Phil M. Ferguson Structural Engineering Laboratory

University of Texas at Austin

By John E. Breen, P.E.

The structural engineering program at The University of Texas at Austin (UT) is internationally recognized as one of the strongest and most balanced. It has produced numerous students who have gone on to professional careers of high achievement in both the bridge and building areas. Recommendations from its research and development programs have had great impact on the AASHTO bridge design and construction specifications, the ACI building code, the AISC design specifications, the API design criteria for tubular off-shore structures, and the masonry design codes. Faculty and students have won a wide range of awards from national and international technical societies for the quality of their reports and papers. Five of the faculty who have been highly active in the laboratory have been elected to the National Academy of Engineering for their career accomplishments.

Figure 1: FSEL faculty in 1983 on Professor Ferguson's last visit to the laboratory.

History

The graduate program in structural engineering at UT was a "Johnny come lately" in comparison to the historically well-developed programs at institutions like Lehigh, Cal-Berkeley, Cornell, Illinois, Purdue and Wisconsin. The Austin program was largely an undergraduate teaching program, with a small number of MS degrees, until the end of World War II. During the postwar boom in education, UT added more graduate courses and developed relatively limited experimental facilities in Taylor Hall, the home of the Department of Civil Engineering in the heart of the Main Campus. In quite primitive facilities, Professor Phil M. Ferguson and J. Neils Thompson began structural research using small but well-thought-out specimens in reinforced concrete and masonry. Their insights into important practical problems unlocked several structural design mysteries. Some of their research in bond and diagonal tension received an ACI Wason Medal.

In 1960, an unusual opportunity presented itself. The need for very large reinforcing bars, for use in facilities like the Atlas missile silos, required structural testing of specimens to determine bond, development lengths, splice lengths and shear design provisions. The specimens were so large that it was physically impossible to handle them in most existing US structures laboratories, and certainly in UT's Taylor Hall. Neils Thompson was Director of an off-campus UT research park, the Balcones Research Center (BRC). A magnesium refining plant during WWII, it had been turned over to the University on a no-cost lease, provided that UT used it for academic research. One of the buildings had a crane bay 50 feet wide by 400 feet long, serviced by a 25-ton overhead traveling crane. Neils suggested to Phil that it would be excellent for structural research, and made about 75 feet of the crane bay available. An ingenious set of steel reaction straps coupled with a mammoth concrete beam served as a loading system, using commercial hydraulic rams. The system was very successful and the present laboratory, then called Civil Engineering Structure Research Laboratory, was begun in the existing Building 24 at BRC, now called the J.J. Pickle Research Center.

The facility housed a wide range of innovative tests in reinforced concrete, prestressed concrete, structural steel and masonry. Dr. Tony Toprac secured funding from the structural steel industry to add a major fatigue testing component with a very large displacement pulsator and a large, elevated strong floor.

In the late 1960s, UT was planning a major building for Civil Engineering, again on the Main Campus. It was obvious to the faculty who had been very successfully conducting tests at BRC that many structural engineering phenomena had to be evaluated using essentially full-scale specimens. There was no way that such specimens could be handled on the Main Campus. The faculty made a proposal to the UT Administration that the Main Campus proposal for a laboratory be greatly reduced, and part of the savings be invested in improving facilities in the old building at BRC. UT accepted this proposal and, under then-Director John Breen, constructed major upgrades in 1972, including an 80-foot by 40-foot strong floor and support offices.

Several years later, under the leadership of Jim Jirsa, a major NSF facilities and instrumentation grant allowed construction of a highly innovative strong floor with integral strong walls. Subsequently, UT has added further load floors and very large capacity reaction frames. Recently, under the leadership of Karl Frank and Mike Engelhardt, the facilities have been upgraded to allow high temperatures for structural fire testing, and fatigue tests on components and joints.

Figure 2: Main 400 foot long crane bay of FSEL.

From the earliest days, the laboratory had been inspired by the philosophy of Professor Phil M. Ferguson. A brilliant researcher who was highly conscious of practical applications, Ferguson insisted on rigorous studies utilizing specimens reflecting careful detailing, and loads simulating real bridges and buildings. He led promising studies in combined flexure, shear and torsion and in slender columns as part of building frames under combined axial, flexural and lateral loads. He emphasized design of loading facilities specifically for a project, rather that investment in large, permanent machines. Ferguson assembled a team of highly qualified researchers – Jack Breen, Ned Burns, Ramon Carrasquillo, Karl Frank, Dick

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Figure 3: Fatigue Test of a full size pretensioned girder on elevated test slab.

