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DESIGN TECHNOLOGY FOR WOOD MATERIALS IN HOUSING

Robert J. Hoyle, Jr.
Washington State University, Pullman, Washington

ABSTRACT

We stand at the threshold of a venture in housing technology that our best skills and efforts could hardly have produced if they had been applied to the task. Housing needs present a situation demanding the skillful use of wood materials and wood technologists. To meet this challenge, the author proposes a modernization of the technology of wood design and an educational program to introduce the new technology to the home manufacturer, building official, and building materials manufacturer.

Such a sweeping change will serve the consuming public more than it can possibly benefit industry. It justifies public sponsorship. As a society, we cannot afford to let wood capitulate its natural position as the leading residential building material, for our own good as people and as resource managers.

Housing constitutes the environment where we spend the largest single portion of our lives. On that basis, housing should qualify for development attention in a program on environmental quality. Should the definition of environmental quality exclude the development of the domestic living space, there must be another place of defined national concern where it does belong.

It has been a human tradition for life to focus upon the home. This tradition has been severely challenged by other satisfiers arising out of our affluence, technology, policies of money-credit, and the free enterprise system. The applications of technology are more evident in the contents of the home and the other markets for our discretionary wealth than in the fundamental structure of housing. The pleasures of the home have not been as successfully promoted as other consumer product pleasures.

While our highways are congested with holiday-bound traffic and our public parks and recreational areas are bursting at the seams with visitors, many people are looking toward the home as a place to enjoy their leisure. Homes, designed and built to certain definable requirements, can be and are real human satisfiers. For some middle- and low-income groups, houses fall short of this. Consciously or not, these people turn elsewhere for their satisfactions. To them the house is a place of toil or confinement, a bedroom, nursery, restaurant, and warehouse—an operating base. It is also a financial millstone.

There undoubtedly are physical and economic limits to our systems of highways and accessible outdoor recreation facilities. A good balance should be possible between home and field, as has been achieved to greater degree in some less mobile societies. The house should be developed in coordination with public parks, auditoriums, athletic fields, and the like. Recommendations for housing research involve these and other aspects of environmental quality including air, water, sound, and climate as a part of the entire fabric.

The kind of housing research that interests wood scientists, technologists, and engineers ties in with the science of wood as a material, and the technology of applying information to design. It is one segment of the whole housing research picture. We feel it is a potentially fruitful area in which to find realistic means to economic housing ends. Because wood technologists are materials-oriented toward wood, we are susceptible to the charge of harboring blind spots to the advantages of other materials. On the other hand, because we have such a detailed knowledge of wood, we are in a unique position of understanding. Virtually no materials science department of any United States university has a place for wood in its program; hence their graduates could be non-wood-oriented to a like degree.

R & D people working in the structural timber area are deep into the study of many problems applicable to a sophisticated timber design and building technology. The application of this work to housing development can move forward quite rapidly, in areas that I will describe. Before doing that, I would like to advance a case for my belief that wood belongs in the picture of housing structure on a permanent basis.

The notion that timber is an obsolete material from a dying industry is common and unfortunate, but there are reasons for this view. It is close-coupled to the traditional house building practices, which enjoy a similar reputation, especially among managers of housing programs and planners newly arrived from other fields of accomplishment. Men with industrial production backgrounds are bound to be impatient with the traditional building industry and all its accoutrements, including wood. Certainly no one, today, would build an airplane or a refrigerator by gathering together a supply of aluminum, steel, and plastics at a building site and proceeding from there. That era of housing is also on its way out, but the vision remains.

In producing high value materials, it has been highly economic to develop a refined materials and design technology. Lumber has not been a high value material; consequently there has been little incentive for an input of science and engineering. In fact much of the existing input, by public agencies and a few far-sighted manufacturers, has difficulty surfacing into practice. The climate is changing. Housing manufacturers cannot simply use production skills to build traditionally designed houses. As the factory-built house emerges, it must abandon traditional design methods if it is to exploit fully the advantages of manufacturing and quality control. This is the route to better housing.

