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Durability of adhesives

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RÉSUMÉ

Les colles aux protéines, telles que les colles animales, à la caséine et à l'albumine du sang, sont sujettes à une destruction de la part des micro-organismes. Elles ne sont pas propres à être employées à l'extérieur ou dans des locaux où règne une forte hygrométrie durant de longues périodes. Par contre les colles aux résines synthétiques généralement se caractérisent par leur résistance aux micro-organismes. Dans cette classe de colles, les acétates de polyvinyle montrent une faible résistance à l'eau tandis que les colles du type urée-formol résistent à l'eau froide; mais ni l'un ni l'autre de ces types de colles ne durent aux intempéries. Dans les cas où s'impose l'emploi de colles résistant à l'eau et aux intempéries on aura recours à celles constituées par des résines phénoliques.

Les colles à l'urée-formol et au phénol-formol se conservent plus longtemps sous forme de poudre que sous forme de sirop.

INTRODUCTION

The use of adhesives has greatly extended the use of wood both technically and architecturally. It is now possible to produce structural members of any size and shape from short length stock. Panels to suit any requirement and taste are possible. In plywood we have a structural material of large area and of definite properties. Various types of improved woods and building boards have also become possible by the use of adhesives. Composite elements of wood and metal or wood and plastics without rivets or nails are also easy to produce by bonding with adhesives.

Fastenings between parts in a structural element constitute weak and critical points. For example, in spite of its simplicity, a bolted joint in wood is not

SUMMARY

Protein glues such as animal, casein and blood albumin glues are liable to destruction by micro-organisms. They are not suitable for exterior use or for use in locations where high humidities prevail for long periods. Synthetic resin adhesives, on the other hand, are generally characterized by their resistance to micro-organisms. Among this class of adhesives, polyvinyl acetate resin has poor resistance to water while urea-formaldehyde adhesives resist cold water. Both are not durable to weathering. Where water and weather-proof adhesives are required, phenolic resin adhesives should be chosen.

Urea- and phenol-formaldehyde adhesives in syrup form have only short storage life. In powder form they last longer.

satisfactory because of the low bearing and shearing strength of wood. But the inefficiency of bolted joints can be overcome by the use of glued joints. In contrast to nails and dowels, glued joints do not weaken the members.

The most important requirement of a good adhesive is adequate strength under all service conditions. In order to meet this requirement, the adhesive should be resistant to water, weather, micro-organisms and other biological agents of destruction. The degree of resistance required will vary with the use to which the adhesive is to be put and the conditions of service. A thorough knowledge of the behaviour of adhesives under such conditions will enable us to choose the right type for the purpose in view. The shelf life or storage life of adhesives is also affected by the prevailing conditions of temperature and humidity. This paper summarizes the data available on the storage life and durability of adhesives for wood in India.

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TYPES OF ADHESIVES

The number and types of adhesives suitable for bonding wood are large. They can be classified into those based on natural products such as proteins, and those based on synthetic resins. The former group is particularly susceptible to deterioration by biological agents.

Synthetic resin adhesives, though of comparatively recent origin, are by far the most important group of adhesives. With their great durability, high strength, resistance to weather, moisture, heat and microbiological organisms, and ability to bond practically any type of material, they have extended the use of wood products and facilitated the production of new ones.

Synthetic resin adhesives are generally classified into two groups: thermoplastic and thermosetting. Thermoplastic resins soften at temperatures characteristic for each, that is, they are permanently fusible and soluble. They are linear polymers formed from bifunctional molecules by addition polymerization. In the thermosetting type the condensation reaction when once completed either by the application of heat, or catalysts, or both, results in large infusible cross-linked molecules. The majority of synthetic resin adhesives for wood belong to this class.

ADHESIVES BASED ON NATURAL PRODUCTS

Animal glue. Animal glue is prepared from the hides and hoofs of animals and is available in pearl, tablet or flake form. It has long storage life if kept dry. It finds use in carpentry work. Joints prepared with animal glue have good dry strength but no resistance to water and to bacteria. The use of this glue is therefore restricted to interior locations where humidities are not high and conditions for microbial attack are not favourable.

Blood albumin glue. This type of glue has been prepared from dried blood meal and has been found to have excellent cold water resistance. Plywood prepared with this glue gave a high joint shear strength even after eight months of continuous soaking in cold water.

The durability of joints made with blood albumin glue depends to some extent on the species of timber used. With timbers which are both non-durable and easily permeable to moisture, the joints lose strength readily. In outdoor exposure tests such joints delaminated within five months presumably due to microbiological attack. When plywood was treated with ASCU wood preservative, delamination started within sixteen months, some samples surviving for nearly three years. Sodium pentachlorophenate, when used as a protective both for the glue and the wood, gave somewhat better results. With a non-permeable species of timber, the plywood may be serviceable even after three years.

