Techniques and Practices of Forest Products Laboratories and Industries in the U. S. *

by

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DIVISION OF SILVICULTURAL RELATIONS

Functions

1. "Plans, directs, coordinates, and conducts fundamental and applied research on the relation of *growth condition* and *heredity* to the *structure and property of wood,* the relation of the *cellular structure* of wood to its strength, shrinkage and other properties; identification of wood and the *development of identification keys,* and the compilation of information on foreign species of wood.

2. "Consults with technicians and other officials, both public and private on research policies and plans and on the application of the results of research on wood structure and properties.

3. "Analyzes and interprets research data and prepares and reviews reports and publications incorporating the results of research on the *growth, structure,* and quality relation of wood.

4. "Develops and maintains cooperative relations with public and private agencies to advance research on the relation of wood structure and properties to growth condition and to improve the utilization of wood through better knowledge of its properties in relation to its structure."

It has been found here that as a rule fast growing trees of some species have higher specific gravity than slow growing ones. This is due to the fact that in coniferous woods there is more area of solid wood than slow growing wood. This seems to be just the opposite in the Philippines where hardwoods of the same species are growing in different locations. The faster growing trees due to abundant rainfalls well distributed throughout the year have less dense woods than those growing in drier regions. This is shown in our studies on specific gravity of woods from Basilan Island in the South and those from Cagayan Province of Northern Luzon.

The Division has done quite an extensive work in correlating the work on growth with the specific gravity and the strength of wood or the modulus of rupture. All available publications covered by the work of this Division are being secured for ready references in the Philippines.

Structure and Identification Section

This appears to be a small section with only two men but there is a tremendously important work being done here in the way of systematizing the identification of wood. This work is not only confined to the native American woods but includes all other woods coming from all parts of the globe. Dr. Kokacha is a member of a Committee of 3 of the International Anatomy Society which is trying to evolve a system by which wood of any country could be identified through the use of the IBM cards. He is working an index scheme to guide him in grouping anatomical wood characteristics that are helpful to identify a family, a genera, then the species.

* Second of a series on the report of Prof. E. de la Cruz.

The use of the punch card system is a tremendous help in this work instead of the old system of using identification keys which could be in most cases confusing than otherwise. In identifying a piece of wood he makes a tangential and radial specimen. He mounts these in glass slides and examines each under a powerful microscope using either 200, 400 or 800 magnification but ordinarily 200. Then he picks first the salient anatomical characteristics and with the use of the index he developed, he orders an IBM card for this particular specimen. Once this is done, then the rest of the cards on file are sorted by the sorting machine to find which one of these reference cards may have a similar record of a specimen—by family, genera, then species. The one found exactly having the same characteristics is the identification of the specimen in question. Otherwise it must be a new species.

I found the IBM machine very interesting because of its versatility and accuracy in reproducing and tabulating figures and computing at the same time from mere punches made on original cards. I saw them punching cards for U.S. imports of lumber for various countries, showing the country of origin, port of entry, species, board feet and value in dollars. When they get through preparing these cards they place them in the tabulating machine and in less than a minute a complete tabulation comes out with all the figures totaled.

All the results of fundamental researches in the Forest Products Laboratory are now being filed in IBM cards. After a master card is prepared, the operators can prepare any number of cards along the same pattern. These are filed in cabinets that can hold big quantities of data because of the small space a card occupies. I was shown the filing room and told that there are already on file more than a million cards of various nature representing the results of various scientific tests done in the Laboratory.

I have found too that even the payroll card is being kept in this IBM card for each individual showing the salary grade, the base pay and all the deductions, and the net pay for each pay period, all computed by the machines.

I understand that this machine can be rewired to do practically any job one can think of. But it is not for sale. The laboratory is paying a monthly rent of $300.00. It is worth it as it can do a job of more than 20 to 30 men depending upon how complicated is the task.

They have devised here various short cuts in the determination of specific gravity. But they use also the immersion system using a balance that gives direct reading of specific gravity with 100 cc specimen oven dry.

