FPRI Technical Notes

FIBERBOARD

"Fiberboard" is a broad term for various kinds of sheet materials very much thicker than paper and made from wood fibers or other vegetable fibers. Fiberboards are also known according to use as insulation boards, hardboards, wallboards or building boards.

To avoid or minimize overlapping in the classification of fiberboard by use, the Food and Agriculture Organization of the United Nations has recommended the following classification according to density:

Classification of Fiberboard

Type of Board	Density g./cu.cm.	Density lb/cu.ft.
1 Non-compressed[a] or insulation board		
Semi-rigid insulation board	0.02-0.15	1.25- 9.50
Rigid insulation board	0.15-0.40	9.50-25. 0
2. Compressed or hardboard		
Intermediate or medium density fiberboard or semi-hardboard	0.40-0.80	25-50
Hardboard	0.90-1.20	50-75
Special densified hardboard	1.20-1.45	75-90

Raw Materials

Wood still remains the biggest and best source of raw material for fiberboard manufacture, although other lignocellulosic materials can be used. Without taking into account the use of pulpwood (i.e., logs primarily for pulp manufacture), the Philippines has also a tremendous amount of potential raw materials in the form of wastes from the operations of wood industries. In 1962, an estimate of these wastes and their sources are as follows:

1. Logging industry (in the form of usable tops and branches, damaged logs, and stumps) 900,000,000 bd. ft. (2,123,643 cu. m.)
2. Sawmills (as slabs, trimmings, edgings, sawdust, and bark) — 406,000,000 bd. ft. (957,-999 cu. m.)
3. Veneer and plywood plants (as bolt cores, trimmings, etc.) — 129,000,000 bd. ft. (304,-389 cu. m.)

These waste are conservatively estimated to be equivalent to 1,253,000 metric tons of dry materials annually. A very small part of the estimated waste is used for fuel and construction purposes while the rest is unused.

So far, there is only one fiberboard mill in the Philippines which uses sawmill waste profitably as its raw material. Many of the hardboard mills in existence are built near or integrated with sawmills, plywood mills and veneer mills in order to fully utiize the wood. The possibiities, therefore, of integrating fiberboard mills with other wood-using industries in the Philippines should be thoroughly explored.

One advantage of the fiberboard industry is that it can utilize wastes such as unbarked wood, small-sized wood (down to 2 inches or 5 cm. diameter). For any given board composition, of course, sawdust and bark can be used up to a certain proportion only without adversely affecting the quality. In certain cases, the addition of bark even improves some desirable properties of the board.

Among the non-wood fibrous materials, bagasse and rice straw are available in the Philippines. It should be realized, however, that the biggest problem in the use of these raw materials lies in their collection and storage and the lack of suitable equipment (in the case of rice straw) for this purpose. Another problem is the seasonal nature of sugarcane and rice crops. Furthermore, bagasse is also used to some extent as boiler fuel by sugar centrals.

Due to the springy, tough nature of the fibers, bagasse is better suited for insulation board than for hardboard. At present, intermediate density board or semi-hardboard as well as insulation board is being made from bagasse in the Philippines. Rice straw can be used for insulation board and hardboard. However, the nodes and the silica content of the straw and extraneous foreign matter such as dirt and weeds present problems during processing.

[a] (Board is "non-compressed" when it is not pressed while undergoing drying. "Compressed" board is dried while under pressure.)

Methods of Pulping

1. *Mechanical pulping.* — This is done in the same manner as in the manufacture of newsprint, using grinders except that the pulp produced is relatively "fast draining" compared with pulp produced for newsprint.

2. *Thermal and mechanical pulping.* — The raw material is given a preliminary treatment with direct steaming followed by grinding, also under steam, usually in disc refiners. The well-known Asplund process is an example of this method.

3. *Chemical and mechanical pulping.*—Some raw materials may require a mild chemical cook using neutral sulfite, sodium hydroxide or lime liquor followed by refining in a disc mill.

4. *Explosion process* (*Masonite process*). — The wood chips are steamed at an extremely high temperature in a high-pressure vessel and then expelled. The sudden release of pressure causes the steamed chips to explode into a fibrous mass.

