LAMINATING STRUCTURAL TIMBERS: SOME WORDS OF CAUTION

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LAMINATING STRUCTURAL TIMBERS: SOME WORDS OF CAUTION[1]

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Laminated structural timbers, made by gluing thin material together to provide the necessary length, width, and thickness, are finding their way into many new fields of usefulness and additional uses are constantly being suggested. More things can be made of laminated construction than from solid wood for, by laminating, many things are practical that are not satisfactory when produced from solid wood. In addition, practically every solid-wood product can also be made with laminated wood. There is good reason, therefore, for much of the enthusiasm now apparent for laminating structural timbers.

Among the advantages that can be gained by laminating are (1) the production of wood articles of greater width, thickness, and length than are practicable from solid wood, (2) the manufacture of articles of high strength preformed to almost any desired curvature or shape, (3) the fabrication of large timber that are uniformly dry and free from checks and other seasoning defects, and (4) a reduction of waste in producing articles of odd and irregular shapes to meet special requirements. In special cases other advantages can be cited. The many products into which laminated wood is now going include ship timbers, barge timbers, automobile and truck bodies, arches and beams for buildings, airplane parts, prefabricated housing, gunstocks, propellers, wagon tongues, maul heads, shoe lasts, shuttle blocks, and many others. The products that have been suggested for manufacture by laminating include practically everything else that is now made from wood and many things that are usually made from other materials.

It is not the purpose of this paper, however, to promote the use of laminated products or to sing their praises. Their usefulness may be taken for granted and promoters are not lacking. My desire is to point out some of the things that must be done to insure successful performance of laminated products and the continued popularity that can result only from satisfactorily meeting the needs of the user.

In the first place it may be well to point out that, although practically every wood product can be made by laminating, it is not always

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desirable or economical to do so. Laminating costs money and, in some cases, may waste rather than save material. A good rule to follow is to use solid wood wherever it is available, satisfactory, and economical and to resort to lamination only when advantages are gained that increase the serviceability, availability, or economy. When proposing to make any product by laminating, two good questions to ask are "Why not make it of solid wood?" and "Will laminated wood be enough better than solid wood to justify the increased cost?"

Laminating is not new, as some writers seem to infer. Laminated structural arches and beams have been used in Europe for 20 or 30 years. Laminated spruce and Douglas-fir wing beams and struts and laminated propellers of walnut, oak, birch, and other woods were used in airplanes in World War I. Laminated table legs, table tops, and grand piano rims have been in use so long that probably no one knows when their use began. Even laminated automobile parts have been used for years. What we are seeing today are new applications of old knowledge, made possible by war demands and war economy and by the development of new glues of outstanding performance.

Never before have we had glues that were so resistant to severe exposure conditions. Strong glues have been available for many years and there has been no need for greater strength than that of the good animal, starch, and casein glues of the past. None of these glues, however, will stand up very long in contact with water or under warm humid conditions. Laminated structural arches and beams have been produced in considerable numbers with casein glue and many buildings are now dependent upon them for roof support. If well glued, these casein-bonded timbers will give satisfactory service and last indefinitely long while they remain dry. They will not give long life under damp or wet conditions, however, or when exposed to the weather without protection.

The new synthetic-resin glues, on the other hand, greatly widen the field of usefulness for laminated timbers and afford new opportunities for pioneering. There are literally hundreds of resin glue formulations and their properties and characteristics vary over a wide range. Not all of them are superior to casein glues and most of them fall far short of the ideal but there are some resin glues of outstanding performance and of great promise in the laminating field. As a class, the good urea-resin glues show higher resistance to water and to damp conditions than casein glues but even the urea glues are not good enough for unlimited exposure to water or weather or to very high temperatures. Under sufficiently severe conditions they will ultimately weaken and permit delamination. The responsible manufacturers of urea-resin glues generally do not recommend them for timbers to be used outdoors where maximum service life is desired.

The most durable glues we have today under severe exposure conditions are those of the phenolic-resin type. In this broad class are included glues derived principally from phenolic resins and also those derived from cresol, melamine, and resorcinol resins as well as those from straight phenolic resins. The best of these glues show very high resistance to extreme exposures of various kinds and give good promise of being more durable than the wood under any conditions to which the wood is likely to be exposed in service. Many of the glues in this class, however, are of the hot-setting type and must be heated to temperatures higher than are practical in the usual laminating process with timbers more than 2 or 3 inches thick. They are practical for plywood and for relatively thin laminated products but, as the thickness of the package increases, the time required to heat the innermost glue line increases rapidly and quickly passes the point that is economical from the standpoint of press time or damage to the wood.

