EDUCATION OF ENGINEERS ON STRUCTURAL USE OF WOOD

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Abstract

The paper examines the present situation and the role that different organizations play in the education of engineers regarding timber design. Universities are expected to provide the basic education and, in the timber structures area, some do at the undergraduate and graduate levels. Also, some offer continuing education courses on timber design.

One of the main problems at the university level is having the technical expertise and resource material to provide such a course. Perhaps equally important is the need for an interest and a general realization that timber design is an important part of structural engineering. The information developed in the Clark C. Heritage Workshop Series does provide the teaching modules, and the instructors who attended the workshops are better prepared to teach courses in timber design.

The wood industry sponsors different levels of effort in the education area. Some of their seminars are targeted at the design audience. Also, professional societies provide opportunities for continuing education.

Some challenges for improving the education network are examined.

Introduction

One of the critical aspects of expanding the use of wood in nonresidential building markets will be having the technical know-how in place to design the structures. Given three conditions: 1) the need (the markets) exists, 2) the products are available, and 3) the economics are such that wood is competitive, there is a question regarding the extent of capabilities available for the design of such structures in wood. The technology exists and there are a limited number of designers and design firms that have a high degree of competence in this area. But, that limited number is certainly in a minority among design professionals.

Thus, the education of design professionals is a real issue that should be addressed at this conference. By design professionals, we include both the architect and the structural engineer. This paper will address the structural engineer whom we recognize is only part of the team.

Several different groups play key roles in educating engineers in timber design. Universities are expected to provide the basic engineering education and some provide training in the timber design area. The wood products industry needs to play a key role in supporting the university education system and providing continuing education through product information and technical seminars. Technical schools, professional societies, and government organizations also can provide support to both the university and the wood products industry. The objective of this paper is to explore the present situation and challenge these groups to develop an improved educational network of timber design. We wish to acknowledge the assistance we received from 12 different consultants, educators, and industry representatives who shared their thoughts with us on this subject.

Universities

We will divide the role of the universities into three sections--undergraduate education, graduate level education, and postgraduate or continuing education.

Undergraduate. Civil and agricultural engineering students at some universities have an opportunity to take a timber design course. In a

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1984 survey, Wadlin (12) found that, while over three-fourths of the curricula leading to a bachelor's degree in civil engineering required a course in either steel or concrete design, only 13 percent required one in timber design. The survey did not reveal how many others offered an elective course in timber design, although two-thirds of the respondents indicated that a three-credit course in Materials Engineering, which may or may not include timber, was required.

Through participation in a 1983 workshop of university instructors interested in timber design, we found that an undergraduate course in "Timber Structures" was offered more widely than we had thought. However, from a national perspective, the general knowledge of timber at the design level is weak. Tom Williamson, former chairman of the American Society of Civil Engineers (ASCE) Structural Division Committee on Wood, points out that timber is not used extensively in engineered structures in the Eastern United States and in speaking of the designers, says, "...the overriding reason...is their unfamiliarity with wood design and thus their reluctance to specify it." His experience with LAMFAB, a design and construction company in Indianapolis, IN, suggests that wood roof systems are economical alternatives to systems employing other materials in the Eastern United States.

During the next year, Dr. Keith Faherty, Chairman of the Civil Engineering Department of Marquette University will be conducting a study of civil engineering departments to determine 1) the extent to which courses on timber structures or timber design are offered, 2) what is covered in the courses, and 3) what teaching aids are needed.

Several universities have wood science or wood technology departments that offer materials-type elective courses for the engineering students. This provides valuable support and broadens the appreciation of engineering students for the unique properties of timber. Along this line, we who are familiar with these unique properties always are quick to point out how wood differs from other structural materials, such as steel and concrete, which are well represented by design courses in engineering schools. Perhaps it might be more beneficial to first emphasize the similarity between steel and timber design. Engineering schools in Sweden teach design of these two structural materials in the same course. Since it is not realistic to expect a timber design course to be widely required for an undergraduate, the student should be put more at ease by emphasizing first the similarities between wood and other materials, then dwell on the differences.

