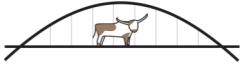


Ferguson Structural Engineering Lab Newsletter



Volume 6, Issue 2

THE UNIVERSITY OF TEXAS AT AUSTIN - STRUCTURAL ENGINEERING

June 19, 2014

Congratulations to the 2014 FSEL Spring Graduates!

Spring 2014

- Kostas Belivanis (MS)
- Jose Gallardo (PhD)
- David Garber (PhD)
- Yi-Te Tsai (PhD)



Monitoring Stresses in Prestressed, Precast Concrete Arches - Hossein Yousefpour

This will be the last summary concerning the monitoring study on the world's first precast network arch bridge. The instrumentation in this project served to ensure the safety of the innovative arches and provided unprecedented data regarding the structural response of concrete arch bridges, which can also be used to verify the modeling assumptions for concrete arches of any type. Some of the key conclusions to date are as follows:

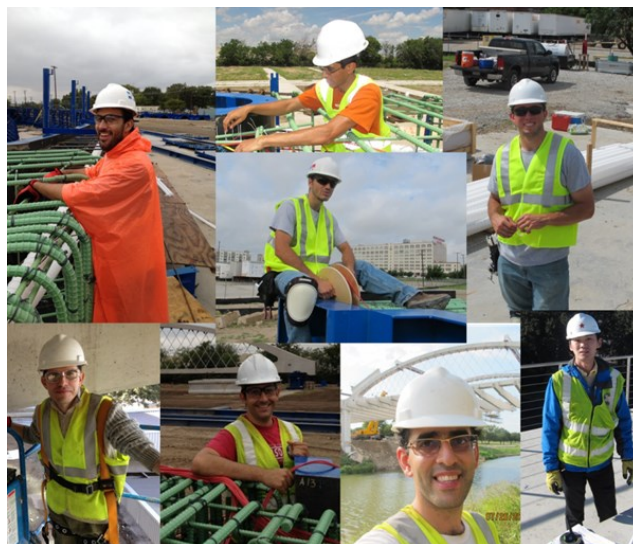
- Finite element simulations were generally successful in capturing the structure's short-term response.
- The prestress losses in the arches were relatively small, most likely because the inclined hangers restrain the shortening of the rib and the tie. However, the prestress in the concrete might diminish over time due to stress relaxation and redistribution.
- The construction stresses in apparently identical arches could be highly variable from one arch to another. Such variability did not result in endangering the safety of the monitored arches. However, reliable stress calcu-

lations for network arches must consider uncertainties due to time-dependent deformations in the concrete, unknown hanger forces, and thermal effects.

The TxDOT-sponsored project finished this past semester, but parametric studies on the short-term and time-dependent behavior of concrete arches are still in progress. Stay tuned for several interesting publications!

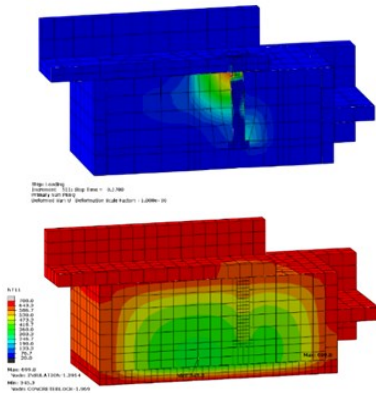
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The instrumentation was made possible by great help from Jose, Ali, Dave, Kostas, Vasilis, Hemal, and Liwei!

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



Heat-transfer and stress-displacement analysis of a specimen

Over the experimental part of this research study, ten steel-concrete composite specimens were tested under different heating conditions. Furnace target temperatures were chosen within the range of room temperature to 760° C. The results of the experimental study will be used to

validate the computational analysis of the shear studs.

Abaqus® finite element software is being used for the computational portion of this research study. A sample of heat-transfer and stress-displacement analysis on a specimen is presented in the figure. The investigation on

the contributing factors to the behavior of shear studs at elevated temperatures will be completed through a parametric study. The effect of different material properties, geometries, and heating scenarios on the behavior of shear studs will be investigated.

Slip-Critical Performance of Galvanized Steel - Sean Donahue

Slip test setup



Current provisions require galvanized pieces to be hand-roughened by wire-brushing before they can be used in slip-critical connections. These provisions are based on a limited number of tests from several decades ago and may not accurately de-

scribe the behavior of modern coatings. Testing done at multiple galvanizers on different steels has shown that current galvanized pieces have much higher slip coefficients than previous research indicates. The tests also suggest that roughening of the galvanized surfaces does not improve their slip behavior and actually may polish the surfaces, lowering the slip

coefficient. Thus, it is recommended that the need for roughening be removed from the bolt provisions. Testing is also underway to determine the effect of creep in galvanized coatings on the pre-load in fully tightened bolts, and if necessary, to recommend reduction factors for slip-critical galvanized connections to account for this loss.

