BUILDING RESEARCH ASSOCIATION OF NEW ZEALAND

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ADHESIVES AND THE NEW ZEALAND BUILDING INDUSTRY (1985-1986)

P.J. Watkinson and A.F. Bennett

BUILDING RESEARCH ASSOCIATION OF NEW ZEALAND

PREFACE

The variety of adhesives available in the New Zealand building industry has been growing. Correct adhesive selection and a knowledge of the pitfalls involved in their use will help to realize their full potential in the building industry. This report gives an overall view of the uses, problems, existing research and potential research on adhesives in the New Zealand building industry.

ACKNOWLEDGEMENTS

The data presented in this paper come from a selection of adhesives manufacturers, suppliers, users, specifiers, and researchers. Their cooperation is gratefully acknowledged.

This report is intended for manufacturers, and other users and specifiers of adhesives in the building industry.

ADHESIVES AND THE NEW ZEALAND BUILDING INDUSTRY (1985-1986)

BRANZ Study Report SR5

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REFERENCE

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KEYWORDS

From Construction Industry Thesaurus - BRANZ edition: Adhesives, Construction industry; Failure; New Zealand; Research; Selecting; Surveys; Use.

ABSTRACT

An overview is given of the adhesives made or used in New Zealand by the building industry. The main uses of these adhesives are given together with some ranking according to the volume of end use. General market trends are included. The problem areas associated with the use of adhesives in the building industry are identified. Existing research topics are investigated, and this information, together with knowledge of the problem areas, is used to give an idea of the potential research areas for adhesives in the New Zealand building industry.

C O N T E N T S

INTRODUCTION

The four objectives of this technical paper are to obtain an overview of:

(a) Adhesives made or used in New Zealand for the building industry.

(b) Problems of building industry adhesive use.

(c) Existing research on adhesives in the New Zealand building industry.

(d) An idea of what potential research areas exist for adhesives in the New Zealand building industry.

Most of the information was obtained by surveys from adhesives manufacturers, suppliers, specifiers, users and researchers. These surveys consisted mainly of interviews (in-person) in 1985-1986 with some telephone conversations. Questions were designed to fulfil the objectives. The information is not claimed to be exhaustive, but the aim was to obtain information from at least a representative cross section of each major group (e.g., manufacturers) in the adhesives industry.

For an overview of adhesives for wood and wood-based products, (a major component of adhesives in the building industry) the reader is referred to BRANZ Building Information Bulletin 246. This bulletin gives definitions of terms, principles of adhesive selection and use, characteristics and potential applications of adhesives.

TYPES OF ADHESIVES AND CURRENT USE

In New Zealand, adhesives relevant to the building industry produced locally or imported, include the following general types: thermosetting adhesives, thermoplastic adhesives, elastomeric adhesives, and other adhesives.

Thermosetting Adhesives

A thermosetting adhesive is cured by cross-linking, normally using heat. It does not soften significantly with heat. Cross-linking is the formation of extra chemical bonds within an adhesive, generally toughening and improving adhesive durability. This class includes formaldehyde based adhesives, epoxy adhesives, and cross-linked polyvinyl acetate emulsions.

Formaldehyde Based Adhesives

Formaldehyde based adhesives are produced in larger quantities than any other broad class of adhesive. Most of the 20,000 to 30,000 tonnes used in New Zealand is produced locally. These adhesives are used mainly in factories to produce products used in the building industry.

Urea formaldehyde (UF) is the cheapest formaldehyde adhesive and forms about three quarters of the total New Zealand formaldehyde adhesive production. Most UF is used as a binding agent in particleboard and medium density fibreboard (MDF).
Two New Zealand companies produce particleboard and three produce MDF.

Other uses for UF include wood gluing (fingerjointing, glulam beams, plywood, veneering, and doors), making laminates, coatings and mouldings.

The main use of melamine urea formaldehyde (MUF) is for particleboard. A smaller amount of this adhesive is used as a binder in MDF. The higher the proportion of melamine in MUF, the higher the water resistance, and the higher the cost.

