

Re-engineering an Undergraduate Summer Research Site

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Abstract

Since 1996 a summer Research Experiences for Undergraduates (REU) site in structural engineering, funded by the National Science Foundation (NSF), has operated at the University of Alabama at Birmingham (UAB). During this time 41 students from 25 colleges and universities have participated in the site. Participants are recruited nationally and have come from as far away as California and Puerto Rico. The program is intended to provide students interested in graduate studies with an introduction to research methods, and to provide students who will not continue their studies past a BSCE with a better understanding of how research provides the theoretical foundation of engineering practice. Students work individually with faculty on literature reviews, computer modeling, laboratory testing, and field research. Four students have researched structural failure case studies and the technical and ethical lessons to be learned from them. Participants also have the opportunity to tour construction sites and construction material manufacturers' and fabricator's facilities. During the past three years, an ethics seminar series has been added. At the end of the program, students prepare research papers and web pages documenting their work and present their results to faculty, students, and other participants. Recently, a change of site focus to Infrastructure and Sustainable Development has been proposed. This paper discusses the lessons learned during the conduct of the site over the years, changes made to improve the quality of the undergraduate research experience, and the evolution of the site's ethics components. Results of participant surveys on completion of the program as well as follow-up surveys are also reviewed.

Introduction

The Research Experiences for Undergraduates (REU) site in Structural Engineering, sponsored by the National Science Foundation (NSF), has been operated by the Department of Civil and Environmental Engineering (CEE) at the University of Alabama at Birmingham (UAB) since 1996. During this time, 41 students from 25 colleges and universities, from as far away as California and Puerto Rico, have attended the site. Two papers have been written documenting the operations of the site^{1,2}. Some background

information and comparison with other sites has been reviewed². A number of other references also discuss the undergraduate research experience³⁻⁶.

In a world with expanding population and finite resources, it is necessary to find ways to make new infrastructure last longer, preserve existing infrastructure through nondestructive testing and innovative repair materials and techniques, and integrate social and environmental concerns with engineering practice. Research into materials and systems that last longer, reduce the need for scarce and nonrenewable resources, or make use of byproducts that would otherwise enter the waste stream will promote sustainable development of built infrastructure. For all of these reasons and others, the site is changing its focus from Structural Engineering to Infrastructure and Sustainable Development.

Objectives of the Program

The objectives of the current UAB REU Site in Structural Engineering are to:

1. Introduce students to research and inspire them to continue with research in their undergraduate studies, and to consider continuing their education with a Master's degree including a thesis.
2. Identify and prepare promising students for doctoral research.
3. Enhance student understanding of the relationship between research and engineering practice.
4. Provide students with the experience of successfully completing a research project.
5. Promote awareness of the importance of ethical conduct for practicing engineers and researchers.

The objectives will not change with the change in focus of the site, but the examples, cases, and projects will.

Recruiting

Over the past seven years, the UAB REU Site in Structural Engineering has been able to fill all positions with qualified students. In addition to the web site, which has proven to be a powerful recruiting tool, a database of 82 faculty addresses has been assembled. Every year, these colleagues are sent a color poster along with other application materials. These contacts include a wide variety of institutions across the continental U.S. and Puerto Rico. This list is updated and expanded frequently. Many applications arrive from students that encounter the UAB REU site on the web.

The UAB program has been very successful at attracting women and minorities. Over the past four years, more than half of the participants have been women. A few UAB students are usually included in the group to act as "guides" for the out-of-town students. The 2002 group of participants is shown in figure 1.



Figure 1: 2002 UAB REU Site participants

Structural Engineering REU Program

The program is intended to provide students interested in graduate studies with an introduction to research methods, and to provide students who will not continue their studies past a BSCE with a better understanding of how research provides the theoretical foundation of engineering practice. Students work individually with faculty on literature reviews, computer modeling, laboratory testing, and field research. Four students have researched structural failure case studies and the technical and ethical lessons to be learned from them.

Participants also have the opportunity to tour construction sites and construction material manufacturers' and fabricator's facilities. During the past three years, an ethics seminar series has been added. At the end of the program students prepare research papers and web pages documenting their work and present their results to faculty, students, and other participants.

Because of the short duration of the program, it is important to get students started quickly on their projects. It is also important for the faculty to select projects that are achievable within this time frame, but that will also represent a significant accomplishment for the students. Project selection remains a difficult challenge for faculty, but gets easier with experience.

A list of research areas and projects for the years 1999 through 2002 is shown in Table 1. They are grouped under common areas, as appropriate. Some projects are offered only one year, and others are repeated.

