Proceedings of the
SYMPOSIUM ON
FASTENINGS FOR WOOD IN
HOUSE CONSTRUCTION

Sponsored jointly by
National Lumber Manufacturers Association
and the Forest Products Laboratory

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No. 2241
Summary

This report summarizes the main points considered and the conclusions reached during the Symposium on Fastenings for Wood in House Construction, held January 29 to 31, 1962, at the Forest Products Laboratory.

Purpose of this symposium was "to disseminate information on new fasteners and assembly methods and to create new ideas that would lead to research on the development of better fasteners and fastening methods for wood in house construction."

More than 100 individuals representing various phases of the wood industry, home builders, fabricators, manufacturers of mechanical fastenings and adhesives, housing officials, educators, and research workers discussed various phases of fastening as applied in house construction. From these discussions emerged a better picture of present trends and a realization of the opportunities that exist. Recommendations were made of some approaches that might be fruitful.

The Forest Products Laboratory would like to be kept informed of all new developments as they occur and will be glad to assist wherever possible in expediting such developments.

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1 Sponsored jointly by the Special Committee on Technical Studies, National Lumber Manufacturers Association, 1619 Massachusetts Avenue, N.W., Washington 6, D.C. and the U.S. Forest Products Laboratory.
Program for Symposium on

FASTENINGS FOR WOOD IN HOUSE CONSTRUCTION

Held at

U. S. Forest Products Laboratory, Madison, Wis.
Jan. 29-31, 1962

Jan. 29, 1962--Morning session

Presiding--J. A. Liska, Chief, Division of Physics and Engineering, Forest Products Laboratory

Sponsors' Welcome--Edward G. Locke, Director, Forest Products Laboratory,
--Gerald F. Prange, Vice President, Technical Services Division, National Lumber Manufacturers Association

Keynote Address--"Improved Fastenings for More Wood Use"--
Philip E. Frankfort, Executive Vice President, Southwest Forest Industries

"Wood As a Material to Be Fastened"--Stephen B. Preston, Chairman, Department of Wood Technology, University of Michigan

"Fastenings for Wood in Home Building"--Ralph J. Johnson, Director, Research and Technology Division, National Association of Home Builders

"Fastenings and Manufactured Homes"--J. A. Reidelbach, Jr., Technical Director, Home Manufacturers Association

Question Period

Jan. 29, 1962--Afternoon session

Presiding--John L. Zerbe, Assistant Director, Engineering and Technology, National Lumber Manufacturers Association

"FHA Standards for New Assembly Methods"--Donald J. Guthridge, Chief, Building Engineering Section, Federal Housing Administration
"Code Problems Governing New Fastening Methods"--Verner L. Lane, Second Vice President, Building Officials Conference of America, Inc.

"Evaluation Methods for Fasteners of Wood in Housing"--Lyman W. Wood, Division of Physics and Engineering, Forest Products Laboratory

"Solution of a Fastening Problem"--Harold H. Webber, Research and Development Division, Arthur D. Little, Inc.

"Academic Viewpoint of Fastening Needs"--Albert G. H. Dietz, Professor of Building Engineering, Massachusetts Institute of Technology

Special Report--"Wood Screw Holding Power"--John Reno, Pacific Lumber Co.

Question Period

Jan. 30, 1962--Morning session

Presiding--H. O. Fleischer, Chief, Division of Timber Processing, Forest Products Laboratory

"Present Adhesives as Fasteners for Wood"--R. F. Blomquist, Division of Timber Processing, Forest Products Laboratory

"Wood, Adhesives, and Houses"--Alan A. Marra, Professor, Department of Wood Technology, University of Michigan

Presiding--R. P. A. Johnson, former Chief, Division of Physics and Engineering, Forest Products Laboratory

"Durability of Threaded Nail Performance in Wood Construction"--Arthur S. Tisch, Assistant Vice President, Director of Technical Sales, Independent Nail and Packing Company

"Fasteners for Prefinished Beveled Wood Siding"--Gerald A. Koenigshof, Manager, Product Development, Timber Engineering Company

"Truss Plate Connectors in Present Use"--J. C. Jureit, President, Truss Plate Institute

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"Automatic Application of Mechanical Fasteners for Wood In House Construction"--Harold T. Decot, Research Division, United Shoe Machinery Corp.

"Plastic Coatings for Fasteners"--Nelson J. Hoppe, Assistant Sales Manager, Spotnails, Inc.

Question Period

Jan. 30, 1962--Afternoon session

Round Table Discussion (Two discussion groups named for each of five subjects)

House Construction:
  Group 1--Chairman, Donald H. Percival, Small Homes Council, University of Illinois
  Group 2--Chairman, S. B. Slaughter, Jr., American Building Components

Standards--Codes--Test Methods:
  Group 3--Chairman, L. J. Markwardt, former Assistant Director, Forest Products Laboratory
  Group 4--Chairman, T. K. May, Director of Technical Services, West Coast Lumbermen's Association

Adhesives:
  Group 5--Chairman, Harold E. Worth, Division of Forest Utilization Research, Pacific Northwest Forest and Range Experiment Station
  Group 6--Chairman, Willard Worth, National Homes Corporation

Mechanical Fasteners:
  Group 7--Chairman, O. C. Heyer, Division of Physics and Engineering, Forest Products Laboratory
  Group 8--Chairman, Arthur S. Tisch, Assistant Vice President, Director, Technical Sales, Independent Nail and Packing Company

Research (Academic Viewpoint--Solution of a Fastening Problem):
  Group 9--Chairman, S. K. Suddarth, Professor of Forestry, Purdue University
  Group 10--Chairman, Nicholas V. Poletika, Vice President in Charge of Research, Union Lumber Company
Jan 31, 1962--Morning session

Presiding--Gerald F. Prange, Vice President, Technical Services Division, National Lumber Manufacturers Association

Summary, Recommendations, Discussion, and Resolutions Based on Reports of Round-Table Chairmen:

Research and Development--Alan D. Freas, Assistant to the Director, Forest Products Laboratory

Standards and Codes--John G. Shope, Chief Engineer, National Lumber Manufacturers Association

Committee for Planning and Conducting the Symposium

Forest Products Laboratory:

L. O. Anderson, Chairman
John A. Scholten
Robert S. Kurtenacker
Richard F. Blomquist
Alan D. Freas, Liaison

NLMA coordination--G. F. Prange
John Shope
John Zerbe
After a review of the Symposium presentations and evaluation of the problems, the suggestions and recommendations from the 10 round-table discussion groups can be broadly grouped in two areas: (1) Research recommendations and (2) recommendations related to codes or standards.

