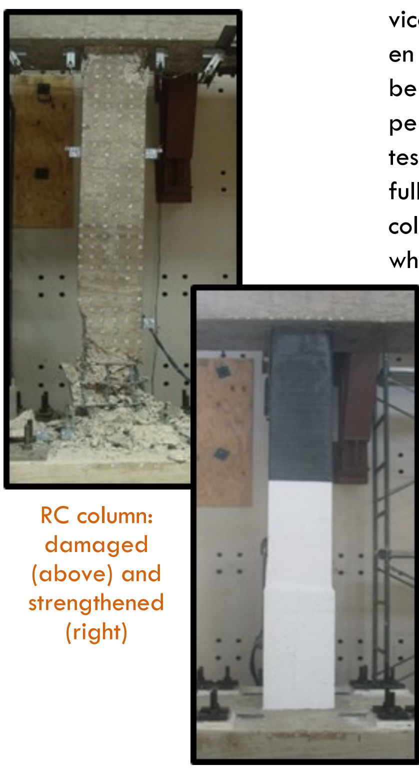


Typical shear-deformation curve of rubber (above)



FEA results for shear specimen

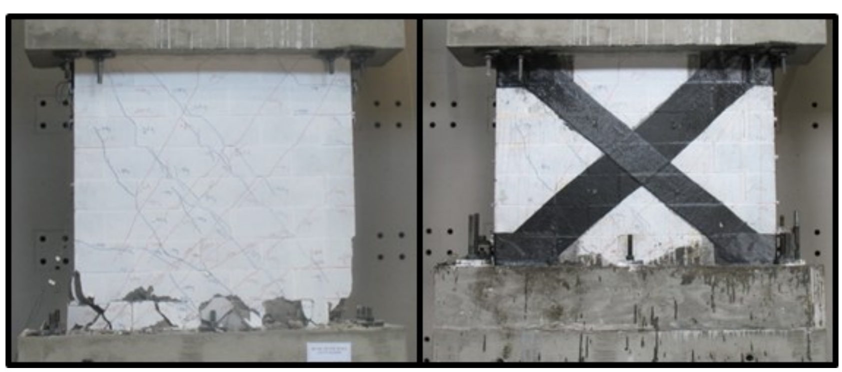
Seismic Rehabilitation of RC Structures - Guillermo Huaco



RC column: damaged (above) and strengthened (right)

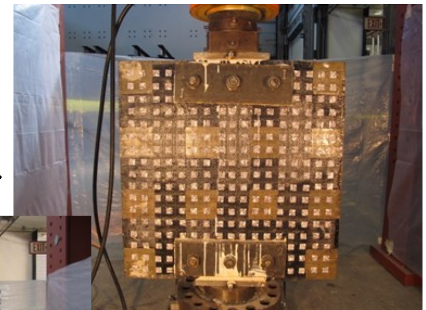
Innovative materials and devices can be used to strengthen reinforced concrete members for improved seismic performance. Laboratory tests have been conducted on full scale reinforced concrete columns and a masonry wall which were retrofitted using new techniques after suffering severe damage. CFRP sheets and anchors were used to provide additional shear capacity and ductility. These sheets were applied both as column jackets and as diagonal ties on the masonry walls. Mechanical splices were used to provide continuity to the reinforcement and to replace buckled bars in areas of heavy damage. The performance of the retrofitted members was found to be comparable to that of similar members strengthened using more conventional techniques.

Based on the results from the laboratory tests, backbone curves were developed following the existing ASCE 41-07 provisions and the proposed ASCE 41-13 procedures. These backbone curves were then used to create behavioral models for certain types of concrete members. The inclusion of the behavioral models for these new retrofit techniques into current Performance Based Seismic Design procedures will be proposed to enhance our capabilities to strengthen existing buildings and repair damaged structures.