The pulp made from any of the above processes may be washed, further refined and screened before the necessary additives are blended with the pulp to be followed by formation of the sheet.

Additives

Sizing is added to the pulp to improve its resistance to water absorption and, to certain extent, increase the strength of the finished board. For insulation board, rosin, paraffin, cumarone resin, or asphalt could be used. Paraffin wax and rosin are also used for hardboard sizing. The sizing material is precipitated on the fibers by alum. For dry-pressed hardboard, drying oil emulsion is used and precipitated by ferrous sulfate and sulfuric acid. For air-felted hardboard manufacture, wax is added to the chips in the digester or before or after disc refining. Phenolic resin, which is primarily used to improve the strength of the air-felted boards, is added separately in a blender.

Sheet Formation

1. *Wet-felting.*—This is the most common method and is used for all insulation board manufacture and most hardboard manufacture. The mat or sheet is formed from a water suspension of pulp on fourdrinier machines, deckle boxes, or cylinder formers.

2. *Air-felting.* — The relatively dry fibers are formed into a sheet by air or mechanical means.

Insulation Board

After cold pressing, the sheets or mats are cut and trimmed, if necessary, and dried to about 10 per cent moisture content or less. The boards are further trimmed after drying. If desired, preservative and fire-resistive treatments may be applied. The boards may be coated, painted, laminated or perforated.

Hardboard

Pressing methods

The sheet formed by either wet-felting or dry-felting may be wet-or dry-pressed in steam-or hot-water-heated presses.

1. *Wet-pressing* is generally used at present, utilizing a wire screen on one side of the mat to allow steam to escape from the board itself. The wire screen used gives the wet-pressed board its characteristics "screen-back".
2. *Dry-pressing* is applied only to make of sufficiently low moisture content. Smooth, two-side (S-2-S) boards are produced by this method since no wire screen is necessary. The pressing time is shorter, but the pressure and temperature used are higher than that used for wet pressing. Furthermore, such additives as resins are necessary and the amount of wax sizing used is higher than the amount used for wet-pressed boards.

Based on the overall method of manufacture, i.e., from pulping to pressing, hardboard processes can be classified as *wet*, *semi-dry*, and *dry*. Pulping is quite similar for the three processes. In the more common *wet process*, water is added after pulping, the pulp is wet-felted and wet-pressed; the moisture content of the mat being about 65-70 per cent before pressing. In the *dry-process*, the pulp is dried to about 6 per cent moisture content, the pulp is air felted and the mat is dry pressed. In the *semi-dry* process, the pulp is dried to about 12 to 15 per cent moisture, is air felted but water is added just before pressing increasing the moisture content to about 30 per cent.

At present, the semi-dry process does not offer any decided advantage over the wet process even in the case of water consumption. The dry process is recommended where water supply and water pollution are problems. It is also possible to make S-2-S boards and a wider range of board thicknesses in the dry process than can be made with the wet process. However, the wet process has been so highly developed that, at present, it has a lower cost of production than the other two processes.

Additional Treatment

Like insulation board, hardboard from the press may be trimmed and used as such or given further treatment:

1. *Heat treatment.* — The board is exposed to a high temperature (about 155 to 160 deg. C.) for a few hours. This process improves the strength and resistance to water absorption and lessens thickness swelling.

2. *Oil-tempering.* — The board is impregnated with drying oils like linseed or tung oil and then heated at 160 to 170 deg. C. for several hours. This treatment increases not only board strength and water resistance but also resistance to weathering and abrasion, making the board more suitable for outdoor use.

3. *Humidification.* — Boards from the hot press or after treatment or oil-tempering are humidified to 5 to 8 per cent moisture content to stabilize the dimensions and to prevent warping.

4. *Other treatment* — The hardboard may be painted, covered with overlays, given preservative or fire-resistive treatments, grooved, laminated or perforated. The smooth surface may be printed with any design such as wood grain. Hardboards with embossed patterns are made by using press cauls of the desired designs.

Standard hardboard, in American practice, refers to the product from the hot press which is subjected only to minor treatment such as humidification and trimming. In Scandinavia, as in the Philippines, heat-treated board which is subsequently humidified and trimmed is called *standard hardboard.*

Uses

1. *Insulation Board.* — Some insulation boards are used at present in the Philippines for heat insulation and accoustical applications. Other fields of use are for concrete forms, interior walls and ceilings, roof insulation, structural purposes, paddings for truck, rail and ship loading, packages, and underlays for parquet and other wood flooring.

