AC 2009-458: CIVIL ENGINEERING INTRODUCTION TO FRESHMAN ENGINEERS

Fazil Najafi, University of Florida

Kathryn Jenner, University of Florida

Kathryn Jenner is a first year Master's student focusing on structural engineering at the University of Florida. She graduated with a Bachelor's Degree of Science in Civil Engineering from the University of Florida in May 2008.

Sarah Jayasekaran, University of Florida

Civil Engineering Introduction to Freshman Engineers

Abstract

"Introduction to Engineering" (EGN-1002) is a course offered to freshman students at the University of Florida. The purpose of this course is to familiarize students with the curriculum of eleven different departments within the College of Engineering and is focused on aiding students in the process of making an informed decision for their futures. This paper is focused on only the Civil and Coastal Engineering section of the course. The civil engineering portion is a three-hour class that includes a civil engineering concept and curriculum lecture, elementary lab work, and lab demonstrations. The first part of the class is a lecture introducing students to the purpose of civil engineers in society and general civil engineering principles and concepts. The lab portion involves teams of four or five students from different engineering disciplines building a truss bridge from basic materials. The teams design toward given criteria such as cost, efficiency, and strength. Each team is provided with the same quality of materials, and all materials are assigned a certain cost based on their properties. Teams are given a time limit of 30 minutes to complete the task of building the truss bridge. Each team's truss bridge is loaded with weight, and the team with the highest weight to cost score wins. The third part of this session includes a demonstration of hurricane forces on hypothetical debris with an air pressure cannon as well as a demonstration of the compressive strength of a concrete cylinder through a compressive strength test. This exercise introduces students to civil engineering concepts and creates a better understanding of compressive strength, stress, strain, neutral axis, tension, and compression. The students also gain an understanding of how engineering theory and concepts can be applied to real world projects and that engineering is the application of science to solve problems. Throughout the presentations, the students also learn about the American Society of Civil Engineers Student Chapter and its activities including canoe building, steel bridge building and technical paper writing for local and national competitions.

Introduction

Introduction to Engineering, EGN 1002, is a one-credit, freshman engineering course geared to eliciting an understanding of the various departments of engineering offered within the College of Engineering. This course was developed under a National Science Foundation Grant by Hoit[1]. The departments that are covered in this course include Aerospace, Agricultural and Biological, Chemical, Civil and Coastal, Computer, Electrical, Environmental, Industrial and Systems, Materials Science, Mechanical, and Nuclear and Radiological. The purpose of this course is to create an understanding of each department among freshman engineers[2]. This one-credit course requires the student to visit each department for three hours, switching departments each week. Each department has instituted their own itinerary for the three hours, although all are sure to include an introduction to their form of engineering and then allowing the student to participate in a hands-on project demonstrating the basic engineering principles associated with each department[3].The primary focus is for the student to choose a department which matches their interests and talents best.

The focus on this paper will be on the curriculum and itinerary of the Department of Civil and Coastal Engineering. The first objective on the agenda is to introduce the teaching assistant and professor to the class and provide relevant qualifications. The grading scale is based solely on attendance and therefore attendance is taken at the beginning of class. The professor offers their formal welcome to the class and explains the agenda. Following this, student representatives of the student chapter of ASCE are introduced. These student representatives then discuss the ASCE student chapter as an organization and the projects in which they are involved such as concrete canoe, steel bridge, and their annual conference. After the student chapter has finished their presentation, the instructor discusses the multitude of areas that civil engineers work in, such as water resources, geotechnical, structures, transportation, construction, public works, and land development. Furthermore, the instructor discusses the particular degree requirements of the department for both undergraduate and graduate degrees. In addition, the instructor discusses research being performed as well as typical salary expectations[3].