Among the phenolic-type glues, however, there are a growing number that set or "cure" at intermediate temperatures and are called "low-temperature phenolic-resin glues", or "warm-setting" glues. The time and temperature requirements for the complete setting of these glues vary considerably and have not yet been completely explored. No glue of this type that has thus far become available appears to cure completely in any reasonable time without the application of some heat but the temperature requirements of some of them are very moderate and not difficult to attain. The strictly cold-setting phenolic-type glue is not with us yet but it is not too much to hope that it will ultimately become available.

One important characteristic of the low-temperature phenolic-resin glues that has become apparent in recent months is that they can give relatively strong joints with incomplete set at moderate temperatures but require curing at higher temperatures before they reach the degree of cure required for maximum durability. This fact has led manufacturers of these glues into recommending curing times and temperatures that are inadequate for maximum resistance to moisture and weathering. Studies are continuing with these glues to learn the minimum curing temperatures and times that can safely be depended upon to insure durable joints in timbers exposed to severe use conditions.

One possible method of using the phenolic glues in large timbers is to do the heating by means of high-frequency electrical apparatus that induces heat in the wood by electrical energy and heats the entire mass at once instead of depending upon the slow conduction of heat from the surfaces towards the center of the assembly. The method appears promising and, if it can be made to work successfully in production, could bring about some revolutionary changes in laminated timber manufacturing methods. A number of obstacles remain to be overcome, however, before high-frequency heating can be relied upon for the economical production of large laminated timbers.

Good glues and good wood are not all it takes to produce good laminated timbers. A poor cook can spoil the best of food and poor manufacturing technique can make good glues and good wood into a very poor laminated timber. It is too often assumed that anyone with a few woodworking machines and glue clamps can turn out laminated structural timbers on short notice but there is more to it than that. In addition to good glues and good wood there is needed the will to do a good job and also suitable equipment and skill in its use.

We can assume that the prospective manufacturer of laminated structural timbers has the will to make a high-quality product in which he can take pride and for the character and performance of which he has a feeling of responsibility. Otherwise he will be content to just "get by" and his product will not be a credit to him or the wood manufacturing industry and will not be reliable as a structural element.

Good equipment is essential for a high-class job. The manufacturer must have what it takes to dry his lumber uniformly and to the right moisture content and to keep the moisture content within the necessary range. He must have good surfacing machines, scarfing apparatus, special jigs for bent members, glue storage, mixing, and spreading equipment, special glue clamps, curing chambers with accurate temperature, humidity, and air circulation control and a variety of other equipment. Seldom, if ever, will an ordinary woodworking plant be found equipped with all the necessary apparatus for making laminated structural timber for it is a specialized business and requires special preparation.

Few woodworkers have familiarized themselves sufficiently with moisture content control and distribution and practially none have potentiometers and thermocouples for measuring the temperatures within laminated timbers during the curing process. Most plants are not equipped with devices for determining the pressure applied in gluing or the strength of glue joints and few employ methods for determining specific gravity or straightness of grain in lumber. The woodworking industry has been getting along moderately well without these things and only a few pioneers know much about them. In the manufacture of high-quality laminated structural timbers, however, these things become important and the fully equipped plant will be prepared to take advantage of them.

I will not go into detail as to the requirements for uniformly smooth and parallel surfaces in machining lumber for laminating; the necessity for strong scarf joints and the proper distribution of such joints, the control of glue mixing, spreading, pressing, and curing procedure or other manufacturing details. It is enough to point out that these things must be kept under close control in the production of superior products. Efforts that are being made to develop processing specifications covering these and other details are very much in order and the specifications, when perfected, will have great importance.

These refinements in equipment and in the control of manufacturing processes are getting beyond the capacity of workmen and supervisors who do not have technical knowledge in wood technology, engineering, chemistry, or physics. The modern laminating plant, as never before, needs at least one technically-trained man as a part of its basic equipment for doing a high-class job. Well trained men who are college graduates in wood technology, engineering, chemistry, or chemical engineering, and who have a certain amount of common sense in addition to their technical training, are assets of high importance.

Assuming now that good materials, equipment, and technical control have produced a high quality laminated timber, there is still the problem of protection from deterioration of the wood in service outdoors or under damp conditions. In dry places, well laminated timbers should last as long as the building without special protection but under conditions that favor checking, decay, insect attack, or marine borer damage, laminated wood like solid wood must have suitable protection to assure satisfactory performance. There may also be need in some cases to provide special protection against fire.

Checking of properly constructed laminated members can be very largely controlled by painting the exposed surfaces and repainting often enough to maintain a good film over the surface. What the paint accomplishes is to slow down moisture changes and keep the moisture content of the wood more nearly uniform and within a narrower range than prevails in unpainted wood. Checking of timber in service is caused by rapid changes from high to low moisture content and by wide differences in moisture content between the surface and the interior of timbers. Painting, by slowing down these changes and narrowing their range, greatly reduces the tendency to check and also to delaminate. Even casein or urea glue joints, although not desirable for outdoor use, will resist delamination much longer if painted than if exposed without paint protection.

