**MCEER RESEARCH TASK STATEMENT**

<table>
<thead>
<tr>
<th>Education and Outreach</th>
<th>Budget:</th>
<th>Yr 8 Assigned</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Task Title:</strong></td>
<td>Integrated Research and Education on Engineering Effects of Earthquakes and Technologies for Seismic Protection</td>
<td></td>
</tr>
<tr>
<td><strong>Project Number:</strong></td>
<td>8.5.4</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Co-Investigator:</strong></th>
<th>Anil K. Agrawal*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Investigator Institution:</strong></td>
<td>City College of New York</td>
</tr>
</tbody>
</table>

* indicates task leader

**Statement of Project Goals:** *(Conceptually describe what the work is intended to accomplish, in 100 words or less. Do not provide detailed description here.)*

The goal of the project is to develop an integrated research and education approach to investigate the effects of earthquakes and advanced technologies for seismic protection with emphasis on minority students. With current and previous funding, the PI has been educating undergraduate students about earthquakes and advanced technologies through the use of the UCIST instructional shaking table in a course in dynamics and direct mentoring of four undergraduate students, including three women students. For year 8, the PI is proposing the development of aggressive educational components through student competition on earthquake-based themes and exercises on these aspects across the curriculum through courses, presentations and web-based modules using experimentally recorded data. The work is intended to motivate undergraduate students learn about advanced concepts in structural dynamics and earthquake engineering through activities across the curriculum, laboratory experiment participation and research under the mentorship of graduate students. The final outcome of the task is to have new graduates with increased awareness about the destructive effects of earthquakes, and effectiveness of advanced technologies in protecting structures.

**Problem Description and Research Approach of Proposed Work for Year 8:**

**Educational Component:**

With current and previous funding for integrated research and education of undergraduate students, following activities have been carried out by the PI:

(i) **Individual study courses on structural dynamics during spring 2002 and spring 2003:** Seven minority students attended the two courses. The students studied basic concepts of structural dynamics, learnt response simulation using Matlab and Simulink, developed simple computer modules in Simulink to study effects of damping and other response modification strategies, and carried out simple experimental concepts using the instructional shake table from Quansar Consulting. The students studied assigned topics from a textbook in groups, and discussed with the Graduate Student Researcher and the PI about the topics covered.

(ii) **Seminars:** Seminars on WTC collapse and possible solutions, and seismic retrofit of Reinforced Concrete Building at the City College Campus by Mr. Richard Donald, RSD Engineering, New York, Progressive Collapse of Structures by Dr. Ettouney, Weidlinder Associates, New York, seismic design in Northeast USA by Dr. A. Khan,
STV, Inc., NJ, and development of smart energy dissipative systems by Dr. He, CCNY, have been organized previously.

(iii) **Undergraduate Students Research:** The PI mentored 4 undergraduate students (Susan Romero, Myriam Vargas, Alma Platero and Mervin Fontennele) during last two years. The students carried out activities such as preparing a case study on use of protective systems, and shaking table experiment using UCIST instructional shaking table. Two of the students, Ms. Susan Romero and Myriam Vargas, were selected for REUJAT program in Japan and were hosted by University of Tokyo and Kajima Corporation, Japan, during summer of 2002 and 2003 to learn about recent advances in advanced technologies. After returning from Japan, both students carried out advanced studies on structural control. In fact, Ms. Vargas is finishing a paper that will be submitted to a Journal.

**Year 8 Educational Effort**

For Year 8, the PI proposed to develop an aggressive educational approach to encourage undergraduate students in research in earthquake engineering, structural dynamics and structural control. Specific points of the proposed educational component are:

