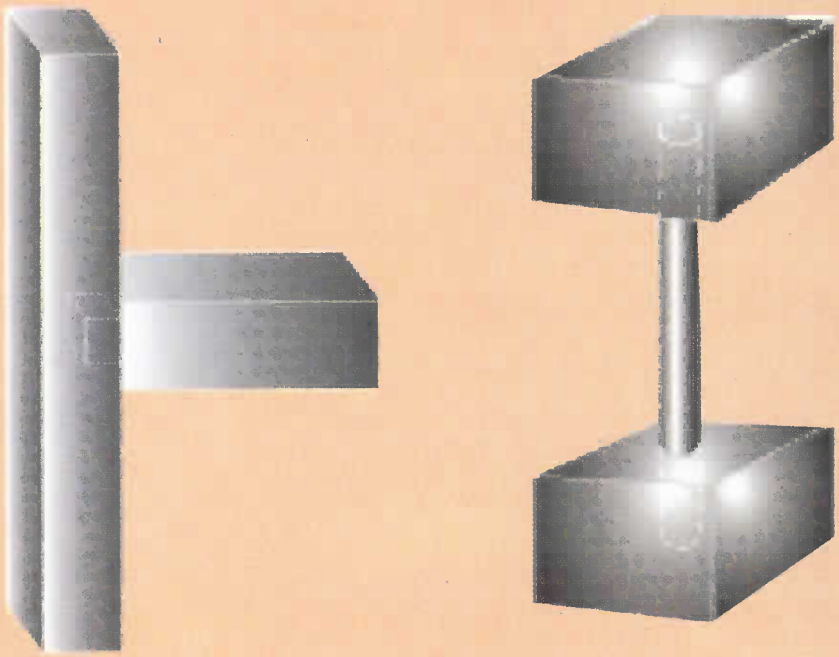
Guideline No...

CHOICE AND UTILIZATION OF ADHESIVES IN WOOD GLUING

Guidelines for users of Wood Adhesives



By

Muthike, GM and Githiomi, JK.

KENYA FORESTRY RESEARCH INSTITUTE
Forest Products Research Centre - Karura

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1. 0 INTRODUCTION

Adhesives are increasingly playing an important role in fabrication of wood products. Adhesives are some of the most important production inputs in furniture industry and account for up to 30% of the total production cost. Adhesives determine the strength and visual appearance of the final product and consequently quality (Chikamai *et al.*, 1996). The increased use of adhesives has been attributed to development of new adhesives and modification of old ones. New adhesives have resulted in improved gluing techniques that provide great advantages over mechanical joints as the resultant joints are strong, durable and can be made over both small and large surface areas (Marra, 1996). In addition, the absence of visible fasteners such as nails and screws presents products with high aesthetic values. The selection of an adhesive suitable for a specific condition, proper machining of the wood and control of the moisture content before glue application and maintenance of appropriate workshop temperature are key factors contributing to the production of strong adhesive joints (Muthike, 2003). Two main industries affected by the recent development of adhesives are those involved in making of plywood and glue laminated beams. Currently, there are many kinds of adhesives available in the market and users have difficulties in selecting the most appropriate one. This guideline provides information that will assist users in making correct choices of adhesives.

2. 0 CLASSIFICATION OF ADHESIVES

Adhesives can be classified according to the origin of the primary components, curing temperature and durability. They can be further classified as thermoplastic or thermosetting.

2. 1 Origin of Primary Components

Adhesives for wood can be divided into several groups in accordance with the origin of the primary components. They include natural and synthetic adhesives.

2. 1. 1 Natural Adhesives

Natural adhesives are those whose primary components are either plant or animal based. Plant-based sources of adhesives include starches, dextrins, natural rubber and vegetables such as soya beans and peanuts. Animal-based sources of adhesives include hide, sinews, bones, hoofs, horns, fish skin and casein from milk curd. Animal-based adhesives were common in the history of woodwork. They have a wide application but despite their advantages of high initial tack, they are expensive, rare and are now being replaced by synthetic products.

2. 1. 2 Synthetic Adhesives

Synthetic adhesives are manufactured from industrial raw materials that have no natural origin. They include resins mainly based on urea, melamine, phenols, resorcinol, furan, epoxy and other unsaturated polyesters. Other resins are based on cellulose esters, ethers, alkyd and acryl esters, and polyamide, polystyrene, polyvinyl alcohols and their derivatives.