2. *Hardboard.* — This is used widely for walls, ceilings, partitions, flush doors, cabinets, backs for radio and television sets, wall for exhibitions and other temporary structures and shipping containers. Other uses are for blackboards, concrete forms, building exterior walls, underlay for linoleum, rubber, plastic tile, and other types of flooring, doors (as core and facing materials), furniture and panelling for buses and railway coaches.

REFERENCES

1. Casey, J. P. 1960. Pulp and Paper. Vol. I. Interscience Publishers, Inc. New York.
2. Defibrator AB. 1960. Manufacture of fiberboard by the Defibrator system. Stockholm.
3. Food and Agriculture Organization of the United Nations. 1958. Fiberboard and Particleboard. Rome.
4. Mañalac, G. 1963. RP wood industries have problems. The Manila Times 19(58):15016A.
5. Nourivaara, E. 1963. Economic and technical aspects in a comparison of wet and dry processes for hardboard. International Consultation on Plywood and other Wood-Based Panel Products. Food and Agriculture Organization of the United Nations. Rome.
6. Swiderski, J. 1963. An evaluation of different hardboard processes. Wet, semi-dry and dry. International Consultation on Plywood and other Wood-Based Panel Products. Food and Agriculture Organization of the United Nations. Rome.
7. Tamesis, F. 1963. Tropical usage of wood-based panel products. International Consultation on Plywood and Other Wood-Based Panel Products. Food and Agriculture Organization of the United Nations. Rome.
8. U.S. Department of Commerce. 1949. Commercial Standard CS42-49. Structural Fiber Insulating Board. Washington.
9. U.S. Department of Commerce. 1063. Commercial Standard CS251-63. Hardboard. Washington.

PROSPECTIVE PULPWOOD SPECIES FOR PLANTATION IN THE PHILIPPINES

Paper, one of the many products derived from the forest has oftentimes been taken for granted; but its indispensability in our modern daily living cannot be denied. We come in contact with paper almost every hour of the day in many forms, uses and applications such as in books, newspapers, writing pads, wrappers, paper bags and a thousand other uses. This continuous need for paper has induced scientific and industrial research institutes and laboratories all over the world to look for raw materials and improve processing techniques in pulp and paper manufacture.

In the Philippines, one pressing problem of the pulp and paper manufacturer is the inadequate supply of fibrous raw material. The Forest Products Research Institute, in an attempt to help the infant pulp and paper industry, conducts research studies on fiber measurements, proximate chemical analyses, and pulp and papermaking evaluations of Philippine fibrous materials in search of promising species for pulp and paper production.

In pulp and papermaking, softwood species are the principal raw materials in producing good quality paper. In temperate countries like Sweden, Canada, and the United States, where the forests are mostly of the coniferous type, the problem of securing raw materials for paper manufacture is not as difficult as in the tropics, where the forests consist mostly of hardwoods in varying degrees of mixture with a relatively small quantity of conifers.

The scarcity of conifers in the Philippines has focused the attention of the paper industry to the utilization of hardwoods. The number of tree species in the Philippines is estimated to be around 3,800. Less than 100 species, however, are being utilized commercially by the lumber and plywood industry and the rest are potential raw materials for the various wood-using industries like the pulp and paper industry.

The Forest Products Research Institute, in its exploratory studies on pulp and papermaking, using the Runkel[1] and Muhlsteph[2] classifications as well as other basic concepts concerning wood fiber and pulp-sheet properties, had determined the fiber dimensions of around 400 species. About 200 species were found suitable for pulp and papermaking so far.

In the utilization of these suitable species for commercial pulp and paper production, there are a number of problems involved. Not all of them can be readily used because many are not available in sufficient quantity to supply regularly the needs of the pulp and paper mills. Moreover, some of these species are difficult to propagate in plantations so that an adequate supply of planting stocks would not always be available. In addition, the cost of procurement is not reasonably economical.