a. **Earthquake Theme Based Competition:** It has been observed that students respond positively to challenges that result in recognition and reward beyond coursework. In order to engage students in advanced concepts of earthquake engineering, competitions based on both theoretical and experimental work will be organized. For the theoretical portion, the theme of the competition will be based on current advances in earthquake engineering. Students will be asked to submit 5-10 page essay on the theme through research using Internet, MCEER database or other technical materials. All submissions will be reviewed critically and best 3 essays will be given certificates of recognition by the department and pre-determined monetary awards in the form of fellowship. In the experimental competition, students will be challenged to develop small models of buildings or bridges (using wood, plexi-glass or other materials) based on prescribed criteria and tested on the shake table. Participants will be encouraged to develop passive damping mechanisms using items available in hardware stores, e.g., friction dampers using corner brackets, fluid dampers using door accessories, etc. Top 3 winners will be given certificates of recognition by the department and pre-determined monetary awards in the form of fellowship. This type of approach will encourage all students in the department to participate in the competition and learn about key concepts of earthquake engineering beyond course work.

b. **Earthquake Engineering Across Curriculum:** Given total course credit constraints for an undergraduate degree, it will be difficult to introduce a new required course in earthquake engineering. Although the PI offered individual study courses in earthquake engineering during Spring 2002 and Spring 2003, enrollment was 4 and 3, respectively, during the two semester. To disseminate key concepts of earthquake engineering to wider group of students without increasing course contents, key concepts can be introduced in required courses. For example, the course on CE Data Analysis (CE 26400) teaches students about role of Statistics and Probability in civil engineering. Data collected during shaking table experiment, e.g., peak amplitude versus time during free vibration for exponential curve analysis, response versus damping ratio, etc., can be supplied to students along with a description of how and why data were collected. The students will be asked to derive conclusions based on analysis that will indirectly lead to
learning dynamics concepts. Similarly, a module based on linear static method can be given to students in courses on structural analysis (CE 34000 and 44000) to calculate earthquake loads and analyze the behavior of frames. The PI is teaching CE 44000 in Spring 2004 and intends to introduce this module. In Dynamics of CE Systems Course, the PI requires students to carry out series of experiments using the UCIST shake table, collect data and analyze them to identify frequency, damping ratio and response behavior. Experimental modules for this course will be refined in Fall 2004. Similar modules will be designed for graduate courses also. Since these modules will fit within existing framework of courses being taught, they facilitate learning key concepts without additional burden on students and faculty.

c. **Community Awareness**: The graduate students at the CCNY have fabricated a 3-story building frame model on 10,000 lb shaking table. This model is going to be equipped with MR Dampers as braces. The CCNY frequently organizes community events, such as Engineering Open House, Homecoming events, etc. During this event, more than 200 visitors from nearby community visit various facilities in the college. The PI is preparing a presentation module on CD that will be demonstrated to visitors along with live experiments on earthquake engineering using 10,000 lb shaking table. The goal of this task will be both outreach of high school in civil engineering and community education.

d. **Seminars and Presentations**: For Year 8, the PI plans to invite engineers involved in seismic retrofit of infrastructures in the NYC metropolitan areas for a presentation to undergraduate and graduate students. Similarly, new research concepts developed at the CCNY will be presented to practitioners and engineers through seminars and conferences.

**Research Component**

The focus of research component of at the CCNY is on theoretical and experimental research on passive and semi-active protective systems. The research group at the CCNY has developed an analytical model of near-field ground motion pulses to optimize the design of energy dissipation systems. Preliminary results show that the passive dampers are effective only when the frequency of structures is close to the predominant period of ground motions. For semi-active dampers, it has been shown that they are as effective as active control using the same force capacity when controllers are designed by incorporating the model of ground motion pulses in the controller design. For the experimental verification of this concept, a 3-story building model has been developed. The model will be base-isolated. A MR-damper will be installed between the base of the building and ground (shaking table). A semi-active controller designed by including the model of ground motions in the controller design will be tested for effectiveness.

Semi-active dampers have already shown to be effective and have been implemented in several structures in Japan. Performance of these systems depends on the type of control algorithms. Typically, semi-active controllers have artificial hysteresis loop that can be maximized to dissipate energy. Currently, the PI has working on a new approach in which a nonlinear hysteretic semi-active controller is designed by designing a hysteresis loop that will maximize the dissipation of energy for a particular structure. The focus of this research will be both theoretical and experimental research. Preliminary research in this direction is already underway. This work will be a part of the Ph.D. dissertation of a graduate student, Mr. Xu (fully supported by departmental fellowship). The requested funds will be used for laboratory
development and involvement of undergraduate/graduate (M.S.) students in research.

