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The Giant Northern Termite — *Mastotermes darwiniensis*

By C. D. Howick, Preservation Group

Mastotermes darwiniensis Froggatt has greater powers of destruction than any other termite in Australia. However, because of its northern distribution, the total economic damage caused by its attack has frequently been exceeded by that of less voracious species which occur in the more populous parts of the continent.

In recent years, the possibility of introducing plantation trees to northern areas has depended on solving the problem of *Mastotermes* attack in seedlings. Furthermore, increasing settlement of the more remote areas and particularly the development and exploitation of the vast mineral resources of northern and north-western Australia have brought about a closer confrontation with *Mastotermes* and a new realization of the hazard it poses to susceptible materials.

Whilst the infestation of buildings and urban structures by *Mastotermes* has often been an unfortunate penalty of tropical settlement, modern building practices and an increased awareness of the problem have minimized serious losses. Although the destructive potential of *Mastotermes* should never be underrated, there is no doubt that it can be reduced to minor proportions in developed areas if modern technology is properly applied. This includes foresight, careful planning, building practices designed to defeat a persistent subterranean termite, the use of insecticides and preservatives for the treatment of soil and wood and a careful consideration of the environmental impact of effective chemicals.

The more conventional methods used in the protection of buildings are less readily applied to other structures and materials, e.g. wooden sleepers in iron-ore railway lines that stretch for miles through country where man is scarce but *Mastotermes* is abundant. Such situations require special investigation and some trial-and-error may be necessary to obtain effective control at the lowest cost, with complete environmental safety. It has therefore become increasingly apparent that the susceptibility of materials to *Mastotermes* and the efficacy of insecticides and preservatives used to protect them against the insect are of particular importance. Equally, thorough knowledge and understanding of the habits and behaviour of the species are necessary before recommendations for protection of materials and structures can be determined.

Some Biological Features of *Mastotermes*

Origins

The time or place of the origin of *Mastotermes* is not known, but the distribution of fossil species indicates that the genus was widespread by early Tertiary times and did not necessarily originate in Australia. Despite the fact that fossil species have been found in Europe, Asia and the Americas, *Mastotermes darwiniensis* is the one Australian species and the only survivor of its family in the world.

Although it may not be the most primitive living termite, it is interesting that as a single, abundant species *Mastotermes* has survived in tropical Australia where it co-exists and competes for food with a large fauna of advanced, tropical termites.

Distribution

Mastotermes is found north of the tropic of Capricorn in both coastal and inland localities, with a few records marginally south of the tropic. Within this limit it has a rather patchy distribution, occurring neither in rain forest nor in those high rainfall areas that once carried extensive rain forest. It is also absent from the extensive bauxite soils of Cape York Peninsula. The species is, however, sporadically abundant in areas of vegetation from which it has spread to localities where food, in the form of susceptible material, has been introduced by man.

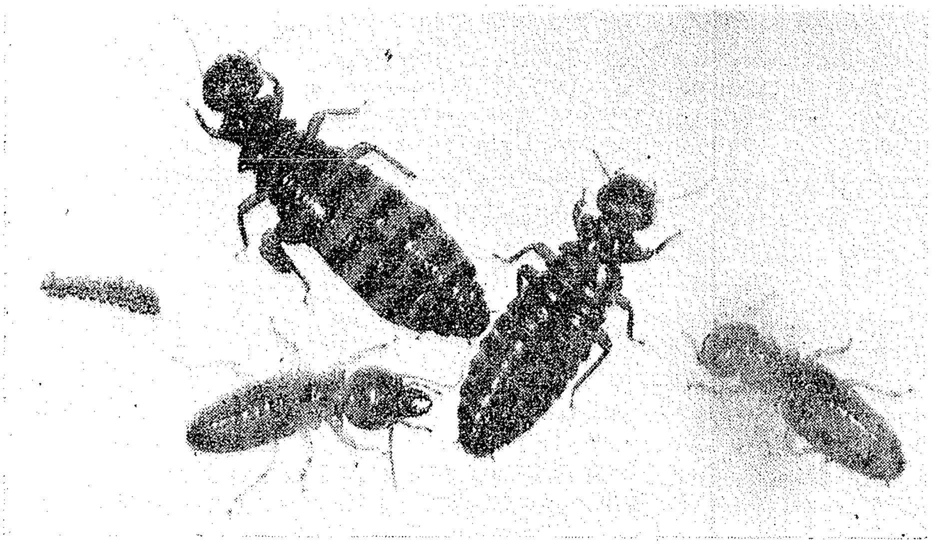
Materials Attacked

Mastotermes is as omniverous as it is destructive. It is a voracious wood-eater and attacks a wide range of species of timber in service as well as living trees, shrubs and vegetables. It has also been recorded as feeding on or damaging plastic cables, sugar cane, cow-dung pads, paper, leather, hides, wool, corn, ivory, hay, flour, bagged salt, bitumen, rubber, ebonite and even lead and billiard balls! It is doubtful whether any other termite species approaches *Mastotermes* in severity of attack.

Colony Structure and Nesting Habits

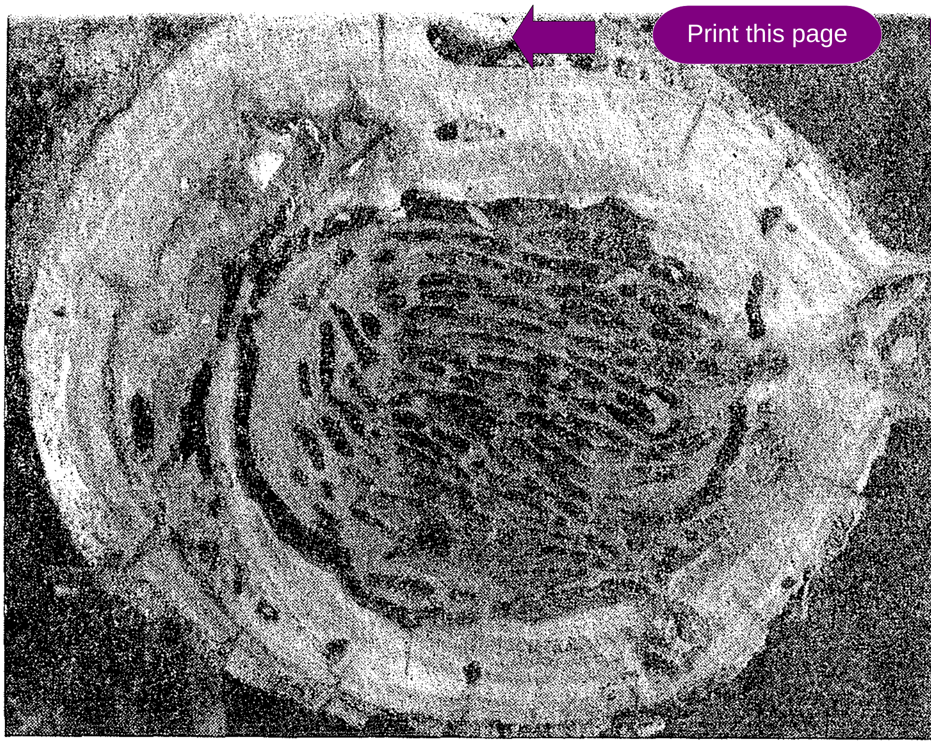
Like other species of termites, *Mastotermes* is a social insect, living in colonies that vary in size from a few individuals to several hundreds of thousands. It does not build mounds but nests in the trunks of living or dead trees, in stumps or logs or in root systems below the ground. Although the caste system is somewhat different from that of more advanced termites, there are soldiers and reproductives in the *Mastotermes* colony and "worker" duties such as feeding, foraging and building are carried out by a so-called "pseudergate" caste. At an early stage of their development, these "pseudergates" may change into nymphs which eventually develop into the winged "alates" that fly away to form new colonies as primary reproductives. Under suitable conditions, certain pseudergates also have the ability to develop into "neotenics" or supplementary, wingless reproductives without necessarily leaving the main colony or those areas and materials infested by individuals from the original colony. Thus, colonies are often headed by numerous secondary reproductives, enhancing their ability to increase populations rapidly in the presence of abundant food supplies.