Melamine formaldehyde and MUF are used to make decorative laminates used in kitchens and work areas, coatings and clear mouldings. These adhesives are used for wood gluing, both being used for scarf and fingerjoints, and MUF also being used for glulam beams.

The main use for phenol formaldehyde (PF) is for plywood production, almost all New Zealand plywood using this resin rather than UF. (There are four plywood companies in New Zealand). Other major uses for PF are as a binder in glass insulation, for laminating (including glulam beams) for mouldings and impregnating (to make high pressure laminates, for instance).

Although resorcinol formaldehyde (RF) and resorcinol phenol formaldehyde can almost be used interchangeably, the following uses were found. RF, generally the most expensive and most durable formaldehyde adhesive, is used in laminated beams and arches, particularly when the product is exposed to the weather. Resorcinol phenol formaldehydes are less expensive than RF, and are used for fingerjointing and laminating. The end products include fingerjointed timber weatherboards and exterior joinery.

Tannin (wattle-based) formaldehyde is used as a binder in exterior grade particleboard. *Pinus radiata*-based tannin formaldehyde has been used as a binder in flooring particleboard. A tannin phenol formaldehyde adhesive has been used for plywood manufacture.

Epoxy Adhesives

Although epoxy adhesives can be used in structural applications, similar to those of the formaldehyde based adhesives, the high cost of epoxies excludes them from very large scale use.

In the building industry epoxies are used for specialised purposes in laminating (e.g., for very large fingerjoints in laminated beams).

Epoxy mortars are commonly used to bond concrete to concrete or steel to concrete. When used with metals, a viscous epoxy formulation is used. For wood they must have low viscosity and good penetration of wood. They are sometimes used for exterior joinery. Epoxies can be custom made to bond a large variety of substrates. For example, epoxy with polyurethane can bond to polyvinyl chloride (PVC). Epoxies can be supplied in a gun-applied form, which is a convenient form for use on a building site.

Cross-linked polyvinyl acetate emulsions

Cross-linked polyvinyl acetate (cPVA) emulsions have improved water resistance and a small improvement in creep (adhesive movement) resistance compared to PVA emulsions. However, cPVA is not generally used in load-bearing applications since it softens when heated and loads (e.g., weight) cause the adhesive to creep. Cross-linking agents include chromium and aluminium salts. Several sources indicated that isocyanate cross-linking agents may be used in New Zealand although no use was actually identified in this survey. Isocyanate cross-links with 'impurities' in the PVA, including hydroxyl and carboxyl groups. This cross-linking agent results in a more water resistant (and more expensive) cPVA emulsion than chromium and aluminium cross-linking agents.

Emulsions of cPVA are used for fingerjointing, and bonding decorative laminate to wallboard. There are reports of the use of cPVA in joints for window frames.

Thermoplastic And Elastomeric Adhesives

A thermoplastic adhesive softens with heating and hardens with cooling without undergoing any other basic physical change or any chemical change. This process is repeatable. An elastomeric adhesive has elastic or rubber like qualities. The adhesives in this category can be put in the following groupings: PVA emulsions, hot-melt adhesives, rubber-based adhesives and polyurethane adhesives.

PVA Emulsions

PVA emulsions are used as wood adhesives, the main applications being general woodworking, and furniture. They are relatively cheap for adhesives which are commonly not used in a factory situation (i.e., used on-site). Since PVA softens with heat, resolubilises in water, and exhibits creep under a load, it is not used for loadbearing applications, in damp environments, or exposed to the weather.

Factory uses of PVA include: interior building components, furniture and joinery production. Examples of use in building components are: bonding aluminium foil to gypsum-based wallboard, and bonding cardboard honeycomb to wallboard in sandwich panel construction. PVA copolymer with ethylene (called EVA) is used to bond vinyl foil to gypsum-based wallboard and to laminate vinyl foil to MDF. Modified PVA is used to laminate papers to MDF and particleboard.

Hot-melt Adhesives

This variety of adhesive is based on a thermoplastic resin blend, being 100% solids. They are commonly based on ethylene-vinyl acetate copolymers, but other resin bases include polypropylene, polybutylene and thermoplastic rubbers. This type of adhesive is heated on to the substrate and a bond is formed on cooling. The applications relevant to the building industry are the manufacture of doors and edge-bonding of veneers on some kitchen, bathroom, or laundry units.

