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Workmanship and the Light Timber Framing Code

By the Timber and Domestic Structures Group

This is the second in a series of articles drawing attention to examples of bad building practice and/or bad workmanship in domestic construction.

Overcutting

The advent of the portable electric saw has certainly made the job much easier for the on-site framer. At the same time, the overcutting of notches in studs, props and other members appears far more prevalent than it was. The tradesman with a hand saw was unlikely to overcut, except in error, because this took more time and extra physical effort.

Fig. 8 shows the notch in a ridge prop overcut badly both horizontally and vertically. With the subsequent drying of the prop splitting from the end of the vertical cut is likely, in which case the prop will probably become largely ineffective.

Fig. 9 adds to the examples given in the previous article (Newsletter No. 397) of gross over-notching of studs.

Making Do

Very frequently at a building site a relatively large pile of timber off-cuts accumulates and it is only reasonable that as much as possible of this off-cut material is put to sound practical use. However, improper use of this material on the basis of 'making do' or 'near enough is good enough', as illustrated in Fig. 10, is definitely unsound building practice: Fig. 11 shows an even worse example. Noggings, particularly those at mid height of the studs, serve an important structural function and are not there just to provide fixing for the wall linings. They also provide restraint against buckling of the studs in the plane of the wall. The noggings illustrated in Figs. 10 and 11 could not possibly perform this duty.

Fig. 12 is another example of making do. Here the two pieces of top plate have been joined with a piece of galvanized iron

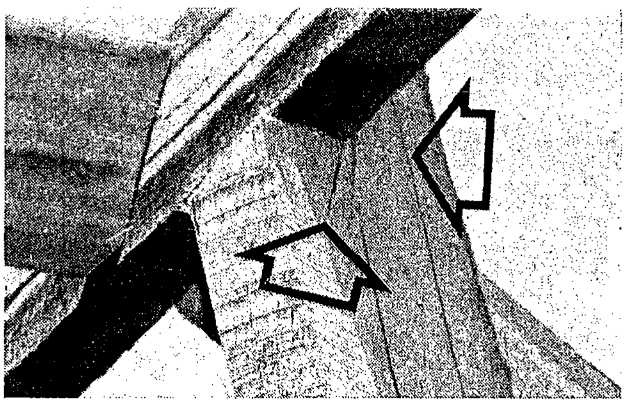


Fig. 8. Excessive overcutting of notch in a ridge prop.

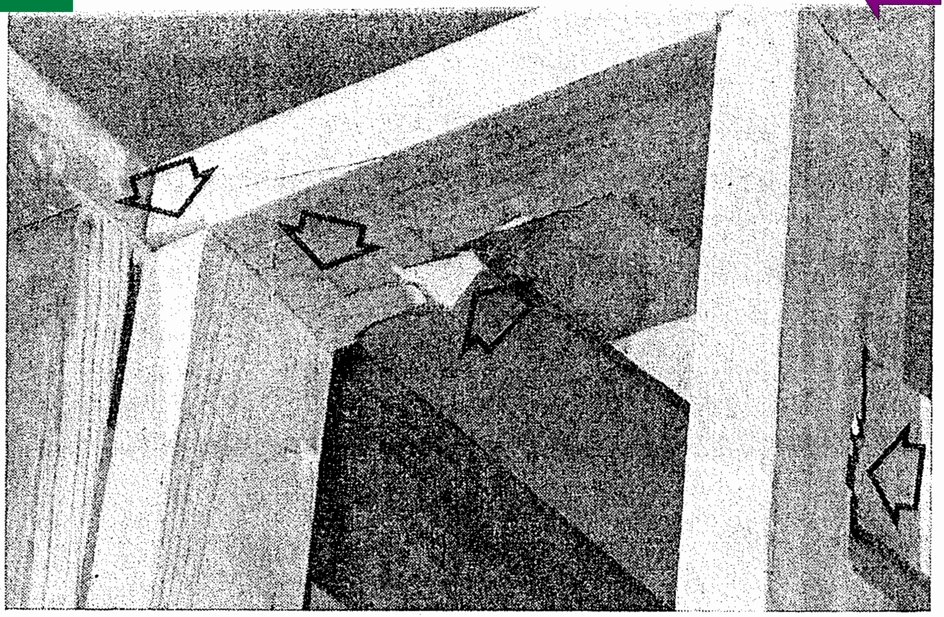


Fig. 9. Another example of over-notching of stud and top plate.

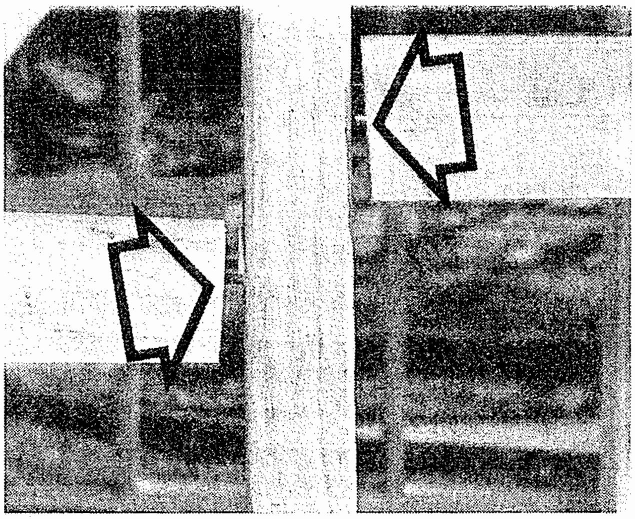
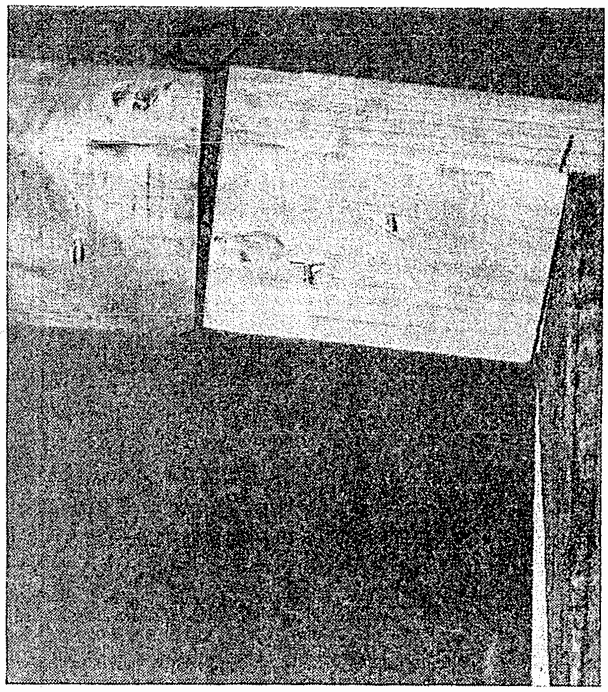


Fig. 10. *This stud is not going to get much help from the noggings.*

plate. Such a joint, particularly with the nailing used, one nail on one side two on the other, serves no useful purpose. Indeed it has not even helped to keep the plates in the same line.