The rarity of primary reproductives and the prevalence of relatively small colonies containing supplementary queens suggest that in this species new colonies are formed most commonly by a process of "budding off" from parent colonies. It can be seen, therefore, that although the total colonial system is very populous under favourable conditions its extent is variable according to availability of food. The "budding off" approach also enables subcolonies to spread gradually from the original colony to increasingly widespread



Mastotermes *castes showing eggs* (left), *female and male secondary reproductives* (centre), *soldier* (below), *and pseudergate* (right).

Photo: Division of Entomology



Section of tree trunk infested by Mastotermes.

Photo: Division of Entomology

food sources. It is therefore probable that the adaptability of *Mastotermes* might create an unfortunate situation for Australia's developers. Where areas of sparse vegetation which have supported small numbers of the termite for very many years are linked by iron-ore lines containing susceptible rail sleepers, subcolonies of *Mastotermes* may be formed to take advantage of the new food source. Having thus developed, they may be forced to attack material they do not normally infest in the presence of alternative or preferred food.

Current Laboratory Studies

Experience with *Mastotermes* under field conditions has shown that large numbers of individuals can be obtained by systematically splitting infested trees, poles or posts and extracting termites from the wood. By severing those roots of infested trees that are fairly close to the surface and then pulling over the tree, termites attacking the root system below ground are exposed and those within the tree are isolated from escape.

In recent years, termites collected in this way have been used for laboratory studies of the biology, physiology and development of *Mastotermes* by the CSIRO Division of Entomology, and for the development of a reproducible standard laboratory bio-assay technique by the Division of Building Research.

Although laboratory maintenance and preservative assessments with other species of termites have been well established in Australia for many years, the early attempts with *Mastotermes* showed little promise and were not pursued. The only successful maintenance of *Mastotermes* under laboratory conditions for extended periods had previously been by imitation and replication of field conditions, where entire or partial colonies within a tree or pole were transported in large metal containers and maintained virtually undisturbed in an approximation of their natural environment.

Laboratory studies of such aspects as the optimum temperature, humidity and food preferences of *Mastotermes* have now resulted in the establishment of techniques whereby large numbers of field-collected individuals can be maintained in the laboratory for considerable periods. This stock is used in assessment programmes to determine the

Laboratory jar colony (below) *showing* Mastotermes *attacking test specimen.*

degree of susceptibility of certain materials to *Mastotermes* and the efficacy of various insecticides and preservatives used in their protection. This information, together with that obtained from field trials of preservative formulations and processes applied to rail sleepers, poles and other experimental material exposed to natural *Mastotermes* attack, forms the basis of recommendations made by the Division of Building Research to those who wish to share the land of the giant northern termite.

A WARNING—OR TWO!

By H. Kloot, Timber and Domestic Structures Group

The increasing use by the timber and building industries of more up-to-date technology in relation to timber and timber fastenings is both welcome and encouraging to those of us who have worked for many years to develop this technology. However, as in any other field, there are dangers if these modern techniques are applied with ignorance or with an inadequate appreciation of their significance.

Within 24 hours, two cases were brought to notice in which a lack of understanding could render the techniques potentially dangerous. These cases are discussed here, not because either is of outstanding importance in the overall picture but in order to draw attention to the need for proper understanding to avoid the possibility of bad performances, which almost inevitably lead to a technique being blamed rather than its method of application.

(1) Stress Grading of Finger-jointed Material

The mechanical stress grading of finger-jointed structural timber does not itself prove that the finger-joints are structurally sound.

When a piece of timber is passed through a mechanical grader a load is applied to it and the piece is classified into a stress grade according to the amount it deflects under this load. The applied load is relatively low, and is not high enough to establish that any finger-joints in the piece are of adequate strength. As a matter of interest, in the U.S.A., the mechanical grader was originally developed for proving the structural adequacy of finger-jointed material and proved a failure for this specific purpose. Later, of course, the procedure was applied to timber not containing finger-joints and its success in this field is now well known.

The mechanical grading of finger-jointed material can only be used with safety if, either every finger-joint is independently proof tested by some other technique or the finger-joints are subject to a quality control procedure similar to that set out in AS 1491-1973. The mechanical grading is not itself a quality control procedure for finger-joints.

(2) Metal Framing Anchors

Various metal fasteners, ranging from a simple strap of galvanized hoop-iron to patented types of framing anchors, are being increasingly used, particularly as the need for holding down roofs against wind uplift is more widely recognized. Strangely, however, there appears to be some lack of appreciation that the performance of these anchors is dependent not only on the number of nails used in fastening them in place but also on how they are used.

For example, in tying a top-plate to a stud, there is nothing to be gained by driving five nails through the anchor into the top-plate if only three are driven into the stud. The performance of the anchor in this case depends on the three nails in the stud not the five in the plate, nor on the fact that a total of eight nails has been used.

Of course, to use only one or two nails as though there were some magical fastening power in the anchor itself would be too absurd to contemplate, except that it sometimes happens!

There is only one way in which these anchors should be fastened, and that is strictly in accordance with the manufacturer's specification. Generally, unless specified otherwise, there should be a minimum of four nails driven into each timber member to which the anchor is to be connected. When in doubt, use more nails rather than less!

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Workmanship and the Light Timber Framing Code

By the Timber and Domestic Structures Group

'Workmanship shall be of a quality equal to good standard practice...'. This statement, or something rather like it, appears in virtually all house building specifications. What constitutes 'good standard practice' is seldom, if ever, defined. To a large extent, AS CA38, 'Code of Recommended Practice for Construction in Light Timber Framing', fills this gap. According to its scope clause, 'the Code provides rules for the selection, placement and fixing of the various structural timber members..., and describes procedures which are designed to prevent misuse of timber...'.

In the last analysis, however, the onus falls almost entirely on the building inspector to detect gross departures from good building practice or good quality workmanship. There is ample evidence that he does not always succeed in this.

Of the several reasons for bad practices being overlooked, three might be mentioned. Firstly, limited time on a particular job precludes the inspector from making a detailed inspection. Secondly, unless a practice is blatantly bad, the inspector, because of legal implications, is loth to insist on the removal and reconstruction of part or all of a structure. Thirdly, there are situations where the building inspector may himself be unaware of the structural significance of a departure from good practice.

What is Bad Workmanship?

Whilst a distinction could be made between quality of building practice and quality of workmanship, such a distinction serves little useful purpose as in the final analysis the long-term satisfactory performance of the total structure is the real consideration. Hence bad practice can be defined as any procedure in construction which significantly reduces the capacity of part or all of the structure under normal service conditions to perform, and continue to perform throughout its expected life, according to the design requirements.

In a conventionally framed house, most of the members such as the bearers, joists and rafters act as beams, and the studs as beam-columns. These members are designed according to engineering principles in establishing the maximum spans for given timber sizes as set out in the Light Timber Framing Code. In applying these principles, it is assumed that a piece of timber is not reduced in size, for example by notching, below that allowed in the Code and that members acting as beams are, in fact, adequately supported as beams. These assumptions can be readily realized in practice, but if because of poor workmanship or bad building practice, they are *not*, then individual members or groups of members cannot be expected to reach the performance standard of long life and the low level of maintenance which the Light Timber Framing Code aims to achieve.

Examples

In relatively few field inspections, officers of the Division of Building Research have observed many examples of bad practice at all levels in the framed structure, i.e. from the subfloor system to the roof timbering. This article is the first of a proposed series in which attention will be drawn to such practices. Reasons for considering them undesirable or just plain bad will be given.

