California State University, Fresno
Department of Civil & Geomatics Engineering & Construction

Potential Joint Research Projects between CSUF and USC Structural Engineering Faculty

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1. <u>**Research Facilities at Fresno State:**</u>

1.1 Structural Engineering Laboratories

The Structural Engineering Research Laboratory at California State University, Fresno was constructed in 1992 and is housed in the East Engineering building. A unique attribute of the lab is the strong floor and reaction wall. A brief description of the components of the Structural Lab follows:

1.1.1 *Strong Floor and Reaction Wall:*

The strong floor is a 2 ft thick, reinforced concrete, floor slab with plan dimensions of 52 ft by 23 ft that is used for testing of large- or near full-scale building and bridge components or systems. Floor tiedowns, spaced 2 ft on center in two directions and embedded 1.5 ft into the strong floor, are used to connect test specimens to the strong floor. Each floor tiedown is capable of resisting 50 Kips of force in tension and 12 Kips of force in shear. A 5-ton capacity crane services the lab to position specimens and test equipment frames for testing.
The reaction wall is a 2 ft thick reinforced concrete wall that extends perpendicular to the strong floor to a height of 30 ft. Wall Support locations extend up a height of 18 ft and spaced 2 ft on center. The wall is L-shaped in plan with each leg extending to cover the entire strong floor plan; therefore, testing of specimens under biaxial and triaxial loadings can be readily accomplished, such as biaxial and axial loadings. The wall is capable of supporting a total load of 250 Kips applied at a height 18 ft. The wall is supported at the roof level by a tie back diaphragm to allow the support of large reactions with small deformations. The wall height of 30 ft allows for testing of large-scale components or systems, such as bridge columns or piers, or multi-column bent with bent cap.

1.1.2 *Testing and Fabrication Equipment:*

Two 50 Kips hydraulic actuators are housed in the Structural Lab to apply loads or deformations to test specimens. The actuators and matching load cells have a capacity of 50 Kips of force with 10 inches stroke. One of the Actuators has a 90 gpm Servovalve enabling it to apply the 50 Kips force at a frequency up to 100 Hz. The test actuators are served by an MTS 290 service manifold. The Hydraulic system is powered by a custom-built Hydraulic pump operating at 100 gpm at 3000 psi pressure. The built-in hydraulic distribution system runs three sets of hydraulic lines at three different set up points in the lab.
Specimens can be constructed off-site and shipped to the lab for testing or specimens may be fabricated on-site. For on-site fabrication of reinforced concrete specimens, rebar cutters and bender will be available. The cutter and bender can be used to produce rebar various hooks, as well as hoops, crossties, and spirals. Welding facilities will also be available in the lab and the nearby machine shops. The nearby machine shops also house equipment, such as drill press, lathe, band saw, etc, for fabrication of precision test fixtures.
The concrete Lab is located next to the Structural Lab that has a concrete mixing and a

large moist curing room. Concrete can also be obtained from local suppliers. A 12 ft x 18 ft overhead door provides direct access to the lab for the ready mix truck.

1.1.3 *Instrumentation and Data Acquisition:*

Instrumentation and data acquisition equipments are available for monitoring specimens during testing. The instrumentation includes linear potentioeters, wire potentiometers, LVDT's, pressure transducers, accelerometers, extensometers, and strain gage conditioners. The strokes for the LVDT's range from ±0.2 to ±6.0 inches. Ten-channel strain gage conditioners are available for monitoring strain gages, attached or embedded in concrete or attached to steel. A Data Acquisition System (DAS) with current capacity of 16 channels, a 486 personal computer, and the MTS Test-Star software are used to monitor and collect data.

1.1.4 *Non-Destructive Testing Equipment:*

Pulse echo and impact hammer equipment are available to assess the strength and integrity of concrete.

1.2 **Computing Facilities:**

The department has tremendous computing facilities available to analyze test data. Facilities include PCs, Unix workstations, IBM, Silicon Graphics machines and a wide variety of software.

In addition to the department's computer facilities, the lab contains its own computing facilities, including a personal computer for data acquisition and data reduction and a laser printer. The computing facilities in the structural lab are networked to the campus computing facilities, allowing use of mini-supercomputers and Unix workstations, as well as color printers and other accessories. Access to supercomputers is available through the network at national supercomputer facilities.

1.3 **Summary:**

- Features of the Structural Engineering Research Laboratory allows the test of large- or near full-scale building and bridge components or systems
- The strong floor and the L-Shape strong wall allow many types of tests to be performed
- Fabrication facilities available in the nearby machine shops and in the department allow the construction of a wide variety of test specimens
- Computer facilities and data acquisition systems allow a powerful collection and analysis of data
- The new Silicon Graphics machines and the Alias Wave Front software installed on them allow for powerful graphical representation and animation of research results

2. <u>Potential Research Areas</u>

2.1 Composite Materials in Construction

The behavior of new and advanced materials, which include ceramic, polymer, metal, and intermetallic matrix composites, pose unique problems. These problems range from a fundamental characterization of the defect behavior controlling basic flow and fracture processes, to understanding the interactions between the constitutive behavior of various components in a composite system. Also, the description of the evolution of damage induced by combined loading and environmental assault is an important factor to investigate. Successful solutions require combining fundamental knowledge of material behavior with novel mechanics analyses that account for the heterogeneity of the system and the complexity of the loading.

