Wood As An Engineering Material

Professor Frank J. Worzala*
Professor Jerome F. Saeman**
College of Engineering
University of Wisconsin
Madison, Wisconsin

ABSTRACT

Timber is our most abundant renewable resource and wood is used extensively as an engineering material. Yet most engineering schools devote minimal attention to wood. The major reason for this lack of course work is the unavailability of text material and the general lack of expertice on wood by most faculty members. This is particularly true in materials science, materials engineering and metallurgy departments, where the background of most professors is in the area of metallurgy.

Over the past three years, the Engineering College of the University of Wisconsin has been working with the Forest Products Laboratory (FPL) to provide pertinent and current text material for use in teaching students about wood. In the summer of 1979, the First Heritages Workshop was held in Madison, on "Wood-It's Structure and Properties", organized by FPL with funding from the Clark C. Heritage Bequest. This workshop brought together world renowned experts to present a series of coordinated lectures on wood. These lectures were written up as educational modules and presented to 35 materials science and engineering educators for review and criticism. The modules were subsequently published in the Journal of Educational Modules in Materials Science and Engineering (JEMMSE) and are available for classroom use. The lectures were videotaped and are also available at the University of Wisconsin, Madison.

Using the modules and the videotapes as primary teaching tools, a course was offered by the Metallurgical and Mineral Engineering Department on Wood as an Engineering Material. This paper describes the course, the format used to present the material, and the response of students. On the basis of our experience, we feel that coursework can be incorporated into the engineering curriculum by faculty members not having prior expertice in wood. Through the use of the educational modules and the videotapes, this important engineering material can receive the attention it deserves.

*Professor of Metallurgical Engineering and Materials Science
**Adjunct Professor of Chemical Engineering. Formerly Director of Research, Forest Products Laboratory, Madison Wisconsin.

Introduction

On June 16, 1976, Dr. Jerry Saeman, Associate Director of the Forest Products Laboratory, presented a paper at the Annual Meeting of the American Society for Engineering Education.[1] In his paper, Dr. Saeman made an impassioned plea to the assembled engineering educators, asking them to look upon wood as an engineering material and to discover its many attributes. His major points were--

- that non-renewable resources, particularly metals, are being consumed at such rapid rates that shortages can be expected in the not-too-distance feature;

- that wood, our most prominent renewable resource can be used as alternative to energy-intensive and scarce mineral, metal and petrochemical products--in a very cost effective manner;

- that wood as an engineering material is given minimal attention in engineering texts or materials science courses. Under these circumstances, engineering students know little of the nature and behavior of wood or where to obtain such information;

- that the ASEE and engineering educators have an obligation, in the national interest, to correct these deficiencies in existing materials course being taught to engineering students. Furthermore, he argued that new courses and research programs on wood should be initiated so that some of our engineering graduates might be inspired to pursue advanced work on wood in either engineering or wood technology departments.

In the five years that have elapsed since Dr. Saeman presented his paper, entitled, "Wood as an Engineering Material--An Issue for Educators", a substantial degree of progress has been made toward helping educators meet the obligations mentioned above. The most important event was the Heritage Workshop,[2] on "Wood-It's Structure and properties", held in Madison in August of 1979. Organized by the Forest Products Laboratory (FPL), with funding from the Clark C. Heritage Bequest, this workshop brought together world renowned experts to present a series of coordinated lectures on wood. These lectures were written up as educational modules and were presented to 35 materials science and engineering educators for review and critisim. The modules were subsequently submitted to the Journal of Educational Modules in Materials Science and Engineering (JEMMSE) for publication. After completion of the workshop, a course was offered in the engineering College at the University of Wisconsin, using the modules as a text. The FPL agreed to sponsor the course by providing partial salary assistance to Professor F. J. Worzala and travel expenses for the speakers to return to Madison for presentation of a one-hour lecture. Each lecture was videotaped. A report describing the course (taught in the

Spring semester of 1980), and an analysis of the reaction of students to the modules and the course material, was included in reference 2.

In order to determine the effectiveness of using the videotape lectures as a teaching tool the course was again scheduled in Semester II of the 1980-81 school year. This paper is a description of the course and an analysis of student response.

Course Format

Because of the close proximity of FPL and the Engineering campus, the course was taught at the lab. This allowed for participation of FPL personnel in question and answer sessions that followed the showing of videotaped lectures.