The Barap Tie

The so-called Barap tie is now commonly employed as an effective means of increasing the strength and stiffness of a timber member such as a hip rafter when used over a rather large span. This tie is basically a steel rod fastened to each end of the timber member and propped away from it with a strut (Fig. 1). The principle on which the Barap tie operates is by no means new and is well known to engineers as the king or queen post truss. When the truss is under load, the tie is stressed in tension and the whole structural unit becomes equivalent to a beam much deeper than the actual timber member used.

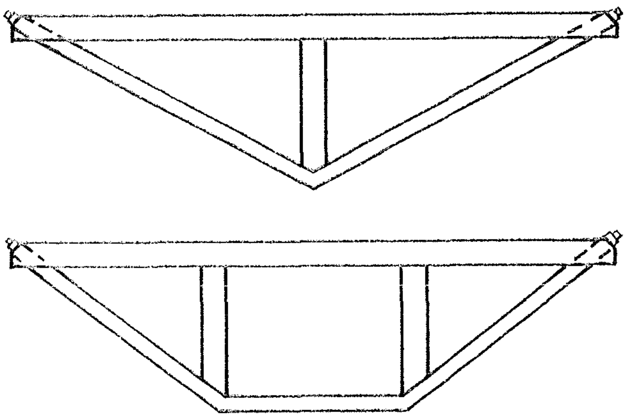


Fig. 1. *Use of the Barap tie to stiffen and strengthen a hip rafter. Trussed beam with king post (top) and with queen post (below)*

Fig. 2 illustrates a Barap tie fitted to a hip rafter, the strut being comprised of two small timber offcuts bearing on two underpurlins which, in turn, are nailed to the hip rafter. For practical purposes, the tie, as applied in this case, is absolutely useless. Between the steel rod and the hip rafter there is approximately 200 mm of side grain green timber. Even allowing a conservative 5% for shrinkage, the intended strut will shrink 10 mm. This will have the effect of completely unloading the steel tie so that the hip rafter itself will have to carry the full load. Obviously it is too small to do this for otherwise a Barap tie would not have been fitted in the first place, and so the rafter will eventually sag well beyond the limits allowed for this type of member.

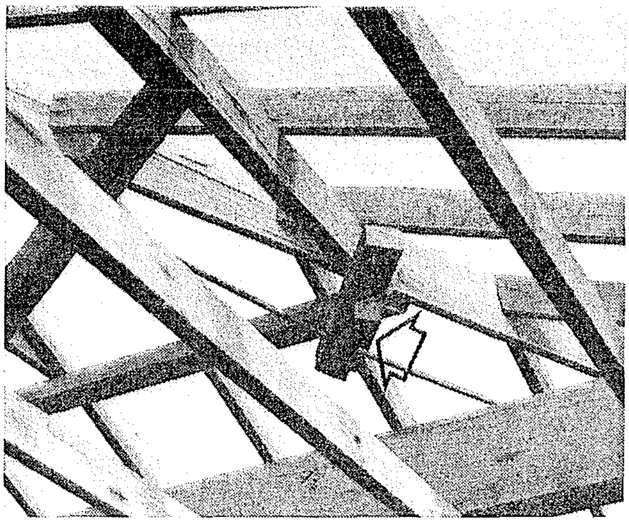


Fig. 2. *Green timber used on its edge as a prop for a Barap tie means that the tie becomes useless as the timber shrinks.*

Fig. 3 shows another such installation, only in this instance a steel prop has been used.

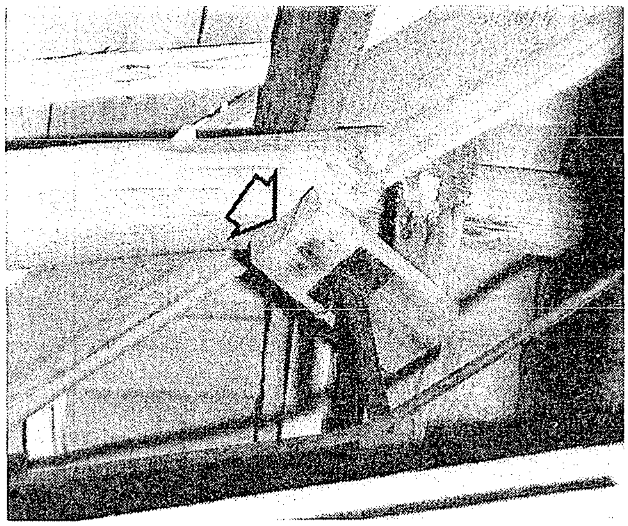


Fig. 3. *The steel prop goes part of the way towards making the Barap tie effective. Shrinkage of the packing piece, however, will tend to reduce the tie's effectiveness.*

Unfortunately, this prop is bearing on the side grain of a packing piece which, in turn, is bearing on two underpurlins. Here again, shrinkage will tend to unload the steel tie, although not quite to the same extent as in the previous example.

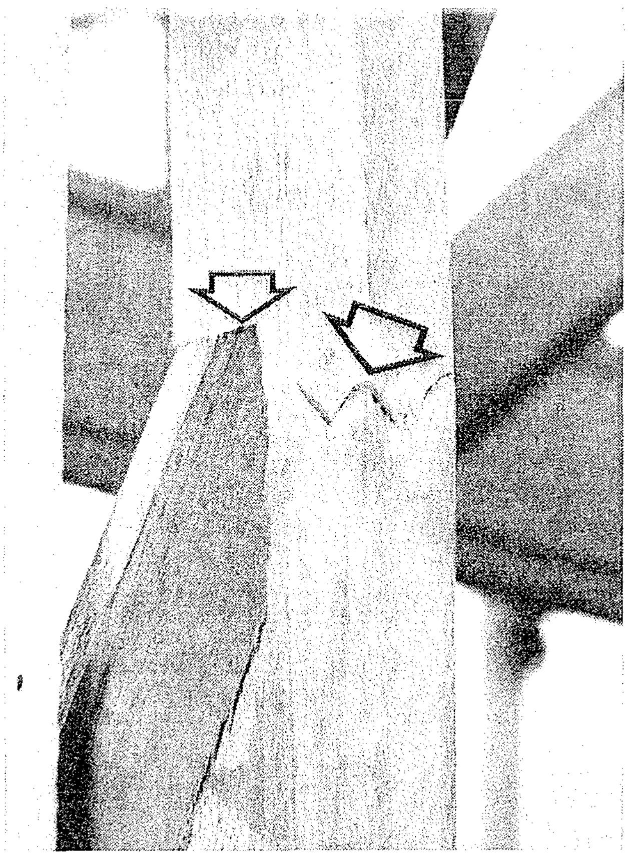
For a Barap tie to be fully effective, the strut should be of steel as in Fig. 3 or a piece of timber *loaded on end grain*. Moreover, the top end of the strut should bear directly on to the timber member to which the tie has been fitted.

Notching for Braces

A stud, particularly in the outer wall, has to carry its share of the roof weight as well as resist horizontal wind forces even when the structure is clad with brick veneer. Yet in spite of its importance, the stud is probably the most abused of all of the structural members.

Notches decrease the strength of studs and to some degree their stiffness, the decrease being greatest when the notch is near the centre of the height of the stud. In preparing the tables for notched studs in the Light Timber Framing Code, an allowance was made for loss of strength in a stud when the notch was no more than 5 mm deeper than the specified thickness of the brace.

