NSF NEXTGEN HS
FIRST YEAR ACTIVITIES SUMMARY

The first year of the NextGen HS module for integrating local high school students into a 4-week program was successfully completed on August 16, 2010. The objective was to help students understand some of the basic premises of earthquake design. The outcome of the course was *designing cost efficient earthquake-resistant two-story wood homes* using software (SAP2000) and live shaking table testing.

A report of the activities follows.

The personnel who involved in the NextGen HS module are

1. Dr. Thomas Attard
2. Chase Wharton
3. Kittinan Dhiradhamvit

Please visit: http://web.utk.edu/~cwharto2/The%20NextGen%20Team.htm and http://web.utk.edu/~tattard/ for a comprehensive overview of the program. The websites also include several pictures taken during the module, including shake table testing and classroom instruction and student participation.

Activities Reporting:

We started the NextGen HS program on July 23rd with an Introduction to the 4-week program. It was the intent of the course to provide students with a conceptual understanding of basic structural engineering, earthquake ground motions and earthquake mechanics, structural and nonstructural engineering concepts and definitions, wood construction techniques, computer technology applications (SAP2000), and hands-on experience with a visual of a seismic test. These concepts were embedded into four the NEESR-NextGen Learning Step (NLS) tutorials that constituted the Individual Students Educated in Earthquake Engineering (I-SEEE) protocol of our NextGen HS module. Each tutorial centered on a different theme during each week culminating in the construction and testing of a scaled wood home on a seismic shaking table using a scaled version of one of the components of the 1994 Northridge earthquake.

For this first-year module, we received 74 applications for the course that included references from high school guidance counselors in the Knoxville area. The NextGen team visited 9 local high schools to announce the **"Stop the World from Shaking"** themed program – see attached.

We ran the course for four weeks. Seventeen students attended the first class on July 16th although 30 students had been selected to attend. Each student had received a letter notifying them of their acceptance (see below).

Dear <Student>,

Congratulations! You have been accepted to the **2010 NSF NEESR Module 1** program. You were selected out of a pool of 74 applicants, so your efforts are to be commended.

For your information, the meetings are as follows:

July 23 (Friday)

July 28 (Wed)
July 30 (Fri)

Aug 4 (Wed)
Aug 6 (Fri)

Aug 11 (Wed)
Aug 13 (Fri)

Aug 16 (Mon)

Each session will **start at 1pm and last until 3pm**. If students want to stay longer after each session, we will also have the facilities available for that as well. We will meet in Perkins Hall on The University of Tennessee campus in Room 209.

We look forward to seeing you in about one month. If you have a friend or a favorite teacher who you think might be interested in learning a little more about earthquake engineering, you are more than welcome to invite those individuals as well.

If you have any questions, please email us at tattard@utk.edu or cwharto2@utk.edu.

Congratulations!!

Dr. Thomas Attard
Chase Wharton, Graduate Researcher and NSF Outreach Assistant
Kittinan Dhiradhamvit, Graduate Researcher and NSF Outreach Assistant
The University of Tennessee
Department of Civil and Environmental Engineering

Following the initial class session held on July 23rd, the NextGen HS course received get 3 more attending students who showed up starting by the third class on Friday July 30, bringing the total students in attendance to 20.

NLS 1
On *July 23rd*, the following links were used to show the direction in the Introduction to NextGen-HS program.

http://web.utk.edu/~cwharto2/NextGen%20HS-link_files/UT%20HS%20Presentation%20-%20For%20Site%20Post.pdf

Introduction to basics of structural engineering:
http://web.utk.edu/~cwharto2/Earthquake-tutorial1.htm

The session covered earthquakes, some of their causes, the concept of seismic waves, and the idea behind quantifying the severity of earthquakes via their magnitude measure. Common analogies were drawn to assist students with their understanding of these concepts at a grade-appropriate level.
On *July 28*, the following topics were covered with .PPT presentations attached in the links:

1. Earthquake mechanics "What is an Earthquake?"
2. Energy dissipation and recent earthquake dissipation

http://web.utk.edu/~cwharto2/Earthquake-tutorial1.htm

Three .PPT presentations were included to address these concepts
BasicStructures.ppt
EarthquakeMech.ppt
EnergyDis.ppt

On *July 30*, we covered Mode Shape Demonstration using a Plexiglas Frame that we constructed in order to show a live earthquake 'hand-shake' of a simple wood frame. This provided an immediate impact on base shaking for students too visually understand the concepts of the effects of having various floors with various mass and stiffness distributions. See the link covering the Experiment and Calculation of Mode Shape and Natural Frequencies http://web.utk.edu/~cwharto2/NextGen_module2.htm

