Structural Mechanics

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Abstract

Development of new technological advances, such as computer software packages, are increasing and can easily be incorporated into the classroom to better illustrate difficult and important concepts. In contrast, these same ideas have been and still can be taught using effective teaching methodologies without the use of any computer technology. There exists an optimal point of education that that can be achieved by bridging the two beliefs with a balance of new technology and new teaching methods. Educators need to understand that technological advances should help in the teaching process as opposed to take over the teaching process. Educators must be certain that they not rely entirely on computers to express important concepts and theories. To effectively teach, they must teach the fundamentals, introduce current topics, and explain practical applications through merging traditional teaching styles with new technological advances.

Introduction

To enhance the learning process, educators must tailor teaching styles to integrate our society's technological advances with traditional principals. From the conception of our Structural Mechanics course, forward strives have been taken in the laboratory and lecture setting to emphasize both theory and the practical applications of the material being taught. Recently, the implementation of new computer technology and laboratory developments has resulted in an increase in both course effectiveness and student interest. Emphasis has shifted from witnessing of standardized material tests to new intuitive methods to illustrate like concepts while at the same time introducing discipline specific practical applications. Included in the transition have been improvements in the manner experimental data is now obtained, transferred and processed. The authors would like to express that the methods described hereinafter are suggestions to accommodate the growing emphasis of computers in society. This paper is intended to focus primarily on the positive aspects of our course developments, most of which have occurred in the laboratory. However, implementation of new methodologies sometimes leads to potential for difficulties to arise. Thus the paper will also identify the reader of such problems and furnish solutions where applicable.

New Experiments

Advances are most evident in new experimental procedures being performed in the laboratory. In order to benefit from a laboratory setting, students should work in smaller groups. The intent is to get students involved in the experiments to reinforce the concepts being discussed in the lecture and provide practical applications where applicable. The new procedures are less cookbook and more self-directed than in the past, lending themselves to group collaboration. Several experiments have been created to better illustrate difficult concepts through inexpensive and easily fabricated models. Examples of some experiments emphasizing these principals are as follows.

A common connection in many structures, but usually not discussed in great detail at the undergraduate level is the nail. In the laboratory, students drive nails into a piece of wood at various depths and angles to the grain. This focuses not only on the behavior of the nail connections but it also shows the importance of normalizing data with variables in order to make reasonable comparisons. Materials, such as PVC, are being used to illustrate the axial effects of a pipe subject to a concentrated load under various boundary conditions. Enabling students to easily fabricate models in order to see the response of determinate and indeterminate systems. PVC is also utilized to show torsion effects when a pipe is subject to a torque.