Furlong, Jim Jirsa, Rich Klingner and Joe Yura (*Figure 1, page 18*). He set a good example and then stepped aside, letting his young colleagues do their thing. In 1980, the UT Board of Regents named the laboratory after Professor Ferguson, recognizing his international leadership in the field.

Facilities

The Phil M. Ferguson Structural Engineering Laboratory (FSEL) is one of the largest such research facilities in the world. Multi-story structures, full-scale structural components, and multi-girder bridges have been tested there.

The laboratory occupies 45,000 square feet, and the main structural test area is 400 feet long by 50 feet wide. Most of this area is provided with structural tie-down floors for attaching loading frames and test specimens. Two overhead traveling cranes serve the structural test area (*Figure 2, page 18*).

Auxiliary shops are located on each side of the crane bay. Complete facilities are available for fabrication and instrumentation of test specimens. A comprehensive range of hydraulic actuators, pumps, and closed-loop loading systems permit application of static, dynamic, and fatigue loads.

A super-sized frame is available for testing large columns under combined axial and lateral loads. The three-dimensional reaction system includes a 44-foot by 32-foot strong floor with 19-foot buttressed walls along the east and south edges.

A major structural test floor is 140 feet by 40 feet, and an elevated fatigue test slab is 60 feet by 30 feet (*Figure 3*).

The high-temperature test facility includes three MTS uniaxial test frames with capacities of 22 kips, 220 kips, and 550 kips. The environment chambers are capable of reaching temperatures up to 1600 degrees Fahrenheit.

A large-scale beam test facility can accommodate spans of up to 21 feet, with maximum applied loads of 4,000 kips.

Philosophy

Throughout its 50-year history, FSEL has adhered to a clear set of principles. All research projects are an integral aspect of graduate education; this means that the graduate students are full partners with the faculty in all studies. While the laboratory has a small core of well-trained technicians as support and maintenance staff, the design, fabrication, instrumentation and loading of test specimens is largely a graduate student activity. This teaches the students not only technical lessons, but also very important managerial and human interaction skills. Generally, most projects require “borrowing” manpower from other projects, which is repaid by helping their fellow students. Reports and papers are jointly authored as teams, with multiple faculty members involved.

Faculty and students not only work together – they also play together. The J. Neils Thompson Memorial Golf Tournament is held annually on the day following the last final examination of the spring semester. Last year, some 88 students, faculty and alumni participated. Approximately every four years, STEER (Structural Engineering Education and Reunion) is held, bringing alumni of the FSEL program back to campus to share their professional experiences with current students.

Major Contributions

There have been many research programs at FSEL that have received major awards from professional organizations, or resulted in major additions to codes or standards – or frequently both. A sampling is included herein.

- Interaction of Shear, Diagonal Tension and Required Development Length.
- Interaction of Flexure, Shear and Torsion in Reinforced Concrete.
- Behavior and Design of Slender Concrete Columns in Frames.
- Lateral Bracing Requirements in Structural Steel Buildings and Bridges.
- Behavior and Design of Tubular Joints.
- Corrosion and Fatigue Protection for Cable Stays.
- Development and Splice Length Requirements for Reinforcement.
- Anchorage Requirements for Hooked and for Headed Reinforcement.
- Effect of Painted Surfaces on High Strength Bolt Groups.
- Behavior, Design and Construction of Precast Post-Tensioned Segmental Bridges.
- Improving Corrosion Resistance of Post-Tensioned Bridges.
- Behavior and Design of Neoprene Bearings under Repeated Loading.
- Fatigue Design of Highway Light and Sign Masts.
- Design of Post-tensioned Anchorage Zones.
- Strut-and-Tie Modeling in Structural Concrete
- Anchorage to Concrete.
- Jointing of Jumbo Steel Members for Seismic Resistance.
- Behavior and Design of Multipanel Unbonded Post-Tensioned Slabs.
- Behavior and Design of Composite Columns.▪

The FSEL website provides access to completed PhD dissertations, MS theses and many research reports. It can be visited at **http://fsel.engr.utexas.edu/publications/**.

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