Ferguson Structural Engineering Lab Newsletter

THE UNIVERSITY OF TEXAS AT AUSTIN - STRUCTURAL ENGINEERING

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Welcome to New Faculty Member!

We're pleased to welcome a new faculty member to the Ferguson Lab family: Juan Murcia-Delso!

Dr. Murcia-Delso is formerly a senior researcher at Tecnalia Research & Innovation. He received his BS/MS in Civil Engineering from the Universitat Politècnica de Catalunya (UPC); an MS in Structural Analysis of Monuments and Historical Constructions, which is a joint degree from the University of Minho and UPC; and a PhD in Structural Engineering from the University of California, San Diego, where he was also a post-doctoral researcher.

His research interests are in the behavior of reinforced concrete structures, and the development of innovative analysis, design and retrofit methods for enhancing the performance of structures under extreme loading and aging effects, all of which involve structural testing and computational modeling.

New Faces at FSEL

Apostolos Athanasiou

I was born and raised in Athens, Greece. Right after my graduation from National Technical University of Athens, I moved here to Austin in order to continue my studies as a PhD student. I am interested in mechanics of concrete structures and I am sure that through my participation in FSEL's research programs, I will further improve my knowledge in order to become a highly competent structural engineer. In my free time I enjoy cooking for my friends and excursions to near cities.

Rodolfo Bonetti

I was born in the Dominican Republic and earned my BS in Civil Engineering from Pontificia Universidad Madre y Maestra (PUCMM) in Santiago, Dominican Republic.

After several years of working in the construction field with my father, I discovered my real passion for Structural Engineering and obtained an MS from Virginia Tech. At my return to the DR, I became a Civil Engineering professor, working at PUCMM in Santo Domingo.
I feel blessed for this opportunity to pursue my doctoral degree at UT Austin and working at FSEL is a long dream come true.

Inside this issue:

Special points of interest:

- JNT Golf Tournamant, Date TBD

Daniel Camacho

I am a first year Master's student from Ciudad Juarez, Mexico, working on 3D printing applications for construction with Dr. Clayton and Dr. O'Brien.
I have a Bachelor's degree in Civil Engineering from New Mexico State University. Outside of work, I enjoy playing soccer, social dancing (salsa, bachata, merengue), and learning/practicing German.

Korkut Kaynardag

I joined the FSEL family just in August. I finished my MSc Degree at Bogazici University in Turkey where I carried out analytical and experimental research combined with vibration-based system identificaition techniques and structural reliability methods. I am very excited to be here because I am also going to work on ultrasonic and acoustic wave based non-destructive damage detection techniques. I loved the athmosphere in Austin and and FSEL. I am very glad to be here and looking forward to meeting with you all!

Jennifer Kurkowski

I am a first year master's student from Dallas. I received my bachelor's degree in Civil Engineering from Georgia Tech before moving to Austin. This year I am working on a masonry seismic vulnerability project with Dr. Clayton. In my spare time I enjoy being active and outdoors, reading, and spending time with my family and friends. I am looking forward to working at the FSEL and getting to know everyone!

Ghassan Fawaz

I was born in Chhim, a peaceful village in Mount Lebanon. After completing my Master's degree in Structural Engineering from the American University of Beirut (AUB), I worked as an instructor in the Civil Department at AUB for two years. In addition, I worked as a designer in an engineering firm in Beirut where I was involved in the design of projects in the gulf area. During this period, I discovered the importance of pursuing a PhD degree; fortunately, I am here now at UT working with Dr. Murcia-Delso on the modeling of nonlinear mechanics of RC structures. I enjoy photography,

Farid Khosravikia

Having received my Bachelor's and Master's degrees from Sharif University of Technology in Iran, I have started to pursue my PhD at The University of Texas at Austin. My main research interests have centered around probability models, Risk-based decision making, structural reliability, earthquake engineering, and soil-structure interaction. I am currently working on assessing vulnerability of Texas bridges to natural and Induced seismic hazards as a graduate research assistant of Dr. Clayton's research group. I am so grateful of working at FSEL not only because of its perfect work conditions, but also because of meeting such wonderful people as you.