Rubber-Based Adhesives

Rubber-based adhesives (or elastomers) are typically based on one of the following chemical types:
polychloroprene - contact type or gap-filling (solution or latex)
styrene butadiene rubber - solution or emulsion
nitrile and natural rubber - contact type or gap-filling (solution).

Gap-filling polychloroprene (solution or latex) and styrene butadiene rubber are often gun-applied and have some load bearing ability. This survey indicates that they are used in a greater range of applications than gun-applied acrylic based emulsions. A gun-applied form of rubber-based (or acrylic-based) adhesives is typically used on-site to bond sheet material to timber framing. This form is very convenient for on-site use. Regardless of the chemical classification of the adhesive, if it is gun-applied and has some loadbearing ability it is sometimes called a construction adhesive. However, note that rubber-based adhesives are generally unsuitable for carrying loads for structural applications, since they normally creep in these types of joint.

Wallboard-to-stud glued joints is the largest market for a gun-applied adhesive. Ceiling panels have been nailed plus glued in New Zealand houses for at least twenty years, normally using a rubber-based adhesive. There is a small market for a gun-applied adhesive used together with nails to join floor joists to floors. Solvent-borne rubber-based gun-applied adhesives are usually used to bond roofing membranes to timber or a wood-based substrate (plywood or particleboard), and to bond wet-area wall linings (oil tempered hardboard substrate) to timber framing. New houses with demountable walls use this adhesive to bond laundry, kitchen, or bathroom units to the walls. (Nails cannot be used to fix heavy objects to demountable walls.)

Floor coverings such as carpet or PVC sheet are typically bonded to concrete or particleboard floors using rubber-based adhesives. This is a major use of this type of adhesive.

Factory based applications of rubber-based contact type adhesives include bonding polymer laminates or vinyl foil to particleboard or MDF for laundry, kitchen, or bathroom units; bonding expanded polystyrene to aluminium for sandwich panels; and timber weatherboards to aluminium sheet coverings. Polychloroprene is used to bond phenolic foam to gypsum based wallboard.

High alumina cement rubber latex is sold in small amounts (compared to solvent-based polychloroprene) and used to bond floor coverings to floors. It is used in cases where other adhesives would be damaged by plasticisers migrating into them from PVC sheet floor coverings (e.g., bonding PVC to PVC sheet). Since it does not release significant amounts of solvent or water on curing it is used where solvent or water would be confined to the joint (e.g., bonding PVC to PVC sheet).

Polyurethane Adhesives

Moisture cured polyurethane adhesives can be used in a gun-applied form. Being relatively expensive, they have a small market.

Polyurethane-based contact-adhesive is used to bond printed (eg., woodgrain) PVC foils to particleboard or fibreboard when the foil must be wrapped around the woodboard. This is mainly done when making furniture. These adhesives are sometimes used to bond PVC sheet to shower bath walls. Some polyurethane adhesives consist of two components which are mixed together prior to use. These polyurethanes are used for laying floors in areas near water (e.g., near swimming pools).

Other Adhesives

This survey indicates that acrylic emulsions are the second most common chemical type used in a gun-applied form following rubber-based types. Acrylic emulsion gun-applied adhesives have similar applications to those listed for rubber-based gun-applied adhesives. Acrylic emulsions have the advantage over the solvent-borne rubber-based adhesives of having an inert medium: namely water. Thus there is no health or fire hazard from solvent vapour and there is no possibility of the medium dissolving plastic substrates such as PVC foil. However, water has the disadvantage of evaporating more slowly than the solvents used in solvent-based adhesives thus the waterborne adhesive cures more slowly. Water-based adhesives can cause a swelling of wood-based substrates.

Acrylic-based emulsions (e.g., PVA-acrylic copolymers) are used extensively to fix PVC floorcoverings to concrete or wood-based floors.

Gypsum plaster fortified with PVA is used to bond gypsum-based wallboards to gypsum mouldings, masonry or concrete.

Casein is used in small quantities for the manufacture of laminated beams and general woodworking.