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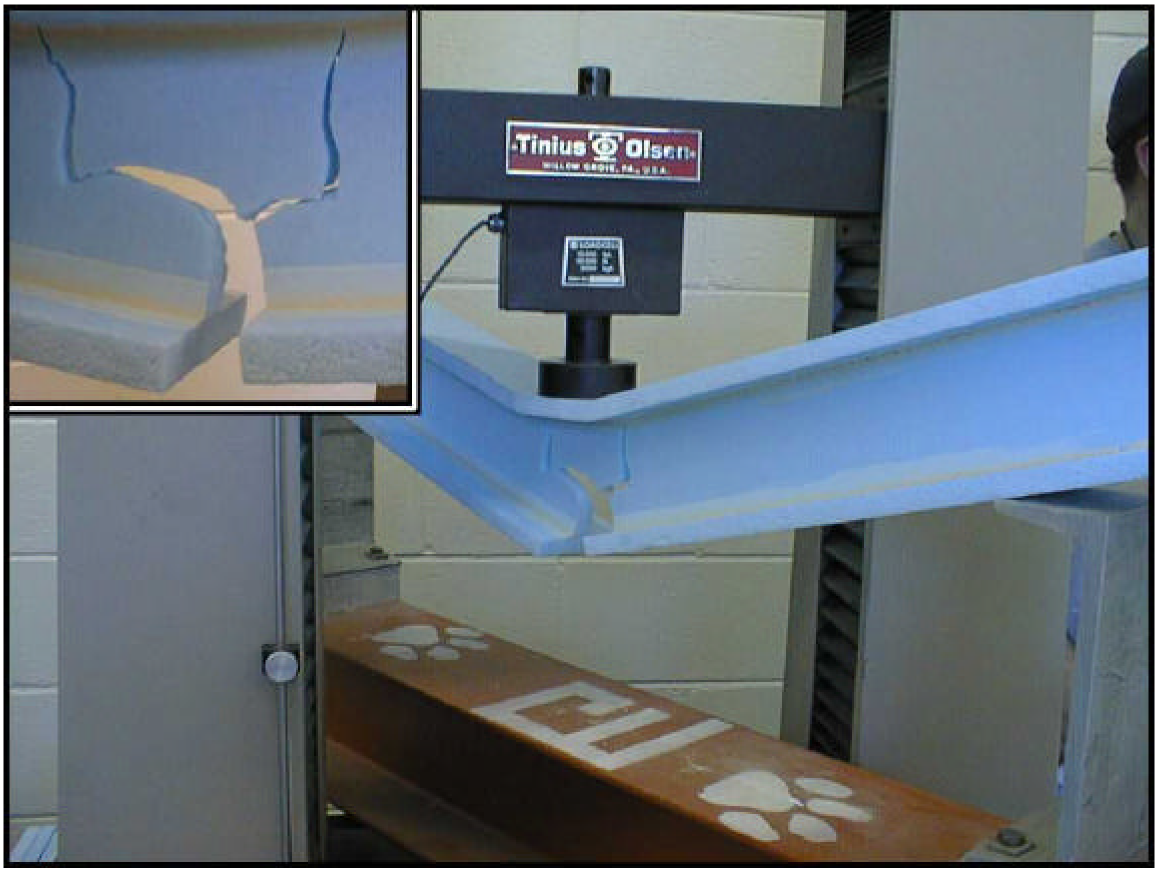
Beam design concepts are addressed using miniature models constructed from Styrofoam and concrete, as seen in Figure 1. Easy to construct and handle, the Styrofoam models demonstrate how beams and built-up beams react and respond under various loading conditions. Material orientation and deflected shapes are concepts of particular interest with these models. Plastic forms, deformed steel rods, and concrete are used to expose students to the importance of proper placement of reinforcement material in miniature concrete beams. Students devote their time in constructing and testing various reinforcing schemes. The testing of the beams emphasizes the brittle and ductile characteristics of concrete and steel, respectively, while the students enjoy the hands on experience and conveniently gain an understanding of a practical application of the models. Again, simple and cost effective models are being used to reinforce a theoretical concept and practical application.

