THE IMPORTANCE OF LUMBER SEASONING IN WOOD GLUING

by Raymond A. Currier
In Charge, Manufactured Products
Oregon Forest Research Center - Corvallis

INTRODUCTION

The art of wood gluing is not new; in fact, the process may be traced to ancient Egypt, where glued wood veneering was practiced in the era around 1500 B.C. As is true with many phases of our modern technology, knowledge of the art of gluing has increased greatly during the past few years.

Probably the most significant factor leading to development of wood-gluing technology as it exists today was discovery of the synthetic-resin adhesives during the years immediately preceding and following World War II. Today, these synthetic or man-made glues have largely replaced the older natural-type glues for all but specialized applications. Research in the field of wood glues continues at a fast pace, and new types of wood adhesives undoubtedly will be placed on the market in the future.

The ultimate goal in producing a glued wood product is to obtain a glue bond having strength equal to, or greater than, the individual wood components and possessing durability for the expected service life of the product. Actual mechanism of the adhesion process still is not fully understood; many explanations have been proposed to denote the true nature of wood-to-wood bonds. However, no single explanation as yet is accepted universally by glue technologists.

Every step in gluing is important, if high-quality products are to be produced consistently. Selection of proper species and grade of wood, and the correct adhesive are of paramount importance. This paper is concerned with another critical factor, the role of proper seasoning in the wood gluing process. All lumber for gluing must be seasoned to a uniform moisture content prior to gluing. As yet, a wood glue has not been developed that will glue undried wood sucessfully. Present wood glues generally will work satisfactorily with wood at moisture contents from 7 to 15 per cent. A selected few glues will produce bonds at higher moisture contents, but this practice is not recommended either by glue producers or by glue technologists.

In gluing wood, moisture is important in many respects. Dimensional stability and strength of the product are affected by amount and distribution of moisture present in the wood. Secondly, moisture plays and important part in the actual adhesion process, being especially related to flow, transfer, and penetrability of the adhesive.

Wood too low in moisture content will reduce flow and penetration of the adhesive, thus impairing bond strength. Conversely, too high a moisture content of wood often leads to excessive penetration of glue, resulting in a starved joint with inferior strength. In addition, certain glues, mainly those of natural origin, cure or harden primarily due to loss of moisture in the glue line.

Many different types of glued products are produced from West Coast woods. Of particular importance to those concerned with lumber seasoning are structural glued laminates, end-and-edge-glued boards, prefabicated building components, furniture and lumber core plywood. All-veneer plywood certainly is a glued wood product; however, seasoning or drying of veneer is accomplished by specialized equipment and will not be considered here.

PROPER MOISTURE CONTENT FOR GLUING

A general rule of thumb for determining proper degree of seasoning for wood prior to gluing is to have the completed glued product at a moisture content approximating the mid-point of the range in moisture content the product will reach under conditions of intented service. In the United States, wood used inside heated buildings will reach a moisture content from 6 to 11 per cent, varying with local climatic conditions and season of the year. Wood in unheated interiors will range from 8 to 14 per cent in moisture content. For typical exterior applications, the moisture content may range from 12 to 20 per cent.

If large changes in moisture content of the glued product take place, the wood will shrink or swell, resulting in development of serious stresses in the wood and glue line. In laminated beams, excessive drying accompanied by shrinkage usually is more detrimental than gain in moisture content, because of possible development of checks in the wood or glue line as shrinkage occurs. Therefore, for optimum results, the wood should be seasoned to a moisture content slightly below the mid-point of the expected range in service.

Another factor in determining proper degree of seasoning is the type of adhesive used for bonding. All commonly used liquid adhesives for wood contain water in various amounts; thus, they add moisture which must be taken into consideration in seasoning lumber for gluing. Generally, natural adhesives, such as casein, soybean, or animal glue, contain larger amounts of water than do the synthetic-resin adhesives. Actual amount of liquid glue spread upon the wood varies with glue type, species of wood, and whether the glue is cured by hot pressing or cold pressing.

The following formula for determining percentage of moisture added to wood by the glue has been taken from Bulletin No. 1069, U.S. Department of Agriculture, Fabrication and Design of Glued Laminated Wood Structural Members. The formula applies only to laminations of equal thickness.

