Ferguson Structural Engineering Lab Newsletter

THE UNIVERSITY OF TEXAS AT AUSTIN - STRUCTURAL ENGINEERING

Volume 1, Issue 1

September 1, 2009

Welcome To 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, twenty-five 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.

In the next issue (end of the fall semester/ beginning of the spring semester), each research project will be updated and those projects that started this fall will be highlighted.

New Faces at FSEL

A few students have started working at FSEL recently. If you haven't met or had a chance to get to know them yet, here is a little introduction. I'm sure they would still appreciate it if you bought them lunch* some Thursday.

Tim "*Sweet Tea*" Jennings

I grew up in several different states (Virginia, Missouri, Arizona, Alabama, and Florida), but home for me is really the south. I finished high-school in Jacksonville, FL (where my parents still are), and went to undergraduate at the University of Florida where I majored in civil engineering. During college I met my wonderful wife, Abby, who is from Midland, TX, and she brought be to the great state of Texas. For the next four years I worked for MACTEC in Austin doing transportation. Spring of 2009 was my first semester at UT.

Adam "*Snackam*" Kirk

I was born and raised in Oklahoma City and did my undergraduate at Oklahoma State (not OU!) I wandered down to Austin and UT in the fall of 2008, and started my research at FSEL this summer. Outside of school I enjoy golf, frisbee, camping and taking my 2 dogs to all the parks in Austin.

Andrew "*Make Love Not*" Wahr

There once was a boy from Col'rado

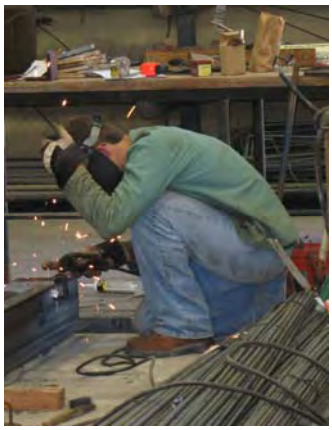
Who took his bachelors West of Ohio

He went down to Texas

In search of a princess

But found himself stuck with you schmoes

Inside this issue:

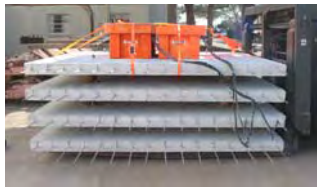


Stephen's Hot Tip!
"Welding for 6 straight hours without a welding jacking is a great way to work on your base tan"

Editor's Note: Welding without proper protection will cause severe burns (i.e. you need a welding jacket).

Cracked Panels - James Foreman & Stephen Foster

We are working on a TxDOT-sponsored project aimed at controlling cracking in bridge deck panels and optimizing bridge deck reinforcing. The project really has two different parts. One part is studying cracking in precast concrete panels (PCP). The cracking occurs during production and transportation. We currently have four PCP specimens at the lab. Three are stacked outside the lab and one is currently being tested on the lab floor. The second part of the project is aimed at optimizing the layer of reinforcing steel used in the 4" CIP topping on bridge decks. TxDOT currently recommends a uniform mat of #3@6" and #4@9". We will be exploring the possibility of smaller bars, tighter spacing, and potentially using welded wire mesh. Most research so far has consisted of literature review and analysis. Soon large scale specimens will be cast on the lab floor to allow for testing of different top options.

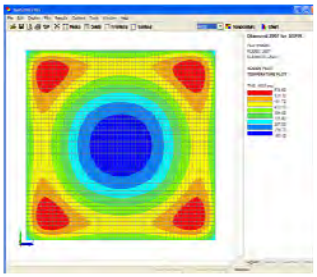


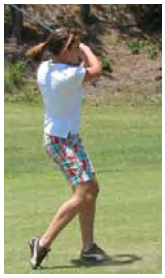
"IF THERE IS ONE THING STUDYING HEAT TRANSFER HAS TAUGHT ME, IT'S THE VALUE OF A JUMBO SWEET TEA."

-TIM "*THE MANN*" JENNINGS

Structural Fire Heat Transfer - Tim Jennings

This project is one of many needed steps to better understand behavior of structures during fires. A powerful program called SAFIR developed at the University of Liege is available for structural fire modeling, but the user interface does not allow full use of SAFIR's capabilities. My program, built with Visual Basic, will allow quick and user friendly production of common structural sections. The user can produce common shapes with the I-Section, Rectangular, Circular, or Circular Hollow Wizards, and then customize that section to their need. The user can then assign up to 25 different materials to the section as well as assign various fires.