Truss Bridge Laboratory

The second portion of the lecture is a brief tutorial on basic engineering concepts as they apply to a truss bridge. Some concepts that are covered include, but are not limited to, tension, compression, neutral axis, stress, strain, buckling, and deflected shapes[3]. These concepts are related to the students through demonstration with a foam board and drawings on the blackboard. The instructor conveys the purpose of the laboratory, which is to design and build a truss bridge, in teams, that will hold the most weight and "cost" the least. Finally, the instructor discusses the main failure modes for the bridge, so that the students could apply the engineering concepts they learned to design a more effective bridge. For example, the bridge is likely to fail at the bracing points since these represent a weakness in the craft stick.

The students are then given 30 minutes to design and build the truss bridge out of two sizes of craft sticks and bolts. This time constraint forces the students to form teams wisely and initiate leadership. This emphasizes the need for project management and timely delivery of materials[4]. They are given a cost estimate sheet quantifying the cost of the materials as $0.75 for short craft sticks, $1.00 for long craft sticks, and $2.00 per bolt and nut combination. Given the information, material, and time constraints, the students are allowed to complete their work. Figures 1 and 2 represent frames created by students.

Once the truss bridges are completed, they are loaded into the plexiglass and wooden testing frame. Figures 1 and 2 are examples of truss bridges loaded in the frame. Once the truss bridge is placed in the frame, a bucket is attached to the truss bridge where the weight will be placed. Figure 3 depicts a student placing weight into the bucket. The truss bridge is then loaded until failure. Figure 4 depicts a typical truss bridge failure outside the frame. Figure 5A and 5B depict the before loading and after loading of one team's truss bridge in the frame.