Recommendations Relating to Research—Summarized by A. D. FREAS
Assistant to the Director
Forest Products Laboratory

As might be expected, considerable emphasis was given to adhesives. For example, a need was expressed for an adhesive system that would quickly develop moderate strength to permit handling in manufacture, with slower development of the higher, more permanent strength. At least two possibilities were suggested. One approach was a two-part adhesive, one part of which would be a contact adhesive capable of quick development of moderate strength; the second part would be a more conventional adhesive that would develop strength more slowly. A second approach involves applying heat energy rapidly to cure parts of the glue bond—a sort of spot-welding system to provide handling strength—with the remainder of the adhesive curing more slowly.

A number of needs in adhesive development were expressed. For example, there is the need for adhesives suitable for on-site bonding of assemblies—siding to studs, gusset plates to framing, and so on. Specific needs for factory assembly, however, were not neglected; a request was made for adhesives with controllable setting time and high tack capable of developing a strong bond with limited pressure and capable of being used over the range of temperatures that might be found in a factory.

There was recognition of a point brought out during the presentations. That is, let’s not be too quick to reject a new adhesive and, in so doing, discourage those who are trying to develop new adhesive formulations.

There was ample recognition of the lack of fundamental information on the problems connected with adhesive-bonded joints. The need for better methods of design was reflected in a proposal for research on the pattern of stress distribution in adhesive-bonded joints. This analysis should consider joint geometry and the elastic and plastic behavior of the wood-adhesive system. Neither were the long-time considerations neglected, as exemplified by a request for study of the rheological behavior of wood-adhesive systems.
Specific problems were recognized. One is the current problem of adhesives and techniques suitable for the gluing of fire-retardant and preservative-treated lumber.

As we know, glue joint quality is largely governed by control of the adhesive and the techniques of using it. But what of the inspector who must accept or reject a joint? This was recognized by a request for development of a means to identify whether adhesives have been properly used in a joint.

All this emphasis on adhesive-bonded joints should not, however, be taken to mean that mechanical fastenings did not receive full attention. Both fundamental and applied aspects were considered and were the subject of numerous recommendations.

The presentations in the first two days brought out the fact that fastenings have been examined analytically, as, for example, treating a bolt or a nail as a beam on an elastic foundation. Continuation of this work was suggested to correlate the analytical method with empirical data as a basis for establishing design criteria. Still in a fundamental vein are proposals for (1) studies to attempt to correlate the micro-structure of wood to the behavior of fastenings, as well as (2) to make detailed studies of the micro-environment and micro-stresses in fastening systems to explain their behavior.

A variety of more direct approaches were suggested. Examples would be development of concealed fasteners for siding, interior finish, and full-size components, such as floors, walls, and roofs, or a fastening to improve the efficiency of end-grain nailing.

A suggestion was made that reflected some of the comments during the formal presentations—the development of light, portable power tools for efficient installation of metal fastenings and application of adhesives. Still another went beyond this, to suggest the employment of industrial engineering techniques to determine the most economic methods of using fastenings. While this was not spelled out, I presume that this implies such things as time and motion studies to cut down the several hundred thousand hammer blows now used in nailing, or materials handling systems to get the parts to the spot and into position for assembly with a minimum of lost motion, time, and effort. At least it implies a whole new look at techniques that have grown up over the years.

Additional and refined data on current and new fastenings were requested. Such factors as moisture content, temperature, duration of load, repetition of load, spacing of fastening elements, and environmental conditions in general were mentioned. Particular mention was made of the necessity for knowing more about the behavior of fastenings in fire.

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As was true during the discussions of the first two days, the round-table groups recognized the problems of durability. One of the first needs expressed was for a short-term means of evaluating long-term durability. A number of groups made specific requests for data on durability, not only on adhesive-bonded joints but on joints made with mechanical fastenings as well. One broad request was for more precise information on the environments that houses must withstand.

I have already mentioned the suggestion that more information be obtained on exactly how various fasteners operate. In addition, the round-table groups pointed out that we need to know more precisely how the loads are distributed to the various members of both simple and complex structures, so that we will know more precisely the loads and moments for which a joint must be designed. For example, a joint subject to a moment tends to rotate. What are the rotational characteristics of such a joint, and how is the load in such a joint transmitted to the various fastening elements? One approach suggested was to install strain gages on the various structural elements of a house and to derive from stresses, measured under loads due to snow, wind, and so forth, the distribution of loads, or, perhaps more precisely, the stresses that occur in the individual members.

I hope that none of the round-table groups will feel neglected if they have not heard, in my remarks, their suggestions in exactly the way they were presented. This does not mean that I have overlooked them or disregarded them. Rather, it means that I have attempted to put these suggestions into broad classifications and thus to generalize.

I was pleased with the breadth and depth of thought put forward in the round-table recommendations. Quite a number of interesting and, no doubt, productive research proposals resulted that should lead to a good overall research program. In some instances, I know the work suggested to be either in the planning stage or underway. On the whole, however, answers to all the questions raised will require long-term, costly research by a variety of organizations. The Forest Products Laboratory hopes to be prominent in its contributions.
Structure

Additional standards are needed for a completed structure, as well as for such items as walls, roofs, floors, partitions, and connections between them. It is recognized that different geographic areas will require different approaches to these problems, and may require different limiting values because of differences in external forces possible in service.

Current acceptance criteria should be reevaluated, particularly with new materials and combinations.

It is important to put the sheathing nails in the proper place, and to use the right amount. If the sheathing is properly nailed to the bottom plate, end nailing of studs to plate is adequate, and would be a permissible process.

Trussed Rafters

Trussed rafters of four basic types (nail-glued, nailed, ring connected, and plate connected) have made major inroads over the more conventional rafter systems. Efforts of present groups to develop standards for these structural units should be encouraged. Standards should recognize the effects of (1) handling, (2) moisture change in service, (3) manufacturing tolerances, and (4) manufacturing methods on the in-place strength of trussed rafters. Research information on effects of the above variables should be consolidated, published, and made available to people at field and official levels.

ASTM Committee E-6 should reexamine E 73-52 "Methods of Testing Truss Assemblies" to update the method as needed so as to reflect recent testing methods.

A method for testing light metal plate connectors should be developed. The need for this is illustrated by the present required system of testing full-scale trussed rafters to affirm the adequacy of the joint devices. With the approaching availability of criteria for analysis of these trusses, and other-than-truss uses for these connectors, there is a very real need for a means of establishing design properties of the devices for both short- and long-time load conditions. Effect of moisture content on long-time behavior should be included.
Fastenings, General

Better communications are needed between people involved with fastening problems, such as researchers, manufacturers, and users.