Another method of familiarizing undergraduate engineers with wood is through senior design projects. Some schools offer this option during the final year, and have students who express interest in timber even though the school may not have offered a formal timber structure course. Recently, a university professor we are working with suggested that the wood products industry could assist him in the senior design projects. Assistance could be in the form of a prize for design competition at the local, regional, and/or national level. Civil and agricultural engineering along with architecture students could be included. Professional societies could also play a role in the organization of this effort. In order for this to work, there would need to be a key faculty member who can counsel and guide each student.

A key faculty member (or a key group of faculty members) is needed to get the first course in timber design started and carried through to the graduate level. Dr. Faherty, who now chairs the ASCE Structural Division Committee on Wood, points out that "...many colleges and universities lack persons who feel adequately prepared to teach a strong design oriented timber course."

Graduate. For a graduate level program in timber engineering to exist, the key group of faculty members is an absolute necessity. Fortunately, there are several key faculty with an interest in this area throughout North America, and we believe that there are now more opportunities than ever to maintain interest at a large number of engineering schools. But, most are having problems obtaining support for wood-related research and need encouragement.

Several factors join together to form a successful graduate level program in engineering which features timber or any other material. First, as noted, the key staff is needed in order to provide training, guidance, and inspiration. Second, some resources are needed to support graduate students. And third, techniques are needed for periodically injecting vigor into the program. Training, guidance, and inspiration can be provided by the key staff person through an advanced course in timber design or by one-on-one instruction.

Graduate students can be supported in a number of ways. For example, one of the best ways might be by funding graduate student projects and, as expected, this is preferred by the schools. However, funding is not always necessary, and we suggest that contributions of ideas and research material may give the wood industry a large return on investment. We'd be interested in comments from some companies who have experience in this area.

The third factor we noted is the need to inject vigor into the program. This can be accomplished in several ways--certainly research grants that fund faculty and student salaries are effective. Another method is through seminars or visiting lecturers that bring in outside expertise, such as designers, fabricators, builders, associations, etc.

We suggest that it is vital that all projects, whether research or design problems, represent real-world problems. This realism can be assumed by maintaining effective liaison between the key staff and designers or industry representatives.

Continuing Education. The previous discussion targeted preparation of the young engineer for timber design. This has long-range benefits in that these will be the decision-makers of the future. But, today's, and to a large extent tomorrow's, design decisions will continue to be made by engineers who were educated in the past 10-30 years. Today's challenge is to reach these people with the right type of information. Many universities do an excellent job in continuing education by conducting engineering extension short courses. Following are several examples:

- Colorado State University
  - Wood Pole Design
- Purdue University
  - Truss Analyses
  - Reliability
- University of Wisconsin
  - Timber Bridges
  - Structural Use of Wood
  - Inspection, Maintenance, and Repair of Wood Structures

In order to reach today's decision makers, increased emphasis needs to be given to continuing education.

Resource Material. Effective instruction in any design course requires a critical amount of resource material. A primary textbook that the student takes to the job following graduation is needed. But the backup design manuals that are up-to-date are just as important. Also, examples of product information along with instructions on how to obtain later editions are needed valuable references.

The primary textbooks commonly used in today's timber design courses are either by Hoyle (9), or Breyer (6). Both of these texts are being revised. Another book is being prepared by Faherty and Williamson.

To complement these textbooks, several volumes of educational modules suitable for development of courses in engineering and materials science curricula have resulted from a series of four workshops sponsored by the Forest Products Laboratory in cooperation with the University of Wisconsin. The workshops were made possible by a bequest in the will of Clark C. Heritage, at one time a member of the Laboratory staff and for many years director of research for the Weyerhaeuser Company. For each of these four workshops a theme was selected, and seven or eight educational modules fitting the theme were outlined. Selected specialists were then invited to prepare modules in their field of competence. These modules were presented to an audience of engineering professors who were invited to critique the material. Their suggestions were used to improve the modules.

The revised modules were published serially in the Journal of Materials Education and its predecessor, the Journal of Educational Modules for Materials Science and Engineering (JEMMSE). After all the modules of a particular workshop had been published in the Journal, they were assembled into a book. These books are available from:

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The books from the first three workshops are now available; the modules from the fourth workshop are still being published. It is expected that a book presenting these modules will be available in 1986. The first workshop, titled "Wood: Its Structure and Properties" (13), is presented much as a wood scientist views wood.