A case of near enough being not good enough is shown in Fig. 13. The header has been cut too short; it is virtually hanging on the nails at its ends instead of sitting on the base of the notches cut in the studs to receive it. Any roof load which happens to fall on the top plate would probably be transferred to ground through the architraves.

Fig. 12 (Below). *The galvanized plate linking the pieces of top plate is no more than a token gesture. It is difficult to see it performing any useful function.*



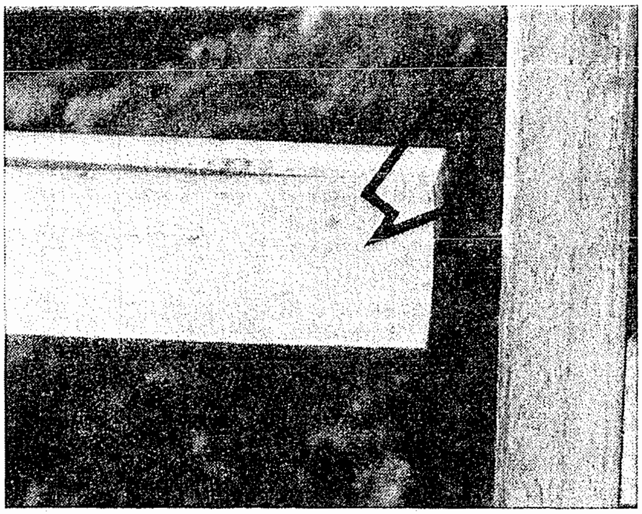


Fig. 11. *For all the good it can do this nogging might as well not be there!*

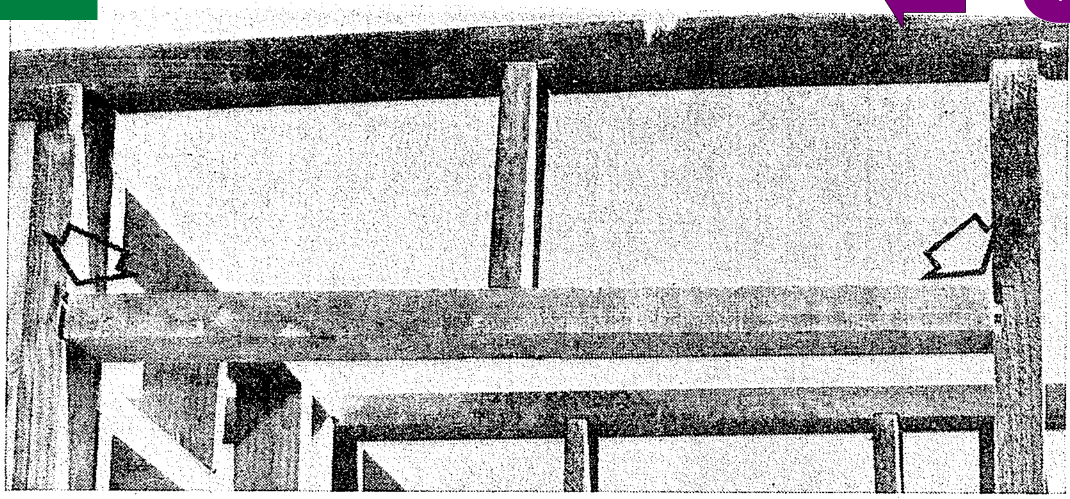


Fig. 13. *The header is more of a hanging beam—hanging on the nails.*

Props

Fig. 14 shows an underpurlin prop at an angle of 70° to the vertical. At this angle it cannot do its job effectively. The builder seems to have had second thoughts as the end of the underpurlin has been packed up with mortar from the brickwork. When the mortar has set it will probably be much more effective than the timber prop.

Party Walls

The type of unit construction illustrated in Fig. 15 is becoming increasingly common. Building regulations require a brick party wall between the units. The builder of these units has not only made sure that the units were divided according to regulations but were *seen* to be divided! Because no allowance or certainly a totally inadequate allowance has been made for the roof members (whether rafters or trusses) sagging as they inevitably will do, the roof battens are now bearing on the party walls. The consequent effect which is accentuated by the long length of unbroken roof is hardly pleasing to the eye. A similar effect results when an extra rafter is placed each side of the party wall as in Fig. 16. These extra rafters, at much closer centres than the common rafters, make the roof much stiffer at the party wall because each of these rafters is more lightly loaded than the rest. They will therefore not sag as much and the roof will show a wave over the top of the party wall. A uniform spacing of *all* the rafters would avoid this problem.

Most of the sag in the roof members takes place in the first 12 months after the tiles have been laid. So in these examples,

Fig. 14. *The mortar is doing more to support this underpurlin than the carefully notched strut.*

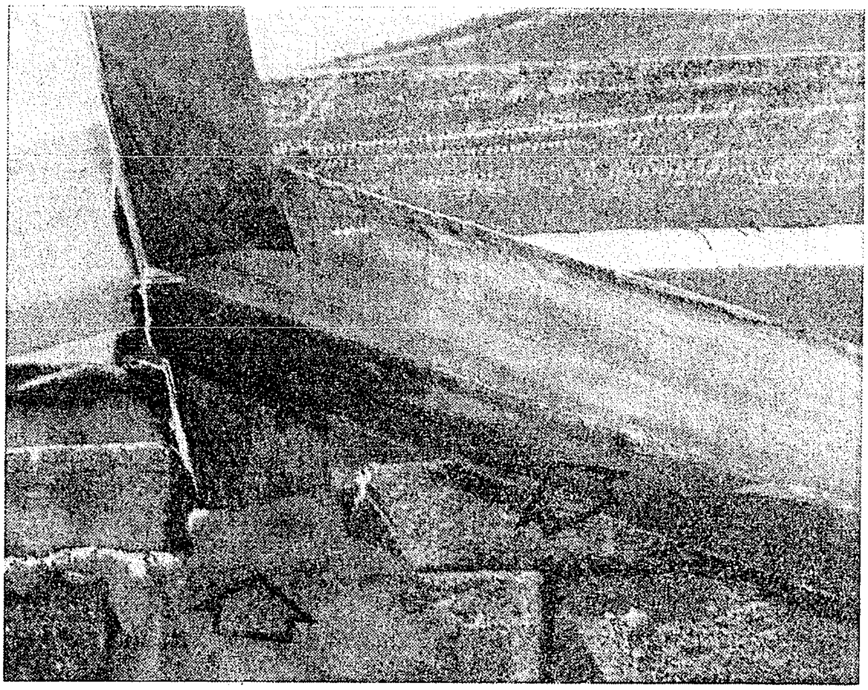


Fig. 15. The whole appearance of these units has been spoilt because insufficient clearance was provided between the party walls and the roof system.

which are typical of many that can be seen around the suburbs, the overall fresh and clean appearance of a new building has been quickly depreciated by the poor appearance of the roof line.