There is a need to define the performance requirements of various types of joints in terms of rigidity, stress-carrying capacity, and other physical and chemical requirements.

Standards and test methods are needed to evaluate the performance of structural or semistructural fastening devices that are exposed to either normal weathering conditions or corrosive conditions in use.

It is recognized that the design and performance of various types of joints and structural units employing fastenings are dependent upon the geometry, quality, design details, and tolerances of the material of the component fastenings.

A survey should be made as to what are the most common call-backs for contractors in house construction, and what are the larger problems as far as fastenings are concerned.

There needs to be a definition of the real performance requirements for fasteners for specific end uses.

To achieve a better understanding of end-use requirements in fastening systems, the following areas should be studied:

1. Function definitions
   a. Mechanical (structural and nonstructural)
   b. Appearance
   c. Durability

2. Economics
   a. Cost of materials
   b. Cost of installation
   c. Maintenance cost

Wood Screws

Though wood screws are infrequently used structurally in the present conventional methods of light-frame construction, anticipated rapid advances in the development of component construction indicate that wood screws will
probably be used to a considerable extent. The present chaotic situation involving wood screw sizes and general dimensions will be detrimental to their use in this manner. It has, therefore, been resolved that there is a need for establishment of standards for wood screws.

Concealed Fasteners

Because of the increasing interest in siding and paneling, it is recommended that the requirements which concealed fastenings should meet for various specific applications should be developed.

Bridging

Consideration should be given to the omission of bridging in the floor and roof framing where there is distribution of concentrated load from floor or subfloor, and where lateral support is not required for framing members whose ratio of width to thickness does not exceed six.

Adhesives

Existing standards for glues used in construction have been established by the Military for room temperature and intermediate temperature (MIL-A-397B "Adhesive, Room-Temperature and Intermediate-Temperature Setting Resin (Phenol, Resorcinol and Melamine Base)") and for high temperature (MIL-A-5534A "Adhesive, High-Temperature-Setting Resin (Phenol, Resorcinol and Melamine Base)") for exterior use, and Federal Specification MMM-A-125 "Glue, Casein-Type, Water and Mold Resistant" for interior use. These standards tend to remain dormant for long periods and thus become obsolete. It is therefore recommended that necessary reference standards for glues be established by a recognized standardizing organization of producers and users and maintained by them. This group should also be responsible for developing standards applicable to new adhesives as they become available.

There is a need for specific definition of the terms "structural" and "non-structural" with respect to adhesives.

A need exists for accelerated test methods for reliably predicting service performance of new adhesive systems without long periods of confirmatory service experience.

Because of the increased interest in on-site gluing, establishment of requirements is needed for supervision, technical requirements, and quality control for on-site gluing for structural and other applications.

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Building Codes

It is recognized that performance requirements for various house components are established by the different code authorities, but the requirements are not presently uniform among the different standards. It is recommended that every effort be made to coordinate among the different authorities a unification of the performance requirements with respect to various components, such as trusses.

Each industry should develop minimum standards for their products, and their use in combination with other associated products for recommended application. With proper supporting evidence they should be submitted to the various code groups for acceptance on an industry-wide basis.
IMPROVED FASTENINGS FOR WOOD

Philip E. Frankfort
Executive Vice President
Southwest Forest Industries

Speaking for the lumber industry, we are convinced that to stay competitive in the building materials market today, we must develop more efficient uses of wood. Maximum efficiency has always applied to heavy construction where the strength of individual members is critical, and it is becoming increasingly important in housing and light construction. We are certain that the position of the lumber industry in the housing market is dependent upon making wood easier and more economical to use.

The smooth shank wire nail has been the standard for house construction for more than a century and is still the principal fastener used. However, much research effort has been directed toward improving the holding characteristics of the shank. According to George Stern, more than 560 pounds of nails are needed to build a 24- by 50-foot, five-room house of standard design with attached garage. The cost of such a quantity of nails approaches 1 percent of the total construction cost. Assuming that 75,000 nails are required to complete a house, and that four hammer blows are required to drive each nail, then 300,000 hammer blows are required to assemble a single house. Certainly no one can argue that we need more efficient mechanical fasteners; that we need to develop technical information concerning their proper use; and that there is a tremendous demand for a truly portable power nailing device.

The ring connector stands as a guidepost to us as we look for new fasteners for housing. Joint efficiency is so enhanced by the split ring timber connector that, under certain conditions, the full working stress of the timber may be utilized. Large loads are transmitted between members without seriously reducing the cross sectional area, and small cross section sizes of structural quality lumber can be utilized with the spaced member principle. The efficiency of the ring-connected joint was directly responsible for the economy of trussed roof construction in houses. Today, over 50 percent of new single-family dwellings use trussed rafters.

Although the ring connector pioneered in the field of trussed rafters, other fastening types have made their appearance. Among these are the glued-nailed plywood gusset plate and the metal truss plate. With new metal truss plates appearing on virtually an annual basis, the design variety in this fastener is beginning to approach that of the nail.

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Under the stimulus of World War II, numerous advances have been made in the development of structural adhesives for wood. The significant thing is that structural bonding with adhesives has expanded the market without affecting the demand for mechanical fasteners. It has, in fact, stimulated the development of new fasteners to suit the requirements of this new dimension. The development of special high strength concealed hangers for this type of construction is one indication of this expansion.

The use of structural adhesives by the lumber industry need not be confined to laminated timbers and arches or to plywood. Adhesives remove the barriers of dimension and shape and project wood outside the limits of the log. The engineering of structural components and other building elements based on adhesively bonded joints is needed if we are to take full advantage of present adhesive research.

Development of simplified field bonding techniques and adhesives which are more tolerant to field fabrication is the type of progress which could bring a revolutionary breakthrough. Adhesive fabrication is a field in which other materials would have extreme difficulty in equaling the performance of wood.

There is an unmistakable trend toward the fabrication and erection of homes using the component principle. In 1962, the lumber industry will be presenting a system of house construction employing modular planning and dimensional standards which should encourage this trend. Certainly, if the builder can purchase components at a greater profit than can be obtained from on-site fabrication and can also speed up the job, there is no question that components will be more profitable.

The continued forward progress of the component principle is dependent to a great extent upon the development of fasteners which will effect speedier erection and provide for more efficient use of material. As an example, three fastener problems encountered in component construction desperately need a solution: (1) exterior wall panel joints, (2) joints at partition intersections, and (3) concealed fasteners for prefinished materials.