Where non-wood materials are displacing forest products, they often do so on the basis of the versatile design and construction practices that exist for these materials. They also exploit the advantages of ready acceptance of established structural reliability. When wood is employed in new configurations needed for factory production, no precedent exists for the new arrangement. It has tough sledding with the codes and the consumer. People who are highly progressive in their car-buying tastes, for example, are reactionary with respect to houses. This is changing rapidly, if we listen to youth.

The skillful use of wood has produced structures that withstand the tests of time and service admirably. This is evident in old-world structures and in relatively modern bridges and commercial buildings. While wood has been displaced by other materials (notably house siding, millwork, and finish flooring), these inroads have generally been for nonstructural uses. Two natural characteristics of wood, amenable to the housing situation, are its structural performance and its ability to renew itself in terms of supply. Witness the tree. Today we need both of these material characteristics.

Our problem, then, is to bring forth a wood building technology to fit the times. The climate for this is good. We need housing, we need more housing for the individual, and we have a growing number of individuals. An attitude toward innovation has developed among consumers and regulatory bodies that enables wood technologists to present concepts they have long nursed for such a day. The day when the building official confined his concern totally to public safety with no interest in economic aspects of construction, or human utility, is gone, retired along with the official.

We are looking for more timber resources. Forest land managers believe they can improve the productivity of timber lands. Estimates range upwards from 10%. One simple change in *building practice* of which I am aware could add 20% to the supply of framing lumber available for housing. Pursuing this search further could conceivably double the amount of housing generated by a unit of lumber production.

Getting down to specifics, I would propose *a complete updating of the technology of wood design, and an educational program to introduce this technology* to the new breed of home manufacturer, the building official, and the building materials manufacturer. I would wed this program to the composite use of all materials that can effectively serve together to produce adequate homes where families can find the privacy and the involvement the human spirit requires.

DESIGN METHODS

Much pioneering work has illustrated the inefficiencies of our design habits with wood. The opportunities to design more accurately have also been established. The problem before us is to reduce this experience to a practical theory and to verify this theory by test, polishing it to a point of consistent reliability. It is not expected that this procedure will alter good performance standards for housing. It is expected that it will reduce the waste of overbuilding; reduce the cost of housing via factory economies brought about by quality control and supervision; and involve a larger part of the material that is used, in the structural function. A program to accomplish these objectives could encompass a dozen separate and specific projects.

CONSTRUCTION ADHESIVES

Essential to the above is the exploitation of superior joint performability through the use of construction adhesives, both alone and in combination with mechanical fasteners. A design procedure for elastomeric adhesive joints is needed. Anyone familiar with the variability and inefficiency of many of our mechanically fastened joints should be able to affirm superior potential for the adhesive system.

ADHESIVE DURABILITY TESTS AND STANDARDS

A widely recognized system of adhesive evaluation is desperately needed. On the basis of experience, we know that some adhesives perform well. We need new adhesives with different properties, and we need to be able to use them without a 10- or 20-year period of durability testing. This research is already well beyond the planning stage and now requires massive support. The organization responsible for this program is SCATA (Steering Committee on the Accelerated Testing of Adhesives), a cooperative effort by the forest products research laboratories and certain adhesive manufacturers centered in the Pacific Northwest.

PERFORMANCE REQUIREMENTS

Our knowledge of performance needs for housing is incomplete. We should develop information on the behavior of dwelling units, covering static load performance, dynamic response to moving loads and environmental forces, and acoustical performance with reference to equipment noise, and isolation of internally and externally generated noise. I believe that thermal and lighting requirements are already well defined. This program is visualized as a field survey of performance conditions, application of bioengineering measurement methods, and prototype testing of structures built to evaluate design procedures.