"Git off my concrete island."

-Nancy "*Use it or Lose it*" Larson

ASR Damaged Box Beams - Tz-Wei Wang & Nancy Larson

The goal of this project is to measure the shear capacity of alkali-silica reaction (ASR) and delayed ettringite formation (DEF) damaged box beams. We hope to be able to compare the levels of deterioration and the performance of the beams. So far we have tested two moderately damaged beams and one with mild expansive cracking.

We are currently in the process of testing one of our more heavily damaged box beams followed shortly by one with little to no cracking.

CFRP - Yungon Kim & Kevin Quinn

Project 0-6306 is continuing to experimentally observe the performance of RC elements strengthened in shear with carbon fiber reinforced polymer (CRFP) sheets. Past research has demonstrated that CFRP sheets have a significant deformation capacity (rupture strain equal to 0.01 or greater). However, these sheets have a tendency to debond from the concrete substrate before the rupture strain can be reached when sufficient anchorage is not provided. Project 0-6306 is developing an anchorage detail to effectively "pin" the CFRP sheets to the concrete elements without the need of any additional mechanical anchors. Experimental results have been very promising, providing up to a 45% increase in shear capacity.

Kevin loves his project so much, he could talk about it for 18 hours straight.

Improperly Placed Shear Stirrups - Jason Varney

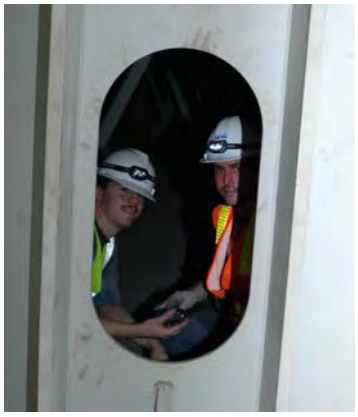
Over the course of several projects, WDP and Associates has observed various improperly anchored shear stirrups in reinforced concrete beams. Although detailed correctly in contract drawings, field observations include unanchored center legs and the lack of longitudinal bars in the corners of closed stirrups (contrary to requirements set forth by ACI 318-08). The objective of this project is to evaluate the effect that these improperly constructed sections have on the shear strength of the beam so that appropriate repairs can be designed for affected buildings.

"I EAT LOBSTAH FOR BREAKFAST, LUNCH, AND DINNAH."
-JASON "*HOT WHEELS*" VARNEY

Curved Plate Girder Design - Jason Stith & Brian Petruzzi

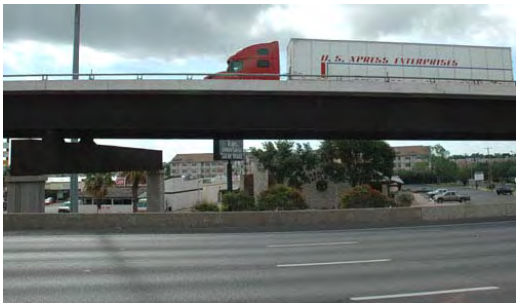
The project goals included field instrumentation, parametric studies, and program development. Currently, the field instrumentation has been successfully completed on the SH71 to SH130 direct connector as well as an additional test at Hirschfeld Steel Plant in San Angelo, Texas. Parametric studies to understand the behavior of curved girders during lifting and of bridges partially constructed have been completed using ANSYS 3-D models. Two programs are being developed. UT Lift, a macro-enabled Excel spreadsheet for lifting of curved girders, and UT Bridge, a 3-D finite element analysis program with a GUI preprocessor and post-processor for bridge erection sequencing and concrete deck placement, are currently being verified and improved.

You might not have guessed it from his pale LCD tan or his soft, girly hands, but Jason is actually an avid outdoorsman. His favorite hobbies include gig'n frogs, skeet shoot'n, and canoe'n.



Wireless Fatigue Monitoring - Jeremiah Fasl & Vasilis Samaras

Earlier this summer, we investigated wireless devices for use in monitoring fatigue-sensitive areas in bridges. Specifically, two different systems, one based on IEEE 802.11g (typical Wi-Fi) and the other on IEEE 802.15.4 (ZigBee: a low-power system that is low-cost), were evaluated at two bridges in Austin. The results were promising with individual ZigBee nodes being able to transmit data over longer distances (even in steel, which tends to disrupt wireless signals) as compared to the Wi-Fi system (480 ft vs. 260 ft). We also collected acceleration data for a week (over 600 million data points!!) to determine typical vibration ranges due to traffic for the energy-harvesting side of the project. Over the next few months, we will continue to evaluate both technologies in the laboratory and field as well as explore the literature for other wireless systems and damage detection algorithms.