NLS 2
On *August 4*, the second NLS began with the topic of Mode Shape Calculation using Excel that included a *Mode Shape File* (in MS Excel) for students to calculate structural mode shapes through a user-input that had been created. The file enabled students to gain a visual understanding of the mathematical nature of mode shapes. A sample of the Excel file was attached to the following link.
http://web.utk.edu/~cwharto2/NextGen_module2.htm

On *August 6*, we held an Introduction to **SAP2000** that included a tutorial that we wrote for the students. This step-by-step tutorial may be found at http://web.utk.edu/~cwharto2/NextGen-Tutorial3.htm where students could download a free trial of SAP2000. The students were walked through several examples of file building using SAP2000 that allowed them to gain valuable insight to using a powerful design/ analysis software tool for engineering applications. The students used this approach to designing their wood homes for resisting earthquake motions.

NLS 3
The *August 11* class focused on Wood Structure Design and Static analysis Using SAP2000. The cost function below was used to inform students how their wood design would be checked for earthquake-resistance:

Cost function, $C = C_f \times C_a \ddot{x} + C_d x + C_w W + C_T (\#connections)$

The cost function included factors, C_i, to account for accelerations resulting in potential non-structural damages to wood homes under earthquake excitation, displacements, overall structural weight, and connections. The factors provided students with a guide to ***designing cost efficient earthquake-resistant two-story wood homes***.

On *August 13*, the students concluded their Wood Structure Design using SAP2000 and were introduced to the nonlinear time-history code NON-LIN (Attard and Fafitis, *Engineering Structures*, **29**(8)). A (nonlinear) dynamic time-history analysis was performed using NON-LIN to show students the potential response of various structures constructed of various materials to indicate the benefits of energy dissipation.

NLS 4

Finally, on August 16th, the winning design model was tested (after being constructed over the weekend on Aug 14 and 15) on a small seismic shaking table at The University of Tennessee. The winning student was Bronson Peterson of Bearden High School. Bronson's design included a wood frame structure with cross bracing on the bottom story and a shear wall on the top story (12x12x24). The shaking table test utilized a scaled Northridge earthquake along with resonating sine waves. The structure successfully withstood the seismic shaking.

Impact Factors

The number of high school students who were impacted is roughly 250 students who heard the presentations across the nine local high schools.

The first-year program has impacted several students in the Knoxville region and that brought o light several concepts and implications of earthquake-resistance. It provided students with a goal for potentially entering into an academic program focused on structural engineering that could lead to an increase in student enrollment at The University of Tennessee. The 20 students who attended the program seemed very pleased with the course. Two sample letters are provided below.

You guys did a good job with instructing the course. You provided good visuals and demonstrations. You adequately explained the SAP program and how to use it. You all provided help if needed on our designs.

One of the only problems I personally had was not seeing the shake table and its full effects ahead of planning and designing. As a result, too much caution was taken and designs were too stiff. If the class had seen a demonstration of the shake table in person, I think the class would have benefited.

Thank you for the opportunity to learn about earthquake engineering!