2.1.1 *Using Composites as Alternative Construction Material*

Research on the applications of advanced composite materials in structural engineering can be conducted at CSU, Fresno both analytically and experimentally. Although advanced composite materials have been introduced in civil engineering applications since the 1970’s still there are many issues that need to be resolved for successful application of these unique materials. Experimental and analytical research can be conducted in areas such as buckling of pultruded shapes under compression; strength and stiffness of dry and bonded connections; fatigue behavior of pultruded members under cyclic loading, etc.

2.1.2 *Using Composites in Retrofitting*

In many parts of the country, especially in California, the issue of seismic retrofitting of structures is very important. Advanced composite materials are being considered as the materials of choice to retrofit building and transportation structures worldwide. Various techniques have been developed, some of them under various commercial trade names, to retrofit bridge and building components. CSU, Fresno has capabilities to conduct testing of coupon and small scale level, as well as at the member level. Experimental verification of retrofit techniques can be conducted in isolated members or in small-scale and coupon specimens. Analytical algorithms for design and analysis can also be developed for retrofit techniques.

2.1.3 *Using Composites in Strengthening*

Research can also be conducted in the area of strengthening of existing structures with composite laminates. Although this area of research has been pursued very successfully in the United States and abroad during the last 10 years, still there are problems to be addressed and CSU, Fresno can make a contribution to this effort. For instance, research can be conducted on the durability of strengthening materials such as fiberglass, carbon, and Kevlar laminates under saline environments, under freeze-thaw cycling, or under high temperatures.

2.2 Seismic Response of Civil Structures Interacting with Liquids

The dynamic response of liquids has significant influence on the response of civil structures interacting with them such as liquid storage tanks and concrete arch dams. Inappropriate approximation of the liquid dynamic may lead to major errors in estimating the seismic response of the structure. The liquid pressures and the impact forces form the measurable level of the energy transferred to the structure. In addition, the motion of the structure is one of the primary sources for the liquid energy. Since this energy transfer occurs simultaneously throughout the liquid-structure boundary, it is essential in the dynamic analysis of such problems to use modeling techniques that effectively deals with the coupling between the liquid and the structure. The main objective of this research area is to improve already existing and to explore new techniques in the numerical modeling of the liquid-structure interaction problems.

2.3 Modeling and Control of Structures

Architects and engineering designers are increasingly using more complex and sophisticated structural forms. These structural forms include shell-type (dome-like) structures and long-span space structures, which employ composite materials, membranes, cables and lightweight space trusses. Powerful computational software and high-level professional skills are vital for the analysis and design of these complex structures. In addition, It is becoming critically important to suppress dynamic response of these complex structures due to wind and earthquake excitations, not only for their safety but also their serviceability.

The objective of this research area is to improve on already existing and develop new computational software for the analysis of complex structures and explore the efficiency of passive-type tuned mass, active-type moving mass and passive-active combined hybrid-type structural dampers in reducing earthquake response of complex structures. In addition to numerical simulations, shaking table tests may also be performed to assess the validity of theoretical investigations.

2.4 Reliability Based Design

Quantitative methods of modeling, analysis, and evaluation are the tools of modern engineering. Some of these methods have become quite elaborate and include sophisticated mathematical modeling and analysis, computer simulation, and optimization techniques. However, irrespective of the level of sophistication in the models, including experimental laboratory models, they are predicated on idealized assumptions or conditions; hence, information derived from these quantitative models may or may not reflect reality closely.

In the development of engineering designs, decisions are often required irrespective of the state of completeness and quality of information, and thus are formulated under conditions of uncertainty, in the sense that the consequence of a given decision cannot be determined with complete confidence. Thus, many problems in engineering involve natural processes and phenomena that are inherently random; the states of such phenomena are naturally indeterminate and thus cannot be described with definiteness. For these reasons, decisions required in the process of engineering planning and design invariably must be made, and are made, under conditions of uncertainty. The objective of this research area is to evaluate the effects of such uncertainty on design and planning, and to improve on current probability simulation techniques, and to develop analytical and Monte Carlo simulation methods to evaluate the reliability of various types of structural systems.

2.5 Survivability Assessment of Current Aircraft Designs

The hydrodynamic ram effect in fuel tanks is identified as one of the important factors in aircraft vulnerability. Hydrodynamic ram occurs due to the high pressures that are developed within a fluid when a high-speed projectile penetrates a tank. The passage of the projectile through the fuel causes an intense pressure pulse to propagate in the fuel and strike the walls of the tank. This large internal fluid pressure on the walls causes severe petaling of the walls, usually at the entrance and exit points of the projectile.

Hydrodynamic ram effects have proven to be a major combat related threat to the modern aircraft. Since the fuel tanks of tactical aircraft have the largest exposed area of all the vulnerable components, engineering estimates of fuel tank response to penetrating ballistic projectiles are required in order to design more survivable tanks. Accurate simulations of hydrodynamic ram, including failure mode prediction, are useful in enhancing survivability and in guiding pretest specimen setup to ensure projectile strike and exit at critical locations, thereby minimizing the cost of expensive development tests.

The second item on the aircraft vulnerability agenda is the subject of decompression or depressurization. If for any reason the pressurization system fails, or a break occurs in the aircraft structure due to a missile or internal explosion, the result will be a decompression. A slow decompression may occur where, for example, a door seal fails, resulting in a gradual escape of internal pressure. If a rapid or explosive decompression occurs, the sudden equalization of air pressure poses a safety hazard to the aircraft. The ultimate objective of this research area is to minimize the damages in the aircraft resulting from the hydrodynamic ram and decompression incidents.

Appendix A: **Resumes of Research Faculty**