The second, titled "Wood as a Structural Material" (8), goes beyond the first, aiming more directly at the use of wood in structures.

The third workshop was titled "Adhesive Bonding of Wood and Other Structural Materials" (5). This subject was chosen because so many modern wood products such as glulam, plywood, and particleboard depend upon adhesive bonding for their proper functioning.

The fourth dealt with design with wood and was titled "Wood--Design of Structural Elements." Elements, rather than full structures, were covered because the time available did not permit broader treatment. This workshop was aimed at providing information needed by instructors in both undergraduate and graduate courses in design of wood structures.

The opening module of the fourth workshop reviews typical applications of wood-based materials and their properties. Additional modules cover the design of beams (solid, laminated, and composite), columns, connections, trusses, diaphragms, and curved members including arches and domes. All of the modules include design examples to provide the student with specific applications of design principles to typical design problems. In some cases, examples of good and bad practice are cited. The practicality of the modules is enhanced by the fact that both academics and practicing engineers authored the modules. The authors involved have all had practical experience, and have brought this experience to bear in the preparation of their modules.

As previously noted, backup design manuals are also critical. Both the National Design Specification for Wood Construction (NDS) (11) and the Timber Construction Manual (1) are needed for design in the United States. NDS is the primary reference used by the building codes. In Canada, CSA 086 (7) forms the basis for engineered timber designs. In addition, the students should be acquainted with other information available from industry associations such as the American Plywood Association, Truss Plate Institute, American Institute of Timber Construction (AITC), and National Forest Products Association.

Two books available from ASCE also provide a better understanding of wood properties and wood design:

Wood Structures--A Design Guide and Commentary (2)
Evaluation, Maintenance & Upgrading of Wood Structures (3)

Both of these were prepared by the ASCE Committee on Wood and are reasonably priced. They should be on every timber designer's bookshelf. Because there are sections of the Uniform Building Code (UBC) (10) devoted specifically to timber and because the UBC has been widely adopted by municipalities, this reference is also valuable.

A specific need that has been pointed out by several is the need for a commentary on the National Design Specification which explains the background to the design recommendations. Tom Brassell, Technical Vice President of AITC, pointed out that "...published design procedures do not give the guidance needed by an inexperienced designer." One educator noted that "...the single event that would aid in giving credibility to the wood structures community would be the development of a code commentary." Another engineer commenting on this point said, "...this is the number one educational need for undergraduate and graduate student education in wood design." One can read several different meanings into these quotes. But the message is that lack of understanding exists for certain design recommendations. If the instructor does not fully understand the bases for the recommendations and cannot provide good answers to questions, credibility suffers. We would also suggest that both the NDS and its commentary should be in a format consistent with those for other materials.

Industry

Many wood products associations and companies have made efforts to educate and inform structural designers on the design properties and procedures for their products. For several years, four associations have joined together to present 1-day seminars at various universities. Representatives of the various associations feature examples of effective use of their product. Similarly, some individual companies present 1-day or evening seminars in various locations targeted at practicing architects and engineers. The value of these seminars must be carefully measured against their cost. Ken Smetts, a structural engineer in the San Francisco Bay area, believes "...that the need (for education in timber design) is so great that seminars of a few hours or perhaps a full day are of questionable value." His opinion that more time is needed is based on his experience in teaching a class in timber design at University of California-Berkeley that typically attracts capacity attendance. In his opinion, association resources might be better spent in encouraging (and actively supporting) such courses at universities or more extensive seminars and workshops.

Practicing engineers can also acquire valuable information by attending the Technical Advisory Committee (TAC) meeting of the various associations. Most of these are open meetings, and the attendance of designers is welcomed. Decisions regarding changes in recommended design procedures are made at these meetings. A consultant whom we know has been one of the most valuable contributors to Technical Advisory Committees of one association over the past several years. Yet, he told us that he learns more than he contributes from participation in these meetings.