Table 1. Selected Research Areas and Projects, 1999 – 2002

Research Area	Project and Year
Curved steel bridges	Girder Flange and Cross-Frame Members Earthquake Induced Stresses, 1999
	Dilemmas in the Construction of Steel Curved Bridges, 1999
Failure case studies	Failure Case Studies in Civil Engineering Education, 1999
	Failure Case Studies in Civil Engineering, 2000
	Collapse of 2000 Commonwealth Avenue: A Case Study, 2001
	Preventing History from Repeating Itself: Educating Undergraduates through Failure Case Studies, 2002
Sign, signal, and luminaire support structures	Computer-Aided Design of Support Structures, 1999
	Improving Analysis of Wind Forces on Flexible Support Structures, 2000
Aerated autoclaved concrete	Laboratory Studies of Advanced Cementitious Materials, 1999
	Shear Testing of AAC, 2000
Structural response to blast	Blast Response of Retrofitted Concrete Structures, 1999
	Blast Response of Masonry and Reinforced Concrete Structures, 2000
Concrete performance and durability	Supplementary Cementitious Materials to Enhance Durability of Concrete Bridge Decks, 2000
	Chloride Permeability of Bottom Ash Concrete, 2001
	Design and Quality Control of Concrete Overlays and Repairs, 2001
	Concrete Variability Due to Outside Conditions within the Same Mix Design, 2002
	Mix Design Procedure for Roller-Compacted Concrete, 2002
	Bottom Ash as an Aggregate in Structural Concrete, 2002
Nondestructive testing	Comparing Geological Profile and SASW Results in Alabama, 2000
	Correlating Soil Stiffness Using SPT and SASW, 2000
	Construction of Subsurface Soil Profiles: A Case Study in SASW Testing, 2001
	Bridge Dynamics, 2001
	The Management of SASW Testing, 2002
	Sensitivity Study of the Dynamic Load Rating Method for Single Span Bridge Monitoring Using FE Modeling, 2002
Composite and Repair Materials	The Use of Low-Stiffness yet Highly Ductile Elastomeric Polymers for Maintaining the Composure of Masonry Walls Subjected to Seismic Loads, 2002
	Vibration of Sandwich Beams with Innovative Cores, 2002
	Understanding Issues on Composites Especially with Freeze-Thaw, 2002

One important element of the program has been the field trips. Since 1999 participants have taken three or four tours each summer to manufacturing facilities or construction sites. Manufacturing facility tours have included:

- Sherman International Corporation precast and prestressed concrete facility in Pelham, Alabama, which manufactures bridge girders and other products (figure 2). In this figure, the students are discussing various bridge girder configurations. The concrete batch plant, which is an important part of the tour, is visible in the background.
- Wal-Par, Inc. steel structure manufacturing facility in Birmingham, which manufactures sign support structures. Students are observing a computer-controlled metal cutting operation in figure 3. The field trip allows the students to see cutting, welding, painting, and other steel structural fabrication operations.

- Newmark Infrastructure Solutions prestressed spun concrete pole facility in Tuscaloosa, Alabama.
- Vulcan Materials Company Dulcito Quarry in Birmingham, a producer of construction aggregates.
- Lehigh Cement manufacturing facility in Leeds, Alabama.
- Butler Manufacturing pre-engineered metal building manufacturing facility.



Figure 2: REU students tour Sherman precast facility in 2002



Figure 3: REU students tour Wal-Par facility in 2001

Construction site tours have included several buildings under construction on the UAB campus:

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- Human Genetics Building
- New student dormitory building
- Volker Hall expansion, shown in figure 4. This project was of interest because different construction operations could be seen on the different floors of the building.



Figure 4: REU students tour Volker Hall expansion in 2002

When the UAB REU site was renewed in 1999, an ethics program was added. This program has two components. Each year, one student project concerns ethical issues in structural engineering education and practice, and lessons learned from failures. An ethics seminar series is also included. The author is assisted in this seminar series by Dr. Harold Kincaid, a professor in the UAB Department of Philosophy and Director of the Center for the Study of Ethics and Values in the Sciences. Typical ethics seminars include:

- Viewing the film “When Engineering Fails,” narrated by Henry Petroski, followed by a group discussion.
- A discussion of ethical issues in scientific research. These include well-known scientific fraud cases and issues of proper attribution of work.
- Small-group discussions of ethics in professional practice, using case studies from the University of Washington Ethics Case of the Month web site⁷.
- A discussion on professional licensure issues led by a guest speaker from the Alabama Licensing board. This also provided an opportunity for students to ask questions about the Fundamentals of Engineering examination and Professional Engineer licensure.
- A discussion of the William LeMessurier Citicorp Tower case, and the importance of calling attention to and fixing your mistakes.
- Discussion of case studies prepared by the UAB REU students. Three of these cases have been published or accepted for publication⁸⁻¹⁰.