I am happy to see we will be discussing some of these problems here. Obviously the potential market presents the greatest challenge to the lumber industry and to the manufacturers of fasteners in recent years.
Summary

WOOD AS A MATERIAL TO BE FASTENED

Stephen B. Preston
Chairman, Department of Wood Technology
University of Michigan

Fastening techniques for any material must, in the final analysis, depend upon the physical and chemical characteristics of the material itself. Wood, in solid and modified form, is characterized by a combination of properties unique to construction materials, which permits unequalled simplicity of attachment but at the same time imposes limitations on the effectiveness of fastenings devised to date. Development of radically new forms of fastenings and improvement of existing ones must impinge upon these characteristics, some of which are not, in themselves, fully understood.

Both chemical and mechanical fastening processes relate in part to the physical and mechanical properties of wood. Differential strength, elasticity, and moisture and thermal instability must be recognized. Interrelating mechanical properties and environmental influences on them must be understood. Particularly when the effectiveness of a fastening is dependent upon friction, both elastic and inelastic behavior is important.

Chemical fastenings are influenced not only by the chemical activity of the surface but, in addition, to its topography. Limitations in control of surface topography are imposed by the fact that wood in the solid or mechanically modified condition can be formed only by machining.

Future improvement in fastening techniques may be limited in part to relative ignorance of certain basic wood properties. Important among these are (1) frictional characteristics, (2) rheological characteristics, and (3) physical and chemical surface characteristics in relation to adhesion.
FASTENINGS FOR WOOD IN HOME BUILDING

Ralph J. Johnson
Director, Research and Technology Division
National Association of Home Builders

Existing fasteners for wood construction in home building do a satisfactory job. The basic problem is to increase their efficiency in order to contribute to the production of a better house for a lower cost, not only to broaden the market for home ownership but to assist the wood industry in becoming more competitive with other materials. There is an outstanding need for increasing our scientific knowledge with respect to fasteners in home building and for updating design procedures. In addition, it is inherent that work must go forward to develop scientific data and grading procedures which will make wood a more efficient engineering material. Finally, there is an outstanding need for accelerating development of our scientific knowledge and technology with respect to the whole subject of glues and adhesives, for both structural and semistructural applications in home building.

After reviewing fastening practice, materials, and needs in the context of today's home building industry, the following specific recommendations are presented:

(1) Develop full scientific data for engineering design of nailed connectors, including detailed design procedure for deformed shank nails.
(2) Develop scientific data and grading procedures which will make wood a more efficient engineering material.
(3) Develop wood connectors which will more nearly develop the full moment potential of wood members.
(4) Develop gap-filling glues which are less sensitive to ambient conditions and which can be used on the site as well as in the factory.
(5) Develop blind fasteners or "semistructural" contact adhesives which can be used to attach prefinished materials.
(6) Develop glues, glue procedures, and conditions of use which produce relatively uniform results which can be used as the basis for more efficient engineering design of the glued connection.
(7) Develop glues, adhesives, or more efficient metal connectors for structural joining of metals and wood.
(8) Develop a dependable and more efficient connector (including glue or adhesive for structural joining of wood to masonry.)
(9) Develop new data and extend research on structural or "semistructural" tapes.

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A survey of various home manufacturers indicated a need for improved fastening methods—both for mechanical fastenings and adhesives. Such improvements could change many of the traditional methods of home construction, whether in the factory or at the building site.

A case in particular which illustrates the development of new fastening methods involves one firm's development of a steel stud wall system. In exterior wall panels, the first problem was to find a method of attaching the drywall or gypsum board to steel framing members. Metallic fasteners could not be used because they would produce cold spots on the room side of the wall and would conceivably provide places for the formation of condensation. The problem was overcome by bonding the drywall to steel framing members with a drywall adhesive. As a safety factor, the adhesive was supplemented with nylon fasteners located 24 inches on center. These nylon fasteners positioned the drywall and provided pressure until the adhesive attained its final set.

For interior nonloading partitions, it was only necessary to glue the drywall to the vertical steel framing members and to the top and bottom wood plates. Top and bottom wood plates were used so that the partition panels can later be readily nailed to the subfloor and to the bottom chord of the trusses. The problem noted here was the possibility of fiber separation in the paper back of the drywall. The surface of the board was perforated to a depth of about 1/8 inch with four rows of perforations. A resin binder was forced into the perforations and, in addition to toughening the paper, formed a key in each perforation. After the impregnant dried, a vinyl phenolic emulsion adhesive was applied to the board wherever steel vertical framing members occur. The gypsum board is further secured to the wood top and bottom plates with T-nails or divergent-point staples.

Another type of invisible fastener the home manufacturer has a great interest in is a new fastening device to be used wherever plywood or other sheathing material, including paneling, is fastened to lumber.

Another line of "hidden" fasteners which the home manufacturers are keeping a careful eye on are those which would enable the application of exterior wood siding with no fastener show-through on the exterior or finish side.
Several factors indicate the need for study of actual loads in service. An engineering analysis of roof structures, both conventional and trusses, should lead to lower costs and keep wood use strong. Fastenings are a major factor in this development.

For instance, a conventionally framed roof might fail at 35 to 50 pounds per square foot of loading; a typical truss rafter will fail at 150 to 200 pounds per square foot. Conventional construction has been accepted and performed well for years; yet, based on these figures, trusses are overdesigned.

The Canadians have been comparing the strength of roof trusses with rafter construction. One thing they have learned is that assumed snowloads are not actual snowloads. It becomes a matter of learning the proper design load.

"Failure" of wood structure may mean not complete collapse, but such things as "nail pops," excessive deflection that causes cracks, and other items that would mean unnecessary maintenance.

The philosophy of a new method in evaluation of wood members involves a gratuity of 15 percent minimum increase in working stress assigned to stress grades. This philosophy might also be applied to fastenings.

In consideration of a "safety factor" the lower limits are usually considered. In other words, it is assumed that wood will be under its most adverse conditions of high moisture, high temperature, and long-time loading. Taking into account (a) design load, (b) factor of safety, (c) long-time loading, (d) moisture changes and other factors generally used in design might result in an actual factor of 10 to 20 times normal loading during service. This method of establishing design criteria is not followed in the use of other materials.

A study of actual loads (snow, wind, etc.) on a structure is necessary. This could be applied to the design of components, with relation to fastenings, for more practical and lower cost wood units.