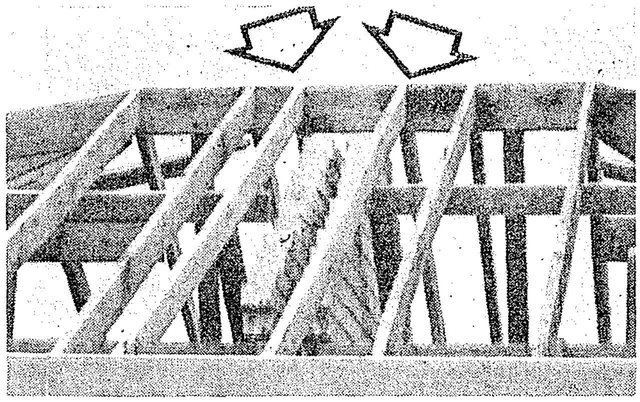


Fig. 16. A wave in the roof line can be expected over the party wall because of the greater rigidity of the doubled-up rafters in this area.

CCA-treated Pine Rounds an Ideal, Safe Material for Playground Equipment

By E. W. B. Da Costa, Preservation Group

For many years now greenish-coloured round timbers pressure-treated with various brands of copper–chrome–arsenic (CCA) preservative have been a familiar feature of both the urban and the rural scene in Australia. This preservative treatment has gained full acceptance as a clean, safe and highly effective method of obtaining very long service life. Because the preservative contains arsenic questions have been raised from time to time as to its safety, particularly in relation to prolonged handling or to ingestion by farm animals chewing on treated fence posts.

Consideration of the evidence shows that such fears are groundless. The arsenic in CCA preservatives is in the relatively non-toxic and readily excreted form of arsenates and is so completely fixed in the wood that it is virtually insoluble. In fact, forced feeding of large quantities of CCA-treated pine sapwood to stock in a New Zealand experiment proved it to be harmless.* The present CCA formulations have been in intensive use for 20 years and are now used at the rate of at least 20 000 tonnes per annum, including 3000 tonnes per annum in New Zealand which has the highest *per capita* usage. There have been no reports of deaths or illnesses from the handling of treated timber even though more workers such as employees in treating plants or farm fencing contractors are handling it continually.

In recent years, CCA-treated rounds of

* Harrison, D. L. (1959). Chemically preserved fence posts are harmless to stock. *N.Z. J. Agric.* **98**, 293–4.

Pinus radiata have found widespread use in Australia for the manufacture of children's playground equipment such as climbing frames. They are ideal for this purpose since they come in a suitable variety of diameters, are light to handle, need no painting, are attractive in appearance, do not produce splinters and being non-corrosive remain clean and non-staining to clothes. Also, because of their texture and insulating capacity they are agreeable to the feel of children who use them.

However, some questions have recently been raised as to their safety in this application. To some extent these fears are quite logical. Children would be affected at much lower doses than are adults and there is a possibility that a few children may get into the habit of persistently handling, picking at, or even chewing or sucking playground equipment. At the same time, fears may be aroused simply by the mention of the word arsenic (that 'notorious' poison), by the green colour (the traditional colour of poison) and by the occasional appearance of crystals of 'preservative' on freshly treated rounds.

However, arsenic is very widely distributed in all natural ecosystems and is present to some extent in all foods. The United States Federal Drug Administration which is very conservative in such matters allows 2·6 mg per kg in food. As previously stated, arsenic in CCA preservatives is in the relatively less toxic form of arsenates and once fixed in the wood is extremely insoluble. The green colour is due to the presence of copper and chromium and has no relation to arsenic content. The whitish efflorescence of salt on freshly treated poles is composed of harmless by-products of the fixation process and in fact is usually sodium sulphate, which as 'Glauber's salts' has been widely used medicinally.

Although on *a priori* grounds the hazard in children's playgrounds appeared to be negligible, to make doubly sure it was assessed experimentally by R. Johanson and F. A. Dale of the Preservation Group in the Division of Building Research. These workers obtained samples of CCA-treated *Pinus radiata* posts from several sources, scrubbed small areas of the surface repeatedly in water and determined the amounts of arsenic removed by analysis of the water. They concluded that the amounts removed, even by repeated scrubbing, did not constitute any hazard. Tests have also been made by the Industrial Hygiene Branch of the Health Commission of New South Wales.

However, it was concluded that as a precaution installers of playground equipment should ensure that the timber has been treated at least six weeks previously (so that efflorescence of the harmless by-products mentioned will have ceased) and should hose and scrub it thoroughly after erection. (A surface spraying with linseed oil in a suitable solvent has also been suggested but, while this might improve appearance and reduce the amount of 'sun checking', care would have to be taken that the oil did not soil children's clothes or collect dust.) The New South Wales Industrial Hygiene Branch has indicated that it considers timber rounds treated in this way to be without hazard to children who play on them.

In general, it can be seen that the recently expressed doubts about the safety of CCA-treated wood for children's playgrounds are without foundation and this attractive material can be used without danger to children or the environment.

Improving Water Resistance of Paper by Impregnation with Tannin–Formaldehyde

By K. F. Plomley, P. J. Collins and R. E. Palmer, Wood-based Panels Group

The commercial use of tannin–formaldehyde adhesives for the manufacture of exterior plywood and flooring-grade particle board is well established in Australia. Laboratory tests have shown that paper impregnated with tannin, which is then reacted with formaldehyde at elevated temperature to form a resin, has improved water resistance. The degree of improvement depends largely on the kind and proportion of tannin present in the paper and the conditions under which the tannin–formaldehyde reaction is carried out.

Pinus radiata bark extract and commercial wattle and quebracho tannins have been found effective for this purpose. However, the greater reactivity of *P. radiata* extract compared with wattle and quebracho tannins is an advantage.

Single and laminated sheets of paper have been impregnated with tannin in the proportions of 35–90% of the final weight of the sheets by dipping in aqueous or dilute alcoholic solutions containing 20–30% of tannin. Control of pH is desirable for different applications; in various laboratory tests pH has been controlled within the range of 3–8.