Although animal glue is available for general woodworking and joinery, no users in the building industry were identified in this survey.

A summary of the purported uses of adhesives in New Zealand building is listed in the Appendix.

MARKET TRENDS

Production Trends

Two of the three MDF plants in New Zealand became operational in 1986. A new particleboard and MDF plant was expected to be operational in 1987. Thus the market for UF is expected to rise in the near future to satisfy the requirements of these new reconstituted woodboard plants. Most of this extra woodboard will be exported.

Changes in Usage

As woodboard production increases, it is likely that there will be a greater local use of adhesives to bond laminates or foils on to woodboard.

Emulsions of cPVA are used in some non-loadbearing applications that traditionally used UF. In general, these emulsions are more water resistant and slightly more expensive than UF. This survey indicates that cPVA emulsions are used in some non-loadbearing applications that have traditionally used RF. (However, this change in usage is not as great as the change to use cPVA in applications previously confined to UF.) Emulsions are less water resistant and significantly less expensive than RF.

For gun-applied adhesives, the wallboard to stud market is growing. There is a large potential market for bonding and nailing floor boards or sheets to floor joists. Bonding gives a stiffer floor that is less prone to squeaking joints. However, to enable bonding to the joist, the standard practice of draping aluminium foil floor insulation on top of joists must be altered to either: nailing battens on top of joists with the draped foil underneath; or placing foil underneath joists and nailing battens below the foil.

New Adhesives

The survey indicates that waterborne elastomeric contact adhesives have smaller sales than expected, when compared to their solvent-based equivalents. The possible reasons include the fact that waterborne elastomers are slightly newer than solvent-based equivalents and face the usual reluctance to try a newer product. Although waterborne elastomeric emulsions have the potential of a higher bond strength than solvent-based equivalents, waterborne emulsions are marginally less convenient to use in that they often have longer cure times and allow a smaller margin for error in open assembly time.

Several companies foresee isocyanate-based adhesives entering the New Zealand market in the future (e.g., isocyanates may come from Western Europe). One company has the capability to produce emulsifiable isocyanates when a market demand develops and another company intends to experiment with isocyanates in the future. Isocyanates can already be used as cross-linking agents for polyurethane and PVA-based (and polyvinyl alcohol-based) adhesives. The more water resistant cPVA emulsions using isocyanates have the potential to compete with PF in plywood manufacture, as occurs in the United States.

It is worth noting that isocyanate-based adhesives are used in the United States, Japan and in Western Europe as binding agents in particleboard or MDF. These binders are effectively replacing formaldehyde-based binders. One reason for this replacement has been the introduction of codes requiring reductions in formaldehyde emission levels from woodboards (e.g., West German codes). Many of the technical difficulties associated with using isocyanates as binders have been overcome.

Tannin based formaldehyde adhesives are expected to replace other formaldehyde adhesives in the future as more research and development here and overseas bears fruit. There is the long term attraction of the large indigenous tannin source available in *Pinus radiata* bark.

PROBLEMS WITH ADHESIVES USE

Problems with adhesives are grouped into four categories:

(a) Interactions between adhesive and timber preservative;

(b) Interactions between adhesive and the substrate (excluding preservatives) and environmental conditions;

(c) Inappropriate use;

(d) Other problems.

Interactions Between Adhesive and Timber Preservative

Some metal ions found in timber preservatives (e.g., copper) can react with an adhesive to form a chemical bond. Since the metal ions do not adhere to the timber, there is no overall bond between the adhesive and the timber.

Borax/boric Acid Treated Timber

The survey found four separate comments on adhesion failures to standard borax/boric acid treated timber. In general, adhesion problems may arise when a film of borax/boric acid salt covers the timber to be bonded. This problem applied to site adhesives in general (usually rubber-based or acrylic emulsions) and to UF adhesives.

Copper Chrome Arsenate Treated Timber

A number of separate comments on adhesion loss to copper chrome arsenate (CCA) treated timber were collected. Two of these comments involved a site applied adhesive, including polychloroprene used on treated timbers with a high loading of CCA. One comment was a general mention of problems with bonding CCA treated timber using UF adhesives.