Alistair Longshaw

I'm originally from Aberdeen, Scotland before I eventually moved to Sugar Land, just outside of Houston. I'm a first year Master's student having just graduated with my BS from UT in May 2016. Although I am only just starting to work on the 0.7" strand project, some of you may recognize me from helping out with the MPR project during the summer of 2015. I'm looking forward to meeting/catching up with everyone at the lab!

Leandro Montagna

I am from a small town on the coast of the Salado River in Argentina called Santo Tome, which is a bridge away from the city of Santa Fe, the capitol of the state, where I did my undergraduate studies and received my Bachelor's degree in Civil Engineering. I came to the UT with a Fulbright scholarship and I am glad to be working since past semester with Dr. Trevor Hrynyk and Gabriel Polo on the Slab-Column connections project. In the time I've been here, I have met a lot of wonderful people working at FSEL and I believe we will have an incredible time.

Andrew Stam

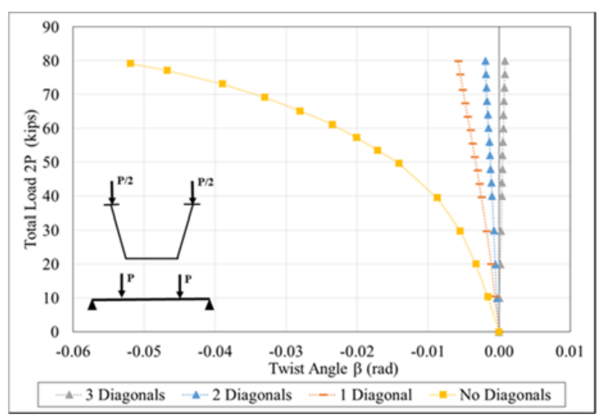
I'm a first year PhD student working with Dr. Bayrak and Dr. Hrynyk. Though I originally grew up in Oklahoma, I've spent the last seven years in Denver, CO, working for a commercial structural design firm called Martin/Martin.

After getting a UT Master's back in 2009 (my thesis was on high mast base plate fatigue... work that's still ongoing!), I just couldn't stay away and had to return for more Ferguson Lab adventures. In my spare time I enjoy music, cooking, ultimate frisbee and hanging out with my wife Emily and 7 month old son Jack.

Improved Tub Girder Details - Yang Wang & Stalin Armijos Moya

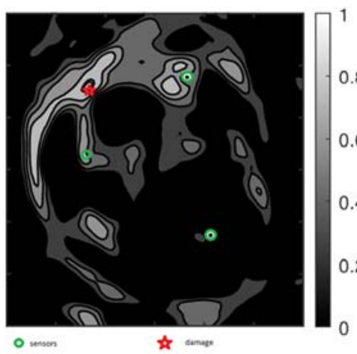
Tub Girder Test Setup

Steel trapezoidal box girders, known as tub girders, are a popular alternative in systems with large torsional demands, such as horizontal curved bridges, because of the torsional stiffness of their closed section. The objective of the current research study is to improve the economy and structural behavior of steel tub girders by modifying tub girder proportions and the bracing details for the girders. The activities during the Spring 2017 semester include experimental elastic-buckling tests of two tub girders with new proposed details. The tubs will be subjected to bending and combined bending with torsion to simulate demands on straight and curved girders, respectively. In order to measure the effectiveness of top lateral bracing and internal K-frame bracing systems, different bracing layouts will be tested on the same tub girder under the same loading conditions. On parallel, the results of the elastic-buckling tests of the first tub girder are been evaluated to calibrate finite element models.