Fig. 4. *General notch in a stud. Note also failure of the stud at the knot cluster.*



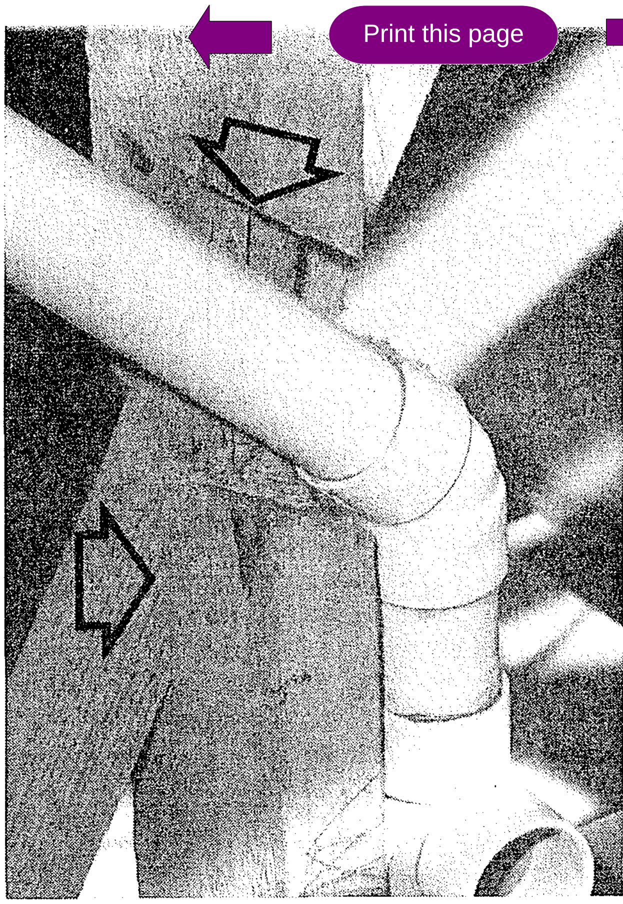


Fig. 5. *This might suit the plumber, but the stud's effectiveness as a roof support is almost negligible.*

Fig. 4 shows a notch cut into a pine stud to a depth nearly twice the thickness of the brace. Furthermore, it can be seen that the stud has actually broken at a knot cluster immediately at the back of the notch. As a load-carrying member, this stud will be totally ineffective. The performance of the stud shown in Fig. 5 would be well below that for which it has been designed after the plumber has provided himself with a notch immediately behind that carrying the timber brace.

In Fig. 6 the notch is longer than necessary and, although not clearly defined in the photograph, the initial sawcuts made to allow the timber to be removed for the notch are substantially deeper than required. This latter example of bad workmanship is well illustrated in Fig. 7.

If the overcutting or overnotching occurred once or twice by accident in a whole house frame, the overall effect would not be serious. However, it usually happens that if one stud is overcut or overnotched, practically all the studs are similarly abused. This is a clear case of bad workmanship.

Even with frames constructed in accordance with Pamphlet No. 112, bad workmanship is critical. While this pamphlet recommends larger sizes for some members than those

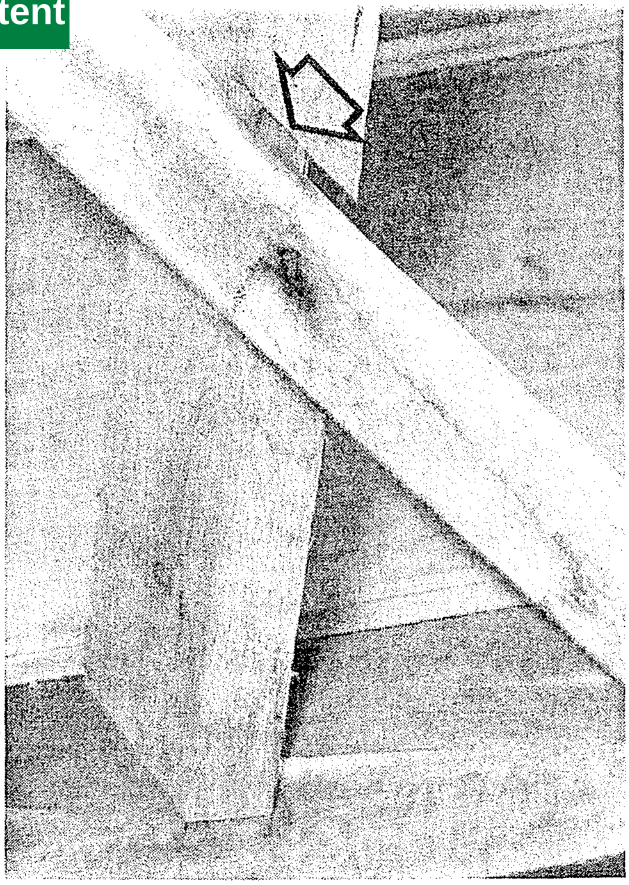


Fig. 6. *This stud's strength and stiffness has been seriously reduced by excessive and unnecessary notching.*

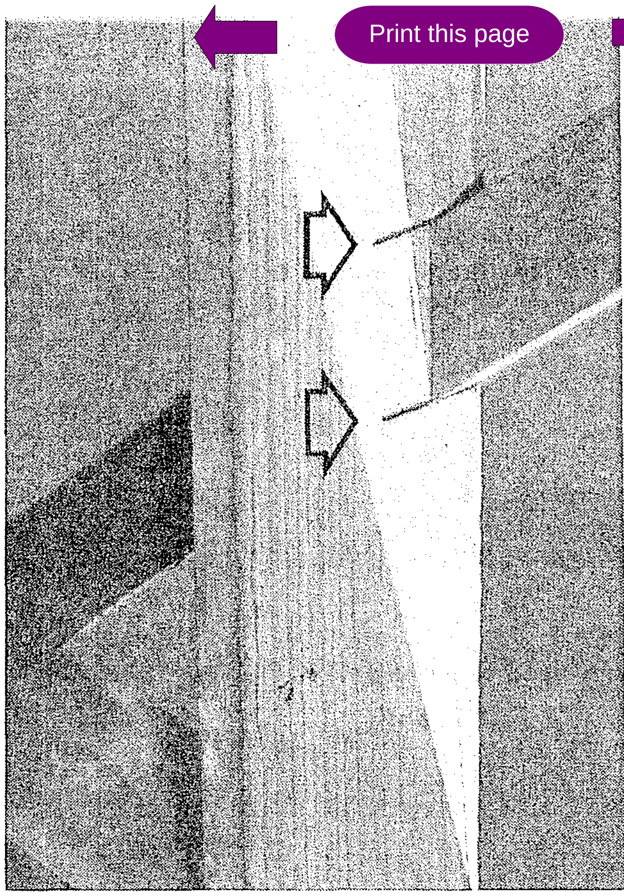


Fig. 7. *Another example of bad notching.*

allowed in AS CA38, this is no safeguard against poor workmanship. In fact, the larger sizes may give the ill-informed builder a misplaced sense of security when he comes to cutting notches, drilling holes etc. in studs and other members. It is of interest to note that whereas P112 has no provisions to control quality of workmanship, AS CA38 has such provisions, including allowable depth of notches and sizes of drilled holes.

(*To be continued*)

Building Research and the Urban Environment

By W. R. Finighan and F. A. Worsley, Urban Environment Group

Recently the CSIRO Executive announced that it intended to encourage the expansion of research into the structure of the built environment and its effect on the life style of the individual, family and community. In line with this decision the work of the Remote Communities Environment Group, which has been operating for some time within the Division of Building Research, is now being paralleled and complemented by an Urban Environment Group. This new group, as its name suggests, will be active in the urban community investigating the likely effects of the various forms of human habitats on the well-being of the residents and the community as a whole. Its program will include investigations into the structural and design variables which are thought to be associated with physical and mental health and the possible development of social malaise in some parts of the community. These disorders are associated with most highly developed countries and Australia is rapidly approaching the stage where serious, widespread, social problems can be expected.

Data collected in the last Australian census showed that in 1971 Australia had about 63% of its population living in the six capital cities. This puts us among the most highly urbanized countries in the world and the indications are that this trend will continue. For example, in 1901 the population of the Melbourne Statistical Division made up 45% of the Victorian total. This had risen to 65% in 1954, 69% in 1966 and 71% in 1971.

Big changes have occurred in the demographic distribution under the impact of immigration from overseas, from farming areas and from rural and provincial centres. As the urban population has increased so have problems concerning community services such as water supply, sewerage disposal, road and rail transport, employment opportunities and so on. Although the lower income groups still tend to be found in the inner suburbs and in areas associated with large labour-intensive industrial complexes, the increasing prosperity of the middle income group has resulted in greatly increased mobility which has extended its choice of living sites.