In one research program, exterior timber veneer was first treated with CCA and then bonded. A fixed shear strength of 7 MPa was used as the criterion for failure. After exterior exposure, PF failed this criterion before cPVA and MUF. However, cPVA and MUF showed delamination after three to four years of exposure. Although there is no large loss in adhesion if the veneer is bonded and then treated later, there is severe checking (splitting of the surface) of the veneer.

Light Organic Solvent Preservative Treated Timber

Three separate comments were received about adhesion problems to light organic solvent preservatives (LOSP) treated timber. One comment consisted of reporting several cases of bubbling of polychloroprene adhesive bonding butyl roofing to LOSP treated timber. The residual solvent in the LOSP may have caused the bubbling in the adhesive. A general mention was made of possible problems of bonding wall board to LOSP timber with acrylic emulsions.

Preliminary research on copper naphthenate/turpentine/pine oil type LOSP treated timber beams showed that MUF, UF, PVA or PF, eight days after treatment, give significantly lower bond strength compared to untreated timber. (Adhesion was satisfactory using the alternative LOSP treatment of tributyl tin oxide/white spirits and wax.)

Interactions Between Adhesive and Substrate (Excluding Preservative)

Five separate comments on high substrate moisture contents were received. Three of these comments applied to wet timber bonded with site-applied adhesives. One comment applied to wet kraft paper in wall board bonded to acrylic emulsions. There was a general mention that moisture together with heat can lead to severe swelling and bond failure in UF adhesives.

Two comments related to PVC (or vinyl) sheet flooring. Plasticiser in PVC flooring can migrate into some types of adhesive and weaken the bond. Polychloroprene-based adhesives are particularly susceptible to dissolution by common plasticisers, but normally, to be a problem, one of these factors must be present: heat, high filler content in PVC, or aging of the PVC. PVC flooring can shrink in-service, weakening the bond and occasionally curling up at the flooring boundary for some adhesives (e.g., polychloroprene-based).

Two comments were received on the possibility of adhesion loss for site-applied structural wood adhesives at low temperatures.

There was a general mention of adhesion problems between UF and thin medium density particleboard. The cause was postulated as wax in the particleboard and the solution was to add 5% methanol to the UF.

There was a comment on the difficulty of bonding heart rimu to UF. The solution was to add acidic UF hardener to the rimu before applying the UF resin. Another commentator uses a chlorinated hydrocarbon solvent (a proprietary product) to remove oil from teak and rosewood before bonding with UF. In his experience, RF is affected by oils less than UF adhesives. Adhesion problems between adhesives like UF and some native and exotic timbers normally arise from the high oil content or high density of the timber.

Inappropriate Use

One commentator suggested that the single job area creating the largest number of adhesion problems in the building industry was bonding floor coverings to floors. (Some PVC to woodboard adhesion problems may be related to substrate rather than to incorrect adhesive application.)

Two commentators suggested that there should be more education of the actual 'hands-on' applicators of flooring adhesives.

Two sources commented on problems with using an incorrectly specified solvent-based adhesive for bonding PVC covered wallboard. The solvent dissolves the PVC. The standard adhesive is water-based. (Note that not all solvent-based adhesives will dissolve PVC.)

Finally, one commentator mentioned a case of inadequate spray-applied adhesive coverage on walls.

Other Problems

Each of the following problems were mentioned by one commentator only.

A significant amount of the less viscous gun-applied adhesives are wasted due to the flow of adhesive continuing after the gun-trigger has been returned to the normal position.

Paint finishes can be disfigured by migration of antioxidant from solvent-based wall board adhesive. This occurs for painted fibrous plaster when it is bonded to a colder wall.

There is a lack of knowledge of the lifetime of adhesives. Even an approximate lifetime could be useful, as found for some sealants.

EXISTING ADHESIVES RESEARCH

The following is based on the larger research projects at the time of the survey. Further information can be sought from the bodies listed.

Forest Research Institute (FRI), Wood Products Group

Below is a summary of relevant results from FRI.

The largest recent and on-going research area is on the effect of timber preservatives on structural wood adhesives. (See page 7: (a) Interactions between adhesive and timber preservative.)