Figure 1 Styrofoam Beam Models

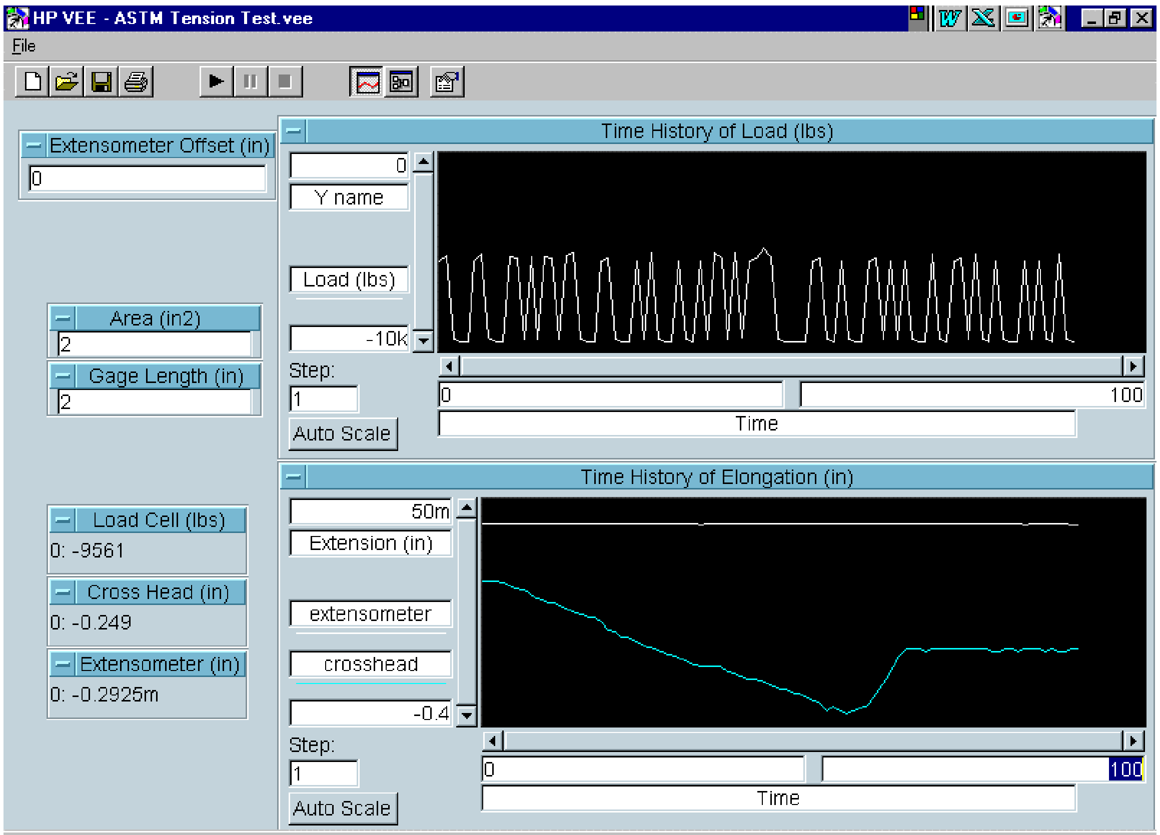


Perhaps just as effective, but slightly more expensive, is the increased use of strain gages in the laboratory. Fundamentals of strain gage technology are established in a prerequisite course thus enabling students to fully appreciate practical applications in the laboratory. Attaching gages to items such as a bar, beam and pressure vessel contribute to the students' understanding of strains and how they are influenced under various loading conditions. Strain gages located on rectangular aluminum bars are used to show the behavior of quarter, half and full bridge configurations when the bar is placed in tension and bending. Two orthogonal gages located on each side of the bar require the students to understand the response of each to appropriately connect the configuration. The apparatus makes use of the fundamentals of strain gage technology and at the same time acquires data that verifies equations for bridge configurations. A subsequent experiment builds upon this basic understanding of strain gages by studying combined states of strain. Here, nineteen strain gages are attached at various locations along a six-foot aluminum W-section. The gages are monitored as the beam is subject to a third point bend test. The apparatus concentrates on both shearing and bending strains in a beam. Strain gages are also attached to a pressure vessel to demonstrate how lateral and longitudinal strain influence one another when the vessel is pressurized and twisted. In all three experiments a computer is utilized to acquire and process the data.

Data Acquisition Improvements

An experiment usually proves to be of little use if the collected data does not support the theory. To address this issue, advances have also been made to acquire precise data. A prerequisite course introduces students to HPVee[1], a "real-world" object oriented data acquisition software package. The software requires students to logically develop computer programs to obtain and process experimental data. Furthermore, technological advances have led to the introduction of an electronic extensometer for collecting the data. By merging the two ideas, accuracy is inherent to experiments that, in the past, have been subject to error. Continuous data is collected throughout the entire duration of a standard ASTM tension test as opposed to readings taken at a pre-determined load increment. We have essentially modernized the data collection of ASTM tests to generate interest in the new generation of technologically inclined students. A typical interface, as shown in Figure 2, displays real-time data that can be discussed to illustrate theoretical concepts. Stress-strain diagrams are then created using the data and examined for material properties and characteristics.