Some of the pulpwood species that have been found suitable by the Forest Products Research Institute for pulp and papermaking and which could be grown in plantations are as follows:

Common name	Scientific name	Fiber length (mm)	Runkel ratio	Muhlsteph group
1. African tulip	*Spathodea campanulata* Beauv.	0.92	0.23	III
2. Big-leafed mahogany	*Swietenia macrophylla* King	1.18	0.47	III
3. Gubas	*Endospermum peltatum* Merr.	1.62	0.52	III
4. Kaatoan bangkal	*Anthocephalus cadamba* (Roxb.) Miq.	1.43	1.42	III
5. Katmon	*Dillenia philippinensis* Rolfe	2.68	1.04	III
6. Moluccan sau	*Albizia falcata* (L.) Back.	1.11	0.41	III
7. Paper mulberry	*Broussonetia papyrifera* (L.) Vent.	0.95	0.38	III
8. Red lauan	*Shorea negrosensis* Foxw.	1.61	0.42	III
9. Toog	*Combretodendron quadrialatum* (Merr.) Merr.	2.36	1.15	III
10. Tuai	*Bischofia javanica* Blume	2.19	0.56	III
11. White lauan	*Pentacme contorta* (Vid.) Merr. & Rolfe	1.37	0.41	III
12. Benguet pine	*Pinus insularis* Endl.	3.45	0.41	II
13. Buho	*Schizostachyum lumampao* (Blco.) Merr.	2.42		
14. Bolo	*Gigantochloa levis* (Blco.) Merr.	1.80		
15. Giant bamboo	*G. aspera* Kurz	3.78		
16. Kauayan-kiling	*Bambusa vulgaris* Schrad.	2.33		

For plantation purposes, African tulip, Kaatoan bangkal, big-leafed mahogany, paper mulberry, and Moluccan sau would be profitable for pulp and papermaking. These are fast growing species. *African tulip* was introduced in the Philippines primarily for ornamental purposes. With the increasing interest in pulp and paper manufacture, however, it was found at the Institute that this species is a good source of raw materials for the manufacture of pulp. Studies made on this species showed that it can be propagated both sexually and asexually. It can thrive on elevations up to 4,000 ft. and is suitable for fairly dry regions. *Kaatoan bangkal* has been described as a "tree-guinea-pig" and has shown in 12 years a strange growth performance of 45 cm. av. diameter at breast height and 26.2 m. av. height. Big-leafed mahogany was observed to yield from a stand of 123 to 156 trees/ha., about 84 cu.m. at the age of 35 to 36 years. With a stand of 228 to 400 trees/ha., about 64 cu.m. were obtained at the age of 17 to 22 years. The mean annual diameter growth of 21-year old trees varied

[1] Runkel ratio — twice the cell wall thickness over the lumen width of the fiber.

[2] Muhlsteph classification — is based on the relative are of cell wall to that of the whole fiber as seen in cross section.

from 1.13 to 1.86 cm. *Paper mulberry* can be propagated sexually and asexually and can be grown to pulpwood size in a few years. Four-year old trees of paper mulberry was observed to attain an av. dia. growth of 12 cms. and an av. height of about 12 meters. *Moluccan sau* has been widely publicized as a plantation species because of its fast growth and its prospects for groundwood pulping. It was found that Moluccan sau reached 45 to 60 ft. high (14 to 18 meters), in 3 years on good sites, and 25 to 40 ft. (7 to 12 meters), on poor sites.

Benguet pine, red lauan, and *white lauan* have been found at the Institute to produce satisfactory paper products by the sulfate pulping process.

Benguet pine is native to the Philippines. It was observed that the 11-year old stand of Benguet pine has a mean annual diameter growth of about 0.99 cm. and a mean annual height growth of about 0.8 meters. *Red lauan* and *white lauan* are "Philippine mahogany" species and although they are already used commercially, they have been found to be potential raw materials for pulp and paper. They grow in closed stand and each individual tree grows vigorously straight with an adequate supply of sunlight. *Red lauan* attains a height of 165 ft. (about 50 meters) and a diameter of 80 inches (200 cms.). *White lauan* attains a height of 132 ft. to 165 ft. (45 to 50 meters) and a diameter of 72 inches (182 cms.). The average diameter of 16-year old trees of white lauan in the Makiling National Park is about 10 cm. and its average height is about 8 meters. Its mean annual growth is 0.64 cm. in diameter and 0.50 meter in height.