In the utilization of plywood in connectors such as gusset plates, more information is needed on design values for shear strength. In the past year a test method has been determined that appears adequate for working stresses in shear. Further sampling will be done to substantiate preliminary results.
Summary

FHA STANDARDS FOR NEW ASSEMBLY METHODS

Donald J. Guthridge
Chief, Building Engineering Section
Federal Housing Administration

In the normal FHA procedures of handling applications for special methods, we often are accused of being ultraconservative. I believe sometimes we have to be. We try first to protect the homeowner, who will have to pay for any possible losses. We can't do that with an unknown material or an unknown product unless we are on the conservative side.

We are still trying to keep up with technology. With limited personnel, the only way we've really been able to do it is to go to other groups such as Bureau of Standards and Forest Products Laboratory, and use their brains. This way we've been able to keep up fairly well with this immediate problem of deciding whether or not any special method of construction or new material would adequately serve its purpose.

We have two relatively new programs in FHA. The first is the technical studies program, tied to building construction in general as well as to design and land planning and all factors involved in housing. The very nature of this program and the money allotted to it does not give much leeway to work with. The best way to handle this program was thought to be through the building research advisory board. It has been a collection of previously assembled data and the opinions of experienced people.

The second new program which really hasn't gotten under way yet is the experimental housing program. The intent of this act was to permit FHA to insure mortgages on properties which had been well thought out by an organization such as NAHB. We feel that we can't insure mortgages on properties where there's a chance the roof will cave in. We don't feel this is the proper place to actually experiment with structural items. The new NAHB research house is the type of thing I believe this legislation is designed to help--an overall study in a few houses and some newer methods of construction or some newer materials where there was no other way of proving these things out.
The building official's problem is quite different from industry's. The forest products industry must be sure that any fastener develops the full intent and potential of the wood. The fastener must be capable of transmitting loads to the wood members efficiently, without destroying the full capacity of the wood to receive such stresses. On the basis of building code interpretation, we must accept or reject the use of the fastener.

Too often in the past, a company broke into the building products field. They hacked away until the obstacles to production and promotion were broken down. Then they turned back to seek approval of this product they had produced and sold. When the building official must reject the material for lack of adequate evidence to justify acceptance, the salesman is bewildered and hurt. He must turn back to acquire the facts necessary to satisfy a code's criteria of acceptance. He has manufactured and promoted a product which has no market, and the building officials and their codes are often blamed.

A closely related code problem is that there has existed a multiplicity of conflicting code regulations. This has made it necessary for the manufacturer to seek acceptance from numerous individual building officials in widely scattered areas.

A simple program could ultimately result in the solution to both problems. Industry and code sponsoring organizations must cooperate in the establishment of acceptance criteria. We must develop acceptance criteria at the same time we develop the product. We must also eliminate the multiplicity of conflicting code regulations by promoting the adoption of one of the performance-type model codes.

If a product is approved by each of the code-sponsoring organizations under their respective materials approvals procedure, approval is accomplished in the hundreds of communities which have adopted one of the codes. If industry utilizes this service, it can avoid costly personal contact and delay.

In summary, the problems are: (a) acceptance criteria; (b) building code uniformity; and (c) mechanics of acceptance. The solutions are:

(1) Cooperation between industry and the Building Officials organizations to establish acceptance criteria before a new product is marketed.
(2) Active participation by all interested in a program to promote the adoption of one of the B.O.C.A. codes or one of the other performance-type model building codes.
(3) Persistent utilization of the materials approvals service provided by the code sponsoring organizations.
EVALUATION METHODS FOR FASTENERS OF WOOD IN HOUSING

Lyman W. Wood
Physics and Engineering Division
Forest Products Laboratory

The art of evaluating fasteners for housing is in a state of rapid development. The basic objective of laboratory evaluations is to predict service behavior and any test method must bear a recognizable relationship to the environment of use. Basic problems to be solved are (1) to represent the variety of service environments in a single standard test method and (2) to reproduce the effects of long-time service in a laboratory test of short duration. Evaluation may be made on a single fastener or on a structural assembly. Properties most commonly examined are mechanical strength and rigidity, response to dimensional change, durability in long service, and fire resistance.

In the evaluation of mechanical properties, strength is the critical factor in a rigid fastening such as an adhesive bond, while slip or deformation may be more critical in a mechanical fastening such as a nail. Test methods most commonly employed place a fastened joint in either direct compression or direct tension. Mechanical test methods of structural elements in which fasteners play an important part include the racking test of a wall panel or tests of light frame wood roof trusses. Although evaluations up to the present have been concerned mainly with the overall strength or rigidity, increasing attention is now being paid to the analysis of the parts of the fastener and the stresses and strains on those individual parts.

Traditional fasteners such as nails have service records that show their durability. The durability evaluation of glued joints is well developed. There is critical need, however, for more information on the durability and aging characteristics of some of the newer types of mechanical joints such as truss plates. The durability may be influenced by moisture or temperature cycles, by loading cycles, or by some combination of these.

Fastened joints are vulnerable to fire, and fire test methods for structural assemblies provide that typical fastening details be included in the specimen. There is presently a trend toward more rigorous analysis of fire performance by separating the effects of fire on materials from the effects on joints or fastenings. In a proposed research program at the Forest Products Laboratory, special emphasis will be given to proper joint design for optimum fire endurance. Here is a field for research with a great potential of value.

The American Society for Testing and Materials has taken the lead in standardizing the test methods by which fastened joints of all kinds have been evaluated. Quality control agencies including the Douglas Fir Plywood Association and the American Institute for Timber Construction have studied the evaluation of glued joints and have developed test methods and performance requirements.
SOLVING OF A FASTENING PROBLEM

Harold H. Webber
Research and Development Division
Arthur D. Little, Inc.

Solving problems is a pretty personal matter and it is difficult to follow any definite procedures. The particular instance I'm going to use today is an example of a fastener problem and its solution.

Our client had a lot of wire he wanted used—the type of wire that ordinarily goes into nails. Wire in its hard-drawn, cold work state is noticeably strong and quite flexible. Among other things we learned about wire was that it had a high compressive strength. Unfortunately it buckles when you put a compressive load on it. But then someone said, "If it were straight, it wouldn't buckle; it would increase in cross sectional area. How much would it take to restrain it from buckling?" Our experiments determined that very low loads would keep the wire from buckling.

A survey of the market was made to see where this concept of wire use might be applicable and where the needs existed. It seemed it might be applicable as a fastener. This is how we came to the problem of fastening prefinished wood paneling in residences—with an invisible fastener. We concluded that we could restrain the wire from buckling and push it into the wood—using wire 0.020 inch in diameter and forcing it into a quarter-inch panel. This was done with a gadget that takes wire off a spool, shears it to a prescribed length, and inserts it into the panel flush with the panel surface.