2. 2 Curing Temperature

Curing temperature is the degree of heat at which the adhesive dries up to a level where the joint is strong enough for loading after adhesive has been applied and the surfaces bonded together. Based on curing temperature, the most common wood adhesive can be classified under three groups.

i) High-temperature curing adhesives which cure at temperatures above 90^{0}C. Majority of these adhesives are utilized in composite wood making. They have a high strength to join thin sheets together.

ii) Intermediate temperature curing adhesives which cure at temperatures ranging from 30^{0}C to 90^{0}C. These adhesives perform well in construction where timber is exposed to temperatures above room temperatures. They have relatively higher strength compared to the low or room temperature curing adhesives (Mutuku, 1981).

iii) Low or room temperature curing adhesives, which cure at room temperature or at temperatures as low as 15^{0}C to 30^{0}C. Most adhesives curing at room temperature are relatively weak in strength and are mainly used in structures like furniture for in-house uses. The polyvinyl acetate adhesives commonly used in furniture making are the best examples in this group (Muthike, 2003).

2.3 Thermoplastic and Thermosetting Adhesives

Thermoplastic adhesives can be softened by heating without undergoing a chemical change and can achieve the kind of strength required for a variety of uses under normal temperature. Thermosetting adhesives are used in heavy duty structural applications and have the ability to form

a permanent solid, heat resistant material. These are based on solvent solutions of neoprene and are common for installation of hard surface counter-top laminates (Marra, 1992).

2.4 Durability of Adhesives

Durability under different environmental conditions is the most important property to consider when choosing adhesives. A three group durability classification is given below together with the names of the adhesives in each class.

Group 1: Weather and boil proof adhesives

Adhesives in this group are indestructible for many years, and exhibit no weakening or signs of failure under different weather conditions, micro-organisms, cold and boiling water, steam and dry heat. They include; Phenol resins, Resorcinol resins and Phenol - Resorcinol resins.

Group 2: Moisture resistant and moderately weather resistant

Joints made with these adhesives will withstand full exposure to weather for only a few years. They will withstand cold water for a long period and hot water for a limited time, but fail when subjected to boiling water. They are resistant to attack by micro-organisms. Urea formaldehyde is one among such adhesives.

Group 3: Interior or dry bond adhesives

Joints from these adhesives have satisfactory dry strength but will be affected by wetting and micro-organisms. Adhesives falling in this category include; animal glues, casein, starch derivatives, contact glues, polyvinyl acetate resins and blood albumin.

3.0 ATTRIBUTES TO CONSIDER IN CHOOSING ADHESIVES

The key attributes to consider when choosing adhesives include; colour, form, shelf life, and pot life. Other attributes are adhesive bonding power and its ability to cover the profile of the surfaces to be bonded together.

3.1 Colour of Adhesive

There are clear, pale coloured, and dark coloured adhesives for bonding wood. Bright coloured adhesives are common in applications where aesthetic characteristics are not a priority, like in heavy laminated beams for covered applications. Colourless adhesives are preferred in areas where uniform wood colour is of importance. The colour of the adhesives and hence adhesive lines are of importance particularly for furniture and plywood manufacture.

3.2 Form of Adhesive

Adhesives are in form of powder, liquid film or jelly. The carpenter will prefer bottle or tin of ready to use liquid adhesive whereas the plywood manufacturer may prefer dry powders that he would use to prepare the adhesives at the time of use.

3.3 Storage Life or Shelf Life

Shelf life (storage life) of the adhesive is the period between time of manufacture and expiry date. This varies from a month to well over a year depending on the type of adhesive. Shelf life is important especially for users relying on overseas supply. It helps one to decide on the level of stocks necessary to keep.

3.4 Pot Life

Pot life is the period when the adhesive mix is in useable state. Manufacturers usually state the pot life of adhesives at various working temperatures. This time varies from an hour to a day. Usually, the end of the pot life is made self-evident by the adhesives changing from a liquid to a rubbery solid. A long pot life reduces the time spent on preparation as only one batch of adhesive needs to be prepared for the day's work.

3.5 Adhesion Power

Adhesion is the adhesive power of adjacent molecules. This power can only develop if the molecules are sufficiently close (distances below 3 x 10^{-8} cm), (Kollman *et. al.,* 1975). For solid bodies like wood, such extremely small distances between molecules of two different pieces are almost impossible to achieve since the surfaces to be joined are usually irregular and contaminated by dust. In such cases, adhesion can be aided and practically achieved by using liquid adhesives, which can adopt and cover the profile of the two irregular surfaces due to their rheological behavior (Muthike, 2003). The glue wets the surfaces to be glued and when they are set or hardened form a glue joint. In practice, a glue line is regarded as thin if in the set state it measures not more than 0.125 mm. Adhesives suiting these conditions are close contact glues in contrast with the gap-filling type made to cope with lines up to 1.25 mm. The latter is used where the more desirable thin glue line cannot be obtained with certainty (KeBS, 1996[b]).