Structure—Property Relations Section

This is a section in the Division of Silvicultural Relations which is concerned in fundamental research on anatomical features affecting the properties of wood. Some of these are to obtain the fundamental information on:

1. Basic variability in anatomical features of annual rings with respect to year of formation or age from the pith, position in relation to the base of the active crown, and rate of increment in diameter of the rings.

2. Combined effects of anatomical features of the wood on its density, strength, and shrinkage, and the interrelations between those properties.

Work of this nature has to be closely coordinated within the Laboratory divisions of Silvicultural Relations and Timber Mechanics right along with the proposed research on the strength of wood as related to the physical structure and chemical composition. This work is based on earlier discoveries that strength and longitudinal shrinkage are jointly influenced by the specific gravity of the wood and the angles at which fibriles of cell-walls are arranged lengthwise in the wood fibers. It is believed that determination of such relations will reveal valuable information for evaluating unknown kinds of wood, superior-progeny trees to supply seed for plantations, and hybrids. These will be used as tools to improve the use of wood by better prediction of its properties from readily determined characteristics.

I am inclined to believe that if we are to orient properly our work in our proposed Forest Products Laboratory fundamental researches along these lines will serve to strengthen and give more light to the varied and multifarious problems we shall surely encounter in the various fields of investigations on increasing the utility of wood and wood products of the country.

To appreciate properly the importance and scope of applicability of one phase of this basic research, let us turn our attention to the occurrence of *tension wood* in some of our well-known commercial species. While we are aware of its presence we are not in a position to appreciate its direct relationships to longitudinal shrinkage and warping. Through the results of basic anatomical studies in the Laboratory, it was found that tension wood is characterized by the presence of gelatinous fibers. One important cause of longitudinal warping of hardwoods is the difference between tension wood and normal wood in shrinkage along the grain. Such difference sets up internal stress that results in warping. Tension wood is frequently distributed irregularly in hardwood lumber.

There is no doubt that we will be confronted with the problem of dealing with wood where growth rings are entirely absent. But we are quite fortunate that we have forest plantations all over the country where specimens of known ages can be secured for this type of studies. As our work on sample plots all over the country expands we shall be in a position to determine the yearly growth by diameter classes from the specimen trees from different regions.

Foreign Woods Section

The work consists of the preparation of information on foreign woods in conjunction with the work of Dr. Kokacha of the Structure and Identification Section.

DIVISION OF WOOD PRESERVATION

Functions

1. "Plans, directs, coordinates, and conducts fundamental and applied research program on the protection of wood and wood structures from attack by decay, borers, insects, and fire, the *painting* and *finishing* of wood and wood structures, the manufacture of veneer and fabrication of plywood and laminates, the *testing* of *glues* and the effects of *heating* of wood.

2. "Analyses and interprets research data and prepares and reviews reports and publications incorporating the results of research on the preservation of wood and wood structures, the manufacture of veneer and plywood, the fabrication of glued members, glue formulation and gluing methods, and the heating of wood.

3. "Consults with technicians and other officials, both public and private, on research policies and plans and the application of the results of research on the preservation of wood, veneer and plywood and glues and gluing.

4. "Develops and maintains cooperative relations with public and private agencies for the furtherance of research in the preservation of wood and to promote the better utilization and protection of wood."

Glues and Gluing Section

At the Forest Products Laboratory tests have been made on a number of *liquid glues*, which were found to differ very widely in strength. The weak ones are entirely unsuitable for woodworking purposes, but there were found some that compare favorably in strength with the hot glues. A high grade liquid glue should have an average shearing strength of not less than 1,700 or 1,800 pounds per square inch, it should dry rapidly, it should remain fluid at all ordinary temperatures, elastic and shock-resistant, and not unusually susceptible to the action of high temperatures, high humidity, molds and bacteria. Of 11 liquid glues examined, the most viscous showed the greatest adhesive strength (T.N. #F-2).

Water resistant glues—several basic formulas for making casein glue were worked out by the Laboratory, but at the present time water-resistant glues are sold in the market and relatively little is compounded by the glue user. Casein glues may be used at room temperature although they are sometimes used in hot-plate presses. They can be made to vary over a wide range in water resistance so the purchaser must have to state specifically what is desired. They are moderately water resistant but not water proof. Well made joints will withstand a certain amount of exposure to moisture but will fail under prolonged exposure to wet conditions. If not protected by preservatives they are subject to mold attack.