Gubas is being utilized as match sticks. However, studies conducted in the Institute revealed that it is a promising raw material for pulp and paper. In plantations, it has been found that the mean annual increments of 11-year old stands based on actual measurements are 2.18 cm. in diameter and 1.42 m. in height. Gubas trees attain an average diameter of 24 cms. and an average height of 21.7 meters in 11 years.

Katmon and *toog* are commercially used as joists, beams, and for other construction purposes. Both species have been tried at the Institute and have been found suitable for papermaking. Toog sulfate pulps were found to be good materials for paper of moderate strength. *Katmon* would yield alkalin-cooked pulp of intermediate to moderate strength. Katmon abounds in our forests and its fruits are edible.

Tuai is at present not commercially used. By Runkel classification, tuai would yield alkaline-cooked pulp with high over-all strength. Experiments conducted at the Institute showed that strong paper can be made from tuai sulfate pulps.

The different species of bamboo like buho, bolo, kauayan-kiling, and giant bamboo were found suitable for papermaking. They are easy to propagate and they grow rapidly. Bamboo is the principal raw material for the pulp and paper industry in India, where bamboo species are reportedly exploitable from 6 to 12 years after planting at a 3- to 4-year cutting cycle.

The search for potential raw materials for pulp and paper-making at the Forest Products Research Institute is merely at its infant stage and for the last 6 years, studies along this line were purely basic. The results, however, indicate that different grades of pulp and paper can be manufactured from prolific sources of Philippine cellulosic materials.

REFERENCES

1. Chine, F.O. 1948. Trial planting of large leaf mahogany (*Swietenia macrophylla* King.). Phil. Jour. For. 6(4):40A-60A.
2. ————. 1932. Notes on cedar and kalantas. Makiling Echo. 11(4):228-230.
3. Delizo, T. 1951. Paper mulberry. Phil. Jour. For. 9(1):107-115.
4. Hess, R.W. 1952. Pulpwood from tropical forests. TAPPI 35(4):133-136.
5. Marcelo, H.B. 1949. Matchwood, gubas (*Endospermum peltatum* Merr.). (Unpublished).
6. Monsalud, M.R. and F.N. Tamolang. 1962. Pulp and paper research at the Philippine Forest Products Research Institute. TAPPI 45(2): 38A-60A.
7. Tamolang, F.N., *et al.* 1957. Fiber dimensions of certain broad-leafed woods and bamboos. TAPPI 40(8):671-676.
8. ————, *et al.* 1958. Fiber dimensions of certain Philippine broadleafed woods and coniferous woods, palms and bamboos, II. TAPPI 41(10):614-621.
9. ————, *et al.* 1960. Fiber dimensions of certain broadleafed woods, bamboos, and agricultural crops and wastes and grasses. III. TAPPI 43(6):527-539.
10. ————, *et al.* Kaatoan bangkal grows in Mt. Makiling. Forestry Leaves 2(4):67-70.
11. Reyes, L. 1938. Philippine woods. Dept. of Agri. & Nat. Res. Tech. Bull. No. 7. Bureau of Printing, Manila.

SOME MANUFACTURING CONSIDERATION IN WOOD GLUING

In the manufacture of wood products, it is often necessary to join two or more pieces of wood to obtain the desired design for either structural or decorative purposes. The joining of these could be attained by using mechanical fasteners and wood adhesives or glues. In most instances, gluing proves to be more economical and efficient than fastening, and permits more versatility of design. However, in a glued assembly, the efficiency and performance of a glue joint under a specific service condition are dependent on several manufacturing variables such as: those occurring during the preparation of the wood stock, preparation and application of the glue, pressing operations, and stacking ot the glued products. In the preparation of the wood stock, variation arises in the selection of the material for grade, grain orientation, surface appearance and moisture content. The determining conditions that occur in the preparation and application of the glue are the consistency of the mix during formulation, "stand-by" time before a batch of mix is consumed, and the amount and pattern of spread on the mating surfaces. Factors to be considered in the pressing operation are assembly time, bonding pressure, pressing temperature, and pressing time. In stacking glued products especially those with glue lines cured by the aid of heat, the principal variable is usually the conditioning time between release of bonding pressure and finishing operations which in turn is influenced by atmospheric conditions in the factory. The atmospheric conditions in the store room for cold pressed products also affect stacking time.