We found we had to place 200 wires in a 4- by 8-foot panel to obtain the same withdrawal resistance as the 40 fourpenny nails that would ordinarily be used. Then we had to do something to this smooth 0.020-inch wire to give it additional holding power, and the obvious approach was coating. We devised coatings that do not dissolve in the wood and yet improve the holding power. We now have the wire holding the panel better than the conventional holding system, and the 0.020-inch hole is not detectable in a wood-grain panel. In addition, the application required only one-third of the time necessary for the fourpenny nails. We think we're closer to a finished product, except that we've got to devise the cartridge supply of wire to be as convenient as possible. Our contacts with the people who do this sort of thing have indicated that the best place for it is on the wrist of the operator.

This solution of a fastening problem is not a pat formula for any of you to follow in terms of product development or new ways to develop fasteners. It's one way that we have found useful—bringing together a wide range of experiences and disciplines in an environment conducive to free interplay of ideas.
ACADEMIC VIEWPOINT OF FASTENING NEEDS

Albert G. H. Dietz
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The primary function of an educational institution is education. It is education for the future. There's not much point in telling students how we do it today, especially in the technological, engineering, and scientific fields. We stick to fundamentals on one hand, and yet try to show things likely to be of importance in the future.

The second great function of any university is the unearthing of knowledge. Preferably this should be as basic as possible so that knowledge will not become obsolete in too short a time.

Now where do fastenings come in? From the educational standpoint they are useful in emphasizing some of the structural and mechanical fundamentals of material. Wood and its fastenings gives us a marvelous opportunity to explore fundamental concepts of mechanical structures with real materials, driving them home with specific concepts—fastenings as related to the strength, rigidity, economy, and design of the structure.

The research aspect is shown in a type of research we carried on a few years ago. This had to do with split-ring connectors. We needed to know how the stresses are distributed in this directional material we call wood. Then we'd have a better insight into how joints should be designed with split-ring connectors.

A number of things developed from this investigation and several other possibilities were indicated. This is the type of research we like to carry on because it goes into fundamentals. It uses new techniques of measurement. Furthermore we could use students on the work. They were given an insight into the manner in which research of this type should be carried out. It gave us new knowledge we could use in our educational process.

We are not much concerned with whether what we're talking about applies to housing or to any other structure. The fundamental principles are the same, and once students have a firm grasp of the principles, they can apply them to any structure—particularly the kinds of housing that will come along 15 to 20 years from now. We emphasize fundamental principles. We hope the end result will be engineers and architects who will be in a position to help solve these problems that face us today.

Report No. 2241 -23-
WOOD SCREW HOLDING POWER

John Reno
Pacific Lumber Company

There are no industry specifications for wood screws which can be used to develop engineering data or to establish fundamental details, such as correct size of hole to prebore for a certain size of screw. The only standard is ASA B18.6.1-1956 which limits head dimensions within close tolerances, but which leaves entirely too much latitude in all other important details. These variations prevent them from fastening wood most effectively.

A wood screw of a designated number will have the same maximum outside diameter of threads from all manufacturers, but there the similarity ceases. Sometimes the outside diameter of the threads tapers the full length of the screws, other times just a portion of the length. Each manufacturer decides the taper he wishes for each batch of screws he makes.

There is no standard for root diameters. They vary from manufacturer to manufacturer and from lot to lot. There is no basis for correct size of prebored holes for wood screws. Length tolerances are from -1/32 to -3/32 inch on wood screws from 1/4 to 2-7/8 inches long.

No standard exists on shape of threads. Crest of the threads can be any width and there are no restrictions on thread angles. Standards on number of threads per inch are loose, permitting variations of ±10 percent of nominal threads per inch. Wood screws are not made from hardened steel. Head styles may be either flat, oval, or round.

By contrast, written standards exist for sheet metal screws in most of these regards, and manufacturers adhere to them. Therefore sheet metal screws should be used in the assembly of many wood products to assure the best screw holding values possible with the screws available today. However, the sheet metal screw is not an ideal screw for the assembly of wood parts. Research to develop specifications for the ideal wood screw is now in progress.
The amount of allowable slip in joints should be based on the use involved. For example, slip or creep in a crossarm can be tolerated, but excessive slip in a truss or similar component, where deflection will result in structural damage or plaster cracking, should be restricted.

Confusion on slip, factors involved between loads in test and use, and so forth, indicates a need for clarification in this field. Limitations on slip and load limitations were placed originally on fastenings to prevent creep in that joint through continued use. The 0.015-inch slip for nails was not a hard and fast limitation—it was set up as an arbitrary evaluation to simulate a proportional limit load in joint, and for comparative purposes. Tests determined that under a limitation of 0.015-inch slip there would be no additional creep under repeated loads or under long-time loading conditions.

Now some feel that a nail has failed at a slip of 0.015 inch—some get along well with a slip of 0.030. Slip may not be a good basis for determining the actual point of failure.

Even measurement of slip has resulted in some confusion. For example, a plate across a tension joint in a truss covering two members would allow 0.030-inch slip; a single plate and the same size member would allow only 0.015. Should not the allowable slip in the entire unit be considered rather than the slip in each joint? In other words, if a specific slip such as 0.03 or 0.05 inch is allowed in the bottom chord of a truss, that should be the controlling factor whether 2, 3, or more joints are used.

Fasteners should develop the full potential of the materials used. Thus the same considerations should be applied to the fastener as to the material.

Determination of the acceptance criteria for new fastening methods should usually be done by the user, or by a building official representing a user. However, standardizing agencies should point out the significance of test methods for a new component and the results that come from these tests.
PRESENT ADHESIVES AS FASTENERS FOR WOOD

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Present wood glues were developed for simpler and less critical uses than are required in structural housing, with the possible exception of structural laminating. But wood glues are part of a large and expanding modern adhesives technology, and it is likely that some of the better adhesive systems that we want may not be much different from some now under development for metals or other nonwood materials.

In selecting an adhesive, one should consider the type and design of the joint, its purpose in the assembly, and the required level of initial strength and permanence required. Next are the working properties of the adhesive required by the bonding conditions of the job. Finally, there is the cost.

For fastenings we are now limited to a few types of glues that are capable of bonding at normal shop temperatures. The use and performance of the earlier casein and urea-resin glues are well known. At present the resorcinol and phenol-resorcinol resin glues best combine the properties of cure at 70° F. and high durability, but are rather high in cost and slow setting. All require some sort of pressure.