Debonding Mechanism of CFRP - Wei Sun & Helen Wang

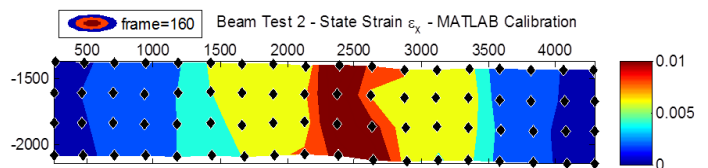
Two possible failure modes: Anchor failure (below) and FRP rupture (right)



Strain contours of CFRP strips near ultimate load (right)

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

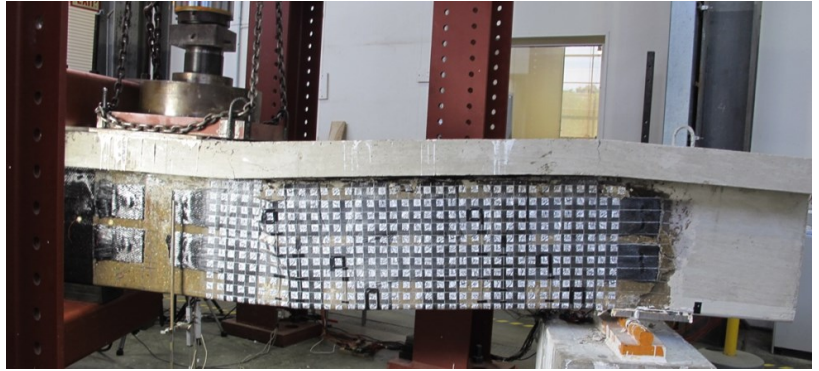
applied to ensure that the sheets reach their full capacity, instead of prematurely debonding before rupture. The debonding process and results are recorded and collected by a visual system. These results are then compared with numerical results from ANSYS simulations.



Bi-Directional Application of CFRP for T-beams - Nawaf Alotaibi, Will Shekarchi

This portion of TxDOT project 0-6783 focuses on evaluating the use of bi-directional CFRP strips along with CFRP anchors to increase the shear strength of concrete T-beams. Eight tests were performed on four 24-in. deep T-beams. The effect of web width, shear span-to-depth ratio, and CFRP layout were investigated in this experimental study. In addition to conventional measurement techniques, such as strain gauges and LVDTs, a digital image correlation technique (Vision System) was implemented.

Unlike the conventional instrumentation techniques, the Vision System provides full-field deformation data. It is also a contact-free measurement that allows the specimen to be monitored after undergoing large deformations. Test results indicate that the use of bi-directional CFRP strips does not improve the performance as compared to the application of uni-directional strips when strengthening deep beams.



Flexibility of concrete!

However, a substantial gain in shear strength can be achieved when using bi-directional strips of CFRP in slender beams.

High Strength Steel in Reinforced Concrete Columns - Drit Sokoli & Chase Slavin

The congestion of reinforcement in concrete columns in seismic areas can be reduced by using higher strength steel. However, the potential usage of high strength steel (HSS) brings up a lot of uncertainties and discussions, mostly related to the decrease in ductility that comes with the increase in strength. This study aims to assess the behavior, stiffness, and ductility of seismically detailed columns reinforced with HSS as

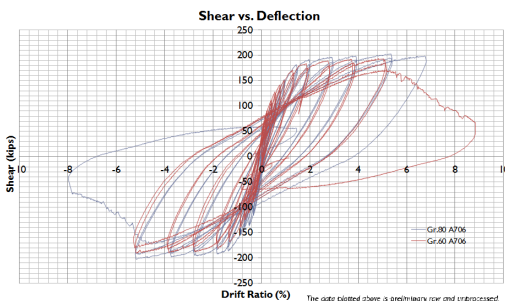
compared to columns reinforced with Gr 60 rebar, which are widely used and well accepted by different building codes.

ACI 318 limits the yield stress used in design calculations for shear to 60 ksi. This is another point of interest that will be assessed in this project. Taking advantage of the 3D Digital Image Correlation System developed at FSEL, it is possible to also produce

performance-based design and assessment methodology, and will be produced for each test.