At the same time a new wave of property revaluation has developed in the inner suburbs. Large numbers of small old houses are being demolished and the sites being aggregated to allow for two and three storey, and more recently, multistorey flat development. In the process, kinship and neighbourhood networks become dislocated and broken so that many people feel alienated from the community in which they live or have resettled. A sense of being part of the community is lost and in some instances this is believed to result in mental and physical ill-health and lack of participation or interest in community and family affairs.

While it seems very likely that the inner suburban problem will continue and perhaps worsen as public and private redevelopment of these areas continues, there is also considerable evidence to suggest that alienation and loneliness are also becoming serious problems in the middle class suburbs, particularly among housewives in the 40–50 age group.

For many years urban sociologists and others have been saying that some of the symptoms of social malaise and disorder could possibly be related to the physical characteristics of the environment such as residential density, population density, community amenities and services and so on. While many subjective descriptions of the possible influence of the built environment on well-being can be found, surprisingly few empirical studies have been made.

In part this is because the study of urban problems presents difficulties quite unknown in the physical sciences. Although the basic unit can be considered to be the individual, each person has a number of social roles and his reactions to the various social environments which make up his existence, e.g. home, leisure, work, etc. can be very different. One situation which is common to most people is that of being a member of a kinship network, usually based on the two-parent family and one or more children. Within this network an individual could well be simultaneously, a son, a father, and a grandfather, with all the differences that this implies. This situation contains in essence all the basic components of human interaction. It provides the individual with the outline of the social structure in which he will spend his life.

One of the consequences of our increasing urban population density is the problem of providing enough space for each person to achieve his own preferred life style. This applies equally to private space, as for example, in the home, as it does to public spaces such as in the trains or trams, in shops or in sports grounds. The concept of private or personal space is of course related to each individual's own personality needs. One person may prefer a room entirely to himself at home, but not mind at all standing in a closely packed crowd watching football for two or three hours.

Ideally, each person should have opportunities to organize and modify his personal space and to form a tolerable relationship to the public space in which he travels and works. This will in turn provide opportunities for meaningful social contacts as well as for privacy and solitude as desired.

The need for privacy obviously has an important bearing on the design of the house, how the internal space is arranged and used and what type of additional shielding is obtained from fences, hedges, trees, blinds and curtains. Within the family environment the form and degree of privacy given and required may vary widely between the sexes and age groups. Even a simple procedure such as the use of the bathroom requires fairly precise planning if conflict is to be avoided.

On a broader front the location of a dwelling with respect to the road, the next door neighbours, community services, and so on greatly affects opportunities for meeting other people and hence the number of contacts and links established.

At the outset it may seem a simple matter to develop an understanding of what people mean by widely used terms such as privacy, loneliness, friendliness, overcrowding, and high density. In practice it is quite a difficult procedure because these are subjective variables which can represent a variety of attitudes and opinions. Even to reach a consensus on what range of concepts are commonly associated with a single social characteristic requires extensive investigation. For example, in a recent scout study on the meaning of privacy the respondents produced a wide range of concepts and opinions, many of which they equated with freedom.

Obviously, it is necessary to know more about these basic ideas before any systematic study of the influence of the built environment on the life style of the individual can be successful.

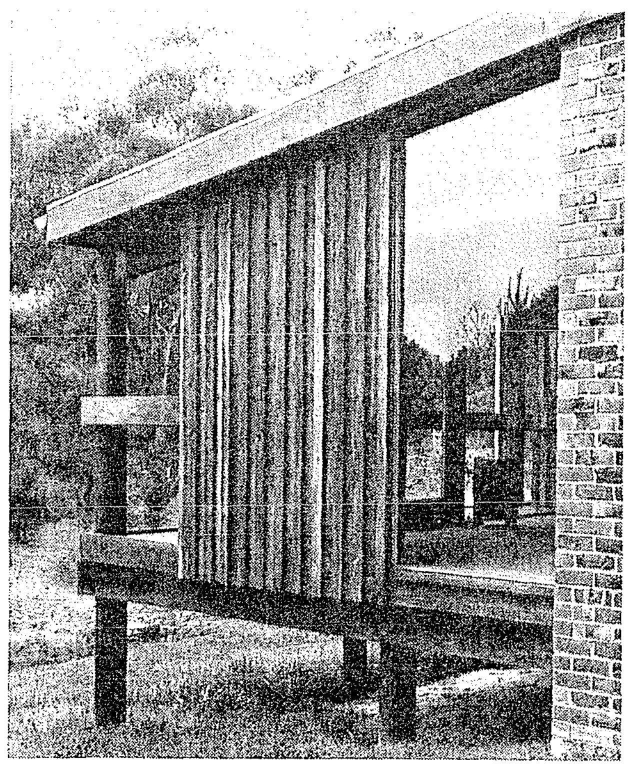
Timber Supports for Houses

By F. A. Dale, Preservation Group

Since Australia was first colonized, timber stumps or piles set in the ground have been used to support the wooden floors of houses. They were cheap and easy to handle where and while highly durable timbers to ensure long life were readily available. In the tropics particularly, there are considerable advantages in raising a house off the ground to avoid floods and vermin, and to improve ventilation and drainage. Timber piles or piers were the most common choice in many areas.

Over the last 50 years this situation has changed. Durable timbers have become scarce in many places and concrete stumps have provided an alternative. Slab on ground construction has also been introduced, although it has not proved as popular as was first predicted. Accordingly, suspended wooden floors will be with us for a long time, no matter how they are supported.

Now a new trend has appeared. *Preservative-treated* timber is being increasingly used for house supports under holiday homes and in better class suburban houses where exposed timber in the form of carports, patios and pergolas is so popular. On steeply sloping sites treated poles make ideal sup-



Treated poles make a cheap, attractive and very efficient support for an elevated building.

ports which can be easily handled by the ordinary builder. As a result, the Division of Building Research has received many enquiries from architects, building surveyors and intending home buyers concerning the durability of treated timber. This article sets out basic rules which should be followed if preservative-treated timber supports are to give satisfactory service. The first question to be answered is how long should a wooden stump or supporting pole be expected to last?

In Victoria, red gum (*Eucalyptus camaldulensis*) house stumps, 100 mm × 100 mm (4 in. × 4 in.) were the standard, but their use has declined considerably in recent years. A survey* by this Division in 1955 showed that the average life of a red gum stump in the Melbourne area was about 39 years, but failure of isolated stumps under a house could occur in as little as 15 years because of variation in natural durability or hazard in service. Red gum is still preferred for re-blocking old houses, but its use under new houses can only be justified if a life of not more than 40 years is required.

Now that houses are being built on treated timber supports, their owners must be satisfied that these will not require premature replacement, and they reasonably expect their houses to be safely supported for at least 50 years. This assurance can only be given if suitable timbers, deeply penetrated with high preservative loadings, are specified.

The ideal stump or pier is a natural round timber with a wide, heavily treated sapwood band. Hardwoods of high natural durability (classes 1 and 2) with at least 19 mm (3/4 in.) of sapwood, or radiata pine or other softwood with not less than 25 mm (1 in.) of sapwood can give this life *if the sapwood is completely penetrated and heavily treated.*

Minimum retention of preservative should be as specified in the forthcoming Australian Standard 0113 'Preservative Treatment of Sawn Timber and Plywood'. For house stumps this requires complete penetration of the sapwood and a minimum retention for each charge of timber treated of 240 kg/m^3 (15 lb/ft^3) of creosote or 20 kg/m^3 (1·25 lb/ft^3) of Tanalith C or its equivalent in the treated zone.

* A. P. Wymond (1955). A survey of the service life and causes of failure of wooden house stumps in Melbourne. Unpublished report.