Figure 2 Typical HPV Interface



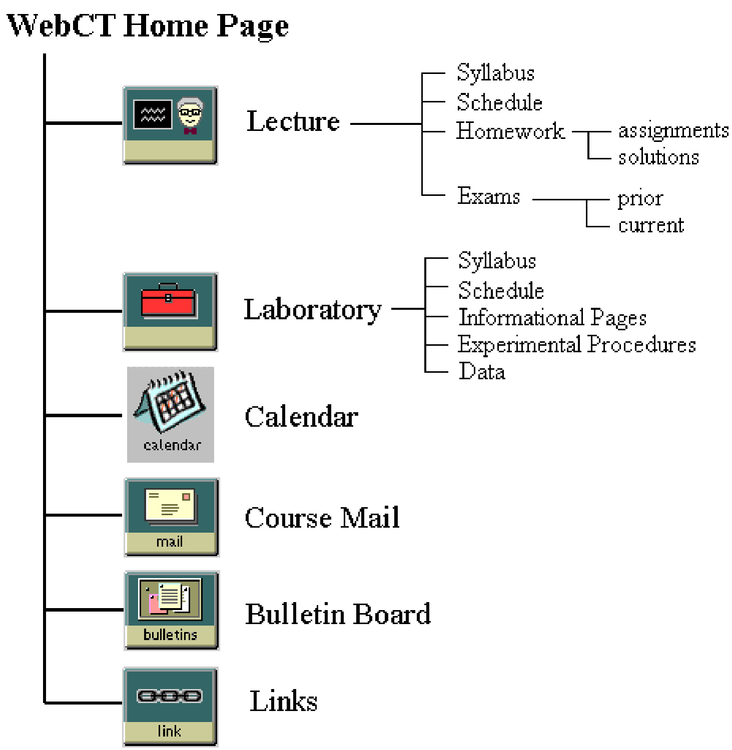
Software Emphasis

Students are often required to process experimental data to study behaviors and relationships that theoretically should exist. Spreadsheets play a key role in this process. Students plot data to study trends and relationships while simultaneously become familiar with a software package they will use throughout their careers. Similar to HPVee[1], Excel is used in some experiments to display real-time results that illustrate trends and system behavior. This supplies students with assurance that, in practice, things behave as they should or indicates when an explanation may be necessary. Educational software packages such as Dr. Beam & Dr. Stress[2] also are employed to graphically illustrate internal beam forces, beam deflections and three dimensional states of stress. Similar mechanics-related packages developed at West Point United States Military Academy and Murray State University are also used.

Course Website

WebCT[3] is a university licensed software package that has allowed the development of an interactive web site for the course. It should be noted that the site is, and only should be, used to provide supplemental class material. WebCT[3] has benefits for both sides of the learning process, students and instructors. Most importantly students are provided a web site devoted entirely to the course. Interactive tools and functions are available at their disposal to promote collaboration and communication on assignments. WebCT[3] also relieves some unnecessary work for instructors. Syllabi and course material are easily posted and maintained for both the lecture and laboratory. Changes can be made to such postings and go in to effect immediately without having to re-distribute a new document. Grades are easily managed and securely posted so students can be aware of their scores at all times. Posting grades on WebCT[3] also gives the students an opportunity to track their performance amongst the class using built-in statistics such as an average and range of scores. Perhaps the biggest benefit of WebCT[3] is its worldwide accessibility. As long as one has Internet access they can access the course material at their convenience. A flowchart of the site is illustrated in Figure 3.

Figure 3 Flowchart of Course Website



The coordination of lecture and laboratory are no more evident than on the web. Schedules for both are posted to give prior notice to what topics will be covered before students come to class. Upon closer examination, the laboratory is seen to coincide with virtually each week's lecture material as to give students a better appreciation for the material being discussed. Most laboratories begin with a "focussed" lecture with emphasis on material pertinent to the experiment for that particular week.