DESIGN SYSTEMS

The anathema of rigorous design is the complexity and time-consuming nature of traditional methods of engineering stress analysis and design. Some research workers in the wood field have developed analytical methods depending on computer programming of complex structural problems. These problems are normally avoided by practicing designers who substitute approximations. Concepts of engineering practice involving ready access to computers via time-sharing and telephone communications are being formed. These projects can now be enlarged into a family of computer design operations that could be economically practical for the practicing designer and the housing manufacturer.

NONDESTRUCTIVE TESTING

A key to effective utilization of wood is in nondestructive testing for purposes of stress grading, and quality checking of manufactured components. Realization of the possibilities of precision design depends on quality inspection and grading. Considerable progress has been made in this area and systems that offer distinct advantages are being introduced in a limited way. I believe that the explanation of some design failures is masked by the imprecise quality information about commonly used lumber and plywood grades. Research is needed in the commercial significance of these methods, as well as on some techniques not yet fully developed.

MATERIALS RESEARCH

As design precision is improved and structural materials are more closely fitted to needs, the subject of time-dependent behavior of wood should be reexamined. Most wood structures are lightly loaded for the major part of their service life. With design efficiency and control of properties variability, stresses in use will increase. This suggests that stresses will come to levels where progressive plastic flow or creep may assume greater significance in design. This is a complex research topic of considerable importance, and it should receive early attention if it is to be available at an opportune time.

EPILOG

The immediacy of our need for economy in housing is a clear, prime consideration. Proposals for research are being judged by the administrators of housing research in these terms. Long-term proposals are not attracting the interest of officials seeking immediate answers. For this reason the first order of business has been methods of design and construction involving as little change as possible in conventional procedures and available forms of material. One can not really argue that point. However, an end point will be reached rather quickly with these limitations beyond which the kind of proposal suggested here becomes necessary. These developments could be achieved within five years, many of them in less time than that.

The degree of control over building practices grows steadily. The authority for this control is becoming more and more an engineering and technical authority. Decisions affecting the use of much lumber are being concentrated in these groups, as building code jurisdictions encompass ever greater amounts of living space.

Construction practices, especially in housing, are now evolving rapidly. The on-site builder tradition is giving way to the more organized on-site operations, and the line-production operations in plants. This concentrates responsibility for supervision of labor, methods, tooling, design, and the logistics of materials, in persons of more specialized skill.

This control over the house construction process makes it possible to use improved manufacturing technology, and in turn use to advantage more advanced methods of design. With no intention to be critical of past practices, I would have to say that the design recommendations for framed structures do not encompass fully the opportunities for versatility and economy that are feasible today. Those of us responsible for current design information have become accustomed to simplifying the presentation for use by the conventional builder. The factors of control, manufacturing practice, and advanced design, mentioned above, all combine to permit the introduction of refinements. Until these factors began to assume significant proportions in the house manufacturing picture, the simplified practices we use for design were certainly the right ones. The competence needed to use these refinements is steadily rising among people who purchase, specify, and fabricate with wood. It is essential that this rising level of supervisory skill be met by a modernized presentation of our material. The direction of some research toward closing certain gaps in our information background would contribute to this purpose.

I view this avenue of development as one deserving the attention and backing not only of wood building materials manufacturers, but equally of the public agencies seeking to satisfy public housing needs. The benefits extend considerably beyond the commercial advantages. The magnitude of our housing problem seems to call for committing some of the financial resources of state and federal agencies with missions in the housing field to the engineering development of wood structures. The advantages should be even more apparent to the technical staffs of public agencies than to the myriad small mills that make up the lumber industry. Marshalling the potential of product technology as well as forestry to the purpose should interest them.

Wood and Fiber publishes abstracts of articles from appropriate foreign journals. These abstracts are not printed in a separate section, as are Thesis Abstracts, but are spaced throughout the journal. Francis C. Beall, of Pennsylvania State University is chairman of the committee responsible for these abstracts. Other members of the committee are: R. M. Kellogg, R. T. Lin, R. L. Ethington, Ali Moslemi, J. D. Wellons, E. G. King, D. D. Nicholas, J. D. Snodgrass, and Joe Yao.

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