Two columns reinforced with Gr 60 and Gr 80 steel, respectively, have already been tested at FSEL. These two columns showed comparable behavior and exceeded minimum necessary performance objectives by a substantial margin. In the near future, a column reinforced with grade 100 steel will be tested, allowing for more significant differences in behavior to be assessed.

Test setup and specimen



objective measurements of damage indices. Such measures are crucial within the perfor-

Hysteretic behavior

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ASR Affected Walls - Gloriana Arrieta, David Wald, Nick Dassow, Trey Dondrea, Alissa Neuhausen, Daniel Elizondo, Joseph Klein, Sara Watts & Beth Zetzman



Expansion anchor shear retrofit

The ASR team has been hard at work this past semester conducting preliminary investigations of the effects of load distribution (concentrated vs. uniform loads) on concrete shear capacity and post-installation techniques aimed at improving or remediating deficient shear capacities. These stud-

ies will continue in the near future, as will efforts to assess the efficacy of retrofit techniques on members with poorly-developed, unconfined lap splices. Meanwhile, the team is excitedly gearing up toward summer testing of ASR-affected specimens and the implementation of

novel instrumentation to analyze the progression of ASR-induced damage.



Uniform load testing using an air bag

Time-Dependent Buckling of Steel Columns Subjected to Fire - Ali Morovat

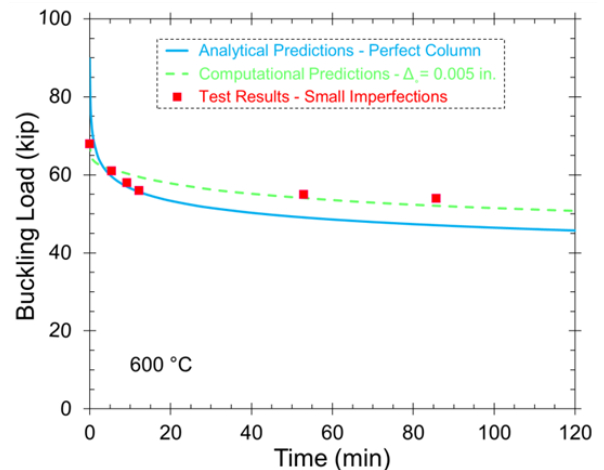


Buckled W4x13 column

Along with the main goal of developing a fundamental understanding of the phenomenon of creep buckling, this project has shown that time-dependent effects are significant in response of steel columns in fire. Now that the buckling tests on W4x13 columns have ended, the methodology developed to account for the effect of material creep on the buckling of steel columns in fire can be further verified. An example of such verification is shown in the graph, where the analytical and computa-

tional creep buckling predictions are compared against test results for W4x13 columns with KL/r of 51 inches at 600 °C. Analytical solutions are based on the concept of a time-dependent tangent modulus. Computational creep buckling analyses are performed in Abaqus®. A material creep model developed in this

study for ASTM A992 steel is utilized in analytical and computational buckling analyses. Considering all of the uncertainties in material creep models and buckling prediction methods, reasonably good agreement between the experimental, analytical, and computational results can be seen.



All good things must come to an end, even at FSEL!

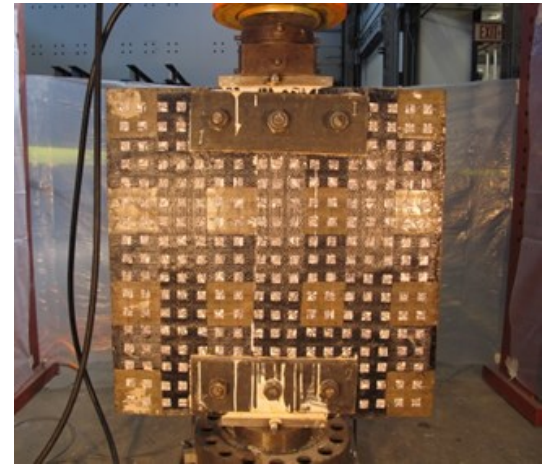
Bi-Directional Application of CFRP for Shear Strengthening of Reinforced Concrete Bridges - Changhyuk Kim

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-

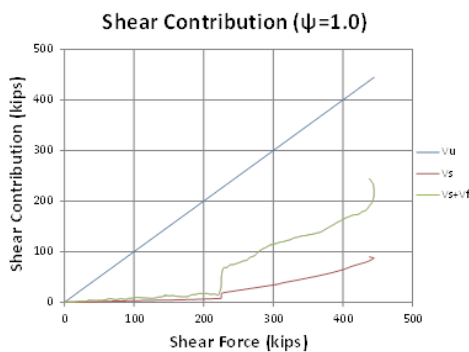
directional strips leads to significantly greater increases in shear capacity. A total of nineteen panels, without and with CFRP anchors, have been tested under compressive forces applied over a restricted area. Such loading will generate a bottle-

shaped compressive strut between loading and reaction points. As panel test results become available, we will focus subsequent tests on targeting the most influential

parameters, such as CFRP strip inclination and ratio of CFRP strip 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 strengthening to the capacity of the panels.