Increase in moisture content (per cent)

$$\frac{W/100 \times G \times (L-1)}{\frac{T}{L} \times 1000 \times S \times 62.5} \times 100 = \frac{0.000192\ WG}{TS} \times \frac{L-1}{L}$$

Where:

- W = pounds of water in 100 pounds of mixed glue
- G = pounds of mixed glue used on 1000 square feet of glue joint
- L = number of laminations
- L-1 = number of glue lines in glued assembly
- T = average thickness of lamination (in inches)
- S = specific gravity of wood (dry)

Another factor of importance in seasoning lumber for glued products is uniformity of moisture content from board to board and also from shell to core. If adjacent board in a glued product vary widely in moisture content at time of gluing, subsequent equalization of moisture may cause development of stresses in the glue line and warpage of the product. Wide variations in moisture content also may affect critical functions such as flow, penetration, and hardening of the glue, thus increasing the possibility of obtaining defective glue bonds.

In laminating stock, the differential in moisture content between boards and from shell to core usually is limited to a maximum of 5 per cent. For lumber to be edge-glued into furniture or other items, the permissable range in moisture content often is less than 5 per cent.

Once the stock has been kiln-dried to uniform moisture content, provision should be made to maintain this level of moisture until the time of gluing. Many progressive wood-gluing operations have installed controls for temperature and relative humidity in their stock storage and gluing rooms. Oftentimes, such equipment will reduce drastically the number of rejects because of faulty glue lines, thus paying for the

initial cost of installation in short order.

Major factors concerning the importance of proper seasoning of lumber in relationship to wood gluing have been discussed. However, there are other important gains to be obtained by doing a good job of seasoning. One example is in surfacing the dried stock prior to gluing. Uniformly seasoned lumber will result in superior surfacing, as there is less chance for torn or fuzzy grain and other surfacing defects. Superior surfacing will produce consistently better glue bonds, as condition of the lumber surface at time of gluing is a most important factor in gluing wood.

WOOD GLUES

The kiln operator normally is not expected to possess a detailed knowledge of woodworking glues. Thus, this discussion will not attempt to explain various technical working properties of wood glues, but will point out for specific glues most likely to be used with kiln-dried lumber the tolerances in wood moisture content at time of gluing, water resistance of the cured glue line and general product applications.

As denoted previously, there are two major classifications of adhesives, the natural-type and the synthetic resins. Glues included under the natural classification are animal, casein, starch, blood and soybean. Starch, blood, and soybean glues are used primarily in gluing plywood, while animal and casein are utilized in general gluing of wood.

The synthetic adhesives include urea, melamine, phenol, resorcinol and polyvinyl resins. In addition, combinations include melamine-urea and phenol-resorcinol. All except polyvinyl are classified as thermosetting glues, that polymerize (cure) in the presence of heat and a chemical catalyst, although some will cure at room temperature. Similarly to the natural-type glues, polyvinyl resin cures mainly by loss of moisture from the glue line.

Animal glue

This glue is used in furniture assembly and general cabinet-making applications, and requires a moisture content for the wood of 5 - 12 per cent. The glue joint has little resistance to moisture.

Casein glue

Casein is the glue usually used in structural laminated lumber intended for interior uses where the equilibrium moisture content will not exceed 16 per cent. Good joints are obtainable at moisture contents from 2 to 18 per cent, and the bond is classified as water resistant.

Urea-formaidehyde resin

Urea resin finds use in bonding hardwood and furniture plywood, end-and edge-glued lumber, and assembly gluing. The permissible range in moisture content for the wood is 6 - 15 percent; urea glue bonds are moderately resistant to moisture. Melamine may be incorporated with urea resin to produce a joint having highly water-resistant properties.

Resorcinol and phenol-resorcinol resin

These glues are used where the joint must withstand the most severe service conditions, as in structural laminates for exterior apolications where the equilibrium moisture content is above 16 per cent. Both glues require moisture contents for wood of 6-17 per cent at time of gluing.

Polyvinyl resin

This class of adhesive is used as an assembly glue in furniture and cabinet-making, and will produce good bonds with wood from 5 to 12 per cent moisture content. The cured bond has low resistance to moisture.

Melamine and phenol resin

These two glues are classified as waterproof, and seldom are used in applications other than plywood manufacture. Phenol-formaldehyde resin is the basic glue in all exterior-type softwood plywood manufactured on the West Coast.

SUMMARY

In summary, the kiln operator plays a most important role in the gluing of wood. Consistently good glue bonds are obtained only when strict attention is alloted every step in the gluing process, and one of the most critical steps is uniform seasoning of lumber. The final moisture content after kiln drying must be within the range required for the particular glued product and the bonding adhesive. Differences in moisture content, both between various pieces and within each piece, must be in a narrow range to produce optimum bonding.

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