Torsional Response with Different Partial Top Lateral Bracing Layouts

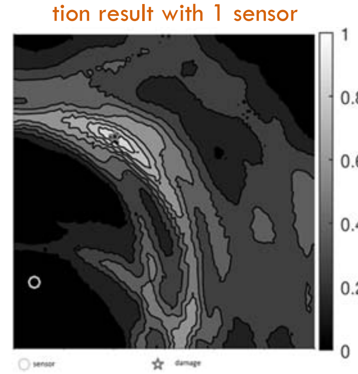
Damage Localization in Metallic Plate Structures using Edge-Reflected Lamb Waves - Arvin Ebrahimkhanlou, Brennen Dubuc



Active damage localization result with 3 sensors

Metallic plates have numerous applications in aerospace, marine, and civil structures. Aircraft wings and fuselages, ship hulls, bridge girders and gusset plates are some common examples. The goal of this research is to monitor and localize corrosion, fatigue cracks, and impact dents on plate structures. The number of sensors is minimized, because one challenge for the structural health monitoring techniques is the number of sensors, costly data acquisition channels, and size of the acquired data. The idea is to efficiently process the data and minimize the redundant data collection. To minimize the number of the sensors the novel idea of leveraging ultrasonic reflections from edges is investigated. These reflections are traditionally considered as noise and a challenge for most damage localization algorithms. However, the reflections carry useful information that can be leveraged with proper signal processing techniques. The extracted information help reduce the number of sensors and improve the localization accuracy. Damage localization techniques are broadly divided into “active mode” and “passive mode”. The group has already published the results for the active mode. Over the summer, the results for the passive mode was prepared for publication. The next step is to report the recently achieved probabilistic source localization results.

Passive source localization result with 1 sensor



Partial Depth Precast Concrete Deck Panels on Curved Girders – Paul Biju-Duval, John Kintz & Colter Roskos

Twin I-girder test setup

-This research program is investigating the use of precast prestressed concrete panels (or PCPs) as bracing elements in curved bridges during the construction phase. This fall, the research team tested designed PCP connection details on a full-scale twin girder bridge for both a simply supported and an overhanging case, applying loads at differing eccentricities to simulate varying radii of curvature. This experimental data will be compared with second-order FEA analysis to predict bracing applications for additional cases. The next step will be to test a steel tub girder system with PCPs attached. For UT Bridge 2.0, the program has been released on the FSEL website and more developments are underway.

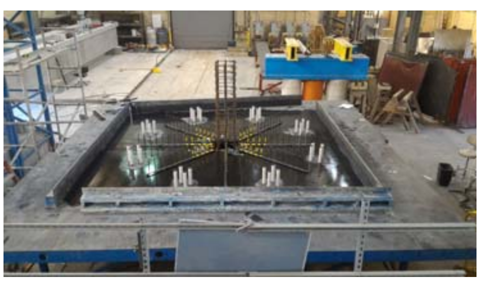
Fatigue Behavior of High Mast Illumination Poles with Pre-existing Cracks – Ying-Chuan Chen

High Mast Illumination Poles (HMIPs) are lighting members used to illuminate highways and major intersections. These poles consist of a lighting fixture and a multi-sided pole that is welded to a baseplate. This welded connection is known to be problematic in that it is susceptible to fatigue cracking. As such, this project aims to quantify the fatigue life of the weld to create viable retrofits for damaged poles (see image), and to estimate the remaining service life of poles currently in use. To do this, specimens are being laboratory tested at stress ranges from 1 to 6 ksi until cracks form. Thus far, six poles have been tested to failure at the Ferguson Laboratory. In the field, five poles have been instrumented with accelerometers, anemometers, and strain gages to gauge the local wind conditions and the HMIP's structural response. This data will be collected over the next year and combined with the results of the lab tests to estimate the remaining fatigue life of in-service HMIPs.

Researchers work to instrument a selected HMIP in Laredo.

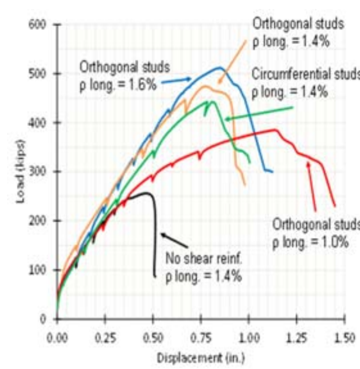
A proposed retrofit involves welding on stiffener plates to alleviate stress at the

Influence of Shear Stud Configuration on the Performance of Flat Plate Slab - Column Connections - Gabriel Polo



Fabrication of slab-column connection using circumferential stud rail configuration