Test specimen with bi-directional CFRP strips



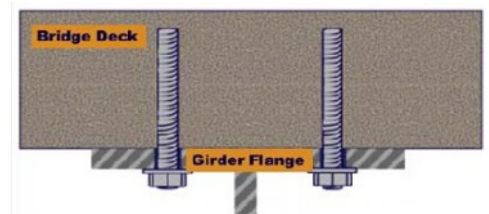
Strengthening Continuous Steel Bridges with Post-Installed Shear Connectors - Kerry Kreitman & Amir Ghiami

This research is aimed at investigating a potential method of strengthening older steel bridges which were constructed with a non-composite floor system. To provide additional strength and stiffness to these bridges, shear connectors can be “post-installed” to create composite action between the existing steel girders and concrete

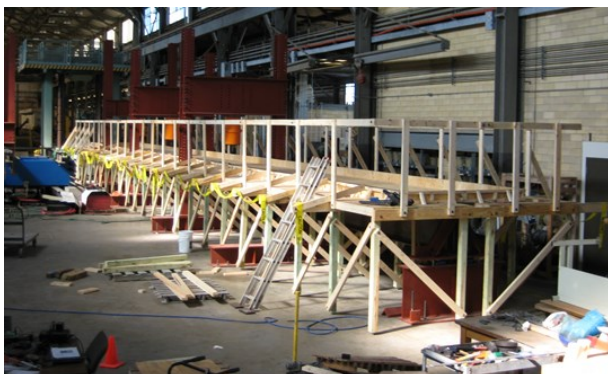
deck. These connectors consist of high strength threaded rods or bolts that are inserted through holes drilled into the deck and top flange of the steel.

This summer’s research activities are focused on the testing of an 85-foot long, two-span continuous steel girder, which is made composite with

a 6.5’-foot wide concrete deck using post-installed shear connectors. Of particular interest in the testing of this first beam is the behavior under large repeated loads, similar to loads that a bridge may see in service from heavy trucks. Future tests will focus on the fatigue behavior of the post-installed connectors.



One type of post-installed shear connector (adhesive anchor)



Many trees were harmed during the construction of the deck formwork. Donations are now being accepted for the newly created FSEL Plant a Tree Foundation

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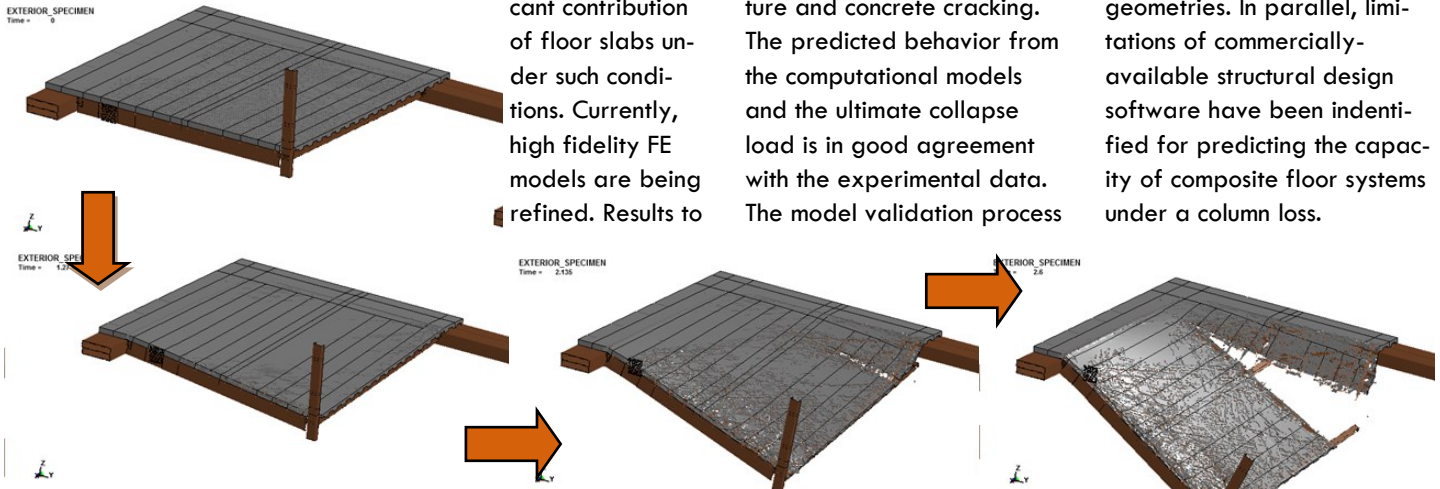
Progressive Collapse Capacity of Composite Floor Systems - Michalis Hadjiioannou, George Moutsanidis & Umit Can Oksuz