Because of the time problems experienced with a 2 credit, 2 hour format (used the first time the course was offered), the decision was made to extend the course to 3 credits. Meeting times were scheduled for 75 minutes, twice a week. This provided sufficient time to run the tapes and allow for question and answer periods. Students were asked to read the modules prior to each presentation. Lecturers from the FPL who had been previously videotaped were given the choice of appearing live or on tape. Most chose to use the tape, and agreed to be available for questions. For the other tapes, selected members of the FPL staff, who were familiar with the material being presented, were invited to answer questions.

For class periods when neither tapes nor lectures were presented, a variety of activities were planned. These included small group discussion, demonstrations, lab experiments, a panel discussion and exams. In addition, students were required to work in small groups on projects related to novel and innovative uses of wood as an engineering material. Students were occasionally given short periods of time to work on projects during class time, but were expected to do the major portion of their projects as homework. The last two class periods were set aside for project reports. Students were required to submit a written project report at the end of the semester. Those students not enrolled for credit were required to submit an annotated bibliography as well as participate in the oral reporting.

Course Publicity and Student Make-Up

Because a course offering in the College of Engineering on the structure and properties of wood was a relatively unique idea, it was felt that some publicity was necessary. Professor Worzala briefly described the course to students enrolled in M&ME 350 at the end of the Fall semester, 1980. This course, An Introduction to Materials Science, is taken by engineers in their junior or senior year. Mechanical engineers are required to enroll in this course, while other engineers take it as an elective. Approximately three hundred engineering undergraduates including about 50 Civil Engineers, enroll in M&ME 350 each semester. The Chemical Engineering Department offers their own materials course. No attempt was made to publicize the course among chemical engineers; however, a handout describing the course was transmitted to the instructor of the Ch.E. materials course. Students in the M&ME 350 class were also given handouts if they expressed an interest in obtaining information about the course. Several copies of the handout were also sent to the Forestry Department.

Course Content

A. Lectures

The syllabus used for the course is presented in Attachment 1. Tapes of all speakers who participated in the Heritage Workshop were presented. In addition, Professor Worzala presented a lecture on "The Importance of Structure", from the point of view of a materials scientist. Modules were available for all lectures, except that of Professor Worzala. Students were advised to read the modules in preparation for each week's lecture. Approximately 20 minutes were available for questions after the tape playing. Generally, a member of the FPL staff familiar with the topic was available for answering questions.

B. Demonstrations and Laboratories

Meeting at the FPL, the class was able to participate in a number of unique demonstrations, as indicated on the syllabus. The demonstrations include a variety of sophisticated equipment used to study wood structure, including the scanning electron and light microscopes, and x-ray analyzers. In addition, demonstrations of moisture effects and mechanical property testing were included. The availability of several pilot plants at the FPL made the demonstrations of papermaking, veneer preparation and wood reconstitution particularly informative and engrossing.

C. Panel Discussion

On one occasion, a panel discussion was used to convey additional information on a topic that was covered only partially in the module and the lecture. This technique was used to expand upon the topic of wood based composites so as to include information on commercial products, adhesives and future prospects.

D. Projects

In order to provide students with an opportunity to concentrate on engineering applications of wood, a project assignment was given. All students were required to take part in small group projects.

Those taking the course for credit were required to write a paper. Those auditing were asked to submit an annotated bibliography at the end of the semester.

Project topics were decided upon by means of several short brainstorming sessions. Students were asked to suggest novel or innovative engineering applications of wood that could be investigated either in the literature or the lab during the course of the semester. A long list of projects (shown in Attachment 2), resulted from the brainstorming sessions. The class was then divided into groups of two or three people in accordance with their preference for topics. An attempt was made to place engineering students and FPL employees in each group, so as to stimulate an interdisciplinary approach to problem solving. The final projects selected and studied during the semester are shown in Attachment 3. Oral reports were presented during the last two class periods.

Student Evaluation

In order to determine student reponse to the modules and the mode of instruction, evaluation questionnaires were distributed to the students on the last class day. The standard engineering college evaluation form was not well suited for this course, since it is directed mainly at an assessment of the individual course instructor. Therefore, a special questionnaire was made up which asked questions more specific to the course. The questions asked and the average scores are shown in Table 1. Included in this table are the average ratings obtained after the first offering of the course. As can be seen from the table, the students felt positively about the course and the instruction. All questions related to the course, except those about the videotapes, were graded at 3.7 or above. These were somewhat below the scores recorded when the lectures were presented personally by the module authors. The instructor ratings for the course were generally higher than the course ratings, averaging 4.4.