Rubber-base contact cements, originally developed for such nonstructural uses as bonding plastic laminate sheets to counter tops, can be used in a continuous "nip roll" bonding process in plants, or under essentially contact-bonding conditions on the job. They give some strength immediately, but this early "green" strength is low compared to usual strengths of cured wood glues. Strength increases somewhat as solvents escape. Other performance has not been established.

The glamor adhesives at present are the epoxy resins, developed originally for structural metal bonding for aircraft. These are 100 reactive and can be modified with various resins for a range of mechanical properties. Their initial strength is as good as other wood glues. Their durability is not yet established, but they should be durable. However, room temperature curing systems are exothermic and reactive in the pot so that pot life is excessively short. Furthermore they are expensive.

There is every reason to believe that these present limitations of adhesives for wood fastening can be reduced or eliminated by new formulations. Therefore, adhesive bonding will ultimately be faster and cheaper than the use of conventional mechanical fastenings, at least on a factory production scale.

Report No. 2241
Summary

WOOD, ADHESIVES, AND HOUSES

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The key to the use of wood in the house of tomorrow resolves simply to its ability to provide the sizes and shapes in demand, at lower cost than any other material. The ease of working with wood is associated with such operations as sawing, nailing, and drilling, using common, low-cost hand tools. In today's competitive world these advantages are no longer as attractive as they once were. The large-volume users are finding other materials which do not need sawing, drilling, and nailing to fabricate articles of commerce.

It appears desirable to consider whether the reputation of wood for easy fabrication can be enhanced by imaginative exploitation of another property, its adhesionability. In house construction, greater efficiency at all levels of gluing is needed, and can be achieved with proper encouragement.

The problem of increasing the acceptability of wood for house construction through improved gluing processes may be classified into a number of distinct categories, which may then be closely studied to determine the features requiring change. Five basic wood forms may be considered as starting units for the assembly of houses. These are (1) timber and studding, (2) lumber, (3) veneer, (4) flakes or particles, and (5) fiber. They are combined with each other or in various mixtures to produce parts of the house. Two distinct modes of assembly exist: One in which the major work is done under factory conditions, and erection involves merely the fastening together of large components; and another in which the structure is erected piecemeal at the site. The combining process, in the ultimate analysis, largely determines the final in-place cost, and hence demands attention to learn what new techniques can be developed to permit greater efficiency.

The two modes of assembly, and the five basic wood forms introduce elements of (1) geometry, (2) handling, (3) timing, and (4) temperature, which impose peculiarities upon the bonding or fastening mechanism. When these are analyzed with respect to particular intermediate or final products such as laminated beams, plywood, sandwich constructions, and houses, a common denominator emerges that suggests some of the essential properties that future adhesives must possess. They include (1) fast-setting, in minutes without heat, (2) high durability, (3) high tack and body, and (4) bonding ability at both low and high pressures. Specifically excluded are long mix life and long assembly time, because these requirements are inimical to an efficient gluing process. Price is also excluded because, even though important, it must be considered only in the context of the total advantages imparted to the production of a particular item.
The combined virtues of threaded nails, when used with lumber whose moisture content is going to change, are sufficient to justify their wider use. These nails will provide higher, longer lasting holding power and result in joints that will resist higher shear loads.

Threaded nails will provide considerably greater withdrawal resistance than the common wire nail when used under conditions where the moisture content of the wood will change. Furthermore, joints fastened with threaded nails retain greater resistance to lateral movement than those fastened with common nails with changes in moisture content.

For nail protrusion, the most obvious solutions are: (1) Use dry lumber that has achieved a moisture content preferably halfway between the maximum and minimum expected during normal exposure conditions within the finished structure. (2) Use the shortest practical threaded nail.
FASTENERS FOR PREFINISHED BEVELED WOOD SIDING

Gerald A. Koenigshof
Manager, Product Development
Timber Engineering Company

Long lasting finishes for wood siding are now being developed and several firms are already marketing preprimed wood siding that will outperform field-applied paints. The ultimate goal is to be able to cover the exterior of houses with completely prefinished wood. This will include door and window frames and soffits and facia boards as well as the siding material.

To accomplish this goal the producers of prefinished wood siding need a method of fastening the siding to the wall without breaking the painted surface. However, this is only one requirement of the ideal fastening. It is important that we recognize the many requirements now, so a fastener will be perfected when completely prefinished siding is ready for the market.

Some of the recognized basic requirements of any such fastener are: (1) Economy, (2) strength, (3) durability, (4) workability and ease of handling, and (5) safety and comfort.

Several fasteners are now being investigated. These fall in the category of gluing, clips that fit in a saw kerf on the butt edge of the siding, clips that have spreading teeth onto which the siding is pressed, common nails with colored heads, and plastic nails. No fastener meets all the requirements. However, some of the devices are very close to providing the essential requirements and will probably be available by the time prefinished siding is ready for the market.
TRUSS PLATE CONNECTORS IN PRESENT USE

J. C. Jureit
President, Truss Plate Institute

The truss plate is a comparatively new mechanical fastener used in the fabrication and assembly of wood trusses. Truss plates are made of steel and most are galvanized. They vary in thickness from 22 to 14 gage. Truss plates may be placed in the following categories: (1) All-nailed plates, (2) nail-augmented plates, and (3) self-nailing plates.

Plate systems involving a modest setup generally sell from the shelf, whereas larger systems of higher production sell usually under franchise arrangements.

In order to develop uniformity in design criteria, the Truss Plate Institute was formed. This organization, made up of the technical people connected with the various truss plate manufacturers, developed a proposed revision of FHA's first trussed rafter criteria. While this revision has not been adopted by FHA, it has provided a valuable background for a TPI trussed rafter criteria published in 1961. This criteria includes not only design requirements, but also tests used to evaluate single plate connections as well as whole trusses.

A Joint Industry Advisory Council, of which TPI is a member, has been formed and will present an interim design and performance for all trussed rafter designs. The final criteria will be based on results of research conducted by Professor Suddarth of Purdue.

Report No. 2241
AUTOMATIC APPLICATION OF MECHANICAL FASTENERS FOR WOOD IN HOUSE CONSTRUCTION

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All builders and subcontractors are interested in reducing the cost of labor and are constantly evaluating the economic advantages of automatic fastening systems. For residential construction, recent surveys indicate that the actual nailing time represents a third to one-half of the total carpentry labor costs.

While hand nailing and hand driving of screws are still common, inroads are being made by powered nailing machines, staplers, and screwdrivers. The relative success of staples, corrugated fasteners, T-nails, and stamped nails can be largely attributed to the convenience of handling oriented fasteners in a package for feeding to a driving tool. Today automatic fastener driving tools are being used in house construction for fastening flooring and subflooring, framing, wall and roof sheathing, roof trusses, shingling, door and window frames, masonry, cabinetry, screening, blanket insulation, building paper, ceiling tiles, and many other materials.