Two large-scale experimental tests on composite floor systems have been conducted. Both specimens were loaded to collapse under a middle column removal scenario, and both tests verified the significant contribution of floor slabs under such conditions. Currently, high fidelity FE models are being refined. Results to

date have demonstrated that these models are able to simulate the response of the physical tests until total collapse. The models explicitly capture failure modes prior to collapse such as bolt fracture and concrete cracking. The predicted behavior from the computational models and the ultimate collapse load is in good agreement with the experimental data. The model validation process

has enhanced confidence that the developed analysis procedure can accurately predict the capacity of structures and can be used to evaluate the response of floor systems with different configurations and geometries. In parallel, limitations of commercially-available structural design software have been identified for predicting the capacity of composite floor systems under a column loss.

Predicted response of the second test specimen until total collapse



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

The use of elastomeric bearings in steel bridge applications provides an economic and reliable means of accommodating the superstructure movement. In addition, sys-

tems are easier to fabricate, erect, and maintain while also improving the long-term bridge behavior.

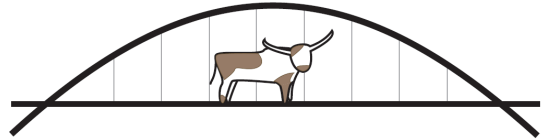
Results from this research study will provide valuable insight into the behavior of large elastomeric bearing pads for use in high demand applications. As design procedures in AASHTO were developed after numerical and experimental research on smaller bearings, there are concerns regarding the applicability of those procedures for larger sized bearings. The main goal of this

study is to verify those design procedures and develop suggestions for corrections where needed.

At this phase of the study, bearings are being testing in compression to evaluate axial stiffness, and results are being used for the FEA parametric study. The ultimate goal of this study is to develop a tool for practicing engineers that will provide them with simple spring element properties for more accurately simulating the support conditions of a long span, stiff bridge.

This is how one bearing "reacted" to a two-million pound compressive force





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

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

The spliced girder team will soon be performing tests to study the performance of the cast-in-place (CIP) post-tensioned splice regions of spliced girder bridges. The precast segments of the test specimens have been fabricated (see figure). The first set of precast segments will soon be transported to the lab for the splicing opera-

tion and to prepare the specimen for testing. Look out for the first of these tests later this summer.

The team will also soon conduct its first push-off shear test to study the strength of the interface between the precast girders of spliced girder bridges and the CIP

splice regions. These tests, along with the full-scale splice region tests, will provide the team with a more complete understanding of the behavior of spliced girders.

Precast segments for the upcoming splice region test



Special points of interest:

- ICE CREAM SOCIAL, JULY 22, 3PM, LARGE CONFERENCE ROOM
- FSEL WELCOME BBQ, SEPTEMBER TBD

Delamination of Curved Post-Tensioned Structures - Jongkwon Choi

The objective of this research is to better understand the behavior and design of curved post-tensioned concrete structures. Several analytical studies on the radial stress distribution have been done, but experimental verification has not yet been

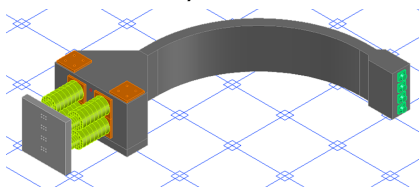
completed. This research will provide the experimental data necessary to model the effect of localized tensile stresses and delamination of such structures.

Simplified analysis on the vertical section of curved post-tensioned structure was conducted during the spring to verify the feasibility of using a 2D sectional analysis with an elastic spring. As

expected, the analysis results shows a good agreement with the theoretical model.

We are now starting to build the pilot test specimen, which will be constructed and tested during the summer. After investigating the results of the pilot test, the design of other specimens will be modified, and additional tests will be conducted.

Steel cage for end block of first specimen



Rendering of test specimens

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 2014, fourteen 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.