There are five distinct phases in the bond between two glued wood surfaces. They are the wood adherend A on one side, adherend A — glue interface, the glue line, the glued-wood adherend B interface, and the wood adherend B on the other side. Under any stressed condition, the behavior of these phases are similar to those of the links in a chain. Failure always occurs in the weakest link. The behavior and properties of these phases are controlled by manufacturing variables and other factors attributable to the wood[1] and the adhesive.[2]

MANUFACTURING OPERATION

Causes of poor glue bond quality could be traced mostly to the inadequate control of manufacturing variables. It is imperative that these factors are controlled within specific ranges in order to obtain the optimum quality of glue bonds with the use of specific adhesives. The optimum range of manufacturing variables may vary considerably for different types of adhesives. It is also probable that a set of control levels in one plant may not be entirely adaptable in another plant when the same basic type of resin is used. However, the basic principles to be followed in the gluing operations are the same regardless of the scale of operation.

Preparation of the Wood Adherends

The stock should be of choice materials. Defects such as decay, loose knots and reaction wood should be minimized, if not totally eliminated, by cutting off such portions in the case of solid laminae or clipping them off in the case of veneers. The desired dimensions could be obtained from short and narrow sound stocks by such processes known as end and edge gluing.

The moisture content of the stcok should be maintained at specified levels such that when the water in the glue line is added, the resulting moisture content is approximately equal to the average equilibrium moisture content[3] it will attain in service. The optimum levels of stock moisture content will vary with the type of adhesive used, glue formulation, stock dimension and species of the wood. Proper control of moisture content tends to minimize the internal stresses in the glue line due to shrinking and swelling of the wood while in service because wood losses or absorbs moisture from its surroundings. Hence, the probability of bond failure while in service is reduced.

There is a necessity to control the moisture content of wood. Lumber intended for solid lamination should be dried preferably in a lumber kiln to the desired moisture content range. There is an optimum kiln drying schedule for each species and stock dimension that will result to maximum production with least drying degrade. This also holds true in the drying of veneer which is conducted in suitable mechanical dryers set to optimum drying conditions.

Another important operation is the surfacing of the stock. To obtain an efficient glue joint, the mating surfaces should be planed or jointed to produce a true plane thus, effecting the removal of loose and damaged fibers, and preventing the occurrence of stress concentrations in the glue line due to uneven glue line thickness. It is also suggested that the lapse of time between the preparation of stock and the gluing operation should be as short as possible to prevent surface oxidation which may interfere with adhesion.

Preparation of the Glue

The manufacturer's recommended procedure of glue mixing should be followed closely. Deviations

[1] Refer to FPRI Technical Note No. 20. Laminated wood, its manufacture and uses.

[2] Refer to FPRI Technical Note No. 13. Adhesives for wood, their characteristics and selection.

[3] Refer to FPRI Technical Note No. 1. Moisture content of wood in relation to air humidity.

from the prescribed procedure or instruction may affect the property of the resulting glue mix. This in turn can affect considerably the quality of bond produced.

The quantity of glue mix per batch should be controlled such that the total mix can be consumed within the stated pot life of the mix. It is a good practice to prepare small batches as often as practicable in order to have a constant supply of fresh mix. The glue mix should be free from lumps and the occurrence of foam should be kept at a minimum.

Application of the Glue

The glue mix can be applied by different methods depending on the geometry of the adherends. For wide and flat pieces, the common methods of application by brush, roller, spray and by mechanical spreader are very popular. The amount of glue spread depends on the type of adhesive and its available resin content, and the quality of the adherent surfaces to be glued. It is a general practice to apply higher spread with natural glues than synthetic resins for the same glue-bond quality requirements. The common range of glue spread for ordinary gluing requirements is about 150 to 200 grams per square meter of single glue line (30-30 lb/MSGL). In heavy laminations, the range of spread runs from 300 to 400 grams per square meter (60 to 80 lb/MSGL). This difference in spread should not be taken to mean that higher glue spreads will result in a higher glue bond strength. There exists an optimum glue line thickness that will develop the maximum glue bond strength The required heavier spread in lamination is to compensate for the difficulty in bringing together the matting surfaces into intimate contact on account of its thicker cross section, thus reducing the occurrence of discontinued glue lines. The important factor in the glue spreading operation is to obtain an even and continuous spread.