This research is focused on investigating the influence of headed stud shear reinforcement configuration. An experimental program comprised of six full-scale reinforced concrete slab-column connection assemblies are used to investigate two shear reinforcement placement techniques: i) headed studs assemblies oriented perpendicular to the column faces, and ii) an evenly spaced circumferential arrangement of headed stud assemblies surrounding the column. The test series includes two control test specimens constructed without through-thickness reinforcement and is made-up of slabs constructed with two different flexural reinforcement ratios. The results obtained from the tests show that the slab-column connections containing a flexural reinforcement ratio of 1.4 percent failed in a highly-brittle punching shear-controlled mode; in contrast, the connections containing 1.0 percent reinforcement ratio exhibited ductile flexure-governed response prior to failure, with only limited resistance contribution provided by the punching shear reinforcement on the total resistance.



Load-Displacement Curves for Different Headed Studs Rails Configurations

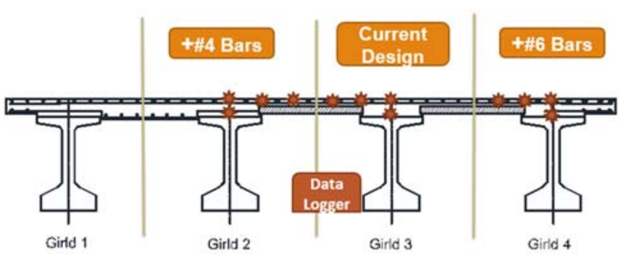
3D Printing Applications in Construction - Daniel Delgado Camacho

Arup's optimized node

Total Kustom's 3D printed hotel in the Philippines

3D printing produces components from 3D models, joining material in a layer upon layer technique. Already being applied in many industries such as aerospace, automotive and healthcare for small scale, large scale 3D printing for construction is still in its infancy. This project is a starting point for research in 3D printing for construction here at UT Austin, and will expand in the many different fields. So far, we have focused in understanding the work already done in 3D printing for construction, understanding the advantages and challenges of this technique, and potential applications in construction. 3D printing will require interdisciplinary research to provide new large scale systems, new materials, standards, optimized geometries, and evaluation of the components during printing and when completed.

Designing for Deck Stress Over Precast Panels In Negative Moment Regions - George Ge, Keaton Munsterman



Field Monitoring with Vibrating Wire Gages

One of the problems faced by designers for continuous girder systems is the lack of clear guidance in the AASHTO LRFD Specifications on the reinforcing requirements in the concrete deck, for both steel and prestressed concrete girders.

This research study will provide a comprehensive set of design guidelines and recommended details for the reinforcing steel to be utilized in the design and construction of continuous bridge systems that utilize partial depth precast concrete deck panels.

The research methods that are to be employed in this study consist of field monitoring, full-scale laboratory testing and parametric finite element modeling of the PCPs on a variety of continuous bridge systems commonly used in Texas.

Delamination of Curved Post-Tensioned Structures - Jongkwon Choi

Research aimed toward understanding the underlying mechanics and behaviors of curved post-tensioned concrete structures subject to prestressing loads is somewhat limited in the literature. Previous research focused on radial (i.e., out-of-plane normal) stress development has been analytical and, to the research team's knowledge, there is no experimental research on this topic currently available in the public domain. As a result, this research study is aimed at producing unique experimental data to gain important insights into the effect of localized tensile stresses and concrete delamination behavior in curved post-tensioned structures.

Three curved post-tensioned concrete structures were constructed and tested to delamination failure under monotonically increasing prestressing loads. In an effort to study the size-effect in delamination failure observed in such elements, all dimensions of the second specimen were double those of the first specimen, while maintaining the reinforcement ratio. Also, in order to investigate the effect of the aggregate size on the delamination failure, the third specimen had identical dimensions and reinforcement ratio with the second specimen except the concrete mix design. (the nominal aggregate size was increased from 3/8 in. to 1 in.) Based on the test results, several conclusions were made as follows:

- The test results showed a size-effect related influence on the delamination failures.
- The compressive stresses at the onset of the first delamination crack were 0.15 fc'~0.23 fc' which are lower than the allowable stress limit, 0.35 fc', specified in the ASME BPVC specification.
- Finally, the friction losses based on ACI 343R underestimated the actual friction measured during testing by 37 to 44 %.