Formaldehyde as formalin or hexamine was used as the cross-linking agent in the proportion of approximately 10% of the weight of dry tannin. (This is probably an excess—studies on wattle tannin–formaldehyde wood adhesives indicate an optimum of about 4% formaldehyde.) Formalin may be added to the tannin solution or applied separately but in tests in which radiata and wattle tannins and hexamine were used the hexamine was applied as an aqueous solution to the surface of dry tannin-impregnated paper.

Rate of cure was slower with hexamine than with formaldehyde but the use of hexamine gave the advantages of prolonged storage life (tannin-impregnated paper treated with hexamine was still reactive after 12 months' storage in the air-dry condition) and of control of tannin migration to the paper surface which tends to occur in drying and especially in hot pressing.

Temperatures of 88–150°C have been used in curing the tannin–formaldehyde resin but minimum temperatures for the different tannins have not yet been established.

For paper overlays on exterior particle board and for laminated paper pressures of 1–2 MPa have been used. Minimum pressures have not been established. Tannin-impregnated overlays with formalin or hexamine applied separately before hot pressing were self-bonding. Moisture conditions for hot pressing were less critical with hexamine.

Single sheets of paper with 50% retention of radiata tannin cross-linked with hexamine and bonded to exterior-type particle board showed no significant deterioration after 24-hr immersion in boiling water or 15 months' accelerated weathering in a weatherometer. Laminated paper impregnated with radiata tannin (90% retention) was equally resistant to immersion in boiling water and to accelerated weathering.

In other tests corrugated fibreboard was impregnated with radiata tannin. Solutions of 6–12% of radiata tannin in water adjusted to pH 6·5 with sodium hydroxide were prepared and 10 parts of ethanol per 100 parts of solution and formaldehyde (as formalin) equivalent to 10% of the weight of tannin were added.

Corrugated fibreboard containers were dipped in the solutions, the uptake of solution being *c.* 1½ times the weight of the untreated container. Evaporation of the solvent and cure of tannin–formaldehyde were effected in an oven at 105°C. The containers treated with the more concentrated solutions were distorted and brittle and were probably unsuitable for packaging operations. However, these faults could possibly be overcome by controlling the concentration of the impregnating solution to the minimum required to give adequate water resistance, by making changes in the solution formulation and by pretreating the papers used in the manufacture of the corrugated board.

When tested by soaking in water for 1 hr and by exposure to high humidity (92% R.H.)

for 24 hr, corrugated fibreboard containers which had been dipped in *c.* 6% tannin solution showed improved water resistance compared with untreated containers; the water resistance of containers dipped in 8, 10 and 12% tannin solutions was equivalent to that of wax-impregnated corrugated fibreboard tested under the same conditions.

The authors acknowledge the help of Mr A. W. McKenzie of the Division of Chemical Technology in carrying out water-resistance tests on corrugated fibreboard containers treated with tannin–formaldehyde and in providing material for impregnation.

PARAQUAT-INDUCED RESINOSIS IN *PINUS RADIATA*

By A. A. Sioumis, L. S. Lau and A. J. Watson, Division of Chemical Technology

It has been reported by D. R. Roberts (U.S.D.A. Forest Service Res. Note SE-1911, April 1973) that the amounts of resinous material in *Pinus elliottii* and other related resinous pines can be greatly increased by treating the trees with paraquat. Paraquat is the common name for the 1,1′dimethyl-4,4′bipyridinium ion and is usually supplied as the dichloride. *Pinus elliottii* and the other related southern pines are recognized as commercial resin-producing species, whereas *Pinus radiata*, the pine most widely grown in Australia, contains much smaller amounts of resinous materials. The amounts of these substances present in *Pinus radiata*, especially in young trees with considerable amounts of sapwood, are insufficient to warrant commercial exploitation.

Experiments have been carried out to ascertain whether the application of paraquat will also stimulate the production of resinous compounds in *P. radiata*, especially in trees in the 10–30-year age group.

All the trials have been made using Gramoxone (ICI trade name for a 20% aqueous solution of paraquat). In one, different concentrations of paraquat were applied to a 2·5 by 2·5-cm bark-chipped area and in another, on the same tree, to a 2·5-cm-wide bark-chipped streak covering one-third of the circumference on the opposite side of the tree. In both cases the paraquat was applied to the recently formed layer of wood just under the bark. Other methods of application such as tangential drilling and adding the paraquat to the drill holes have also been used.

The effects of the application of an 8% solution of paraquat to trees of *P. radiata* at 0·5 m above ground level were clearly evident after about 2 months. Oleoresin could be seen bleeding through the bark in the zones above the treatment areas and extended upwards for 3–4 m. After a further 2–3 months the oleoresin bleeding had extended to about 8 m and the resin flow was more copious. Some exuded resin had collected under the tree.

Disks were cut at different heights from the trunk of a 10-yr-old tree felled five months after the application of paraquat. The paraquat-affected zones extended from the treated area to the centre of the tree. The effects were most marked in the zones immediately above the treatment points but were still apparent for several metres up the stem. There was no obvious resin development below the treatment points.

Tests made on wood from the treated zones and on control samples showed that the paraquat had brought about a large increase in the amounts of resinous materials. Substances soluble in petroleum ether showed a 30-fold increase while the steam-volatile fractions in the petroleum ether solubles increased about 100 times. The steam-volatile fraction contained mainly α and β pinene, the latter predominating. The moisture contents of the affected areas were about 20% lower than the controls.

This procedure can increase the resinous materials in *P. radiata* to a level where it might be considered as an economic source for the production of rosin and turpentine. The high percentage of β-pinene in the steam-volatile fraction could be of considerable interest to the perfumery and related industries.

The work so far has been on trees treated for periods of up to five months. The amounts of volatile and non-volatile extractives would likely increase further with longer treatment times.

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Blue 7—New Diffusion Preservative for Control of Decay in Wood

By R. W. R. Muncey, Chief, Division of Building Research

Since there have been a number of enquiries regarding commercial utilization of Blue 7, a copper–fluorine–boron preservative developed in this Division, it is desirable to set out the current position regarding this preservative.

The use of diffusing preservatives to arrest or prevent decay in wood in service is an old practice in Europe and has recently attracted increased attention in Australia. In particular, occasional failure of creosote treatment of the sapwood of large poles to prevent early development of centre rots has been seen as a reason for such treatments for eucalypt poles in Victoria. Mr R. Johanson, of this Division, studied the theoretical and experimental behaviour of complexes of copper, boron and fluorine and developed several formulations with considerable promise as commercial wood preservatives which are low in hazards to the health of operators and the environment. The preparation, properties and potential uses of these have been described in a number of publications (Johanson 1974*a*, *b*; Johanson and Howick 1975). In conformity with the CSIRO policy of protecting its discoveries from being used ineffectually or unwisely, an application for an Australian patent has been lodged.