Soybean vegetable protein glue is similar in most of its characteristics to casein glue but does not produce a strong joint. It is used extensively in the manufacture of softwood plywood.

Since about 1935 woodworking adhesives from synthetic resin have developed steadily. Some of them make joints that are dependable when continuously exposed to water and to the weather—they are urea-, phenol-, melamine-, and resorcinol-formaldehyde resins. Some resin glues are prepared in the form of dry films, some in powder forms soluble in water, and some in the form of water and alcohol solutions or suspensions.

Well-made joints with urea resins are highly water resistant under ordinary conditions but not as durable as the phenol, melamine and resorcinol resins, especially under conditions involving high temperatures and high relative humidities. The last 3 produce joints that are very durable under all types of weather and water exposure.

Over-heating reduces strength of animal glue solutions. The viscosity of the high grade glue declined more rapidly than that of the veneer glue, but at the end of the heating test, the viscosity of the high-grade glue still averaged higher than that of the veneer glue.

The glues that are adopted for gluing wood may conveniently be divided into six classes:

1. Animal glues made chiefly from the hides, bones, sinews, and hide fleshings of cattle. These glues come in dry form.

2. Casein glues and vegetable-protein glues which have similar properties and characteristics. The former are made from the curd of soured milk, lime, and other chemical ingredients. The latter are made from soybean meal, peanut, and other high protein-containing meals. Both glues are sold in prepared form, requiring only the addition of the separate ingredients to the water.

3. Vegetable-glues, usually made from cassava starch.

4. Blood-albumin glues, made from soluble blood albumin, a product recovered from the blood of animals. These glues must be mixed from the separate ingredients just before use, since they deteriorate rapidly on standing.

5. Liquid glues, commonly made from the heads, skins, bones, and swimming bladders of fish. Some liquid glues are made from animal glue and from other materials. They come in prepared form ready for immediate use.

6. Synthetic-resin glues are products of the chemical industry. Most of them are of two types: urea-aldehyde combinations and phenol-aldehyde combinations. They are sold as powders to be mixed with water, in liquid form, and at least one is available as a dry film. The earlier products were often alcohol solutions.

The term "synthetic resin" was first used to describe synthetic chemical compounds that resembled natural resins in their general appearance. As more synthetic resins were developed, the term came to include many products bearing little, if any, resemblance to the natural resins. At present, it is applied to a wide and heterogeneous group of materials with many uses.

Synthetic-resin glues differ not only in respect to their basic ingredients and as to whether they are thermoplastic or thermosetting, but also in respect to numerous other characteristics, such as type of hardener, acidity or alkalinity, fillers, extenders, solvents, curing temperatures, storage life, and permissible assembly time.

Several of these synthetic resins have found widespread application as woodworking glues. Their use has resulted in improved performance of many glued-wood products and has facilitated the adoption of such products to new uses and the development of new wood products. Plywood for aircraft and other exterior uses, laminated ship keels and other laminated members for use under severe service conditions, wood aircraft assembled with resin glues, radio masts for tropical use, and new types of wood propellers for aircraft are among the many products whose manufacture has been facilitated or whose performance has been improved through the application of synthetic glues.

This is one of the activities of the Laboratory which perhaps made tremendous advances not only in the gluing of wood to wood in various forms to suit multifarious uses but wood to metals, plastics, compreg, papreg, sandwich panels of various descriptions and uses, etc. References are being secured for our Laboratory.

Preservative Treatment Section

The main objective of preservative treatments is to protect the wood where it is exposed to destruction by decay, insects, or marine borers. Wood preservatives are chemicals that, when injected into wood, make it unpalatable or uninhabitable to wood-destroying organisms. For general use, however, a preservative must have high toxicity to the organisms that degrade or destroy wood, must also be chemically stable and permanent so that it will remain in the wood for many years, have good penetrating properties, be safe to handle, relatively harmless to wood and metal, readily available, and reasonably cheap. With few exceptions, these preservatives fall into two general classes: oil-borne preservatives, like creosote and petroleum solutions of toxic chemicals which are relatively insoluble in water and of low volatility; and the water-borne salts that are injected into wood in the form of water solutions.