The third specimen after the failure

Research team and FSEL staff together after the last test (Find Blake and Dean)

Strength Testing of Vertically Loaded Corbels - Heather Wilson

Corbels are commonly used to transfer loads from beams to their supports. The goals of this project are to verify that strut-and-tie design methodology is, indeed, a lower bound design method and to question the necessity of code required checks on the amount of secondary reinforcement. To date, four corbel specimens have been designed, constructed, and tested. Two of the aforementioned corbels were designed using ACI 318-14 Chapter 16 (Legacy Design Method), while the remaining two were designed according to ACI 318-14 Chapter 23 (Strut-and-Tie Design Method). All of the specimens failed at capacities greater than those predicted by either the Legacy of Strut-and-Tie methods. For strut-and-tie design the nominalized capacity (actual over predicted) ranges from 1.35 to 1.44 while for legacy design the nominalized capacity ranges from 1.15 to 1.27. Over the next few months this project will be completed through analysis and presentation.

Test setup and specimen prior to testing

Evaluation of Diagonally Cracked RC Bridge Members - Apostolos Athanasiou, Jarrod Zaborac

Diagonally cracked RC bent cap (Courtesy of Straddle Cracking Database OB)

This project focuses on the development of a mechanics-based and an image-based procedure for the evaluation of diagonally cracked reinforced concrete (RC) bridge members. A typical example of a diagonally cracked RC bent cap is shown below . From the literature review to -date, a majority of RC assessment procedures make use of empirically derived equations or finite element methods (FEM). While both methods have been shown to be successful, empirically derived equations tend to be limited in their applicability and FEM tends to be rather complex and time consuming. There are very few mechanics-based or image-based evaluation techniques (e.g., Calvi 2015; Ebrahimkhanlou et al. 2016). It is envisioned that these types of procedures may be more generalized, as well as simpler and quicker to use, than other procedure methods. A Visual Crack Measurement Database (VCMD) was completed in December 2016 as a tool for development, refinement, and evaluation of the procedures. Procedure development is currently underway on both the mechanics-based and image-based techniques.

End-Region Behavior of Pretensioned Concrete Beams with 0.7-inch Prestressing Strands – Rodolfo Bonetti, Hyun Su (Dennis) Kim, and Alistair Longshaw

This project aims to evaluate the serviceability and shear strength implications of using 0.7-in. strands in pretensioned Texas bulb-T girders (Tx-girders). This objective is accomplished through a series of parametric studies on the design of bridge girders, nonlinear finite-element simulations, and experimental studies on full-scale specimens.

The team pictured with the fifth specimen after failure.

In the fall semester, we fabricated the fifth and sixth specimens in the test program and investigated their behavior at the time of prestress transfer. Recently, both specimens were also tested under shear-critical loading. Results from the six specimens investigated so far have shown relatively satisfactory performance for Tx-girders with 0.7-in. strands at prestress transfer. Atypical shear failure characteristics, most importantly strand slip, were observed in almost all specimens. However, the capacities of the specimens were conservatively estimated using AASHTO LRFD specifications.

Our team is going to fabricate the seventh specimen in the spring semester, in which modified end-region detailing will be used to reduce the crack widths at the time of prestress transfer and improve the bottom-flange confinement to control strand slip.

Congratulations to FSEL 2016 Fall Graduates!!