IN THE COMING WEEKS, ANIMALS, TWO BY TWO, WILL BE ENTERING THE ARK THAT ANDY HAS BEEN BUILDING OUTSIDE THE LAB.

U-Beam Shear Study - Catherine Hovell & Andy Moore

The beams being built within the prestressing frame on the elevated slab are examples of standard TxDOT U-girder sections. We are building them in-house so as to have the time to fully instrument the bars within the beam. Our two loading cases of concern are at release of prestressing and under shear loading. In mid-July, we cast our third beam, a 30 ft section with 45% of the strands debonded. The beam was tested in shear in August. This fall, we will be constructing and testing several new beam designs with the goal of improving the basic design of the U-Beam and dramatically increasing shear capacity.

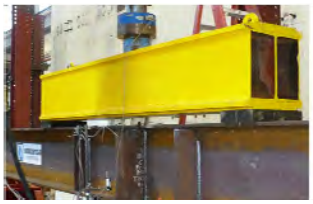
Alejandro: "Watch out—it is going to fail!"
Jeremiah: "You should have used a steel girder—it doesn't make such a mess..."

Shear Performance of Box Beams - Alejandro Avendano

The 10 busted box beams you might see around the lab had plenty of variables being studied. Mainly, half of them were fabricated using Self-Consolidating Concrete (SCC) which we still know very little about. SCC requires no vibration upon placing, making fabrication a whole lot easier. In SCC, the paste fraction is increased and some are worried of this affecting shear performance (hence we broke them to check). Soon we'll be cutting the SCC beams to see if there was any aggregate segregation. After that, we'll fabricate a couple larger specimens here at FSEL and try to improve on some other issues we found.

Bent Plates - Craig Quadrato, Anthony Battistini, & Andrew Whar

Cross frames are essential to the stability of straight steel girder bridge systems during construction. In skewed bridges, current detailing specifications require the end cross frame to be placed in line with the skewed support, and hence at an angle to the girders. Typically plates, bent to match the skew angle, are used to connect the cross frames to the stiffener. The flexibility of this bent plate connection can significantly reduce the cross frame bracing effectiveness. To improve the situation, a proposed connection utilizing a half pipe stiffener is being investigated. The new detail requires less fabrication, creates a stiffer connection, and increases the buckling strength of the girder due to its warping resistance. Right now, small scale tests on the bent plate and half pipe details are completed and show the half pipe's structural performance to be superior. Large live load forces can lead to fatigue cracks at the connections, so fatigue specimens are being run to compare the regular stiffener with the half pipe. As the fall semester begins, large scale buckling tests will be conducted to analyze system performance using both connection types.



FlexCrete™ Walls – Ali Abu Yousef & Hossein Fadaifard

FlexCrete™ walls are fiber-reinforced Aerated Concrete (AC) wall systems. The walls are constructed by attaching the AC panels to wood or steel studs and then wrapping them by fiber mesh. The objective of this project is to investigate the resistance of FlexCrete™ wood-stud wall assemblage to wind-induced suction. To simulate suction, the 7x8 ft wall specimen is attached to a perimeter frame creating a chamber that is evacuated using vacuum pumps. The setup is encased by plastic sheeting to prevent air infiltration. Pressure differential (between the evacuated chamber and air) is measured using a pressure transducer. In our first test, the wood studs failed by flexure at 160 psf. Right now, we are setting up the second specimen…**get ready for the noise**!

FUN FACT!

THE FIRST TEST REQUIRED:
- 12 ROLLS OF DUCT TAPE
- 6 GALLONS OF LIQUID SEALANT
- 2,000 SQ FT OF PLASTIC SHEETING
- 5 SHOP VACS

Hossein - "You can fix *anything* with a roll of duct tape"

AAC Infilled Steel Moment Frame

An infill is a panel of masonry or concrete placed within beams and columns of frames, usually for non-structural reasons (example: partition wall). The objective of my project is to develop design provisions for steel moment frames (SMF) infilled with Autoclaved Aerated Concrete (AAC). We tested an AAC infilled SMF to validate these provisions for AAC infills. We also use ATC-63 methodology, a recent analytical procedure, to determine seismic design factors for AAC infilled SMFs. We propose design guidelines to avoid unfavorable failure mechanisms such as weak stories or local shear failure in frame members from frame-infill interaction. These design guidelines will ensure improved performance of AAC infilled SMFs compared to the bare frame under lateral loads.