CCA Treated Timber

CCA treated timber adhesive joints consisted of crossarms (laminated beams) and veneers (plywood) after natural exposure or ASTM accelerated tests. The results suggest that water-based preservative treated (CCA) crossarms must be painted to avoid checking when used outside. (Checking in timber is caused by shrinkage during drying.) CCA treated with MUF and cPVA (post-bonded) veneer may bond initially, but shows some delamination three to four years later. PF adhesive joints fail the standard 7MPa shear strength criterion much earlier than MUF or cPVA. Similar exposure of veneer which was bonded before CCA treatment resulted in checks appearing in the plywood. Plywood may not be a visually acceptable cladding long term (due to the checking of the surface veneer) unless regular repainting regimes are acceptable.

Pentachlorophenol Treated Timber

The tested pentachlorophenol (PCP) treated timber adhesive joints consisted of crossarms subjected to natural exposure. Unpainted PCP (oil-based) preservative specimens show less checking than their water-based preservative counterparts. The oil medium being a water repellent, allows less water to penetrate timber than in the water-based preservative specimens and so probably allows less checking.

LOSP Treated Timber

At the time of this survey, FRI had recently started a project on the effect of LOSP preservative treatment on timber adhesive joints. The following results represent the beginning of this study, but important long term weathering results are not yet available. It included MUF, UF, PF, RF and PVA adhesive and involves monitoring the shear strength of joints with time. The impetus for this research comes from the increasing use of LOSP in New Zealand including an increasing number of LOSP plants here. To date all the adhesives are satisfactory with the widely used LOSP formulation of : tributyl tin oxide, wax and white spirits. However, when using copper naphthenate, turpentine and pine oil, at eight days after LOSP treatment, only RF yields a satisfactory bond.

Tannin formaldehyde wood adhesives provide an ongoing area of research. There has been work on hydrogen peroxide as a resin cure accelerant. The heat released when this chemical decomposes assists the curing of the adhesive. Recently a literature survey on tannin adhesives was finished.

Ministry of Works and Development (MOWD)

MOWD have performed research on PVC adhesion to concrete (Campbell and Thorby, 1985). The objective was to assess the tolerance of PVC flooring adhesives to concrete floor surface finish and concrete slab moisture content. Surface finish was less important than slab dryness. The solvent-based polychloroprene was the most appropriate adhesive to use, while the acrylic adhesive performed poorly.

Experiments on PVC adhesion to glass fibre reinforced cement coupons highlighted the effects of several factors on the performance (shear strength) of the flooring adhesives (Wong and Thorby, 1985). Water, high relative humidity, and accelerated aging all have long term effects on the adhesives. The polychloroprene adhesive exhibited the best overall performance, followed by the styrene butadiene rubber adhesive. The acrylic-based adhesive was sensitive to high relative humidity, the presence of water, and to plasticiser migration when subjected to accelerated aging.

Department of Scientific and Industrial Research (DSIR)

The organic chemistry group at DSIR has been studying the chemistry of tannins from *Pinus radiata* bark since the early 1970's. They have projects on the chemical modification of these tannins to make them more suitable for use as a tannin formaldehyde adhesive. Specifically, modification of certain functional groups on these tannins produce adhesives with a longer pot life and which are less brittle than the unmodified tannin based adhesive.

These modifications are different to the current commercial treatments of *Pinus radiata* tannins in New Zealand.

University of Auckland, Engineering School, Timber Research

Research has finished on a project which looked at stress distribution in joints between metal plates bonded with epoxy adhesive to timber. Both experimental work and theoretical models showed that under shear tension, a peeling force was exerted on the plate as the timber at the plate end was compressed inwards. This resultant peeling force is perpendicular to the applied shearing force. A similar result was found with nailed plates.

There are experiments with bonding concrete slabs together with modified acrylic sand mixtures as possible replacements for the more expensive epoxy sand mixture in current use.

Other Adhesives Research

Research and development on adhesives is carried out by some adhesives manufacturers. New formulations of adhesives intended for some degree of exterior use are generally exposed to natural weathering in the final product for months or years before marketing. Examples of these adhesives include UF, tannin formaldehyde, and tannin-phenol formaldehyde.