- Vyacheslav Prakhov (MS)
- Mark Eason (MS)
- Nawaf Alotaibi (PhD)
- Dhiaa Al-Tarafany (PhD)

The Role of Gravity Framing in Seismic Response of Structures - Sean Donahue

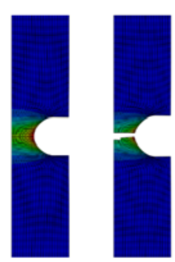
Typical seismic design for steel structures assumes all the lateral strength of a building is provided by the moment frames or braced frames, with the remaining gravity connections having no effective lateral resistance. Although composite gravity connections are known to have significant flexural strength, the nature of their response is currently not well understood. This research will examine the response of typical gravity connections under earthquake loads. Testing has shown composite clip angles can have high strength (50% of the girder Mp) and ductility, reaching 9% inter-story drift. However, this strength comes from a force couple created by binding of the girder and column, and tension in the metal decking. For secondary beams, where the decking is loaded across its ribs, this couple cannot form, significantly reducing the connection capacity. Future tests will investigate alternative connection details to improve the capacity by providing alternate load paths for the force couple.

Test Setup at 9% Inter-story Drift

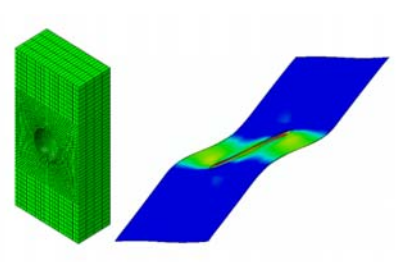
Improved Modeling of Ductile Fracture in Metals - Yazhi Zhu

Ductile fracture is recognized as an important failure mode in structural steel components. Prediction of ductile fracture in crack-free bodies has been of interest and extensively studied during recent decades. This research focuses on improving ductile fracture initiation prediction by carrying out multiscale modeling of ductile fracture occurrence. Such multiscale studies cover from micromechanical simulating fracture-resultant micro-void evolution to structural member fracture modeling. An analytical model for predicting ductile fracture initiation is proposed. The detailed finite element analysis is conducted to achieve more accurate prediction. To better understand the mechanism of ductile fracture, a micromechanics-based model involves the void contained representative volumetric element (RVE) is built to investigate the effects of stress states (stress triaxiality, Lode parameter, shear stress component) on the void growth as well as the mechanism of void coalescence.

Ductile fracture sometimes occurs with strain localization, which commonly exists in steel material. Classical continuum theory shows ill-posedness in describing such deformation process and conventional finite element analysis exhibits a strong mesh dependency and does not achieve a converged physically meaningful solution. This research also uses a 3-D isoparametric element based on Cosserat continuum theory to take account the length effect and handle with the mesh dependency issue in modeling strain localization as well as ductile fracture.



Specimen Modeling



RVE micro-void modeling

JNT Golf Tournament

BASTROP, TX This year is the 24th Annual J. Neils Thompson Golf Tournament. Each year, typically after finals week is over, Ferguson Lab organizes a golf tournament to help connect students, faculty, staff, and members of industry together for a relaxing day of 18-holes in Bastrop, Texas and to honor J. Neils Thompson, the lead developer of UT's civil engineering research program, as well as a scratch golfer.

The tournament is designed to provide golfers of all skill-levels, even those whose skill level is zero (around 25 % of the participants play golf for their first time here), an enjoyable experience. Typical turnout of past tournaments was a mixture of about eighty students, faculty, staff, and industry representatives. The tournament format is "shotgun start" and "best ball scramble." That is, teams of four start on different holes simultaneously and play from the best shot of the four team members for each stroke. This means even if you can't make it out of the sand trap or over the water, all hope is not lost as long as someone else can!

As mentioned before, in addition to the opportunity to play 18-holes with your classmates and professors you see on a regular basis, you will be able to network with the professionals who sponsor the tournament (this means it costs less for students, so be sure to thank them!). There are several "special rules" in place designed to make even a complete newbie into Tiger Woods, so don't be nervous about joining in on the fun just because you haven't played before. Many details are in flux currently, but y'all will be the first to hear about it once the specifics are nailed down.

2016 Winning Team
Wendall Hirshfeld
Todd Helwig
Jacob Helwig
Sam Helwig

Use string to save a stroke

Everyone has a chance to sink the winning putt!

BUILDING24 COMMITTEE

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

Information about the Newsletter

The goal of this publication is to keep those working at FSEL aware of the status of ongoing projects around them. In addition to projects, we may also highlight special events, people, or news of interest. The newsletters will come out once a semester, three times a year.

In this first issue of 2017, 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.

Feedback
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