The accurate evaluation of a wood preservative is a difficult and time-consuming job. It can not be done as easily as the quality of some products of industry the fitness of which may be determined within a matter of hours in the laboratory. To evaluate a new preservative, screening tests must be resorted to. If the preservative in such testing shows up favorably it can then be tried out in accelerated tests on wood stakes in the field. This is desirable since field conditions can not be reproduced in the Laboratory. Actual service tests are necessary which may last several years even in the case of poor preservatives.

Considerable interests has been given recently to a test program by the U.S. Forest Products Laboratory and several cooperators in which the same preservatives are included in coordinated laboratory tests, marine borer tests, and a post service test. This should furnish a good opportunity for the correlation of the results of accelerated and service tests.

Right along with these preservative tests basic studies are to be conducted on rate of disintegration of wood under different heating conditions and different temperatures—whether in steam, water, or an oven. The results are of great interest to those using wood where it will be exposed to various temperature conditions, or to those who must heat it prior to use. Another phase of equal importance are the studies on the effect of temperature on the dimensions of green wood and the temperatures obtained in timbers when the surface temperature is changed after various periods of heating. The following factors were found to have an important effect on the rate of temperature change: (1) heating medium, (2) moisture content, (3) direction of grain in which heat movement takes place, and (4) density or specific gravity.

Heat studies are being undertaken along the following lines:

1. Conductivity or quantity of heat that passes through a given area in a given time for unit thickness.

2. Rate of temperature change in wood.

3. Effect of heat on rate of deterioration of wood as determined by loss in oven-dry weight.

4. Effect of heat on dimension changes in green wood.

5. Effect of heat on strength properties of wood.

A great deal of the test experiments being conducted in this field in the Laboratory are handed down to the different commercial treating plants through an extension service with the idea of improving the operations and securing the maximum results in the most economical way. But certain difficulties were met in various quarters because of the belief of the men handling the operations that they knew their job better than anybody else and are refractory to new ideas and new principles of doing things. But once convinced, they proceed to follow the treatment as outlined by the Laboratory. In certain instances, however, it was found that the operators just slide back to the old system in which they are accustomed.

There were prepared several charts that show what expenses are involved in doubling the life of a treated timber or how to find the average life of a bunch of ties, say 1,000 or more, after 10 or 15% have been replaced.

Fire Protective Section

This is considered to be the most difficult activity to standardize due to the fact that it is inconceivable that all of the interrelated factors affecting fires on different types of structures could be incorporated and controlled in one laboratory test. With the idea of approaching the solution of these varied problems, laboratory investigators resort to different test methods to provide information relative to specific phases of fire performance, by observing the variation in fire intensity resulting from different kinds and degrees of fire retardant treatment. These are roughly classified into two general groups: (1) those used essentially to study or evaluate resistance to the spread of fire, and (2) those used principally to study or evaluate resistance to the penetration of fire.

(1) Plane spread tests include the (a) fire-tube test, (b) modified Schlyter tests, (c) horizontal furnace, (d) ASTM crib test, and the roof corner test.

(2) Flame penetration tests.

Protection of wood against the spreading of fire can be provided by two types of treatments: impregnation with fire-retarding chemicals and surface coverings of fire-retarding coatings. The former has been in use to a limited extent for many years and during the war years large quantities were used in the construction of military installations. But the latter have received little recognition principally because of the lack of standard for minimum requirements enabling the purchaser to know whether he was getting a good product or one with little or no merit.

Various tests have been devised to measure the effectiveness of fire-retarding coatings in checking flame spread under varying conditions for fire severity, but the work done has been insufficient to determine how effective such coatings are in actual use.

Among the failures there is a will to thwart others. —*Chester T. Crowell.*

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If men were bought and sold by the pound, as pigs, heifers, cows, and sheep are, a man would be worth much less than a well-fattened pig.—*M. K. Wisehart.*