Further enquiries on these research topics should go to the appropriate research group:

Forest Research Institute
Wood Products Group
Private Bag
Rotorua

Ministry of Works and Development
Central Laboratories
Building Science Section
PO Box 30-845
Lower Hutt

Department of Scientific and Industrial Research
Chemistry Division
Organic Chemistry Group
Private Bag
Petone

University of Auckland
Engineering School
Timber Research
Private Bag
Auckland

POTENTIAL ADHESIVES RESEARCH

Taking into account the future market trends, the problem areas, and the existing adhesives research, there is inadequate information in the following areas:

(a) The adhesion of PVC floor coverings to reconstituted woodboard.

The factors that could be involved with adhesion problems include high woodboard moisture content or wax content, process chemicals on the vinyl backing, and incorrect use or selection of adhesive.

(b) The effect of LOSP treated timber on site-applied adhesives.

Solvent residues in LOSP treated timber can act as a solvent for solvent-based adhesives and may act as a plasticiser for water-based adhesives. LOSP is slowly replacing some CCA treated timber and has the potential to replace some borax/boric acid treated timber.

(c) The effect of CCA treated timber on site-applied adhesives.

(d) The effect of borax/boric acid treated timber on site-applied adhesives.

(e) The effect of low temperature and high substrate moisture content on site-applied adhesives.

Research on site-applied adhesives would involve elastomeric rubber-based or acrylic-based varieties, since these are what are typically used in the building industry.

SUMMARY

The largest amounts of adhesive used in New Zealand are for wood and wood-based panel products. Formaldehyde-based adhesives have by far the largest use of adhesives involved in the New Zealand building industry. PVA emulsions are second on this list of end use, probably followed by rubber-based adhesives. The use of UF as a binder in reconstituted woodboard is the largest single area of use for formaldehyde-based adhesives. Most formaldehyde-based adhesives are used in factories to manufacture building materials or components. PVA emulsions are used to make building components and for general woodworking. A large amount of rubber-based adhesives are used for either fixing plastic-based laminates or for bonding panels or floorcoverings on a building site. Other adhesives used or made for the New Zealand building industry include epoxies, hot melts, acrylic-based emulsions, cPVA emulsions, polyurethanes, gypsum-based adhesives, animal glue, casein, and isocyanates.

There is an increasing market for UF with the increasing production capacity of woodboard plants using this adhesive. cPVA emulsions are being used in non-loadbearing applications such as fingerjointing, which traditionally used UF adhesives. There is a potential for greater growth in the market for bonding sheet materials to timber framing on building sites using rubber-based and acrylic-based adhesives. Isocyanate-based adhesives are used as binding agents in woodboards overseas but are not used in New Zealand at present.

Problems with adhesives were largely confined to on-site use. Adhesion problems were noted between some formaldehyde-based and 'construction' type adhesives and timber preservatives. (e.g., LOSP and CCA type preservatives). Loss of adhesion with LOSP is due at least partly to the solvent vehicle for the preservative. Other chemicals causing adhesion problems were: plasticisers in vinyl, and waxes or resins in timber or reconstituted woodboards. Low temperatures and high timber moisture levels were also cited as significant adhesion reducing factors. Some problems have been caused by inadequate education of the specifiers or users. For instance solvent-based construction adhesives have been used with PVC coated wallboard, sometimes leading to dissolution of PVC by the adhesive solvent. Water-based adhesives are specified for fixing PVC coated gypsum-based wallboard. The area generating the most adhesion problems is the bonding of floorcoverings to floors. Some of these problems are education related and some are due to incompatibility between adhesive and substrate.

Research topics on adhesives at FRI notably include interactions between adhesives and timber preservatives. Most adhesives are formaldehyde-based, and the preservatives include CCA, LOSP and PCP. This work yields durability information on exterior timber adhesive joints. At FRI and the organic chemistry section of DSIR, there is work on the development of tannin formaldehyde adhesives from *Pinus radiata* bark.

MOWD have completed a project on PVC adhesion to concrete and on adhesives for PVC flooring. The former project examines the effect of variations in the concrete, and the latter project examines variations in environmental conditions. Both projects use several generic types of adhesive.