"Climbing ladders in the lab taught me to take life one step at a time"
-Shiv "*Shearwall*" Shanker

"Patented *Birthday Candle* Ignition System" – best way to celebrate fire!

Just don't forget to blow out the candles!

Positive Pressure Ventilation Research – Mustafa Abbasi, Kevin Carollo, David Gramlich, Craig Weinschenk

Firefighters use positive pressure ventilation (PPV) to remove hot combustion products from a fire room using strategic ventilation and a large fan. Our fire research focuses on characterizing the room environment under PPV, studying its efficiency and fallbacks. Our testing parameters include vent location and a failure in the gypsum walls to represent potential void space for uncombusted fuel. We plan on increasing our fire size in future tests from 150kW, about a trashcan size fire, to 0.5MW using sand burners. The experiments are modeled with the computational fluid dynamics program: Fire Dynamics Simulator. Future experiments for the burn structure include rescue robots and wind studies for PPV.

"Hi-Ho Silver! Away!"

Fatigue Poles - Stephen Pool & James Kleineck

Over the past few years, many DOTs have experienced problems with high mast luminaries and traffic mast arms falling due to cyclic loading from wind. To address this problem from the resistance side, our project has been investigating how to better design base plate to pole wall connections (the typical failure location) through analytical and experimental testing. The project has been active since 2003 and has spanned multiple phases, and now nears completion.

More recently, we have also discovered that small initial cracks can originate under specific conditions in the base plate to pole wall welds due to the galvanizing process. This cracking, and fatigue cracks in the field are both of concern. We are currently developing and testing weld repair procedures to deal with both initial and fatigue

BEST FITNESS CLUB IN TOWN

*Free for students!

Located at FSEL INCLUDES:
-Weight training equipment

-Bridge climbing

-Two "full-size box girder" sauna rooms

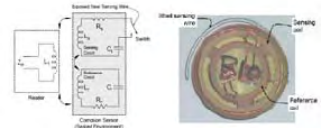
-Many other great amenities!

Trapezoidal Steel Box Girder Bridges - Janghwan Kim & Vasilis Samaras

The development of methods for evaluating twin box girder bridges is the main goal of this TxDOT-sponsored project. A full-size bridge has been constructed and tested dynamically and statically at FSEL. The bridge had minor damage after being loaded with a design truck over a completely fractured girder and dynamically tested. Thus, the bridge was loading statically, where it sustained over 4.5 times the design truck load before collapsing. 26,000 ft of cable and over 220 strain gages and potentiometers have been used to instrument the test bridge. Data from all the tests were used to calibrate the 3-D finite element analysis model. Simplified models were also developed to approximately estimate the behavior of the bridge after a fracture event. Parametric studies on different geometries and other bridge characteristics are currently analyzed.

Corrosion Detection – Chih-Chieh Chou & Ali Abu Yousef


Corrosion of reinforcing steel is a major problem that affects the durability of most infrastructure components. Over the past few years, researchers from the ECE department and FSEL have developed a passive threshold corrosion sensor. The sensor was envisioned to be cheap, reliable and not have an onboard power supply. The sensor is powered and interrogated in a wireless manner using magnetic induction. The sensor is made of an RLC circuit and is connected to an exposed steel wire that acts as a medium for corrosion. A reference circuit is employed to locate the sensor. The change in the resonant characteristics of the sensors is used as an indication of corrosion state. Currently, we are testing a new generation of passive sensors that uses the effect of magnetic shielding on frequency response as means of corrosion level detection. Also, a sensor that detects changes in conductivity in different chloride concentrations is being developed.



"Passion, imagination, and creativity are the three most important components in this project. Any clue appearing in your mind today may be the solution tomorrow."

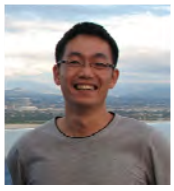
Quality Control of CFRP Anchors - Guillermo Huaco

Carbon Fiber Reinforced Polymer (CFRP) material is used for structural rehabilitation projects. Due to bending and/or shear effects, CFRP sheets lose adherence from the concrete surface and can debond. Thus, CFRP anchors can be designed so that the sheets reach their full tensile capacity. A reliable method to test and control the quality of CFRP anchors has been developed using small-scale high-strength concrete beams reinforced flexurally with external CFRP sheets adhered to the beams with epoxy and CFRP anchors. In this test, a vertical force is applied at the beam`s mid-span. Plastic wrap is used between the concrete surface and the CFRP sheet to ensure that the tensile force associated with bending in the CFRP sheets is transmitted directly to the CFRP anchors. The shear capacity of the anchors can then be found through the measurement of the vertical load.