For the lecture, the web site has been customized to post homework assignments/solutions and previous/current exam solutions without any concern of theft or misplacement that usually occurs when physically posted. For lab, the site acts as an online lab manual. Informational pages such as operation manuals for testing machines are available so students can read them prior to lab. Similarly, experimental procedures are posted for students to download and read before coming to class. The time required to download and print-off pages is a trade off to the students for saving a little money in purchasing a pre-printed manual. Pictures of each week's experiments are posted to illustrate what set-ups of the procedures should look like. These pictures can also be used in students' lab reports. Data recorder during some experiments is posted to the web to save time in obtaining the data for time that can be put forth in processing it. This recently proved to be very beneficial after a testing machine became inoperable for subsequent groups. The groups that were unable to participate in the experiment were informed, via the course e-mail, to access and process the data from the previous section.

Students sometimes learn more from other students. Keeping this in mind, WebCT[3] proves each student with interactive functions such as an e-mail account, bulletin board, chat room, and calendar devoted specifically to the course. Each function allows students to communicate, collaborate and interact on assignments. Regardless of their physical proximity, students can work closely with one another since they can access the Internet. Students can chat with other group members, post a bulletin asking for help or suggesting a hint, check the course calendar for important dates, or even check their course e-mail to see if there are any new messages awaiting them. The course e-mail has been a very convenient form of communication. Also students can check their grades or updated class material.

In the future the web site will include a library of structural related pictures. Such pictures will be used in hypothetical problems to better illustrate both what is being asked as well as ways in which the concept can be used in real-world applications. The problems will show students how the theory will be put to use after graduation. The problems will also help students visualize the behavior and uses of the concepts being taught.

The web site has proved to be very beneficial according to the majority of students using it. Some students' comments are as follows: "It [WebCT] allows me to have access to my assignments and grades whenever I need them. It also allows me to print off procedures prior to lab, so I can go over them before the lab. I think it had been a really good addition to the class." "Having all the class information on the web is very useful. That way I can access it whenever I need to."

Conclusion

Computer technology has endless possibilities. However, it cannot be emphasized enough that there must exist some limit of how much they are used in the classroom in order to achieve an optimal teaching process. Previously, instructors would perform laboratory experiments while students witnessed. If we rely too heavily on computers in the future, the computer will do all the work and essentially take the place of the instructor. The obvious solution is to merge the past and future with the introduction of some computers while simultaneously introducing new intuitive laboratory procedures requiring the students to get "hands-on" experience with the concept being taught. Some problems have been found to occur when trying to rely too heavily on computers in the classroom. The authors recommend that most HPVee interfaces be pre-programmed for the students. This ensures the student is concentrating solely on the concepts introduced in the course.

In the future, a project with a specific objective, but many possible solutions will be assigned to the students at the beginning of the semester. The purpose is to provide the students with enough information in the lecture and laboratory that they can, together in small groups, use to meet the problem statement. Such a project would use and incorporate all the teaching methodologies and technological advances discussed throughout this paper.

References

[1] *HPVee*, Hewlett-Packard Company; Palo Alto, California.

[2] *Dr. Beam* and *Dr. Stress*, Dr. Software, LLC; Seattle, Washington.

[3] *WebCT*, WebCT Educational Technologies; Vancouver, British Columbia.

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Kevin is a structural design engineer with Walter P Moore and Associates, Inc. He received both his M.S. and B.S. degree in Civil Engineering at Clemson University in 1997 and 1998, respectively. While attending Clemson as a teaching assistant, Kevin helped develop new experiments in the Structural Mechanics Laboratory.

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Dr. Schiff has taught undergraduate and graduate courses in the structural engineering area. For the past two years, he has taught the undergraduate Structural Mechanics course and supervised the laboratory instruction. In 1994, he received the Outstanding Teacher Award presented by the Chi Epsilon Chapter at Clemson University. Dr. Schiff is a member of the American Society of Civil Engineers, the Earthquake Engineering Research Institute, and the American Association of Wind Engineering.