The copper contents in these preservatives vary considerably in proportion to the fluorine and boron elements. For use in controlling or preventing centre rots in eucalypt poles, Mr Johanson suggested a formulation called Blue 7, an ammoniacal preparation containing approx. 13·5% copper, 8·8% boron and 16·5% fluorine. This is applied to the poles as a heavy thixotropic liquid which is stable and relatively non-toxic to humans. In wet wood, there is a rapid diffusion of some of the fluorine and boron, with a much slower diffusion of copper. The formulation has in fact been 'tailored' to give a slow long-lasting diffusion so that the toxicants will not readily be lost to the soil.

The State Electricity Commission of Victoria has been interested for some years in the use of diffusing preservatives against centre rots and set up field tests on over 100 pole stubs to compare a variety of fungicides, including Blue 7, applied in either an axial hole from the butt to above groundline or oblique holes drilled down from just above groundline. More recently, it decided to move towards the treatment of new poles of Class 3 durability with a diffusion preservative applied in oblique side-bored holes, before air-drying and pressure impregnation of the poles with creosote or other oils. The Commission proposes to use Blue 7 for this purpose and the Division recommended that manufacture and sale to the Commission for this large-scale trial use be approved. There will also be extensive prior use of Blue 7 by the Commission for diffusion treatment of standing poles. This will include sound poles of varying ages and also poles already showing

<< Content

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some decay. Officers of the Division will collaborate in assessments of both the various preservatives in the field test and the Blue 7 in general trial use.

This approval is for a large-scale experimental use of Blue 7. The Division is not at this stage recommending either that new poles in general should be treated with diffusion preservatives or that the Blue 7 formulation should be regarded as a preservative of proven superiority for this and other uses.

The Blue 7 formulation is still in its developmental stage. We need to know more about its effectiveness against the fungi causing centre rots (or rather about the effectiveness of the diffusing compounds, since these will vary with distance from point of application of Blue 7 and with time). We must also know more about diffusion properties over a long period. For this reason, the widespread use of the Blue 7 formulation is not being recommended at present, and its commercial manufacture and sale are being deferred until the evaluation of its effectiveness is more advanced. However, CSIRO is willing to authorize the manufacture of Blue 7 for experimental and trial use, provided these tests are carried out in collaboration with, or are approved by, the Division of Building Research.

Although Blue 7 has been developed mainly for control of centre rots in poles, it is also effective against termites and is being tested for possible use against the soft rot fungi causing deterioration of treated eucalypt sapwood in transmission poles in Queensland. Another important use suggested is for diffusion treatment of building timbers to prevent or arrest decay. For this purpose, it could be applied either to the surface as a highly concentrated brush coating or in wells drilled into the timbers. Any sanctioning of its use in building timber, however, depends on additional tests of its long-term effect on paint systems and on corrosion of fastenings as well as its fungicidal effectiveness.

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Workmanship and the Light Timber Framing Code

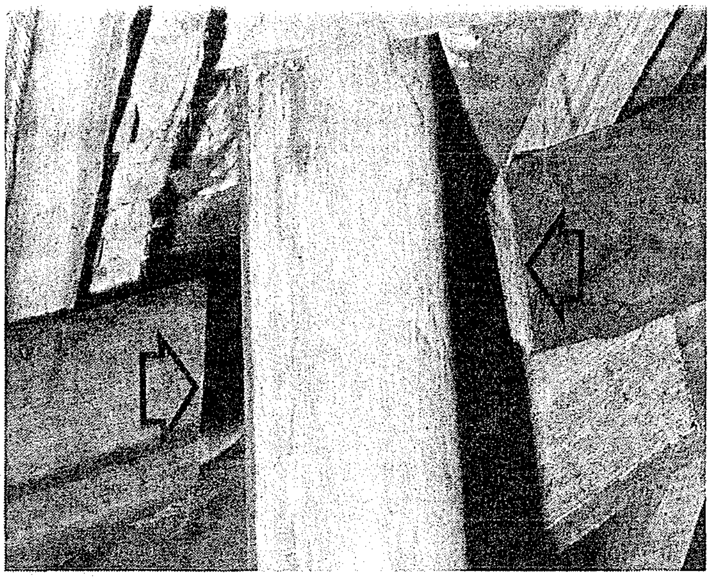
By the Timber and Domestic Structures Group

The third article in this series draws attention to further examples of bad building practice and/or bad workmanship in domestic construction.

Destruction, not Construction

Today, economics dictate that practically every piece of timber, indeed every bit of material, be used in the structure as efficiently as practicable. To this end, every timber member from the stumps to the roofing battens is designed, not over-designed, on engineering principles to provide the framework with a satisfactory structural performance. There is therefore no scope for the virtual destruction or elimination of a member, particularly a principal member, unless adequate structural compensation is provided for its loss. Otherwise, the standard for structural framing set by the Light Timber Framing Code—'. . . to ensure long life and a low level of maintenance . . .'—cannot be met.

Two violations of this principle are illustrated in Figs 17 and 18. The first shows a portion of a rafter removed to allow a chimney flue to pass through the roof. No provision has been made to support the weight of the roof in the vicinity, to perform the function of the rafter before it was rendered



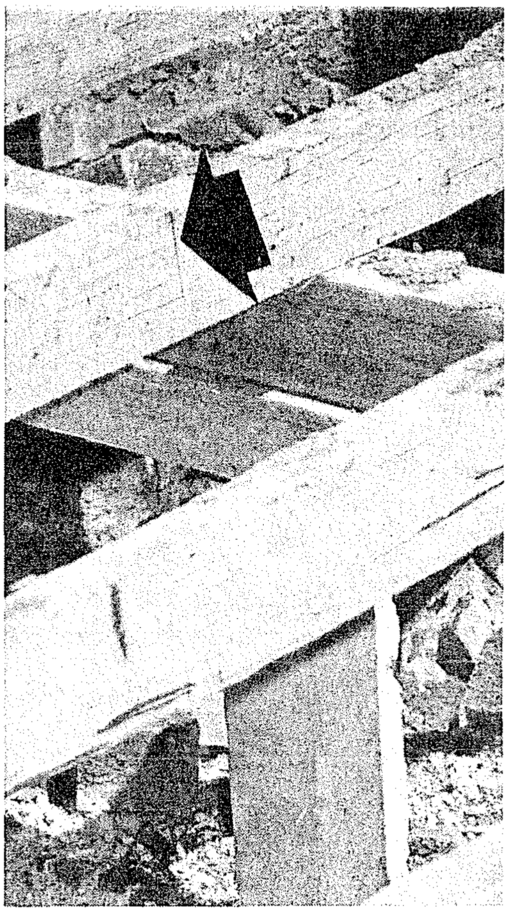


Fig. 17. *Maybe the rafter wasn't needed, anyway!*

Fig. 18 (Right). *The joist is not only crippled, but hasn't a leg to stand on!*

Fig. 19 (Below). *Probably the lining will disguise the fact that the stud not only has a piece missing but is also not sitting in the housing provided for it in the top plate.*