Students present their work on a web site¹, with a final paper, and with a final presentation seminar. One student at the 2002 final presentations is shown presenting her results in figure 5.

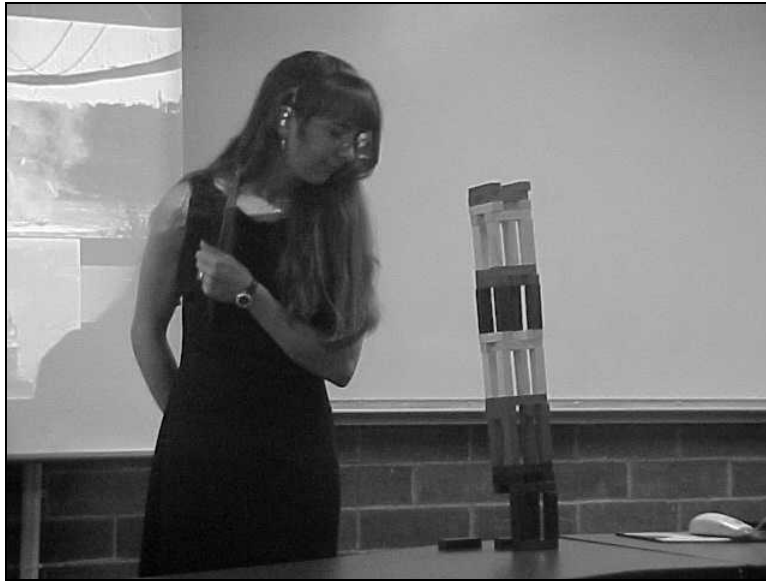


Figure 5: REU student Cynthia Rouse demonstrating progressive collapse

Evaluation and Results

Each year since 1999 the participants have been surveyed at the beginning and end of the program. Another survey of past participants was carried out in fall 2002. Survey results are discussed in detail in reference 2.

The students' self-reported tendencies to continue on to graduate school remains about the same, although follow-up has shown that many have continued on to study for Masters Degrees. The research skills and confidence of the participants went up substantially. The ethics program was very well received, and the students developed an increased appreciation for ethics in engineering research and practice².

Over the years, a number of incremental improvements have been made to the program based on student suggestions. These include²:

- More careful assignment of students to faculty.
- Polling students for their interest before assigning them to projects, and also assigning their projects before they arrive.
- More laboratory and field testing projects.

Developing the Revised Program

Changes at UAB support a change of focus from Structural Engineering to Infrastructure and Sustainable Development. First, UAB and the CEE Department have doubled

research expenditures of the past 5 years, much of it related to the new focus area. Second, much of the new departmental research has been associated with the USDOT-funded University Transportation Center for Alabama, with the theme of Management and Safety of Transportation Systems. Two new faculty members have been hired to support the transportation center. Finally, CEE faculty members have established important research relationships with other UAB faculty in surgery and public health. Newly established Ph.D. programs at UAB in CEE and Environmental Health Engineering support these research areas. As a result, it seemed to be an appropriate time to review the site and investigate a change of focus.

Most of the research focus areas listed in Table 1 also apply to the new focus area. The department's research emphasis on nondestructive testing (NDT) has expanded since 1999, and an expanded focus on infrastructure supports NDT applications to areas other than structural engineering. Many of the projects have concerned applications of sustainable development to concrete technology, such as the use of bottom ash and other byproduct materials.

Sustainable development is of increasing interest to the American Society of Civil Engineers (ASCE), the American Concrete Institute (ACI), and other organizations, and is likely to become more important to engineering education and practice in future years. The change in focus also makes it possible for the non-structural engineering faculty in the department to participate in the site, and will reduce the participant-to-faculty ratio.

Summary and Conclusions

The UAB REU Site in Structural Engineering has operated successfully since 1996. However, many of the funded research areas within the UAB Department of Civil Engineering are outside of that area. Furthermore, it is becoming increasingly clear that the evaluation and rehabilitation of existing infrastructure, and the integration of sustainable development into civil engineering practices, represent areas of challenge and opportunity for undergraduate engineers in the twenty-first century.

Recently, a change of site focus to Infrastructure and Sustainable Development has been proposed. This paper discusses the lessons learned during the conduct of the site over the years, changes made to improve the quality of the undergraduate research experience, and the evolution of the site's ethics components. Results of participant surveys on completion of the program as well as follow-up surveys suggest that the program is meeting the developmental needs of the participants.

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