This research component has a direct link with the educational plan proposed. The integrated research and education plan will provide undergraduate and graduate students an opportunity of engaging advanced research on structural dynamics and control. A continuous development of the integrated research and education program at the City College will certainly encourage undergraduate students, including minorities and women students, to pursue graduate studies in earthquake engineering. One of the unique aspects of the combined education and research program will be the development of interest in research among undergraduate and graduate students. A long term effect of such program may be the development of a research culture and lifelong learning attitude among students.

Assessment of State-of-the-Art: (Describe other relevant work being conducted within and outside of MCEER, and how this project is different.)

This program complements the research and educational goals of the MCEER through an active involvement of a predominantly minority institution in advanced research on structural dynamics and earthquake engineering. The research in new type of hysteretic semi-active controller is completely new and will add to the mission of MCEER significantly.

Progress to date: (If applicable, a short description of achievements in previous years. Clearly distinguish progress achieved in the past year, i.e., accomplishments from April 1, 2001, to March 31, 2002.)

With previous and current funding, undergraduate students were offered the individual course in structural dynamics and earthquake engineering, seminars were organized on earthquake engineering, and research was conducted by undergraduate student under the mentorship of a graduate student in the area of semi-active friction dampers. Two undergraduate students, Ms. Susan Romero and Myriam Vargas, were selected to participate in the REU program in Japan funded by the NSF. After completing the REU Program, they continued their research at the CCNY. Ms. Romero is currently working with a consulting company in New York and is planning to pursue graduate studies in civil engineering at CCNY. Ms. Vargas is planning to graduate in June 2004 and pursue graduate studies in structures.

Role of Proposed Task in Support of Strategic Plan: (Describe how the effort will make a unique, useable contribution to the MCEER strategic plan.)

The proposed effort will make a unique contribution in the strategic plan of MCEER by promoting the education and awareness in the area of earthquake engineering, advanced theoretical and experimental research on semi-active dampers and transfer of knowledge to practicing community through seminars and recruitment of trained engineers. The integrated research and education plan will be instrumental in developing a research oriented environment, lifelong learning attitude and curriculum modification through incorporation of well-designed earthquake engineering modules across the curriculum.

Task Integration: (Describe how the work performed interfaces with other tasks and researchers funded by MCEER.)
Possible Technical Challenges: Possible technical challenges exist in motivating undergraduate students involved in advanced research, which keeping their other coursework and educational activities. The proposed education plan addresses some of these issues.

Anticipated Outcomes and deliverables: The outcomes of the project benefit IAB members in the form of better trained engineers capable of better incorporating seismic design concepts in actual design.

Potential end-users beyond academic community: Potential end-users are IAB members and the practicing community. Potential end-users of the research component are the academicians and industry interested in developing structural control systems.

Educational outcomes and deliverables, and intended audience:

Potential educational outcomes of the project are:

(i) Hands-on experience in earthquake engineering and structural dynamics through competitions and specialized course modules.
(ii) Seminars by experienced structural engineers on seismic design of structures,
(iii) Site visits to see the landmark structures and experiments in structural dynamics
(iv) Participation in research on intelligent structural control devices and new approaches to design buildings for protection against earthquakes.
(v) Development of research culture and lifelong learning attitude among students through participation in research projects.

Project Schedule and Expected Milestones for the Project: The project duration is 12 months, from October 1, 2004 to September 31, 2005. The student work during Spring, Summer and Fall semesters to achieve the described objectives.