Assembly Time

The time lapse between glue spreading and application of bonding pressure is generally termed as assembly time. During this period, the glue line can be either exposed to the atmosphere (open assembly) or the glue spread surfaces can be preassembled, thus protecting the glue lines from the atmosphere (closed assembly). It is generally specified whether a close or an open assembly time should be used. The duration of assembly time for a particular adhesive is also specified and tabulated as dependent on the plant temperature, density of the adherends, speed of the catalyst and conditions of the stock. It is imperative that the optimum conditions of assembly time should be followed in order to minimize common gluing defects such as blisters, starved joints, and precured glue lines.

The mechanism acting during the assembly period can be summed up as follows:

1. Transfer of glue to the unspreaded surface in the case of close assembly.

2. Partial loss of solvent.

3. Partial curing of the glue lines.

The latter two mechanisms contribute to the gradual thickening of the glue. It is evident from these mechanisms that bonding pressure should only be applied after the glue line has attained a specified consistency which could resist excessive flow and penetration into the adherends. This minimizes the occurrence of blistered, starved or weak joints.

Application of Bonding Pressure

The primary role of bonding pressure in the gluing operation is to hold the adherends in intimate contact until the glue line has attained a minimum strength sufficient to overcome any stress that tends to separate the assembly. The bonding pressure also resists the tendency of the glue film to shrink thus minimizing the occurrence of crazed glue lines.

The amount of pressure required in the bonding operation depends on the type and quality of the adherends and the adhesive. It generally follows that thicker laminae requires higher bonding pressure. Certain types of adhesives require only a minimal bonding pressure while others required higher pressure to obtain the optimum glue bond strength possible.

Clamping Time and Pressing Time

The minimum length of time at which the bonding pressure is applied is known as clamping time in cold pressing and lamination works. It is also termed as pressing time in cases where the curing of the glue line is accelerated by heat. In cold pressing operations, the length of claming time is entirely governed by the type of resin and the catalyst system, where there is a definite range of curing temperature at which an optimum bond quality can be produced.

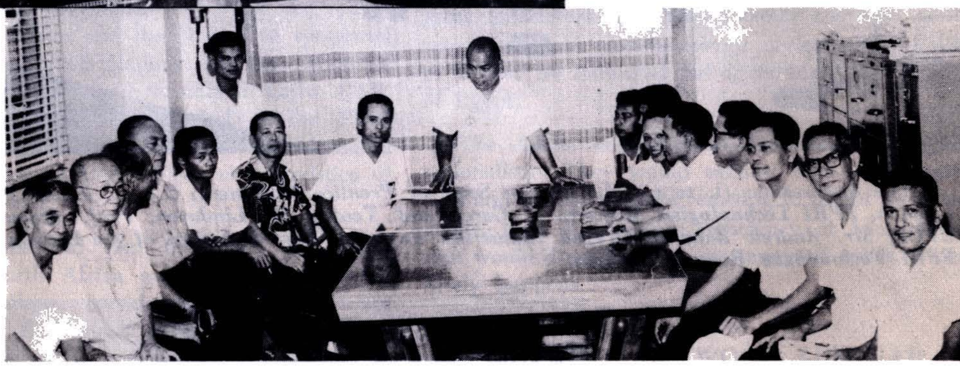
Stacking

Glued wood products especially those bonded with thermosetting adhesives should not be subjected to any finishing operation immediately after the pressing cycle. They should be stacked to attain the plant's atmospheric conditions and allow for the residual curing of the glue lines in order to develop approximately its maximum potential strength.