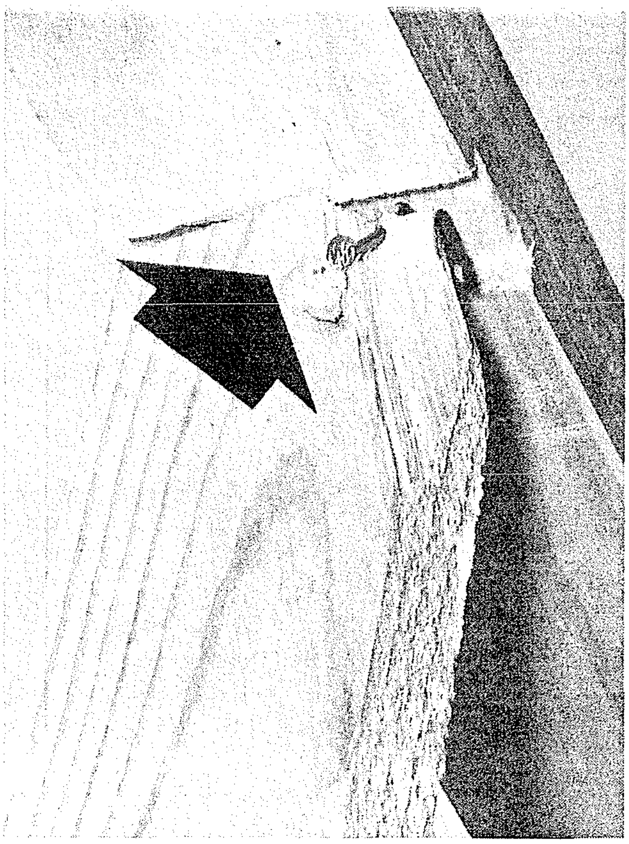
structurally useless. Sag in the tiling battens on either side of the flue and consequent trouble with the flashing are almost inevitable.

The second example shows a floor joist crippled not over a bearer but several inches away. Undue flexibility of the floor in this area is certain, with the distinct possibility that if a heavy piece of furniture or household equipment is placed close to or over this point it will break through the floor, not immediately perhaps but in a fairly short time.

Non-engineering

Shoddy workmanship, as illustrated in Fig. 19, is usually excused on the grounds that 'once it's covered in, you won't notice a thing'. Doubtless this is true in some cases. In others (Fig. 20), the new home owner at first might not notice anything wrong, but in a month or two, or perhaps six, plaster cracks appear and windows and doors jam. By then something else such as timber shrinkage can be blamed for the trouble.

The lintel over a window is a relatively deep member so it can transfer the roof loads to the studs to which it is attached without



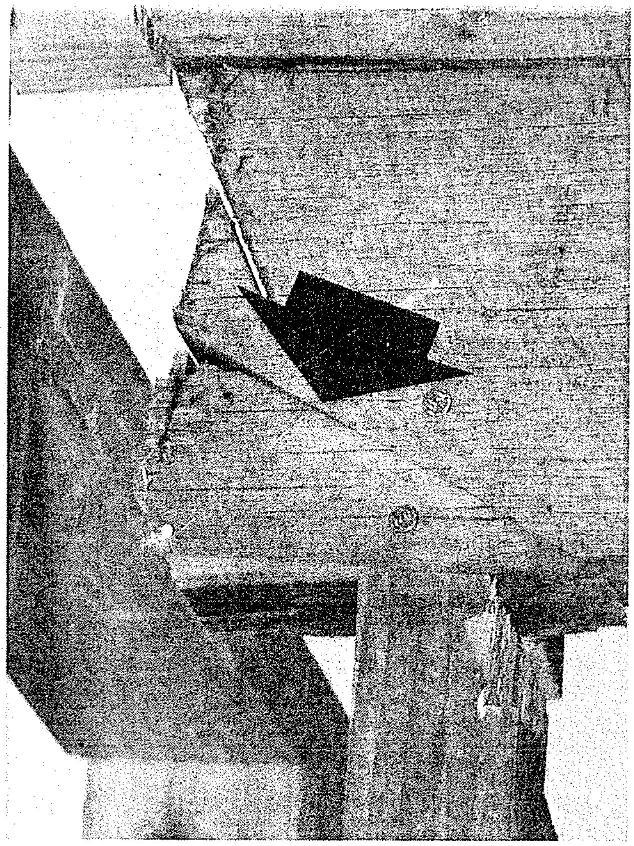


Fig. 20. *If the lintel had been placed the other way up, it would have performed satisfactorily without the shoddy attempt to 'make do'.*

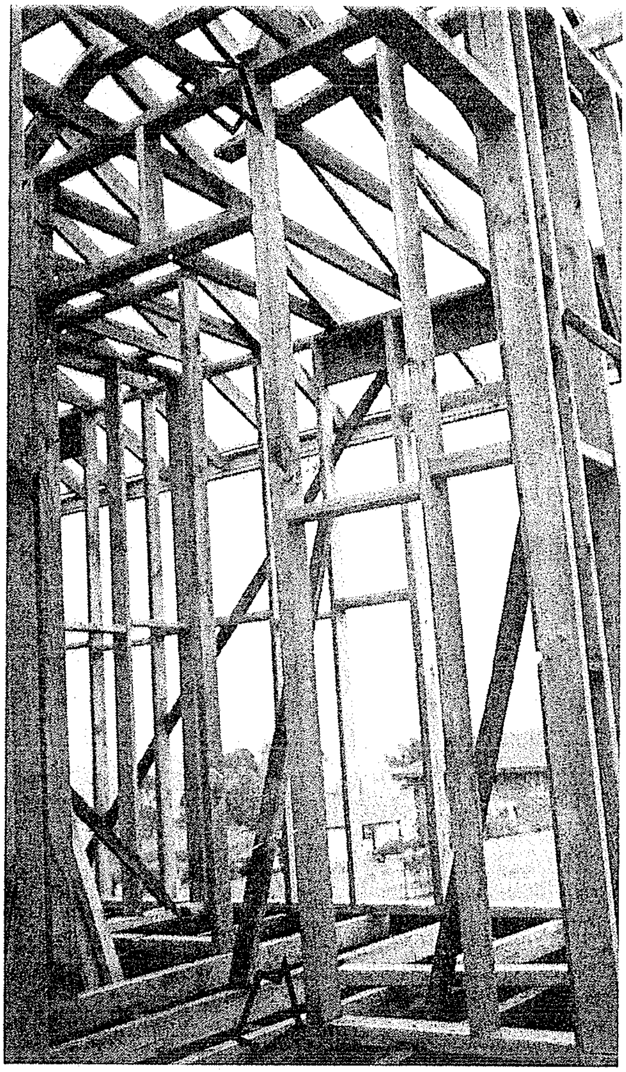


Fig. 21 (Right). *If the door to be fitted here is to operate satisfactorily, it should not be rectangular!*