Hardwoods of lower durability (class 3) may be used under the same conditions as radiata pine, with some reservations regarding their ultimate life. Because of the risk of splitting and exposure of untreated heartwood, the treated sapwood should comprise at least one-third and preferably one-half of the total cross section, when even total failure of the untreated heartwood should not affect the safety of the building. Also, some hardwoods develop longitudinal checks or surface splits on drying which make them less attractive, although their strength is unimpaired. 'Bleeding' may occur in some poles treated with preservative *oils*, and these poles should not be used when clean treatments are desired for appearance or where they may have to be handled in service. These limitations must be understood by both the user and the supplier.

Treated round hardwoods of lower durability than class 1 are not recommended at present for use anywhere north of New South Wales. Although transmission poles of class 2 and even class 3 natural durability are performing well in Queensland, the premature breakdown of the treated sapwood by soft rot in some poles must be explained before treatment of these timbers for house supports can be recommended. Also, because of the generally higher decay hazard, the minimum preservative loading of timbers for use in the tropics should be increased by at least 20%.

Sawn timber may be used for house supports, but the choice of timbers suitable for treatment is limited. Usually the heartwood of radiata pine can be treated with creosote or other preservative oil, but in most cases it is not penetrated by CCA solutions. Most sawn pine of a size needed to support a house will contain a fair proportion of heartwood, and the standard requires a minimum penetration of 13 mm (1/2 in.) from all faces or penetration of at least two-thirds of the whole section in 5 out of 6 samples. Only a few hardwoods can be treated to these requirements, even when pressures of up to 1000 psi are used.

It has been suggested that radiata pine fence posts treated to the standard retention of 12 kg/m^3 (0·75 lb/ft^3) with Tanalith C, Celcure A(P) or their equivalents, based on total volume, could be used safely as house supports. In the present state of our knowledge this would present a significant risk of premature failure which is unjustified by the small saving in cost. Therefore material for house supports must be clearly branded to avoid confusion with fence posts. Although treated piles and stumps are highly termite resistant, it is desirable to reinforce this protection with a barrier of chemically treated soil where a known high hazard exists, if only to prevent the termites building galleries up the supports to attack the house above. Without this barrier, properly applied according to AS CA43, termites can gain access to the house no matter what material is used for its support.

Where a house is completely elevated so that inspection of all supports can be readily carried out, protection can be obtained from properly applied mechanical barriers, i.e. ant caps, provided these extend over all means of access such as verandahs, ramps and external stairs.

It must be remembered, too, that treated stumps will not protect the floor structure itself from decay caused by high moisture levels beneath the floor. The standards provisions for ventilation and ground clearance must still be applied in order to avoid this risk.

This article would be incomplete without reference to methods of installation. Sole plates of timber treated to the same standard as the stumps, or of concrete are required if the holes for the stumps or piles do not go down to a level where the bearing strength of the soil will safely sustain the maximum design load without them. Any cutting to length must be done above ground to avoid untreated heartwood contacting the soil, and the cut ends must be protected from rain wetting.

In poor ground small wooden piles can be *driven* to achieve a stable foundation at minimum cost. When driven to a sufficient depth they offer less risk of settlement or movement than short stumps on soleplates, particularly in moisture reactive soils. Pointing is not essential for driving, and any pointing should be done before treatment to avoid exposing untreated heartwood. A pilot hole some inches smaller in diameter than the pile is a help in locating and driving the pile, while in seaside locations or sandy soil the pile may be inserted with the aid of a water jet.

Piles must be driven or set to such a depth that their load bearing capacity is not affected by changes in soil moisture content. Because piles represent a departure from normal domestic building practice, intending users should first consult an engineer or an experienced contractor.

Where the pile must resist lateral forces such as wind loads on the building, a driven pile is superior to one set in a bored or dug hole, but in soft soils the bearing resistance in the latter case can be improved by backfilling with crushed rock or cement-stabilized soil. Setting in concrete is rarely necessary. Sizes of round and sawn stumps as well as sizes for appropriate sole plates, besides other general requirements are set out in the Light Timber Framing Code (Section 2, Table 3). For cases outside the range of this code, engineering calculations in accordance with AS CA65 (Timber Engineering Code) must be made. Sometimes it may be found that the size as determined would look too light and if so, the size could be increased to give a more robust appearance.

In areas subject to tropical cyclones or very high winds, it is now well established that one of the safest and cheapest forms of construction is a well-designed timber frame securely fastened to poles or piles in the ground. Diagonal bracing of such piles is rarely necessary, but when braces are used they should be of class 1 or 2 durability or pressure treated, unless they are completely protected from wetting by rain. The bottom ends of untreated braces should be kept at least 300 mm (12 in.) above the ground.

Further information on this aspect may be obtained on application to the Chief, Division of Building Research, CSIRO, P.O. Box 56, Highett, Vic. 3190.

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NUMBER 398 JULY–SEPTEMBER 1974

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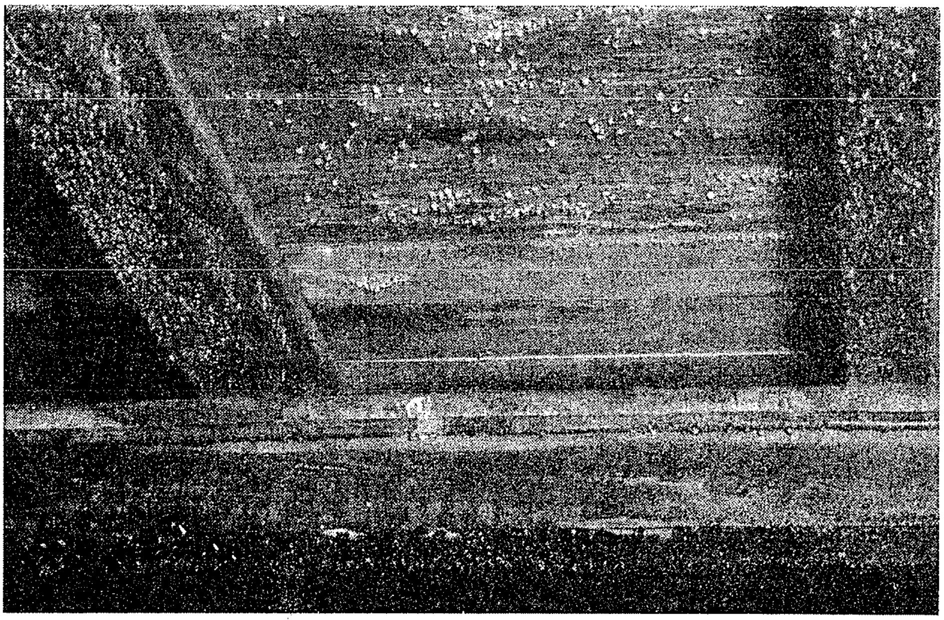
SUBFLOOR VENTILATION

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

Most residences and many commercial buildings in Australia have suspended wooden floors relatively close to the ground and occasionally this flooring suffers from decay and/or from cupping or distortion of the boards. Both these defects are caused by an increase in the moisture content of the wood. This can be due to spillage of water or contact with damp masonry but the major cause is the condensation of water vapour in or on the wood as a result of high humidity in the subfloor space. To obviate this it is usual to provide natural ventilation of this space and most building codes and specifications in Australia make provision for such 'subfloor ventilation'. However, the amount of ventilation and the method of calculating it vary widely, both in Australia and overseas, and it appears that the provisions made are based on arbitrary or traditional figures and not on systematic quantitative observations or experiments. The data for an objective calculation of requisite ventilation are not available but this article reviews the factors that enter into such calculations.