REFERENCES

1. Bergin, E. G. 1948. Effect of wood moisture content on gluing. Mimeograph No. 137. Department of Mines & Resources, Dominion of Forest Service, Forest Products Laboratories, Ottawa, Canada.
2. ————. Glue joint failures and their causes. Forest Products Laboratories Division, Department of Resources and Development, Ottawa, Canada.
3. Casselman, Ralph. 1953. Production gluing. Preprint No. 236, U.S. Forest Products Research Society, Madison 5, Wisconsin.
4. Cockrell, R. A. and H. D. Bruce. 1946. Effect of thickness of glue line on strength and durability of glued wood joints, FPL No. R 1616, Forest Products Laboratory, Forest Service, U.S. Dept. of Agriculture.
5. Englerth, G. H. 1950. Decay resistance of plywood bonded with various glues. Preprint 115, Forest Products Research Society, Madison 5, Wisconsin, U.S.A.
6. Hancock, W. V. and P. L. Northcott. 1962. Characteristics of undercured glue bonds. Wood XXVII (8): 332-4. Tothill Press Ltd. London, S.W.I.
7. Marra, A. A. 1951. Glue line doctor. Proceedings, Vol. 5, Forest Products Research Society, Box. 2010, University Station, Madison 5, Wisconsin, U.S.A.
8. Peterson, R. W. 1964. Wood adhesives. Department of Forestry Publication No. 1055, Roger Duhamel, FPSC, Queen's Printer and Controller of Stationery, Ottawa, Canada.
9. Phinney H. K. 1951. Methods of controlling glue bond quality. Proceedings, Vol. 5, Forest Products Research Society. Box 2010, University Station, Madison 5, Wisconsin, U.S.A.
10. Redfern, D. V. 1950. Gluing operations — Industry trends. Reprint No. 119, Forest Products Research Society, Madison 5, Wisconsin, U.S.A.

U.P. President Carlos P. Romulo (center with coat) administering the oath of office to Hon. Jose G. Sanvictores (second from right) as member of the Forest Products Research Board on September 14, 1965. This oath-taking was held in Dr. Romulo's office in Diliman.



FPRI's Director Manuel R. Monsalud standing in the center explaining some aspects of Forest Products Research work to wood workers and municipal officials of Paete, Laguna, some Bureau of Forestry officials of Laguna, and municipal councilor, Clemente Juliano (extreme left) of Los Baños. The meeting took place in the Forest Products Research Institute some months ago.

Director Manuel R. Monsalud, second from right, congratulating Mr. Lauro A. Ynalvez, Chief of the Chemical Investigations Division, FPRI, for his patent recently granted by the Bureau of Patents on a glue formulation based on tannin and coconut husk powder. Looking on are the different chiefs and assistant chiefs of divisions and the lady secretary of the Forest Products Research Board, Mrs. Liwayway A. Decena.

Philippine Committee of the International Biological Program meeting at the Forest Products Research Institute's Library. Director Manuel R. Monsalud is shown at the head of the table rendering his verbal report on his participation at the Pulp and Paper Development Conference for Africa and the Near East held in Cairo, U.A.R. last March. In this committee scientists from different government agencies such as the University of the Philippines, Commission of Fisheries, Institute of Science and Technology, and the Forest Products Research Institute are represented.

The discussants: (l. to r.) *Mr. Mervin Scott of Prentice Machinery, U.S.A., PMAP President Aurelio Lagman, FPRI Technologists Mamerto L. Garcia and Teofilo M. Lindayen, Prof. Armando Villaflor of UPCF, Mr. Andrew Zabu of Oregon Industries, Forester Gregorio Santos of the Bureau of Forestry and FPRI Technologist Romulo C. Eala.*

Mr. Alcantara of Alcantara & Sons congratulates a participant who just received his certificate from Director M. R. Monsalud (left). Looking on is Engr. R. P. Saraos, seminar coordinator for the FPRI.

"Idea Man" Mr. Dimas Micosa of the Forest Products Research Institute, seated demonstrating his improved mechanized ropemaking gadget for the conversion of cabonegro and other fibers into strong ropes. From left to right are: Regional Director Rafael Cuenca for Southern Tagalog Regional Institute of NACIDA, Director Manuel R. Monsalud of the Forest Products Research Inraos of the Institute, an stitute, Engineer Ramon Saidentified engineer from NACIDA and Deputy Administrator Hilarion A. Pilapil of NACIDA. This cooperative project of NACIDA and the FPRI is intended to help rural folks make ropes at the cottage level.