Looking more closely at individual questions regarding the course, it can be seen that the quality and its value to the student were rated highly. Similarly, the modules, in terms of quality and usefullness as a learning aid were considered to be very good. The points rated most highly were the projects and lab experiences. These questions were rated at 4.4 and 4.2 respectively. The response to the question concerning the recommendation of the course to a friend was positive, with a rating of 3.9.

Regarding the instructor ratings, there was unanimous agreement that the lecturers were knowledgeable and enthusiastic about their subject matter. The questions concerning helpfulness and rapport with students were also rated highly.

The only aspect of the course not rated highly was the use of videotapes. Three questions concerning the tapes had a rating which averaged 3.1.

Several students commented on various aspects of the course. Some of these are reproduced below:

> "I thought this course was run very well and it taught me a lot about something I've somewhat taken for granted - wood. The lab demonstrations were excellent. I think one or two of the more complicated videotapes could be edited or replaced with more interesting material."

> "This course was excellent. I've learned a lot and have no regrets about taking the course. It was well organized, had the proper atmosphere for learning and the instructors were definitely energetic about the subject matter."

> "I liked the enthusiasm of the instructors. I think personal presentations are much more effective than the videotapes, though most of the tapes are quite good. Some seemed too long."

> "I think the class would be improved if there were fewer videotapes and more instruction in person."

Conclusions

It is the personal opinion of the author that the Wood as an Engineering Material course was an excellent learning experiment for all concerned. Based on conversations with the engineering students in the class and their evaluations, it is concluded that a course of this type definitely has a place in the Engineering College curriculum. Philosophically, educators who has been trained in materials science are quite well suited for teaching this course using the modules. The materials scientist looks at all materials to determine similarities and interconnections. The central theme of materials science is the study of structure, its influence on properties and methods by which structure can be varied to improve properties. The wood modules have been organized and written with this viewpoint. An orderly progression is made from coarse and fine structure, to properties (both mechanical and physical), to products and finally, to ways of improving properties. For materials scientists, this same general approach is used to teach engineering students about all materials and wood can be easily included.

Metallurgists, on the other hand, are less suited to teaching a course on wood. They tend to have minimal training in polymers and have specialized in metallurgical phenomena such as dislocation behavior, solid state theory and diffusion mechanisms, to name a few.

Most textbooks they have read or used were written by metallurgists and place a major emphasis on metals. Wood is only briefly mentioned, as an example of a natural composite. If the modules prepared for the Heritage Worshop do nothing more than provide textbook authors with a concentrated and concise source of information on the structure and properties of wood, they will have served a very necessary purpose. The modules represent a very concentrated and well organized compilation of information on wood. With the help of the modules and selected tapes it is my feeling that even the metallurgist can learn enough about wood to teach an effective engineering materials course.

A major objective of this course offering was to determine the effectiveness of the tapes and modules in teaching engineering students about wood. Since there are very few professors knowledgeable on this subject in engineering schools, ways must be found to transfer this information in an effective and interesting manner. On the basis of student comments, the extensive use of videotapes does not appear to be a means of accomplishing this. While students appeared to be enthusiastic about the tapes early in the semester, they seemed to tire of them later on.

Having used the modules for two separate offerings of the course, I continue to believe that a materials science professor could teach an effective course on wood-using the videotapes and modules. However, in view the current atmosphere of overcrowded engineering colleges and staff shortages, I'm beginning to doubt that such course offerings will become common. The majority of engineering professors around the country are being asked to increase their teaching loads in order to accomodate the increase enrollments. Additional staff members are not being hired because of budgetary restrictions. In light of this situation, it might be more efficient to prepare a series of tapes and modules which could become a part of a standard materials science course. Since almost all engineering curricula include a course like this, taken by all engineers but electricals, this would be an effective way to reach engineering students. Perhaps a consolidated three part module and three summary tapes would be most suitable. In this way, a materials science course could be taught which included two weeks of concentrated instruction on wood. Engineers could thereby be introduced to the characteristics of wood which make it a usable engineering material.