Bi-Directional Application of CFRP - Changhyuk Kim

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 have indicated that the use of bi-directional strips leads to significantly greater increases in shear capacity. A total of nineteen panels, with and without CFRP anchors, have been tested under compressive forces applied over a restricted area. Such loading generates a bottle-shaped compressive strut between the load and reaction points. As panel test results become available, we will focus subsequent tests to target the most influential parameters, such as CFRP strip inclination and the ratio of CFRP strips to CFRP anchorage. The last series of test specimens has been cast and will be tested in the next month. The purpose of these tests is to evaluate the contributions of the concrete, steel reinforcement, and CFRP to the capacity of the panels.



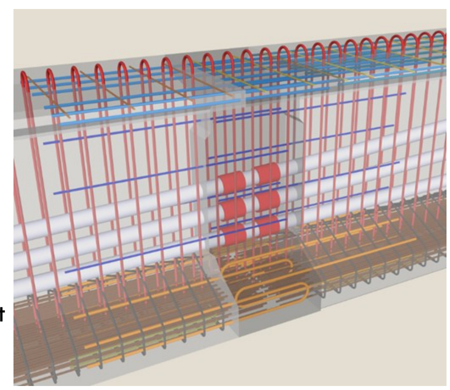
Test with bi-directional strips (above) and uni-directional strips (left)

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

The spliced girder team has been working towards completing our investigation of the shear behavior of post-tensioned concrete I-girders. To date, seven girders have been fabricated and nine shear tests have been performed. Of the seven girders, the first five have a web width of 7 inches and a duct diameter of 3 inches. The last two girders have 9-inch webs and are identical, except for the diameter of the post-tensioning ducts within the web (3 inches vs. 4 inches). This difference will allow us to evaluate the effect of the duct diameter-to-web width ratio on the shear behavior of the girders.

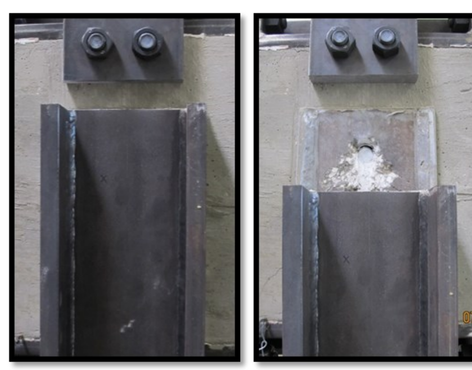
The team is also preparing for proof tests of the cast-in-place splice region of spliced I-girders. The design of the test specimens for this phase of the project is nearing completion, and we hope to have the precast girder segments fabricated soon.

Preliminary splice region details for upcoming tests



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

The ongoing activities of this research project consist of experimental tests to capture the load-displacement behavior of a shear stud at normal and elevated temperatures. Elevated temperature tests are conducted by increasing the furnace temperature to the desired value, and maintaining that temperature for 20 minutes before beginning to apply the load. The distribution of temperature in the specimen is recorded by measuring the temperature at different locations. Comparing the test results at room temperature and at 700°C shows a 50% reduction in stud shear strength at 700°C! Also, as expected, the temperature gradient through the thickness of the steel plate and through the shear stud is much smaller than that in the concrete slab. Insulation is placed on one side of the concrete block to simulate the actual conditions a floor system of a building would experience in a fire. More interesting results to come…



Failure of the shear stud at room temperature under the shear force

Monitoring Stresses in Prestressed, Precast Concrete Arches - Hossein Yousefpour

Aerial photo showing the progress at the end of July (courtesy of Sundt Construction)

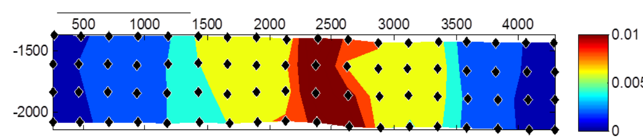
With the construction of this extraordinary arch bridge approaching the finish line, the research in this project is moving towards answering more fundamental questions about prestressed concrete arches in a broader perspective. As of now, 5 out of 6 spans in the Ft Worth arch bridge are completed, and the bridge will be open to traffic by mid-October. The only remaining instrumentation activity is live load testing on the bridge to identify the structural response of the arches and establish their performance baseline. In the coming months, the focus will be on further processing the field data and conducting parametric analytical and FE studies to evaluate prestressed arches in general. Of particular interest is the long term behavior of these arches, hanger arrangement effects, and the level of sophistication needed for realistic modeling of arches.