Firstly, it must be realized that we are usually trying to prevent *condensation* or to dry out wood rapidly if any wetting does occur. Wood does not decay as a result of high humidity alone, in the absence of condensation, although distortion of floorboards may result from high humidity alone. Decay

Fig. 1. Condensation on flooring and subfloor timbers.



is usually associated with condensation of water vapour on the cold floor from the relatively warm moist soil below (Fig. 1). This requires the soil to be moist and the floor to be colder than the soil: the former condition is almost always present. Even if the surface soil is dry it is very pervious to water vapour from the moist subsoil below. The floor is normally colder than the soil in winter, and even in centrally heated homes bathrooms, laundries and pantries are not always adequately heated. The increased use of air conditioning in Australia will facilitate the occurrence of cold floors, so that the temperature of the floor will not only be below the soil temperature but also, in humid weather, below the dewpoint of moist outside air. In this situation, improvement of subfloor ventilation could be ineffective.

Where the wooden floor is uncovered or covered by carpets without impervious backing, the water vapour is able to pass through into the room air without condensing, and if some condensation does occur during short periods when the floor is colder than normal it will dry out rapidly into room air. Where the floor is covered with an impermeable material such as vinyl tiles or rubber-backed carpets water vapour may condense under it and accumulate in the wood, leading to decay. The type of floor covering plays a critical role in the development of decay in flooring which is often severe in rooms (or even parts of a room) with impervious covering whilst adjacent rooms are sound. Sometimes the refurbishing of an old house, which includes new floor coverings, causes sudden decay in an old floor. However, where other conditions are very adverse decay can occur in a bare floor, especially where the 'dry rot fungus', *Serpula* (*Merulius*) *lacrymans*, is present. (The fungi causing decay in flooring are described by N. E. Walters in For. Prod. Tech. Note No. 13, 1973.)

Subfloor ventilation can be provided simply by leaving spaces between timbers or bricks in walls below floor level but for brick or brick-veneer houses it is usually provided by perforated terracotta, stamped metal or woven wire vents included as part of the wall. The number of vents required depends on the amount of free air space in each vent, and on the amount of free air space specified, usually based on length of perimeter wall, on area of enclosed subfloor space or on some combination of the two. At one extreme, some New South Wales specifications call for two terracotta vents in each room. For a 12-ft square room, this is about 8 in^2 of free air space or 0·66 in^2 free air space per ft (1400 mm^2 per m) of perimeter wall. At the other extreme, AS CA38 (1971), Light Timber Framing Code, recommends $\frac{1}{2}$ in^2 free air space for each 1 ft^2 of subfloor area, which is equivalent to 4–5 in^2 per ft (approx. 8500–10 600 mm^2 per m) of perimeter wall.

The Victorian Uniform Building Regulations require 11 000 mm^2 free air space in each 1500-mm run of external wall (roughly 17 in^2 in each 5 ft). Such a recommendation covers not only the number of vents but also their spacing which is very important if no dead air pockets are to be left below the floor. This figure is intended to be high enough to cope with virtually all normal variations in climate, floor covering, air conditioning and so on. Installation cost of such vents during construction is very low but the costs of repairs to a decayed floor and of remedial ventilation can be very high. The recommendation could be inadequate for buildings with a large floor area or, rather, a great distance between opposite walls. Perhaps a further recommendation should be made that, where the minimum distance between opposite vented walls exceeds 15 m, the free air space required is increased in proportion to the increase in distance over 15 m.

This specification assumes that the flow of air under the building is unobstructed. To ensure this there should be a clearance of at least 300 mm between bearers and soil (or between any ducting and soil). All walls below the flooring should have ventilation equal to 15 000 mm^2 free air space per m of wall. All building refuse should be removed since it not only obstructs air flow but also acts as a focal point for build-up of decay fungi. The vents should not be blocked by an inner leaf of masonry or by bearers, plates or joists. Care should be taken that they are not blocked externally by concrete patios, soil or shrubs. Air movement through the subfloor space is influenced by the direction and strength of prevailing winds but they can be so variable and influenced by other build-

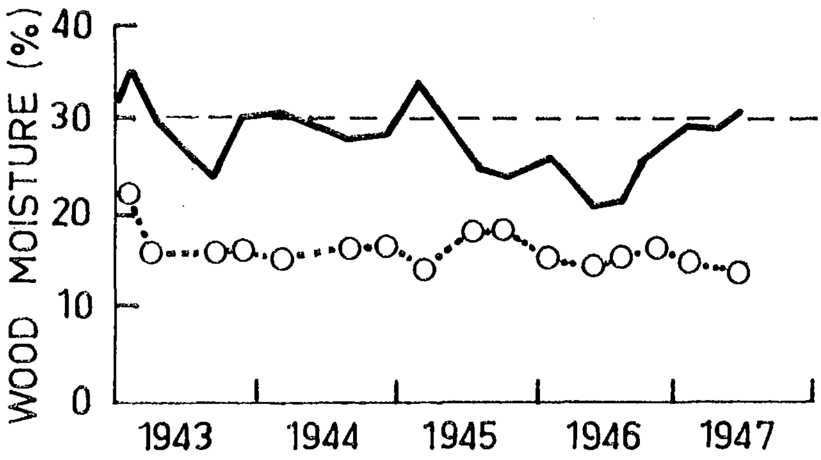


Fig. 2. Effect of soil cover on moisture content of subfloor timbers. Broken line and circles, with soil cover; solid line, without soil cover. (Data: U.S. Dep. Agric.)

ings, trees and even high fences that it is difficult to allow for them.

Although provision of adequate ventilation in new construction is easy it may be difficult in old buildings, i.e. in terrace houses and in contiguous shops where the floor is often almost level with the footpath. Here, stack ventilation with wide vertical flues extending from the subfloor space to above roof level, preferably with an extraction cowl, will provide good ventilation if vents can be installed at the far end of the subfloor space. If normal subfloor vents are impractical, vents in the floor itself along the far wall with a free air space of 10 000–20 000 mm^2 per m of wall may serve. This system is preferable to mechanical ventilation with its higher running and maintenance costs. Forced ventilation with warm air might pick up water vapour where it enters the subfloor space and deposit it as condensate when it meets colder floors further on.

Wherever there is any doubt about the adequacy of the subfloor ventilation 'soil cover' should be used. This practice is not often seen in Australia but it is widely used in the U.S.A. and is mandatory for dwellings in Canada. The surface of the soil is covered with a vapour barrier, e.g. a sheet of polyethylene plastic film. This virtually stops any water vapour coming from the soil and greatly reduces the ventilation required to cope with it (Fig. 2). Ideally, cover should be continuous, with 50–100 mm overlap of adjacent sheets, but even a partial soil cover will greatly help to reduce humidity in the subfloor space. In the U.S.A., use of soil cover enables the ventilation requirement specified to be reduced to 10% of that normally required.

Other factors which affect subfloor ventilation are the capillary rise of water in masonry walls and storm-water drainage. Masonry walls must be provided with an effective dampcourse, and where a large area of masonry is exposed below the dampcourse to the subfloor space it is advisable to paint this exposed surface with a vapour-impervious paint. Drainage should be sufficient to keep topsoil below the building dry. If there is a possibility that water could collect on top of a soil cover the material should be perforated at appropriate spots to allow drainage into the soil.

In virtually every building, especially new structures, it is possible to provide ventilation and/or soil cover sufficient to obviate decay at a very low cost compared with the value of the building or the costs of repair and replacement of decayed flooring. The main disadvantage of providing adequate ventilation is that it may increase the amount of heating or, more rarely, of cooling required, but for most Australian climates this effect is negligible. In a few cases, particularly in old houses where neither adequate ventilation nor soil cover is practicable, any replacement flooring should be of pine, impregnated with preservative as required by the draft AS 0113, or of a durable hardwood.

Framing Timber—Cut Undersize or Shrunk?

By B. T. Hawkins, in collaboration with the Timber and Domestic Structures Group

Two major changes in the light timber framing field have occurred recently. The Light Timber Framing Code, AS CA38, has been accepted and the timber industry has changed over to metric sizes. However, one difficulty has remained and, if anything, has become more pronounced with the introduction of the smaller sizes. This is the task of determining whether or not unseasoned timber that is viewed some time after sawing was initially cut to full size. This problem is occurring more frequently as a result of the current time lag involved in building a house which can result in long delays between the sawing and inspection of timber in frames.