References

1. Saeman, J. F., Wood as an Engineering Material--An Issue for Educators, Event #2585, ASEE Annual Meeting, 1976.

2. Wangaard, F. F., ed., Wood: Its Structure and Properties, Vol. 1, EMMSE, p. 454, 1981.

Table I.
EVALUATION FORM M&ME 401
Wood as an Engineering Material

Course		1st Offering	2nd Offering
1.	Value of course to you.	4.3*	3.8
2.	Overall quality of course.	4.2	4.1
3.	Modules helpful for learning.	4.3	3.7
4.	Quality of modules.	4.2	3.8
5.	The course came up to my expectations as derived from description.	4.2	3.3
6.	Was the interdisciplinary nature of the class helpful?	4.6	4.1
7.	Would you recommend the course to a friend?	4.3	3.9
8.	Was the project a good learning experience?	4.4	4.4
9.	Were the lab periods worthwhile?	3.7	4.2
Instructors			
10.	Knowledge of subject matter.	4.8	4.5
11.	Enthusiasm and interest in subject matter.	4.3	4.5
12.	Rapport with students.	3.5	4.5
13.	Helpfulness in assisting students.	3.8	4.2
14.	Do you think videotapes could be substituted for half the speakers if the course were taught next year?	3.5	
15.	Do you think videotapes could be substituted for three-fourths of the speakers?	2.6	
16.	Do you think the videotapes were effective?		2.9
17.	Do you think the number of videotapes used was proper?		3.1

*Maximum possible rating is 5.

Attachment 1

Syllabus MME 401

Date	Topic
1/19	Overview and Objective
1/21	An Overview of Wood as a Material-Professor Marra (Tape)
1/26	Tour of FPL
1/28	Anatomy and Ultrastructure-Professor Thomas (Tape)
2/2	Light Microscopy and Wood Collection Demonstration
2/4	Project Guidelines and Discussion
2/9	Molecular and Cell Wall Structure-Professor Mark (Tape)
2/11	Demonstraction of X-Ray and Scanning Microscopy
2/16	Project Brainstorming
2/18	The Importance of Structure-Professor Worzala
2/23	Project Assignments
2/25	Moisture in Wood-Professor Tarkow (Tape)
3/2	Kiln Drying and Moisture Discussion
3/4	Physical Properties-Dr. Kellogg (Tape)
3/9	Mechanical Properties and Behavior-Professor Schneiwind (Tape)
3/11	Lab Work on Mechanical Properties
3/23	Mechanical Properties Follow-Up
3/25	Discussion of Projects and Exam
3/30	Chemical Treatment-Drs. Rowell and Fiest
4/1	Pilot Plant Demonstrations Chemical Treatment
4/6	Paper - Properties and Structures-Dr. Nissan (Tape)
4/8	Pilot Plant Demonstration-Papermaking
4/13	Discussion of Projects
4/15	Wood Based Composites-Dr. Zahn (Tape)
4/20	Tour of Veneer Plant
4/22	Panel Discussion - Composites
4/27	Class Time for Projects Work
4/29	Project Reports
5/4	Project Reports
5/9	Exam

Attachment 2

EXPANDED LIST OF POSSIBLE PROJECT TOPICS

1. Energy absorbtion characteristics of wood for applications such as space craft landing pads or automobile bumpers.
2. Cellulosic flywheels for energy storage.
3. Honeycomb structures from wood and fibrous materials - current and future applications.
4. Use of wood for cryogenic applications.
5. Earth quake performance of wood.
6. Biomass conversion of wood - myth or reality.
7. Fracture behavior of wood - how applicable is conventional fracture mechanics?
8. Appropriate technology - undeveloped countries
   a) Most efficient means of extracting heat from wood
   b) Most efficient utilization of wood in shelter construction
   c) Sociological benefits resulting from the use of wood rather than more conventional materials.
9. Design and fabrication of materials having specified properties by reconstitution (engineered wood).
10. Construction of large cargo carrying boads from wood.
11. Limitations on the use of wood-bearing elements for multi-storied buildings.
12. Surgical implants of wood.
13. Most efficient method for producing alochol from wood.
14. Determine the property or properties which give wood its damping capabilities.
15. Use of wood for a hygroscopic switching device.
16. Use of synthetic fibers (Kevlar, Boron, Graphite) in wood based composites.
17. Transition temperature in wood under impact loading.
18. Use of wood in Arctic construction.
19. Use of non-conventional methods for processing (eg. sawing with lasers or water jets).
20. Use of wood as highway barriers.
21. Use of wood for space platforms.
22. Use of cellulose-glass for auto body construction, rather than epoxy-glass composites.
23. Use of lignin as adhesive in composites and laminates.
24. Inexpensive high R-value insulation based on cellulose.
25. Wood based food supplement for cattle.
26. Disposable/biodegradable absorbent matrix for slow-release applications.

Attachment 3

M&ME 401 Projects Spring-1980

1. Alternate use of wood to replace concrete in foundations.
2. Biomass conversion of wood to alcohol or direct conversion to gaseous products.
3. Influence of genetic manipulation on properties.
4. Deterioration of the properties of wood as a result of additives or preservatives.
5. Acoustical characteristics of wood in musical instruments.
6. The development and characteristics of the light truss frame.