Auckland Engineering School, Timber Research section have work on the stress distribution in adhesive-bonded structural timber joints under sheer tension. A peeling force is exerted on joints perpendicular to the applied shear tension.

Some adhesives manufacturers include natural exposure of products using new adhesive formulations in their research programmes.

Taking account of problems (and to some extent, market trends) encountered in the building industry and existing research, some areas can be suggested where not enough is known about adhesives. Adhesion of PVC floor coverings to reconstituted woodboards and the effect of temperature, timber moisture content and preservatives on site-applied adhesives are two examples of this.

FURTHER READING

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Campbell, C.J. and Thorby, P.N. 1985. The adhesion of sheet vinyl to concrete floor slabs. Central Laboratories Report 7-85/1. Ministry of Works and Development. Lower Hutt.

Wong, L.S. and Thorby, P.N. 1985. Adhesives for vinyl flooring. Central Laboratories Report 7-85/6. Ministry of Works and Development. Lower Hutt.

ABBREVIATIONS

ASTM	American Society for Testing and Materials
CCA	copper chrome arsenate
cPVA	cross-linked polyvinyl acetate
DSIR	Department of Scientific and Industrial Research
FRI	Forest Research Institute
LOSP	light organic solvent preservatives
MDF	medium density fibreboard
MOWD	Ministry of Works and Development
MUF	melamine urea formaldehyde
PCP	pentachlorophenol
PF	phenol formaldehyde
PVA	polyvinyl acetate
PVC	polyvinyl chloride
RF	resorcinol formaldehyde
UF	urea formaldehyde

APPENDIX: USES OF ADHESIVES IN THE NEW ZEALAND BUILDING INDUSTRY

ADHESIVE	MANUFACTURER AND SPECIFIERS STATED USES IN THE NEW ZEALAND BUILDING INDUSTRY
Urea Formaldehyde	Binding agent in particleboard and medium density fibreboard, wood gluing, (fingerjointing, glulam beams, plywood, veneering, and doors); making laminates, coatings, mouldings. (Normally for interior use.)
Melamine urea formaldehyde	Binding agent in particleboard and medium density fibreboard; making laminates, fingerjointing, laminated beams, coatings, clear mouldings.
Melamine formaldehyde	Making laminates, fingerjointing, coatings, clear mouldings.
Phenol formaldehyde	Plywood; high pressure laminates; laminated beams; binding agent in glass insulation; Mouldings.
Resorcinol formaldehyde	Laminated beams.
Phenol resorcinol formaldehyde	Laminated beams; fingerjointing.
Tannin formaldehyde (A)	Plywood; binding agent in particleboard.
Epoxies	Special applications in laminated beams, fingerjointing and exterior joinery, concrete to concrete or steel bonding.
Cross linked polyvinyl acetate emulsions	Fingerjointing; bonding laminates to wallboards.
Polyvinyl acetate (PVA) emulsions	General woodworking (non-structural), furniture; joinery; assembly of wall panels. (Interior use only.)
Hot melt adhesives (e.g., ethylene - vinyl acetate copolymer)	Door manufacture, edge bonding of veneers. (Interior use only.)
Rubber-based adhesives (polychloroprene, styrene-butadiene, nitrile or natural rubber.)	Bond sheet material to timber framing, floorcoverings to floors; bond laminates or PVC foil to wood-based sheet material; assembly of wall panels and cladding. (Can be gun-applied.)

Polyurethane	Special applications in bonding PVC to wood-based material, and laying floorcoverings near water.
Acrylic-based emulsions	Bond sheet material to timber framing, PVC floorcoverings to floors. (Can be gun-applied. Interior use only.)
Gypsum plaster fortified with PVA	Bond gypsum-based wallboards to gypsum with mouldings, masonry, or concrete. (Interior use only.)
Casein	Laminated beams; general woodworking. (Interior use only.)
Animal glue (B)	General woodworking; joinery. (Interior use only.)

FOOTNOTES

(A) At the time of the survey, these uses had recently been discontinued.

(B) Although animal glue is advertised as suitable for these uses, this survey found no users in the building industry.

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