4. 0 USES OF ADHESIVES

There is a wide range of adhesives manufactured all over the world. Due to their differences in properties and formulations, their utilization

However, adhesives are broadly used in the wood industry for three main purposes namely; assembly work, plywood manufacture, and veneering.

4. 1 Assembly Work

Assembly work refers to gluing together of pieces of timber or wood component in making of products such as furniture units, laminated structural members, roof trusses, houses, boats and doors. In these types of works, the glued surfaces are usually small and the operations are normally conducted at room temperature using cold pressure clamps (Muthike, 2003; Chikamai *et al.*, 1996). In some isolated cases hot presses are used, requiring specialized personnel and good understanding of the appropriate adhesive for each application. The selection of the most appropriate adhesives for the different work environment and product are crucial (KeBS, 1996[a]).

4. 2 Plywood and Decorative Veneer Manufacture

Plywood manufacturing is the process of making large sheets of cross-bonded wood structures using thin veneers either sliced or pealed from wood. Decorative veneers are thin sheets of wood material which are glued both to plywood and joinery to improve the surface appearance. Both processes are characterised by large areas of relatively thin veneer sheets spread with adhesive and joined under pressure at either room temperature or hot presses using pre-determined temperature to set The Adhesive.

5. 0 APPLICATION OF ADHESIVES

5. 1 Spreading of the Adhesives

Most adhesives are viscous and can be easily spread on the wood by a brush, spatula or roller. The best joint results are obtained when the adhesive is well rubbed on the wood than when poured. Adhesives should be applied on both surfaces with a thin film on each surface. Too heavy spread produces weak joints, particularly in close contact joints (Muthike, 2003). Double spreading (spreading both on surfaces to be joined) is advised when the surfaces are rough to ensure that no voids occur in the adhesive line (Mutuku, 1982). For most adhesives, the best density of application is in order of 200-300 gm^{-2}.

5. 2 Joint Assembly Time

Assembly time is the time taken to apply adhesive, assemble the joint and maintain it under pressure to cure. This comprises of open and closed assembly time.

5. 2. 1 Open Assembly Time

Open assembly time is the time the adhesive spread areas are exposed to the air before joining them together. This helps the excessive solvents to evaporate to enable the adhesive surfaces to begin to cure when joined together.

5. 2. 2 Closed Assembly Time

Closed assembly time is the time between bringing the spread surfaces together and the application of pressure. The allowable closed assembly time can vary from as short as 5 minutes to as high as 8 hours and

sometimes several days depending on the type of adhesive. This time is highly dependent on temperature to which the adhesive should be subjected and which the adhesive manufacturer should indicate on the package. Most adhesives used for joinery work require an assembly time of up to 4 hours.

5. 3 Pressure and Curing Time

Pressure is employed after bringing the spread surface together so as to assume a uniform glue line and to bring the surfaces being bonded as close as possible by squeezing action. The amount of pressure needed depends on characteristics of both the wood and adhesive. High density hard wood species like camphor (*Ocotea usambarensis*) require higher pressure than low density soft woods like cypress (*Cupressus lusitanica*) and the pines (*Pinus patula*) (Muthike, 2003). Optimum pressure must be applied to ensure that air and excess adhesive are expelled at the edges and a thin uniform glue line obtained. The parts should remain under pressure for an optimum period of time to allow adequate curing. Curing time is in most cases dependant on temperature and the type of adhesive and its formulation. An adhesive that may take 20 hours to cure at 20° C could be cured in a few minutes at 150° C (USDA Forest Service, 1987).

5. 4 Use of Hardeners

Hardeners are chemicals used to control setting of adhesives. It may be supplied separately, either in liquid or in powder form or may be incorporated in the adhesive by the manufacturer

5. 5 Use of Extenders and Fillers

Extenders are inert or non-resin forming material that may be added to the adhesive to extend the assembly time. They retard the joint formation activities of the adhesive. They also lower the cost of production by increasing the volume of the adhesive. Fillers are powders added in the glue mix to improve gap filling and viscosity. The most commonly used fillers are, ceral and wood flour, starch pastes and chalk.

5. 6 Condition of Wood Surface for Gluing

The wood must be well dried and well machined before applying the adhesive. The ability of a liquid adhesive to wet a solid substrate determines the compatibility between the adhesive and the substrate (Mutuku, 1982). Higher moisture content during gluing lowers the strength of the glue line enhancing delamination. Proper drying enhances uniform glue spread and contact during pressing. Incorrect machining producing rough surfaces and/or uneven planes, insufficient cleaning of the wood surface as well as other surface defects all contribute to poor joint characteristics hence low strength (Muthike, 2003). Some adhesives however, are tolerant to high moisture content than others. Depending on the adhesive, permissible moisture content usually range from 3-15% in the wood.

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