Debonding Mechanism of CFRP - Wei Sun, Will Shekarchi, Nawaf Alotaibi & Helen Wang

Right: Anchor failure mode

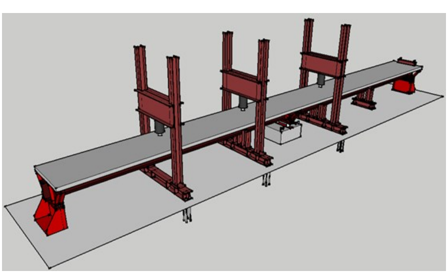
Below: FRP rupture failure mode

This research focuses on the transfer of force from CFRP (carbon fiber reinforced polymer) to concrete using anchors. Around 40 unreinforced 6x6x24" concrete beams have been built and strengthened by either 3" or 5"wide CFRP sheets to increase their flexural capacity. CFRP anchors have been applied to ensure that the sheets reach their full capacity, instead of prematurely debonding before rupture. The debonding process and results are recorded and collected by a visual system. These results are then compared with numerical results from ANSYS simulations.



Strain contours of CFRP strips around ultimate load

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



3D rendering of large-scale test setup

One potential method of strengthening older, non-composite steel I-girder bridges is to "post-install" shear connectors. These connectors would attach the top flange of the girder to the concrete deck, creating a composite structure. Investigation into this potential strengthening method is ongoing at FSEL. The small-scale fatigue tests on individual connectors are complete, and we are now moving on to laboratory testing of large-scale two-span continuous beams (84' long!) strengthened with post-installed connectors. These large-scale tests will be used to evaluate the behavior of a strengthened composite girder under simulated heavy truck traffic which may be experienced by a bridge in the field. Additional fatigue testing under service levels of load will also be incorporated in the large-scale tests. We expect that the more realistic conditions of the large-scale tests will result in improved fatigue behavior of the post-installed connectors.

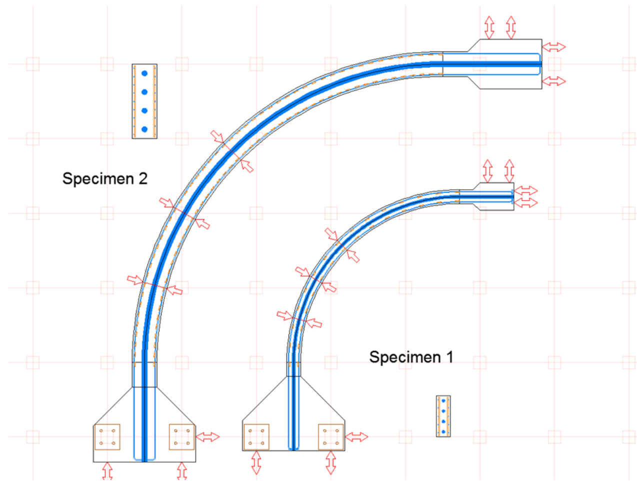
Delamination of Curved Post-Tensioned Structures - Jongkwon Choi

The goal of this research is to develop an improved understanding of the behavior and design of curved post-tensioned concrete structures. The effect of member thickness on the delamination of curved post-tensioned structures without radial reinforcement is of particular interest.

Over the summer, the construction sequence, post-tensioning anchorage design, and reinforcement details of the proposed test specimens were refined to enhance the efficiency and meaningfulness of the test program. In particular, a construction sequence was chosen to ensure that the appropriate boundary conditions are achieved at each anchorage region, as well as to minimize friction in the test setup. Additionally, instrumentation locations and methods (shown schematically in the figure) were determined to adequately capture the global elastic and inelastic behavior of the specimen using a variety of displacement, strain and delamination gages. We are also investigating interesting analysis techniques to provide insight into the applicability and validity of our test results.