Although the most popular power source for fastening machines today is compressed air, certain limitations have long been realized. Probably the tool the trade wants most is a portable, electrically powered hammer, of the size and weight of an electric hand saw, that can feed and drive nails or staples.

One area in which some development work is being done is that of controlling the depth of fastener drive. Dry wall applicators are seeking a machine that can drive a fastener flush and snug against the paper surface without breaking it. The problem of controlling the depth of drive also prevents the more general use of automatic nailing for exterior siding, where an overdrive is prohibitive and splitting of the work cannot be tolerated.

Looking to the future of automatic mechanical fastener driving, watch for the following developments:

2. Development of new inplant fixtures and low-cost portable nail drivers for prefabricating building components such as exterior wall panels, interior partitions, box beams, and trusses.
3. Improved methods of automatically controlling the depth for machine setting nails and staples.
4. Improved nails and screws which are prepackaged for automatic machine loading.
5. High-speed driving of improved fasteners by light-weight, automatic drivers.
To a group dedicated to the furtherance of wood and wood products, it is ironical that we find ourselves leaning on plastics to enhance the favorable use of wood. As a member of the woodworking fraternity—and as a fastener manufacturer constantly searching for better and more effective methods—we bless this little competitor.

There are probably more varieties and formulations of plastics than species of wood; however, for the purpose of this discussion, we shall be limited to just two—a nylon multi-coat treatment and a vinyl dip.

The vinyl is applied to the fasteners in a dip process after the staples or nails have been coherred into sticks. We are using this process on staples and T-nails. In general, it permits the use of shorter and less expensive nails without sacrificing holding values.

The nylon multi-coat process eliminates the usual complaint where plastics and metals are joined—that the plastic does not adequately bond to the metal. This does bond, but it entails a special treatment of the wire before it is formed into fasteners. I have already exalted the advantages of the vinyl dip coating—but the nylon coating is substantially greater in effective holding power. Nylon coated staples are now used for many applications of house construction and crating.

These two types of plastic coatings offer many advantages to the building industry:

(1) Any given length of fastener becomes more effective both in tension and shear values—both immediate and long range.
(2) A shorter length fastener may be used successfully—thus reducing the cost of fasteners used.
(3) Nylon multi-coating, in preliminary test reports, shows resistance to humidity and salt spray longer than do plain galvanized fasteners.
(4) Since the plastics leave no gummy residue in the driving mechanism of the tools, there is less need for cleaning and maintenance of the tools.
(5) Color matching is possible with nylon multi-coating.
Adhesives

At the present time, no research has been done at the Forest Products Laboratory on pure polysulfide elastomers as low-load structural gap-filling adhesives. However, some work has been done on polysulfide elastomers with epoxies.

The use of monomer resin applied to one surface of a member and the polymerization catalysts to the mating surface of the other member for a fast-setting joint, so that all polymerization takes place in the joint, has not been investigated. It might appear that the monomer would penetrate too far. However, it is a new and fascinating approach to the problem in the use of adhesives. The final curing of resin glues in the joint by application of resin to one surface and curing catalyst on the other surface has been used on a limited scale in wood gluing for some years.

The holding value of glues can be equal to the shear strength of the wood itself. For example, for hard maple in a conventional block shear test, maximum values of 2,800 pounds per square inch and up are obtained. Failure is usually in the wood which means that the glue has greater shear strength than the wood itself. This does not mean that the value is doubled by doubling the glued area as much depends on geometry of the joint and type of adhesive.

The development of a short-term test series that will duplicate serviceability of adhesive joints over a 40-year period is a problem which research people have been concerned with for a number of years. An existing test used in plywood specifications and sometimes used for wood glues consists of a boiling-drying-bonding cycle. A 6-cycle test used for hardboards and fiberboards, involving such things as freezing, heating, cooling, and drying, has also been used for adhesives to a limited extent. Each involves some objectional artificial feature. It is difficult to develop a series of short-term permanence tests that are suitable for present-day glues and expect them also to be adaptable to the new glue like the epoxies and the polyurethanes.

The Forest Products Laboratory has two test houses, which are about 25 years old, made of stressed-skin panels. These panels were glue-nailed with casein glues and have given good service. However, while the units have been used as offices, it is felt that conditions do not duplicate those commonly found in a home. Relative humidities within the buildings are low during
the heating season and in addition, vapor barriers were used in all panels. Thus, moisture movement and build-up in the panels has not been a problem and the casein glue has evidently proved satisfactory. These test houses have also generally been kept adequately protected by paint. However, under moist conditions, as shown by laboratory tests, casein glues would not be satisfactory.

Gluing lumber at different angles presents many problems from the standpoint of adequate joint performance because of the internal stresses on the joint caused by moisture changes and resultant dimensional changes, and other factors. This is asking a lot of the glue line to resist some of these stresses and yet not allow preservative failure in the adjacent wood. The problem should perhaps be approached by (1) considering redesign of the joint and (2) developing new adhesives which can absorb some of the internal stresses in the glue line without allowing excessive slippage or creep.

Mechanical Fasteners

The use of truss plates on sections containing knots, checks, or splits within grade is not common because existing codes require stress-graded lumber and fabricators do a certain amount of culling to eliminate splits and checks. Knots are usually not a factor because if 1 out of 100 prongs or nails is bent by the knot, reduction in strength is minor. Crook and twist in members are sometimes a problem, but many connectors can accommodate them with little trouble during pressing operations.

Metal web connectors are designed for both tension and compression stresses to provide for combinations of snow and wind loads which may reverse the normal stresses in a roof truss. This type of member usually has a larger and differently formed cross section than a true tension member.

Threaded and screw-shank nails are manufactured from a wire diameter approximately equal to that of common nails but, because of increased "holding" power, the wire diameter has been reduced. The danger of bending the thinner nail has been compensated for by use of hardened steel. Thus, the performance of a thinner spirally grooved nail, for example, under lateral load is comparable to the thicker common nail.

Plastic-coated staples have a full protective coat except for the exposed points because the coating is applied to the wire prior to forming of the staples.

Design for special hidden siding fasteners should incorporate resistance to high wind velocities such as occur in the Southeast coastal areas.

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Attendance at
SYMPHOSIUM

FASTENINGS FOR WOOD IN HOUSE CONSTRUCTION

Forest Products Laboratory
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