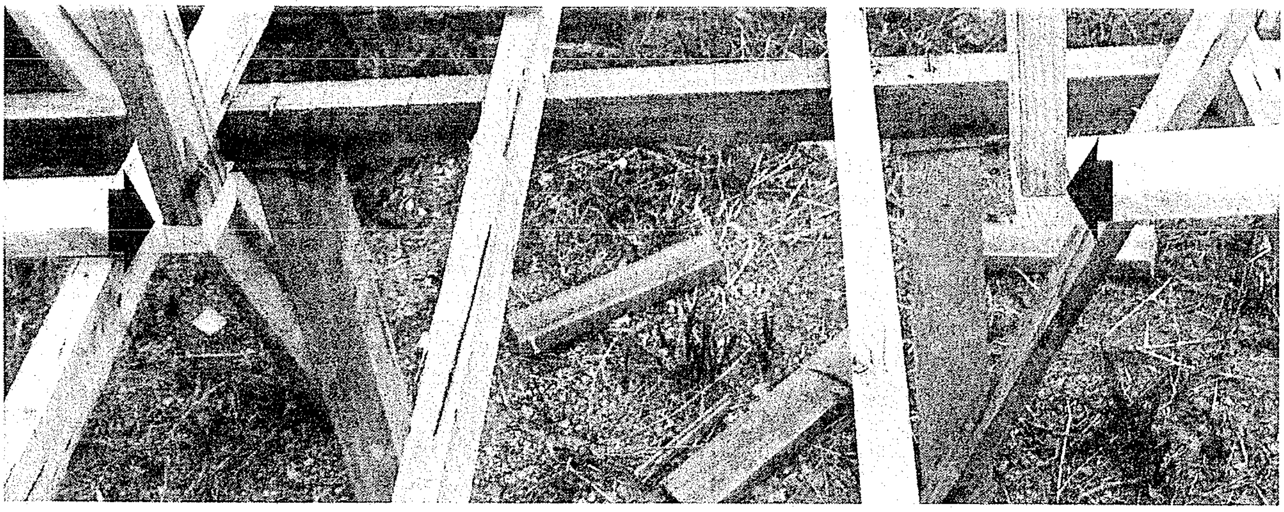


Fig. 22. *A closer view of the doorway construction shown in Fig. 21. The left-hand stud has only its share of the weight of the wall, while the right-hand stud must carry a portion of the roof weight.*

breaking and without an excessive deflection that would otherwise allow it to bear on the window frame. Once the roof load comes onto the top plate over the lintel, as shown in Fig. 20, both the window frame and the plaster lining are likely to show increasing signs of stress.

Similarly, bad building practice can be covered up, but eventually signs of it are manifested by cracks in the plaster or jamming of doors and windows. In the frame shown in Fig. 21, the builder might have got away with the cantilevered bottom plate, but he made the mistake of locating a purlin prop immediately above the stud supported on the end of the cantilever. While the doorway may be filled by a well-hung door when the owner takes delivery, the creep deflection of the bottom plate under the effect of the roof weight will ensure that he has plenty of exercise planing his door every time it jams! Fig. 22, another view of the same construction, shows the other side of the doorway with the bottom plate again cantilevered, but not as far, and supporting a stud that is not as heavily loaded.

THE ASPHALT FOREST

By J. D. Coleman, Division of Chemical Technology

The present world demand for paper is more than 100 million tonnes each year and is rising steadily. It is difficult to appreciate that the odd newspaper, soap packet or banana bag we each toss aside could add up to such a huge total. The pulp needed to manufacture most papers is derived originally from wood and forest is being harvested at a correspondingly high rate to satisfy the requirement. A native eucalypt, for example, 20 m to the crown and 1 m in girth yields only enough pulp for about 1000 average daily newspapers.

Some observers predict that by the 1980s the available forest resources including re-plantings will be hard pressed to meet the demand for pulpwood. Such predictions cannot be made without qualification but there is real and increasing concern about the possible depletion of forest resources. It seems reasonable that a balance can be found between ecological and recreational requirements on the one hand and the demand for products of the forest industries on the other.

The processing side of the pulp and paper industry also presents an environmental problem. Large quantities of process waste must be discharged finally into waterways or the atmosphere. Some of these effluents, such as the characteristic trace odour emanating from a kraft pulp mill, are unpleasant but otherwise harmless to plants or animals. However, quantities of pulping liquors or machine effluents containing organic materials can significantly reduce the dissolved oxygen content of waterways and therefore be deleterious to stream life. In a further category, loss of mercury sometimes occurs from pulp mills producing their own caustic soda and chlorine.

The magnitude of these problems is related to the industry's output. Technologies are being developed to neutralize the various mill effluents and new pulping processes examined to reduce both their volume and initial toxicity. Simultaneously, increasing interest is being shown in utilizing waste papers and 'recycling' the basic wood fibres through the industrial process. The requirement for virgin fibre, and hence the demand on forest resources, is reduced in proportion to the amount of waste fibre reclaimed; thus the more intractable aspects of pollution associated with the pulping stage of paper manufacture are also minimized. At the same time, recycling alleviates the problem of disposing of the ever-increasing volume of waste paper generated in the cities. The city becomes in effect an ever-renewing source of fibre—the asphalt forest—taking its place alongside the natural forest as a source of raw material for papermaking.

The re-use of waste paper has a long history. In 1366, in an attempt to improve their environment, the City Fathers in Venice directed that all used papers be returned to the mills at Treviso. The Danes were recycling in the 17th century and it is believed the Chinese were actually de-inking manuscripts for re-pulping before Columbus set sail for America. In the present context, it is sobering to reflect that had Columbus actually set foot on the northern continent he might have laid claim to more than 1000 million hectares of virtually uninhabited virgin forest, much of it suitable for papermaking. If he were to step ashore tomorrow, his share, per capita, would be less than one hectare!

The recycling process for fibre is very simple in theory, involving no more than the reduction of waste paper to pulp by maceration with water and using the suspension of fibres to form a new paper sheet. However, in practice there are some very formidable problems to be overcome. Firstly, a bewildering assortment of non-fibrous contaminants must be removed from most waste collections. Then the cleaned fibres must be reformed into paper at rates competitive with those obtained with new wood fibres. This is sometimes particularly difficult as wood fibres vary greatly in basic characteristics and behaviour and manufacturers using waste paper cannot always select raw materials for the optimum performance of their mills.