Figure 1. Typical student truss bridge with large craft sticks in testing frame

Figure 2. Typical student truss bridge with small craft sticks in testing frame

Figure 3. Loading of truss bridge

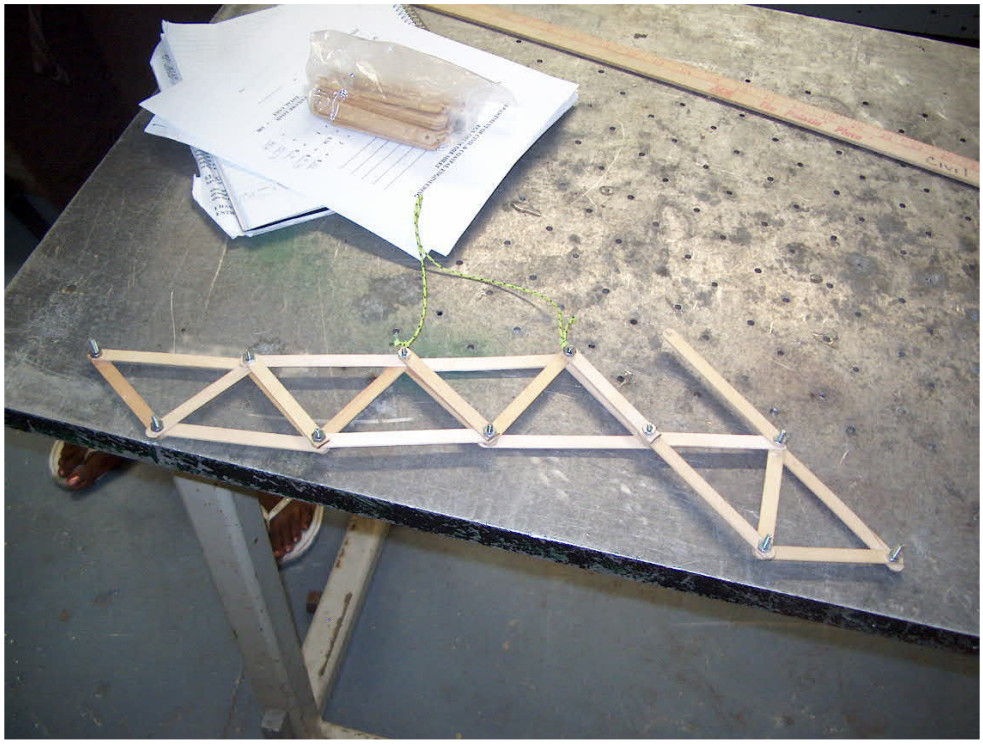
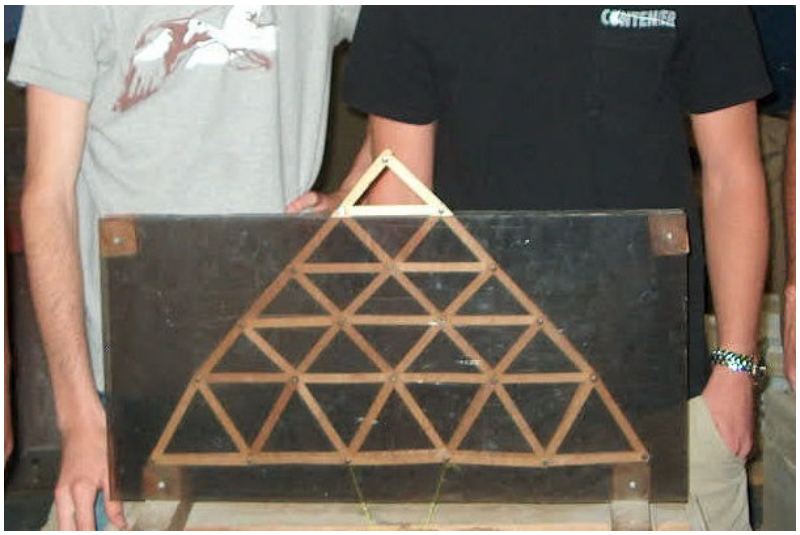
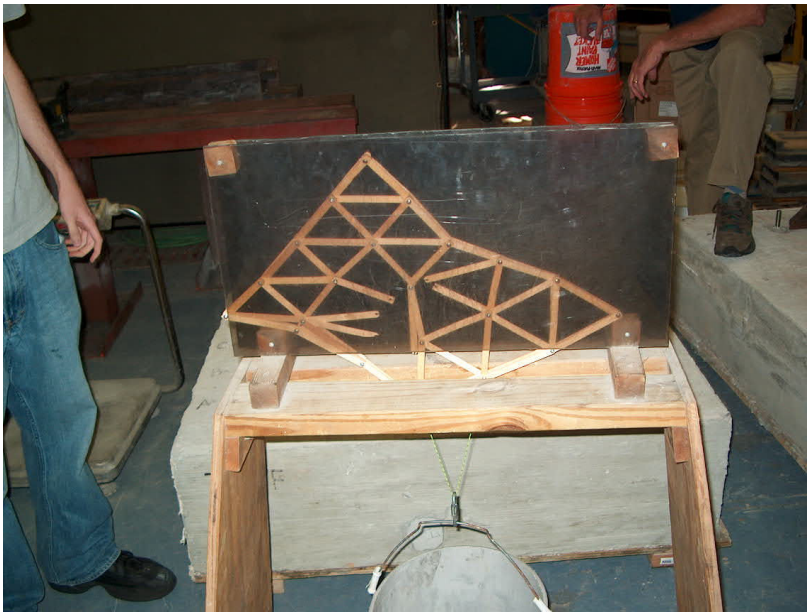


Figure 4. Typical truss bridge failure



A



B

Figure 5. a) Multilayer truss bridge before loading. b) Multilayer truss bridge after loading.

To calculate the scores for the truss bridge laboratory, the following equation is applied:

$$\text{Score} = (\text{Truss Bridge Failure Load} / \text{Truss Bridge Cost}) \times 100 \quad (1)$$

The purpose of students calculating a "score" for their truss bridge is to understand the relationship between cost and performance. They are shown that an engineer's job is to

provide services that provide adequate strength for the least cost. Table 1 gives examples of typical scores received from students.

