# Engineering Student Technology Committee

http://www.engr.colostate.edu/ESTC

## College of Engineering

### Colorado State University

**1. Title of Proposal: Instrument an Earthquake Shake Table**

**2. Proposal Participants:**

*Primary Contact for Proposal*

Name: Joe Wilmetti _____E-Mail: wilmetti@engr.colostate.edu

Department/Major: Civil and Environmental Engineering _____

*Check One:* _____ **Faculty** __X___ **Staff** _____ **Student**

*Additional proposal participants*

Name: Darrell G. Fontane_____E-Mail: darrell.fontane@colostate.edu ____

Department/Major: Civil and Environmental Engineering _____

*Check One:* ___X__ **Faculty** _____ **Staff** _____ **Student**

*Additional proposal participants*

Name: _____E-Mail: _____

Department/Major: _____

*Check One:* _____ **Faculty** _____ **Staff** _____ **Student**

**3. Proposal Abstract (limit to 100 words):**

The Civil and Environmental Engineering department is building a small earthquake simulator or shake table to use in support of various classes in the department. We have constructed the shake table using $4000 of department funds. This proposal requests an additional $9000 to be able to fully instrument the shake table for data collection to enhance its educational value to the students. These funds would be used purchase a data acquisition system, accelerometer sensors, a control computer, and a video capture system.

**4. Proposal Budget:**

*List of items to purchase and cost of each:*

## Data Acquisition System - National Instruments:

| | |
|---|---|
| 1 ea. cDAQ-9174 CompactDaq 4 slot USB chassis with cords and connector cables. | $765.00 |
| 1 ea. NI9206 16 Channel +/- 10v 16 Bit Analog Input Module w/strain relief hood. | $1163.70 |
| 2 ea. NI9234 4 Channel Accelerometer Input Modules (8 Channel total) | $3281.40 |
| Shipping and Handling | $27.37 |
| National Instruments Total | $5237.47 |

## Accelerometer Sensors - PCB Piezotronics:

| | |
|---|---|
| 2 ea. Triaxial High Sensitive Accelerometers | $1863.00 |
| 2 ea. 4 Conductor Low Noise Coaxial 10-ft Cables (for above) | $291.60 |
| 2 ea. Uniaxial High Sensitive Accelerometers | $567.00 |
| 2 ea. Low Noise Coaxial 10-ft Cables (for above) | $97.20 |
| PCB Piezotronics Total | $2818.80 |

## Control Computer:

| | |
|---|---|
| Lenovo ThinkCentre M900 (Tiny) from ENS | $831.60 |

## Total For Instrumentation and Control **$8887.87**

Other Costs:

| | |
|---|---|
| Already Spent on Shake Table Fabrication: | $4000.00 |
| Other Anticipated costs: | |
| Large Screen (27") Monitor (estimated) | $300.00 |
| Video Camera (estimated) | $450.00 |
| Wheeled Stabilized Cart (estimated) | $1000.00 |
| Articulated Mounting Arms for monitor and camera (estimated) | $300.00 |
| Incidentals (unanticipated other hardware, etc.) (estimated) | $500.00 |
| Total Project Costs (estimated) | **$15437.87** |

*Dollar or percentage amount requested from ESTC:*

Requested from ESTC - $9000.00 (cost of instrumentation and control)

**5. Full description of proposal:**

A number of years ago the Civil and Engineering Department (CEE) incorporated a project in its CIVE 103 Engineering Introduction course that required teams of students to build small wooden frames (4ft high with a 1ft square base) that were tested on the research earthquake simulator or shake table at the Engineering Research Center (ERC). This project has been a favorite of the department's undergraduates and videos of these tests are used as a recruitment tool. However, this research shake table is large and designed for larger structures. It requires a trained operator to run this table. Also in recent years it has become increasingly difficult to schedule time on this facility for instructional purposes as the amount of research testing has increased.

Darrell Fontane and Joe Wilmetti developed a concept to build a small shake table to be located on the main campus that could be used not only by the CIVE 103 course but by other undergraduate courses in the department. Several professors in the CEE department, including John Van de Lindt, Hussam Mahmoud, Suren Chen, and Becki Atadero, have indicated that they would like to incorporate this shake table in their undergraduate courses. In past years the student wooden frame structures were tested to destruction and then discarded. There were no data directly measured of the forces or displacements on these structures. The idea for the smaller shake table was to develop a facility that could be easily controlled via Lab-View software and where it would be possible to instrument the test structures and directly collect various kinds of data. This data could then be given to the students and they could conduct various analyses on the measured data. This would increase their understanding of the forces on the structures as well as provide an opportunity to practice their computing skills. A final enhancement as compared to the research shake table is that the on-campus table would be able to simulate motion along two axes. The research shake table at the ERC only allows motion in one direction.

Dr. Fontane had money in an account that could be used to initiate the development of this project and during the Spring 2016 semester we have spent $4000 to construct the table. It has an upper table that is drilled and tapped for ¼ - 20 mounting bolts on a 1" grid pattern to facilitate mounting test structures. This table is mounted on linear bearings that provide x-axis motion to an intermediate table. The intermediate table is than mounted on another set of linear bearings that provide z-axis motion. Both are operated by independently controlled servo motors via a Labview interface that will give a range of motion in ¼ inch (3mm) increments up to 3" (75mm), at speeds from .25 to 3 Hz. The table has been constructed by Joe Wilmetti and Steve Johnson (Mechanical Engineering Shop [EMAC]) and is currently in the final stages of testing. We plan to use it in the CIVE 103 course this semester and demonstrate its use to the faculty of the department. The intent is to get this shake table used in other courses in the

department. The money we are requesting would be used to instrument the table to provide automatic data collection. It is our vision that students would design a structure to be tested, the design would be tested and forces and displacements measured and then this data would be given back to the student teams for analysis. This ability to be able to collect data and have the students analyze the data is a significant enhancement to the project.

To accomplish this task we would need a dedicated data acquisition system and control computer. The data acquisition system would be a National Instruments modular USB unit with input modules for both voltage transducers and accelerometers, to monitor the actual table movement, as well as the forces and responses of the test structures. We anticipate being able to use 2 triaxial accelerometers and 2 uniaxial accelerometers to measure acceleration at various points on the test structure, and be able to derive the other parameters such as Jerk, Velocity and Displacement within the LabView program. This data would be then output to an Excel spreadsheet for analysis and comparison. The LabView program would also provide the necessary motor control for the table motion.

As part of the testing procedure, we plan to take real time video of the test structure and be able to time sync the video with the table movement. The processed video would then be made available so that the students would to be able to watch the structure's response to the imparted movement.

By design, we will have a small self-contained system that is portable enough to move into classrooms for demonstrations, as well as a complete tool for investigating the model structure's response to various design parameter changes such loading, bracing, dampening tools, as well as any other design criteria. Beyond the classroom and instructional use, the system would also be available for demonstrations during our various outreach programs; Engineering Days, high school recruitment, and any other times where we feel it would be an attention getter and an interesting action display.