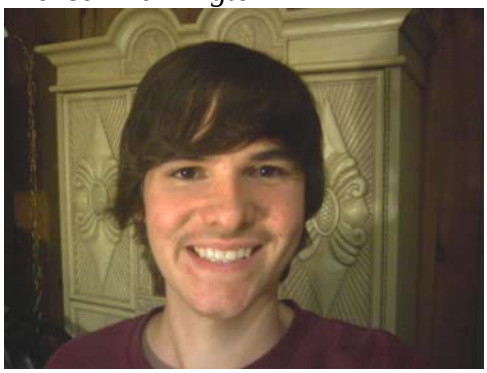
Caleb Allen

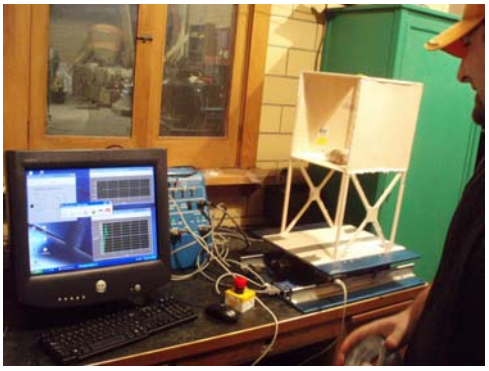
Dear Dr. Attard,

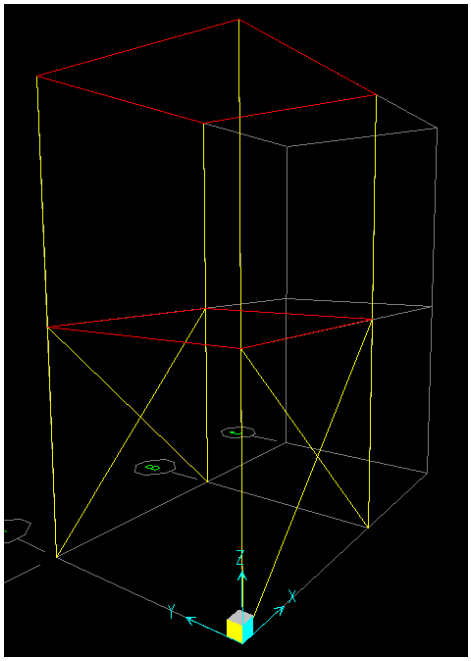
The earthquake engineering program was both educational and enjoyable. I learned much about the civil engineering process as well as earthquakes, which can level the structures of generations in seconds. This was also my first experience with SAP, or any CAD program for that matter. SAP proved to be a powerful, time-saving tool for the design process. I am most grateful that the program (including parking) was totally free. The schedule was quite manageable, at only for hours per week. This was appropriate for summer time, when many students are out of town or have little interest in matters of education. My only regret is that more of the selected applicants did not attend, as they would have felt that it was time well spent if they had any interest in engineering at all (they must have since they bothered to apply). I hope that you all have a grand finale tomorrow; eat plenty of pizza for me. I wish I could be there, but I have to turn in some forms at school and get my parking pass. Have a great school year and thanks for the free knowledge!

Sincerely,

Bronson Pennington







Important activities:

1. Plexiglass Frame Demonstration
    a. A multi-stories building model ("Plexiglass frame") was constructed to provide a better understanding of the concept of structural dynamics to high-school-level students. The model was composed of 4 masses (wood block), 12 columns (made of an acrylic plexiglass) and a 2 x 4 wood block base. The masses and columns were made to be removable so that the degrees of freedom of the model could be changed to indicate the behavior of varying stiffness and/ or mass distributions. In particular, the mass of a given floor could very easily be changed by adding additional wood blocks to the floor. Also, the columns could be constructed for 2 different heights (either 14 inches tall or 18 inches tall). This allowed us to create an interchangeable mass-stiffness system to show the effects of multiple mass and stiffness combinations on the natural frequencies and mode shapes of a structure. The model was used to describe stiffness calculation, natural frequencies, mode shape, resonance and concept of base isolation starting in NLS 1 and served as introduction into the Structural Design Competition and Seismic Shaking Table Experiment among the students.
2. Interactive Websites
    a. NLS Tutorials that were focused on weekly achievement protocols
    b. Mode Shape File for mode shape calculations
3. SAP2000
    a. Design of two-story wood-built homes
4. NON-LIN
    a. Use of a nonlinear time-history analysis code to quantify the response time-histories of the wood home designs
5. Demonstration of Seismic Shaking

Ways we can improve the course:

Even though we included the Mode Shape Demonstration using a Plexiglas Frame session on July 30th during NLS 1, we needed to build a sample wood frame and to test it on the shaking table during this early stage as well. In this manner, the students would have gained a stronger visual understanding of their ultimate goal – to build the best possible earthquake-resistant home.

We also need to 'get the word out' for our program during the entire summer of each upcoming course each year. We need to send reminder emails and letters, and to make phone calls about the program (that started this year on July 23rd) possibly 2-3 times once the school year ends so that students and parents can mark it on their calendars and view the program as an upcoming event for each selected student. Otherwise, there will be a repeat problem of no-shows.

Students, parents, and teachers appeared very excited during our on-campus presentations to the nine nigh schools, but when the school year ended, other matters took priority. The result was that some students failed to show-up. This consequently made it too difficult

for us to contact alternate candidates for the simple reason that once a student misses the first NLS session (NLS 1), it becomes difficult for that student to catch up starting with NLS 2.

Ways we can build on our success:

We will be sending out the attached flyer to all the area high schools announcing the winning design this year in hopes of continuing to grow the interest level through 'word-of-mouth' and visibility for 'Stop the World from Shaking.'