Table 1. Typical scores from truss bridge laboratory

Truss Bridge Cost ($)	Truss Bridge Failure Load (lb)	Score
43	23.4	54.4
50	28.2	56.4
45.5	31.0	68.1
47.5	22.2	46.7
45.5	29.8	65.5

Laboratory Demonstrations

Following the truss bridge laboratory, two laboratory demonstrations are made to the students. These laboratory demonstrations are designed to provide students with a basic understanding of material strengths and how these strengths are determined. The demonstrations are also designed to facilitate stimulation of interest in civil engineering and display the tangible side of civil engineering, as well as to illuminate the theoretical concepts for the students.

The first of these tests is a concrete compression test, which demonstrates the compressive capacity of concrete. A 4 in. x 8 in. cylinder is loaded into the hydraulic compressive-testing machine. The students watch as the compressive strength of the concrete is calculated. It is pointed out to the students that knowing the strength of a material allows an engineer to calculate and design for the structural capacity of a member such as a column.

The final of these demonstrations is a demonstration of the destructive capabilities of a hurricane on a structure. The Civil and Coastal Engineering Department receives funding to do research testing from a multitude of sources and therefore the structures testing laboratory is equipped with a cannon that can be pressurized to simulate hurricane force winds. Using the cannon, a simulation of hurricane winds tossing debris is demonstrated. A 9 lb. piece of wood is fired at a simulated structure wall, in the form of 2, 3/4 in. sheets of plywood placed back to back in a steel testing frame. The wood is loaded into the air pressure cannon, and the pressure is increased to approximately 15 pounds per square inch. This causes the wood to move at speeds approximately 60 miles per hour. It has been determined that debris moves at about half of the speed of wind. Therefore, this demonstration is for category 3 hurricanes, which have wind speeds of 111 to 130 miles per hour.

Following the demonstration, the instructor informs the students about the purpose of this test and how the results are used to modify existing codes and provide future standards. This demonstrates another facet of civil engineering of which a student may have been unaware. Other tests being performed in the structures testing laboratory are noted and explained. Most notably, there is research being conducted on temperature effects on

bridge beams and the strength of anchor bolts constructed with certain adhesives. These are pointed out to further the point that civil engineering is a broad field and many different opportunities are available in civil engineering.