When use conditions favor decay in the wood, impregnation with a suitable preservative is required for adequate protection. Despite all the advertising and traditions to the contrary, paint does not prevent decay but merely protects from checking and weathering. It is possible, of course, to make laminated timbers out of selected heartwood of naturally durable species and thus attain whatever length of life the untreated wood is capable of giving. Cedar, cypress, redwood, and a few of the durable hardwoods may sometimes be used to advantage in this way. With most species, however, the necessity to eliminate all sapwood in order to obtain long life without treatment will make this procedure impractical. The general trend will be to use heartwood and sapwood indiscriminately and that will necessitate preservative treatment to provide high decay resistance.

There is much misinformation in circulation about preservative treatment which has been encouraged by the claims and advertising of the promoters of certain preservatives intended for surface application. Too many people believe that the modern "super" preservatives have magic properties and that, when applied by brushing, spraying, or dipping, they will give protection equivalent to that of a heavy pressure treatment. This is far from the truth. No preservative is good enough to give a high degree of protection when superficially applied. Unless the preservative penetrates deeply and is absorbed in substantial quantity, the protection obtained will be limited. The new preservatives, such as the chlorinated phenols, copper naphthenate, and the like, have certain advantages over coal-tar creosote in their relative freedom from odor, their cleanness and paintability and, with some of them, lack of color. They also have advantages over water-borne preservatives in that they do not swell the wood and are not readily leachable. For these reasons, some of the new preservatives are very promising for use with laminated structural timbers but, as with the older preservatives, the wood must be thoroughly impregnated with them for best results.

In like manner, when a high degree of protection against fire spread is desired, superficial application of fire-retarding salts will do little good. Impregnation with fire-retarding chemicals, on the other hand, gives excellent protection against fire spread and is now being done on a large scale. It is true that there are certain fire-retarding coatings that, when properly applied, have a considerable degree of effectiveness in retarding the spread of small fires and they may be all that is required in some cases. These so-called fire-retarding paints must be applied in thick coatings in order to be effective and they are not durable when exposed to the weather. The fire-retarding chemicals used for impregnation treatments are also not resistant to weathering and leach out of the wood gradually when in contact with water.

The suggestion is frequently made that the lumber be given preservative or fire-retarding treatment before gluing and this plan has possibilities. Many chemicals used in such treatments are likely to interfere with gluing but certain glues appear to be compatible with some of the treating chemicals used and practical combinations of the two may be developed commercially. This subject has not been sufficiently explored to develop its full possibilities and limitations. One disadvantage of treating before gluing is the necessity for surfacing the lumber just before the gluing operation in order to provide a flat, smooth, uniform surface for gluing. This will remove the most thoroughly treated part of the wood and reduce the effectiveness of the treatment, particularly in heartwood faces of species resistant to preservative penetration. It is not, however, an insurmountable obstacle.

Treatment of the timbers after gluing appears more practical and promising where suitable glues are used and the shape and size of the timbers are not beyond the capacity of treating plants. Once glues of the highly water-resistant type have become thoroughly set or cured, there is much less danger of their being damaged by preservative or fire-retarding treatment than during the gluing operation. Creosote and other oil solutions do not seem harmful to glue joints made with any commercial glues and, in various experiments where glued wood has been treated with creosote or solutions of chlorinated phenols, the effect has been to increase rather than decrease the durability of the glue joints. With water-borne preservatives, of course, glues of low water resistance cannot be used and the problems of swelling and redrying are present. It may be inconvenient to send the finished timbers to a pressure treating plant for the treating job but few manufacturers will care to equip themselves with the costly, complicated apparatus required for pressure treatments. The necessity of doing all cutting, framing, and boring before treatment may also be considered a hardship but that is equally important whether solid or laminated timbers are used. Cutting into any treated timber is likely to expose untreated wood and thus reduce the effectiveness of the treatment.

The railroads and other large users of structural timbers under conditions that favor decay have had long experience in the use of treated wood and have learned in the hard way what preservatives and treatments are required for satisfactory service. In promoting laminated timbers for these uses, every advantage should be taken of this accumulated knowledge and experience. Otherwise unsatisfactory service may result and interfere with the further use of laminated wood under such conditions. If all precautions are taken to insure long life, laminated timbers may prove practical and dependable for railway trestles, highway bridges, and various other similar structures. Without such precautions, poor results can be confidently expected.

The foregoing comments have touched but briefly and incompletely on several important aspects of laminated timber construction. Their purpose is cautionary and their meaning can be condensed into the admonition "Don't dive into deep water unless you can swim; even then you may find it cold."