In the near term, the research team will further discuss and refine the stressing and measurement methods. These discussions are essential to ensure the safety of the tests and reliability of the results.

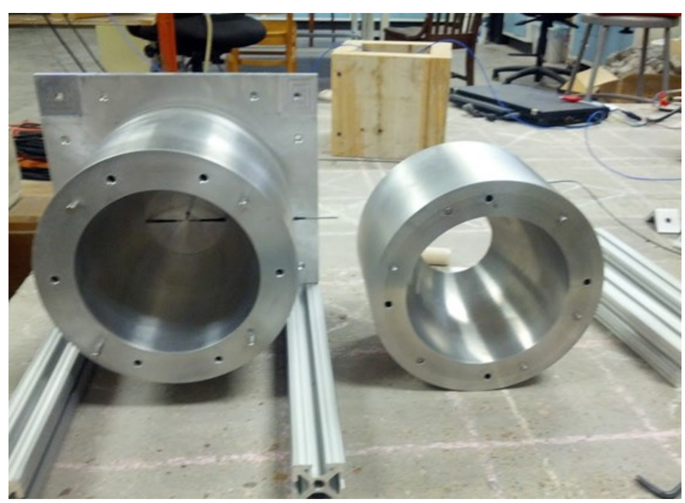
Instrumentation plan for the test specimens



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

This research focuses on the development of a fully air-coupled, non-contact, nondestructive testing (NDT) system employing the impact-echo method (IE) to locate defects in concrete bridge decks. For the air-coupled excitation, we are able to effectively excite stress waves in concrete using a focused spark source amplified by an ellipsoidal reflector. To further increase the power of the focused spark source, numerical and experimental work has been carried out, and we have obtained a better understanding of the system. 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. Simulation results show that the pressure amplitude of the emitted noise can be decreased significantly if an acoustical muffler is attached. The newly proposed acoustical muffler will be optimized and tested experimentally in the near future. We are investigating the use of 3D printing for this testing. Currently we are still searching for an available source for high accuracy rapid prototyping, and are hoping to set up our own 3D printer in the lab. We will be gladly providing 3D printing service to all FSEL members as long as the maintenance fee is properly paid!

The canon (ellipsoidal reflector) for nondestructive testing



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

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

The ASR Walls team is hard at work fabricating beams which will be tested in the future to determine their shear and anchorage capacity after long-term, high temperature and humidity conditioning in the greenhouse just outside of the lab. We have constructed and cast 9 beams over the course of the summer. We are a temporary casting hiatus, and are currently investigating the efficacy of various crack indexing techniques. By mid-semester, we expect to fabricate and test our first control specimens.

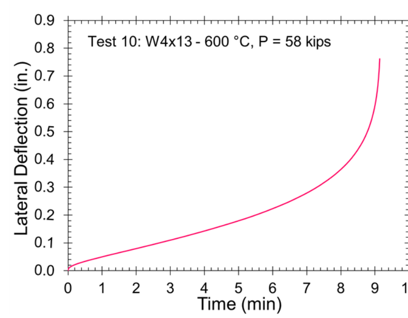
Specimen cast as a wall being rotated to later be tested as a beam

Special points of interest:

- FSEL Welcome BBQ, September 27th; Social hour starts at 5pm, Food served at 6pm
- 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

Creep Buckling Due to Fire - Ali Morovat

The objective of this project is to better understand and characterize the phenomenon of creep buckling of steel columns at high temperatures due to fire. Material characterization tests have been conducted at temperatures up to 1000°C to evaluate the tensile and creep properties of ASTM A992 steel at elevated temperatures. The creep buckling tests on W4×13 wide flange columns are currently underway and will be continued through the fall semester. The creep buckling phenomenon can be visualized by plotting curves of lateral deflection vs. time, a sample of which is shown here for a creep buckling test under the applied load of 58 kips at 600°C. As can be seen, the rate of change of deflection with time increases very slowly at the beginning of the test and then increases more rapidly until the column no longer can support its load. The time at which the displacement-time curve becomes nearly vertical represents the failure time.



Buckled specimen after testing

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 2013, thirteen 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.

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