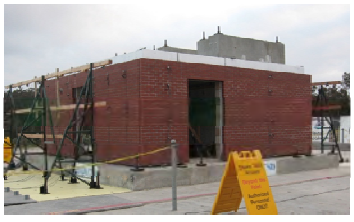
"PERSEVERANCE IS ONE OF THE KEYS TO SUCCESS."

-GUILLERMO "*CANDYMAN*" HUACO

Performance-based Design of Masonry Structures – Seongwoo Jo



NSF NEES is sponsoring a project on performance-based design of masonry and masonry veneer. Many low-rise residential and commercial buildings in North America are masonry structure—Even FSEL! This project examines inelastic behavior of low-rise reinforced concrete masonry structures with masonry veneer, develops an analytical model implemented in FEM-based software OpenSees, and proposes refinements to performance-based design provisions. The analytical model is not complex but can catch all the key behaviors of the low-rise masonry structure. We conducted quasi-static and shake-table testing of reinforced concrete masonry walls with masonry veneer. We also tested on a shake-table in UC San Diego a full-scale, one-story structure of reinforced concrete masonry with masonry veneer. Parameter studies using OpenSees are in progress to better understand the effect of each structural element. The technical information to refine performance-based design provisions will be provided shortly.



"You might not have noticed that Ferguson laboratory is a masonry structure."

Fire of Bouwkunde Building
© Rob Jastzreebski

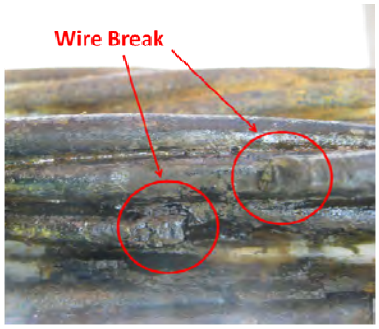
TU Delft Bouwkunde Fire Investigation - Adam Kirk

For structural fire protection to move to a truly engineered design approach, a better understanding of how fires move through large buildings and the behavior of structures at elevated temperatures is needed. This project is a case study in the behavior of a reinforced concrete building in fire.

On May 13, 2008, the School of Architecture Building, or "Bouwkunde," at the Technical University of Delft, Netherlands suffered a fire that resulted in the collapse of the NW wing of the 16-story building. No one was injured but the building was a complete loss.

The collapse of a concrete building due to fire is rare; this project aims to determine likely causes of the Bouwkunde collapse. Other main goals include comparing the design with current US regulations for structural fire protection and identifying areas where modifications to current building standards may be needed. A full analysis of the building's structural system due to the elevated temperatures is underway, utilizing the modeling software developed by fellow UT grad student Tim Jennings.

Response of Damaged PT Tendons - Chris McKinstry



The research project focuses on using the dynamic properties of a grouted external tendon to infer the effective prestressing force in the tendon. The dynamic properties include both the natural frequencies and the mode shapes. The natural frequencies are directly related to the effective prestress force and the mode shapes are related to the geometry and extent of damage. A total of four large scale specimens are to be evaluated, with data collection of two of these specimens ongoing. Damage is induced by accelerated corrosion, which focuses on corroding one wire in a strand at a time. Dynamic data is collected after every wire break.

AAC Research - Miguel Forero

As part of the autoclaved aerated concrete (AAC) research, experimental work is being done to refine the current MSJC value for interface shear strength between grout and AAC units and to verify that the current MSJC provisions for lap splices in grouted cores surrounded by AAC are safe. Test setups were designed earlier this year and construction of the test specimens began during the summer. In this process, blocks were core-drilled: 108 blocks with two cores each for the splice test and 48 blocks with one core each for the interface strength test. Construction should be finalized in the coming weeks, and testing is planned to start in October.

Flexure-Shear Critical Columns - Matt LeBorgne

This research will increase understanding of the complex mechanisms that occur in the end regions of gravity load resisting columns before and after shear failure during a seismic event. More specifically, this research is focused on flexure-shear critical columns which yield in flexure, sustain shear failure, undergo shear strength degradation to a residual capacity, and then experience axial failure leading to collapse. Current work is underway to develop the Rotation Based Cyclic Strength Degradation Model that is able to detect shear failure initiation and model the degrading shear strength until the residual shear capacity is reached. Future work will include full scale testing of columns to gather information on the strain field of the end regions using a non-contact photometric measurement system currently in development at UT. The strain field will provide new insight regarding the locations of struts, rigid body induced rotations from bar slip, plasticity spread in column end-regions, and column shear deformations.