One problem designers face is that they frequently obtain information on various structural wood products in "bits and pieces" rather than as an integrated package. A valuable contribution in this area would be a more "united" front by the wood products industry in presenting the information on the various products. Wood systems would be in a more competitive position if the information on various types of products were presented in a parallel format and let the marketplace determine the most economic type of product for use.

Other Groups

Other groups that have or could have a role in education of engineers include technical schools, professional societies, and government agencies.

Technical Schools. Instructors from these schools are interested in improved information for education of their students as evidenced by their numerous applications for attendance at the 4th Heritage Workshop. Although they were not included in the attendees at the workshop because the emphasis was on the professional rather than the technical level, a workshop aimed at this group would be beneficial. The primary benefit would be better trained technicians and tradespeople. Future builders, design detailers, and others that play a supporting role in the designing and building process could be reached to develop an appreciation for and an understanding of wood design.

Professional Societies. This group could play a key support role in assisting the universities and the wood products industry in combining their efforts to improve the timber design education network. Various professional societies such as the American Society of Civil Engineers (ASCE), American Society of Agricultural Engineers (ASAE), and the Forest Products Research Society (FPRS) sponsor technical sessions at their annual or semiannual meetings. While these are important from the standpoint of research progress, these sessions are of limited value to designers and only a few attend.

We believe that the important role professional societies can play is through special committees, such as the education task committee recently developed within ASCE Structural Division Committee on Wood. The task committee has attracted some interest from university representatives and we suggest that representatives of the wood products industry become involved. Groups such as these could better address some of the issues raised in this paper and propose various solutions.

Government Organizations. The primary role of several government organizations is to provide support to the other groups previously noted. For example, the National Science Foundation (NSF) has funded some wood-engineering-related research at a number of universities and should be encouraged to continue. Currently, NSF is undergoing some reorganization whose impact is not yet clear (4). But a study by the National Academy of Engineering recognized the need for increased NSF funding of engineering research, particularly to update equipment and instrumentation.

During 1985, the U.S. Department of Agriculture funded several engineering projects on material properties and structural analyses as part of its Competitive Grants program.

The USDA Forest Service, Forest Products Laboratory (FPL) conducts research on material properties and analysis procedures for engineered timber, both in-house and through cooperative research with universities. Forest Products Laboratory has long served as a source of technical information on timber products and design. In addition to participating on several timber industry association technical advisory committees, Laboratory staff members are active in professional societies.

Summary

To expand the use of timber in nonresidential construction, design capabilities must be expanded by using both long-term and short-term solutions. Long-term solutions include improved education in timber design at both the undergraduate and graduate levels. To reach today's designers and decisionmakers, the short-term solution is continuing education. These solutions must be approached with a team effort between the universities and the wood products industry. Professional societies can be a catalyst, and industry representatives need to take an active role in their education task committees.

Engineering education is a real issue and a high-priority consideration in expanding the use of timber in nonresidential construction. We're encouraged by the present level of interest by instructors at a number of universities and challenge the wood products industry to take advantage of this interest by taking the initiative to stimulate an improved education network for timber designers.

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The widespread use of wood in construction has appeal from both an economic and aesthetic basis. The ability to construct wood buildings with a minimal amount of equipment has kept the cost of woodframe buildings competitive with other types of construction.Â Wood testing is of paramount importance in structural engineering for assessing the capability of final designs to handle stress and strain during routine use in order to ensure product safety and compliance with international standards. In a four-point bending test, a simply-supported beam is loaded with two equal-point loads at its third point, resulting in a central portion with constant moment and zero shear. This test is critical for floor systems where the wood's structural elements are primarily loaded by bending stresses. national education program for. 6x6 size for columns. Standard lengths are 8 to.Â Prefabricated Wood I-Joists are â€œIâ€ shaped engineered wood structural members that are prefabricated using sawn or structural composite lumber flanges and OSB or ply-wood webs, bonded together with exterior type adhesives. Typical I-joists for residen-tial use are available in 9Â½, 117/8, 14 and 16-inch depths.Â Structural Composite Lumber is a family of engineered wood products created by layer-ing dried and graded wood veneers or strands with moisture resistant adhesive into blocks of material known as billets, which are subse-quently resawn into specified sizes. Common types of SCL include laminated veneer lumber (LVL) and parallel strand lumber (PSL).