Considerable progress in these areas has been made in recent years. Specialized machines, not unlike giant cake mixers, are used to reduce the waste rapidly to a wet 'papier mâché' form; solid contaminants are then separated out by pressure screening and centrifugal means. Finally, bitumen and waxes are dispersed by steam heating the pulp between rotating grinding plates. The resultant fibres, cleaned and sterile, are re-manufactured into paperboards by specialized forming equipment. These machines lay the fibres down in thin continuous sheets or plies which are then pressed together to build up commercially useful thicknesses. Up to eight layers may be required and perhaps 100 tonnes of water will be drained away in the process of forming 1 tonne of paperboard. In this way manufacture can proceed at high speed, unhindered by the problem of draining away such a large volume of water which otherwise limits attempts to form a useful thickness of reclaimed fibres as a single heavy ply. Frequently several top layers of higher quality pulp are added to enhance the strength and general appearance of the basic waste paper sheet and improve its printing properties.

In other developments, old newspapers and printings are treated chemically to loosen the ink particles which are then flushed away, or literally 'floated' off by attaching them with the aid of special chemicals to small bubbles of air injected into the fibre suspension. More care can be exercised over the quality of the raw material in these de-inking processes and the resultant pulp is quite suitable for use on conventional paper machines. Newsprint, tissues and wrappings of very acceptable quality are being manufactured in this way on an increasing scale.

In the last decade or so the use of waste paper has grown significantly, especially for container and packaging papers. This trend is associated with improvements in the methods of fibre recovery and the development of more suitable paper machines. Before then the consumption of recycled fibre was declining in the face of competition from 'integrated' mills, i.e. mills in which the pulp is both made and converted directly into paper in a continuous low-cost operation.

Recycled fibres now account for more than 20 million tonnes or over 20% of paper manufactured annually. Significantly, much of the impetus and technical innovation in this field has come from countries deficient in natural resources, more particularly Japan, Germany and the U.K., where as much as 40% of paper is recycled. In other developed countries such as the U.S.A. and Australia the amount re-used is lower, perhaps 20–25% of production being derived from waste, although the per capita rate of recycling is still high by comparison.

It is worth noting that Australia is not well endowed with forest and the paper industry has always placed considerable emphasis on re-use. In fact, Australian companies have been leaders in installing the high-capacity retrieval systems and forming machines referred to earlier. In countries where pulpwood is available in what was thought to be unlimited amounts, it may now be necessary to legislate to encourage increased use of waste to prevent over-exploitation.

There is, of course, a limit to the amount of paper that can be recycled. The requirements for many products, tabulating cards and quality printings for instance, are such that recovered fibres are never likely to be satisfactory. Usage in other areas will be restricted by the cost of collection and the amount of fibre finally separated from any given waste. Attempts to recycle fibres from household garbage, for example, are currently being discussed, but studies indicate that it generally contains less than 20% fibre and this may be prohibitively expensive to reclaim. Such material might be better disposed of by incineration to recover heat; keeping the fibre separate from general rubbish in the first place can influence these costs, and educating the public and industry to segregate material is therefore an important aspect of large-scale recycling. The Australian public has a very commendable record in this regard and collectors, usually acting in conjunction with charities and service organizations, have so far been able to obtain adequate supplies.

The Division of Chemical Technology recognizes the importance of recycling the tree and has undertaken the development of techniques to upgrade the quality of products derived from waste papers directly as they are formed on the paper machine.

Experimental Mouldings from *Pinus radiata* Sawmill Residue

By W. E. Hillis, Division of Building Research, A. J. Michell and J. E. Vaughan, Division of Chemical Technology

Sawmill operations in Australia each year generate thousands of tons of *Pinus radiata* bark and sawdust, much of which is disposed of by dumping or incineration. However, mature *P. radiata* bark contains about 20% of condensed tannins which could be extracted and reacted with formaldehyde to give a valuable wood adhesive. Alternatively, the bark could be powdered and moistened and reacted with formaldehyde to give an *in situ* adhesive. If this adhesive could be used to bind sawdust into boards and mouldings in a continuous process, both bark and sawdust could be converted into products of value, thus obviating disposal problems.

Experiments have been conducted with mixtures comprising pine sawdust (0·5–1·5 mm) and powdered bark (< 0·15 mm) sprayed with alkaline solutions to give pH 8 and moisture contents in the range of 15 to 30%. Formaldehyde (2% on bark) was added as paraformaldehyde in the mixtures used for making boards but omitted from those used for the extrusion experiments.

It was found that for well cured boards the mixture needed to have a moisture content of at least 20% and be hot pressed at not less than 5·5 MPa (800 lb/in.^{2}). The boards obtained were as dense as tempered hardboard and showed similar crushing strengths and propensities for absorbing liquid water. The modulus of rupture in bending of the boards was somewhat less than that of standard hardboard, whilst the linear swelling with changes in relative humidity was inferior to that of both standard and tempered hardboard. Some improvement in this property was achieved by the addition of small amounts of glass fibre to the mixture before pressing. The press cycle, which was chosen to avoid the problem of splitting at the highest moisture content, would be too long for commercial operation. Further research at a fixed moisture content might yield a more commercially acceptable cycle.

Channel sections, having good appearance, were moulded in a die under similar conditions to the boards above. However, values obtained for the bending moments of these sections were only about half of those expected. This loss of property has not arisen from failure of the material to transmit load, as thicker rectangular sections were pressed quite satisfactorily, but probably arises from the limited flow properties of the mixture that was pressed.

In the extrusion experiments up to 30 cm of material was extruded successfully before a break occurred, and this was accompanied by a release of steam. The flow of material was not re-established readily following a break owing to it sticking in the die and eventually blocking the screw. The addition of polyethylene glycols and waxes before extrusion did not overcome the problem.

The experiments show that mixtures of finely divided bark and sawdust of *P. radiata* can be moulded into simple shapes but an additive is needed to promote flow. The mixtures, in the absence of formaldehyde, can be extruded with difficulty but adequate venting would be imperative for continuous operation.

Full details have been published in Technical Paper No. 3 (1975) of the Division of Chemical Technology, CSIRO, P.O. Box 310, South Melbourne, Vic. 3205.

Error in Light Timber Framing Tables

The Standards Association of Australia advises that there is an error in one table in several of the Supplements issued to the revised SAA Light Timber Framing Code, AS 1684. The table concerned is 6 (S), Studs at Sides of Openings, in which the headings 'Tiled roofing' and 'Sheet roofing' have been transposed. 'Sheet roofing' should head the first group of columns and 'Tiled roofing' the second group, as in the other tables in the Supplements.

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