"Programming in C++ is a good way to learn humility"
– Matt "*Iron-man*" LeBorgne

Bracing Truss Systems - Rangsan Wongjeeraphat

Truss buckling behavior is not well understood due to the complexities of the truss system. The purpose of my research is to investigate the truss buckling behavior with and without bracing system. The load height effect and locations of bracing are also under the investigation. The experiments consist of buckling tests on two 72 ft. long trusses. To understand bracing behavior, the number of brace points was examined as well as both lateral and torsional systems of varying stiffnesses. Gravity load simulators were used to ensure the applied loads remain vertical all the time. Based upon the study results, we will develop the bracing formulations for truss systems that can be used to design and detail proper stability bracing for a variety of truss configurations.

NDT for Members with ASR/DEF - Eulalio Fernández

The objectives of this project are NDT evaluation of four full-scale prestressed beams cast in 1995 and validation of the results by autopsying one of the beams.

The main goal of the NDT evaluation is to determine the extent of damage due to the expansive reactions and estimate the crack depths. The evaluation of the beams includes several techniques such as Surface Wave Transmission Analysis, Impact Echo and Ferro-Magnetic tests.

The autopsy consists of injecting dyed epoxy in the beam to trace the cracks before slicing the beam at various locations to compare the findings with previous NDT evaluation results.

NDT Evaluation of Specimens

Dave downloads thermocouple data and models the latest in neck-scarf fashion

Effect of Pre-stress Losses - Dean Deschenes & Dave Dunkman

Project 6374 examines prestress losses in pretensioned concrete beams. Over time, 25 to 35% of the initial prestress "disappears" from beams due to elastic shortening, creep, shrinkage, and other effects. The AASHTO LRFD bridge code recently adopted new prestress loss equations aimed at accuracy, rather than conservatism. TxDOT engineers, however, were uneasy with the potentially unconservative loss predictions, which could result in cracking under service loading, prompting the project.

This summer, sixteen 40 in. deep I-beams have been cast, half with embedded vibrating wire gages. Using these gages, prestress losses can be monitored over time. Eight more beams will be cast in the fall. After 12 to 24 months of conditioning, the beams will be tested in flexure. From the cracking load, losses can be back-calculated. Until then, the researchers plan to take a lesson from the prestressing strand in their beams, and relax a bit.

"BMW? Porsche? Lamborghini? No thanks. Make mine a Tuckerbuilt."
- Dean "*Big Deal*" Deschenes

BUILDING24 COMMITTEE

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

After finishing a summer full of breaking beams, Alejandro flew back to Panama to cement his relationship with Analissa Icaza. On August 7, 2009, Alejandro married Analissa on a night of love, mystique, and fireworks. Congratulations to both Alejandro and Analissa!

Analissa moved to Austin earlier this month and has just started the Master's program in the Transportation Engineering program at UT this fall.

Special points of interest:

- *Welcome BBQ will be Friday September 11th; Social hour starts at 5pm and food served at 6pm
- First-years vs. Old-timers Flag Football Challenge: October 30
- First home game tailgate is Saturday September 5th. Starts EARLY, location TBD
- STEER 2010: Spring Semester, Date TBD

* beer provided

Fall Tailgates

The UT Football season starts on September 5! Follow the Longhorns as they try to become the Big 12 Champions and earn a bid to the BCS National Championship Game. As with prior seasons, we will be tailgating before the home games. Expect to see an email with details about the location of the tailgates prior to each home game. Hope to see you there!

Although he enjoys working around the lab, if you keep Andrew idle for too long, he may get bored and try to find a place to curl up for a nap.

Intramural Sports

Intramurals are a great way to hang out with your fellow researchers. The fall intramural schedule includes Flag Football, Soccer, Volleyball, as well as other special events. The FSEL soccer team has historically done very well, including even winning it one semester! Though, the team has quite a hole to fill in the goalie position, they should still be very competitive. If you are interested in playing on the soccer team, send Jeremiah an email (jdfasl@mail.utexas.edu), especially if you know a goalie.

Feedback
Jeremiah Fasl
E-mail: jdfasl@mail.utexas.edu