Casein glue. The principal ingredients of casein glue are casein, hydrated lime, and a sodium salt such as sodium fluoride or sodium silicate. The water resistance of the glue and its working life depends on the ratio of the constituents. In India casein glue is generally prepared from the ingredients at site. It is also marketed as a dry powder ready mixed with all the ingredients except water. This mixture has good storage life provided it is kept in air-tight con-

tainers. At the time glue is required for use, the dry powder is mixed with the requisite quantity of water.

Casein glue gives strong joints which if allowed to remain dry are serviceable for several years. They are water resistant but not waterproof. Wet joints, if kept undisturbed, regain their strength on redrying. But joints lose strength with alternate cycles of soaking in water and drying, and also on exposure to alternate cycles of high and low humidities. Continuous soaking in water also weakens them. They are not resistant to moulds and bacteria. In outdoor exposure, unprotected casein glue joints in plywood delaminated in a few weeks or months. Pentachlorophenol when added to the glue offered some protection. When the veneers were also treated with the preservative, some of the plywood samples were sound at the end of two years. Painting the panels was useful in prolonging joint serviceability. The paints afforded some protection by retarding the rate of moisture absorption and desorption and by reducing the "working" of wood with changing atmospheric conditions. The effect of paints and preservatives is, however, temporary.

Other protein glues. Groundnut protein glue has been used for manufacturing plywood in India. It is similar to casein glue in its durability.

Prolamin prepared from maize gluten is slightly better. Un-protected glue lines stood up to fourteen months' exposure and those protected with pentachlorophenol up to two years. Paints gave added protection.

SYNTHETIC RESIN ADHESIVES

Polyvinyl acetate is a thermoplastic resin which finds application as an adhesive. It is supplied as an emulsion in water which has a storage life of over a year if kept in a cool place. Joints produced with this adhesive are very strong when dry, but their resistance to water is not high. Joints subjected to alternate cycles of wetting and drying or to outdoor exposure fail rapidly. Hence the adhesive is suitable for use in sheltered locations only.

Urea-formaldehyde resin adhesive is manufactured both as a syrup and as a dry powder. The syrup has a short storage life of only two months. As a powder, if kept in a cool dry place in air-tight containers it can last for a year.

Urea glues are resistant to micro-organisms. They stand up to 70° C in water. But they have low durability in locations involving high temperatures and humidities. Urea glue bonded laminates at the end of six months' soaking in water were quite sound. On the other hand laminated spars in an aircraft wing showed delamination after four years' exposure out of doors where they were subjected to high temperatures and humidities. Plywood samples exposed to the weather started delaminating within two years. The use of urea-formaldehyde glues should therefore be restricted to interior locations and locations where high temperature and humidity are not likely to occur.

Phenol-formaldehyde resin adhesive in liquid form has only a very short storage life and users of this form of the adhesive in India usually prepare it at site. In film and powder form the adhesive has a storage life of several months if kept in a cool place in air-tight containers.

Hot press phenol-formaldehyde adhesives are weather and water—proof and resistant to microbial attack. They are among the most durable of adhesives. Plywood specimens bonded with the film adhesive and exposed out of doors half buried in the ground showed satisfactory adhesion at the end of eleven years. Plywood, laminated wood and compregnated wood made with phenol-formaldehyde resin adhesive and exposed for over fifteen years have also stood up well. Thin plywood (3 mm) in the skin of aircraft wings exposed for five years showed excellent glue adhesion at the end of the period. Laminated bamboo matting containing resin treated sawdust as filler have not shown delamination to any appreciable extent when exposed half buried in the ground for fourteen years or used as a roofing panel for twelve years. Cavity paper laminates bonded with phenol-formaldehyde resin adhesive was in sound condition when exposed out of doors half buried in the ground for sixteen years. In general it may be stated that the durability of the glue joint is largely limited by the ability of the wood itself to resist the conditions of exposure.

Cresol-formaldehyde resin adhesive is similar in properties to phenol-formaldehyde resin adhesive.

Resorcinol-formaldehyde resin. Two component adhesives of this type where the resin is in syrup form has storage life of over a year. The limited data available points to excellent exterior durability for this adhesive in this country.

Cashew nut shell liquid formaldehyde resin prepared from the liquid constituent of the shell of the cashew nut (*Anacardium occidentale*) has formed the basis of adhesives for plywood and laminated products. The commercial liquid is a mixture of phenols, the major one being m-pentadecenyl phenol. These phenols condense with formaldehyde to give resins. In outdoor exposure tests, plywood bonded with this resin adhesive has shown no delamination for over three years. However, there was some loss in joint shear strength.

CONCLUSION

It is clear from the foregoing that the choice of adhesive for use in the tropics requires care. For members not likely to be exposed to high relative humidity, casein, polyvinyl acetate, and urea glues may be used. For service conditions where immersion in water or intermittent wetting and drying or exposure to high humidities or to outdoor conditions is likely, phenol-formaldehyde resin adhesive should be used.

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