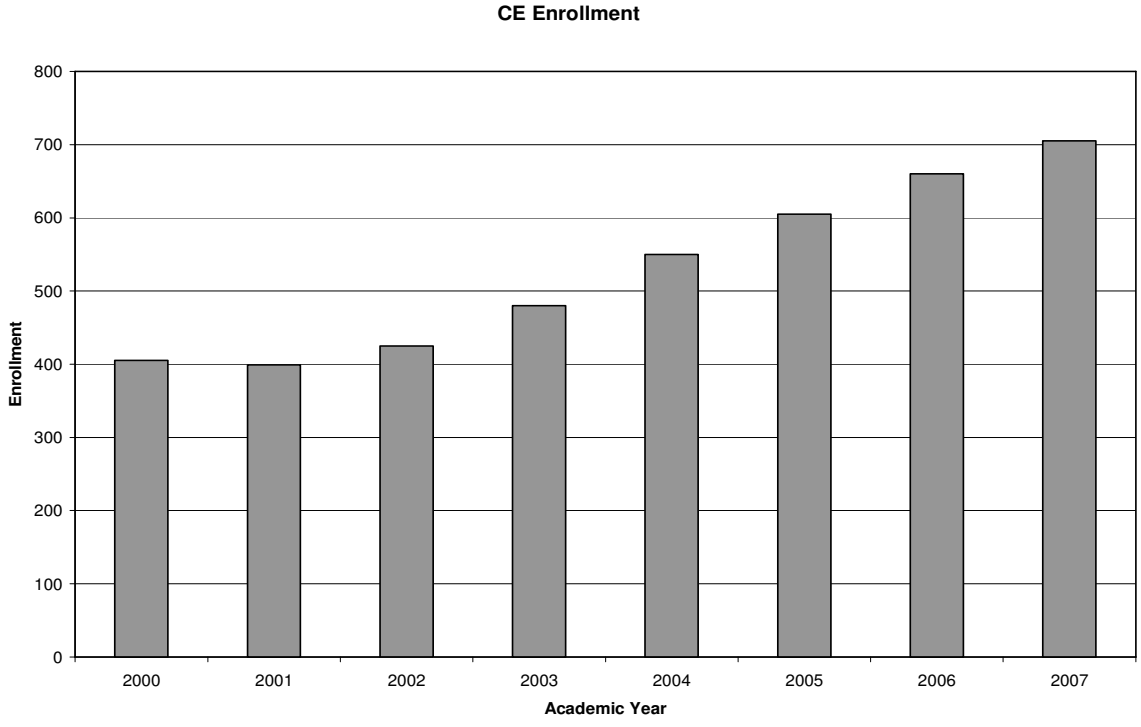
Class Results

At the end of the semester, the College of Engineering asks students to fill out course evaluations, rating the overall value of all of the courses in the department. The evaluation asks students to provide commentary in their own words on what could be done to improve the course, as well as using numerical evaluation to rate specific areas of the course. The results from the Spring 2008 semester yielded that the students taking civil courses had given the Civil and Coastal Engineering department the highest rating of the eleven departments within the College of Engineering.

As the Fall 2008 semester progressed, the EGN 1002 classes were verbally asked how the Civil and Coastal Department presentation compared to some of the other departments they had visited. Some student feedback received included comments that the lecture was more interesting than other departments. The students also commented that the conversational presentation of material as opposed to the utilization of Microsoft Office PowerPoint in the presentation was a welcome change from other departments.

Since the turn of the century, the number of students that have enrolled in civil engineering has increased dramatically. Table 2 summarizes the increase in enrollment from the 2000 Academic Year to the 2007 Academic Year[5].

Table 2. Civil Engineering Enrollment from 2000 to 2007



Conclusion

The Department of Civil and Coastal Engineering provides a brief insight to freshman engineers on the work involved in civil engineering and how it relates to daily life. Basic principles of civil engineering are discussed, put into practice in a student laboratory portion, and demonstrated to the students through laboratory demonstrations. The brief introduction to tension, compression, neutral axis, stress, and strain allow students to begin to grasp the concepts that civil engineers apply to solve problems.

Recent evaluations of the Department of Civil and Coastal Engineering's participation in the introduction to engineering course rated the civil department highly. The students viewed the lecture as informative and stimulating and greatly enjoyed the truss bridge laboratory and demonstrations. Several students have decided to change the direction of their education into civil engineering because of the presentation by the department. Based on this information, the methods approached by the Department of Civil and Coastal Engineering are effective in stimulating interest in the field of civil engineering. These methods would also be effective at stimulating interest in a variety of engineering fields and could be used as early as a middle school or high school to stimulate interest in engineering.

Bibliography

1. Hoit. M.I., Ohland, M., and Kantowski, M., "The Impact of a Discipline-Based Introduction to Engineering Course on Improving Retention," *Journal of Engineering Education*, Vol. 87, No. 1, January 1998, pp. 79-85.

2. Hoit, M.I., and Syfrett, E., "Freshman Interdisciplinary Laboratory - Second Year Results," *Proceedings*, ASEE Conference, Edmonton, June 1994, pp. 2470-2480.

3. Hoit, M.I., and Culpepper, K., "Freshman Interdisciplinary Laboratory," *Proceedings*, ASEE Conference Proceedings, Champaign-Urbana, June 1993, pp. 630-637.

4. Hoit, M., *Lab Manual for Introduction to Engineering* (EGN 1002), Department of Civil and Coastal Engineering, University of Florida, Jan 2004.

5. Tedesco, J., "Annual Progress Report", Department of Civil and Coastal Engineering, University of Florida, March 2008.