Team Members:

Undergraduate Students: Ms. Myriam Vargas and other students to be recruited.
Graduate Coordinators: Ms. Pan Ying, Mr. Yi Zhihua (supported by other projects of the PI), Mr. Xu (fully supported by departmental fellowship)
Post-Doctoral Associate: Dr. Tan Ping (Supported by NSF project of the PI)

Possible Direction of Work in Subsequent Years: Proposed educational component may become part of regular academic activities at the CCNY. The PI is currently involved in developing department-level curriculum reform plan through a NSF proposal and is already exploring to implement several of the concepts in the new curriculum. The research component has significant innovative contribution. The approach can be used to customize a semi-active controller for a structure based on its properties.
Experimental Modules in Undergraduate Courses: Through the MCEER funding support, an experimental component on earthquake engineering has been incorporated in undergraduate course on Dynamics of CE Systems (CE 435). In this course, students use the instructional shake table system to conduct free and forced vibration experiments in structural dynamics to identify frequencies and damping ratio of SDOF systems. Then using various earthquake excitations, they study the effects of earthquake on buildings. The final outcome is a project report submitted by students at the end of semester. Photograph below shows undergraduate students carrying out experiments in structural dynamics.
# MCEER RESEARCH TASK STATEMENT

<table>
<thead>
<tr>
<th>Education and Outreach</th>
<th>Budget:</th>
<th>Yr 8 Assigned Project Number: 8.5.4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Task Title:</strong> Integrated Research and Education on Engineering Effects of Earthquakes, Blasts and other Man-Made Hazards (Geotechnical Component)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Investigator:</strong> George Mylonakis*, Anil Agrawal</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Institution:</strong> University at Buffalo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* indicates task leader</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Statement of Project Goals:** An integrated research-education project is proposed for investigating engineering effects of earthquakes, blasts and other natural and man-made hazards with emphasis on minority students. The project has two Co-PI’s: A.K Agrawal and G. Mylonakis, both Associate Professors at the City College of CUNY. Dr. Agrawal will be responsible for structural engineering issues, while Dr. Mylonakis will be responsible for Geotechnical and Emergency Management issues.

**Problem Description and Research Approach of Proposed Work for Year 8:**

**Geotechnical and Emergency Management Aspects (Co-PI: Prof G. Mylonakis)**

An independent study course is planned for Fall 2004 semester for undergraduate students at the sophomore and junior levels. Four minority undergraduates have been selected to participate, to be supervised by a graduate student, a lab technician and the signatory. The study entails three parts:

1. A group of two students will be working in the laboratory to investigate experimentally soil response to impulsive motions generated by blasts and earthquakes. To perform the experiments, the students will be using a state-of-the-art cyclic triaxial apparatus recently installed by ELE at the Soil Mechanics Laboratory of CUNY-City College. The equipment is capable of testing soil samples under triaxial conditions at frequencies up to 70Hz. Properties to be investigated include dynamic shear modulus and damping constants for Manhattan clayey soils. Dimensionless charts and graphs will be produced indicating how these parameters depend on peak shear strain, consolidation pressure, frequency, and plasticity index of the soil. Deliverables include: (a) a research report summarizing the experimental procedure and results; (b) Matlab and Mathematica computer modules developed by the students to process the experimental data. The modules are expected to be used in the classroom, as part of undergraduate and graduate courses in soil mechanics.

2. Two students will be involved in analytical simulations of foundation response to impulsive motions imposed on the superstructure (inertial interaction). Spread footings, piles and retaining structures (or combinations of the above) will be examined. Pertinent computer algorithms developed by the task leader (DAPGROUP), as well as commercial software (DYNA4) will be used to derive foundation impedances in the form of impulsive functions. Dimensionless charts and graphs will be derived indicating how the response depends on the geometry, frequency, and mode of oscillation (swaying,
rocking). Deliverables will include: (a) a report; (b) animation modules developed by the students for visualizing the analytical results. A report on dynamic response of piles has been completed by Ms. Myriam Vargas.

(3) The students will be visiting emergency management centers at the City of New York to learn about response strategies against earthquakes, terrorist attacks and other natural or man-made hazards. Planned seminars involve alertness, mitigation, and post-event evaluation from a Civil Engineering viewpoint. New York City, State and Federal Emergency Management agencies have been contacted by the task leader and have agreed to participate. Students will be exposed to cutting-edge tools, such as GPS, GIS, and Satellite Interferometry. It is expected that the students will develop sufficient expertise to assist the community in crises similar to that of September 11, 2001. The visits will be coordinated by a supervising graduate student. The students will receive certificates of training from the above agencies.

With reference to the analytical simulations, two minority undergraduates (Andre Chauncey, Myriam Vargas) have worked over the course of the project under the direction of the PI and a graduate student. The two students performed analysis on dynamics of spread footings (Chauncey) and piles, pile groups (Vargas). Selected results for the spread footings have been published in a major MCEER report, co-authored by Andre Chauncey. In addition, the graduate student responsible for the course (Ms. Kathleen Schulze) taught independently a 36-hour introductory course on engineering to a group of high school students.

The laboratory experiments will help students gaining experience on advanced soil testing, data acquisition, developing computer modules for data processing, interpreting data and reporting findings. In addition, sample selection and preparation (topics which are usually not covered in undergraduate courses) will help the participating students developing essential professional skills (for geotechnical engineers).

In Summary, an integrated research and education program for undergraduate minority students is proposed in relation to geotechnical engineering effects of blasts and earthquakes. The proposed work is well balanced, involves an experienced PI, one graduate student, and four undergraduate students. The course will provide strong education and a research experience to minority students at the City College of New York.

Assessment of State-of-the-Art: This program complements the research and educational goals of the MCEER through an active involvement of a predominantly minority institution in advanced research on structural dynamics, foundation dynamics, blast dynamics, and earthquake engineering.

Progress to date: Two minority undergraduates (Andre Chauncey, Myriam Vargas) performed research on foundation dynamics (spread footings, piles). Mr. Chauncey’s results have been published in a MCEER technical report co-sponsored by the Highway program. Ms Vargas has also completed a research report. In addition, the supervising graduate student (Ms. Kathleen Schulze) taught independently an introductory level engineering course to a group of high school students.
**Role of Proposed Task in Support of Strategic Plan:** The proposed effort is expected to contribute to the strategic plan of MCEER, by promoting research, education and alertness in the areas of foundation dynamics, as well as to emergency response to natural and man-made hazards.

**Task Integration:** Task is conducted in coordination with a structural engineering team at CCNY, lead by Dr. Agrawal, which is also funded by MCEER under the same Task title.

**Possible Technical Challenges:** Technical challenges include lack of experience and advanced (“research”) skills of the participating students as well as a heavy academic schedule on their part.

<table>
<thead>
<tr>
<th>Anticipated Outcomes and deliverables:</th>
<th>Potential end-users beyond academic community:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineers trained to design foundations against blasts and earthquakes and help the community respond to natural and man-made hazards.</td>
<td>(IAB members and others.)</td>
</tr>
<tr>
<td>Potential end-users include IAB members and practitioners.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Educational outcomes and deliverables, and intended audience:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential educational outcomes of the project include: (1) Training of students by FEMA and NYCEMA officers in emergency response procedures; (2) Experience in experimental and analytical techniques in soil dynamics and earthquake engineering; (3) Development of computer modules for engineering visualization and for evaluating experimental data, to be used in the classroom.</td>
</tr>
</tbody>
</table>

**Project Schedule and Expected Milestones for the Project:**

This phase of the project starts October 1, 2003 and ends September 31, 2004. Students will work during the Summer (if needed) to achieve the goals of the project. Progress and final reports will be submitted as required by MCEER and NSF.

**Team Members:**

Undergraduate Students (Geotech Team): Ms. Juliet Hurtado, Ms. Gillian Cain, Mr. Joseph Piccolo, Ms. Diana Villacis
Graduate Coordinators (Geotech Team): Ms. Marta Perez, Ms. Kathleen Schulze

**Possible Direction of Work in Subsequent Years:**

The course is currently being offered as an undergraduate independent study at the sophomore to senior levels. Depending on the availability of external funding, the study may become a regular course in the CE department over the next few years.