Seasoned Timber

Seasoned timber is for practical purposes completely free of the problems of shrinkage and distortion and, indeed, the practice introduced with metric conversion whereby seasoned timber is called by its actual minimum dimension with no negative tolerance makes it very easy to determine if a framing member is up to size. At no time should the dimension of a seasoned member be below the called size.

Unseasoned Timber

The allowable undersize tolerance listed in AS CA38 (or its metric replacement) for unseasoned timber represents a sawing tolerance only and the builder or building inspector still has the difficult task of determining some time after shrinkage has started whether the piece of timber was originally up to size. This problem is particularly prevalent in Victoria and Tasmania where timbers with high shrinkage are normally used in framing. As noted previously (Newsletters Nos. 308 and 349), tests show that the strength and stiffness of a piece of timber are virtually unaltered by shrinkage since the loss of section is compensated by an improvement in the intrinsic properties of the timber as it dries. This applies even to those hardwood species that are subject to excessive shrinkage in the early stages of drying due to a phenomenon known as 'collapse'. Collapse often results in the piece being mis-shapen as well as reduced in cross-section (Fig. 1). In this case the increase in density is the compensating factor.

Normal shrinkage in timber occurs mainly when the moisture content decreases from around 30% to equilibrium moisture content (EMC) which is usually around 12%. However, as timber dries progressively from the outside of the piece, at any given time during drying there is likely to be a gradation of moisture content from EMC on the outer part to a much higher moisture content in the

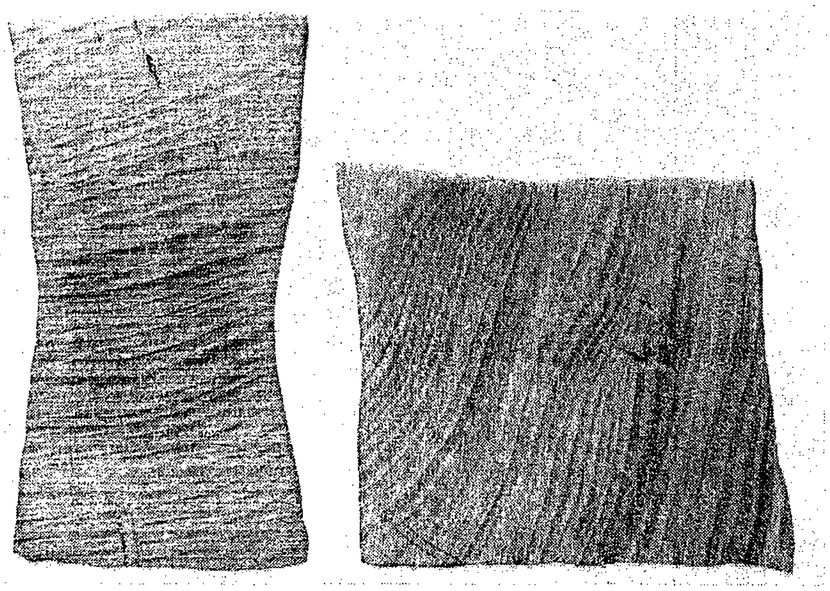


Fig. 1. Typical shapes of 'collapsed' timber.

centre. Consequently, some shrinkage will take place from the time drying starts although the average moisture content may be well over 30%.

Softwoods

For unseasoned softwoods such as Douglas fir shrinkage is usually low and the minimum dimension during drying will normally be the called dimension less the sawing tolerance allowed (usually 3 or 4 mm), less up to a maximum of about 5% for shrinkage, e.g. a piece that is called 100 mm might be as low as 95 mm in the early stages of drying to finish finally around 92 mm.

Hardwoods

As previously mentioned, some hardwoods are subject to collapse which occurs in the early stages of drying. When this occurs the dimensions of the collapsed timber may be taken as the width × depth of a rectangular envelope of the piece concerned (Fig. 2).

The amount of shrinkage to be expected in hardwoods will depend therefore on the length of time after cutting and whether or not collapse is present. Tables 1 and 2 show the expected minimum size for medium- to high-shrinking hardwoods at three stages of drying where collapse is not present (Table 1) and where collapse is present (Table 2). In southern Australia, stage 1 would represent about one month of winter or two weeks of summer, stage 2 about four months of winter or one month of summer and stage 3 about eight months, excluding summer, or about the three months of summer. In all cases it is assumed that the pieces are part of an unclad frame.

Table 1. Hardwood not showing signs of collapse

Orig. called dimension (unseasoned)	Probable min. size still satisfactory (Allowance made for normal permitted sawing tolerance)		
	Stage 1	Stage 2	Stage 3
(mm)	(mm)	(mm)	(mm)
38	34	32	31
50	45	44	42
75	70	68	65
100	94	91	87
150	144	139	132
200	192	186	177

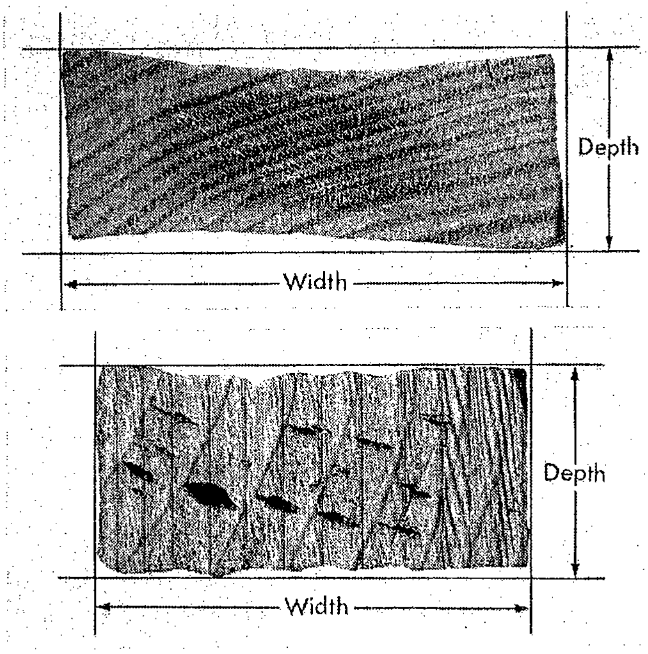


Fig. 2. Measurement of 'collapsed' timber.

It must be stressed that Tables 1 and 2 are only a guide* although, in general, the figures represent the maximum undersize that should be allowed. However, the final decision rests with the builder or building inspector using

Table 2. Hardwood where collapse is present

Orig. called dimension (unseasoned)	Probable min. size still satisfactory (Allowance made for normal permitted sawing tolerance)		
	Stage 1	Stage 2	Stage 3
(mm)	(mm)	(mm)	(mm)
38	32	31	30
50	43	42	40
75	67	64	60
100	91	88	83
150	136	131	125
200	184	178	170

his experience and judgment and taking into account whether the timber is back or quarter cut, species, etc. and indeed if the size was excessive for the particular application, e.g. 83 × 40 mm where 75 × 38 mm is sufficient.

It is also appropriate to draw attention to a

* Div. For. Prod. Technol. Pap. No. 13 shows that in an extreme case the percentage shrinkage for pieces cut from the same species can vary from 1·5 to 21·4%.

paragraph in the preface of AS CA38: 'In all cases the programme of calculations used to obtain the maximum permissible spans for timber sections listed in the various tables was designed to obtain the greatest economy of timber consistent with the strength and stiffness required for the given use or purpose of that member. In consequence, when selecting members, particularly those of smaller cross-section, from tables of maximum span, the user is warned that it may be necessary to give close attention to factors other than load-carrying ability. *The need to provide room for drillings or notchings by service trades and adequate width of grounds for jointing of fixing of linings, together with the need to ensure that sufficient width and thickness of timber are available at joints and bearings to accept the required gauge and number of fixing nails, may require the selection of members greater in size than those which are needed for structural strength alone*'.

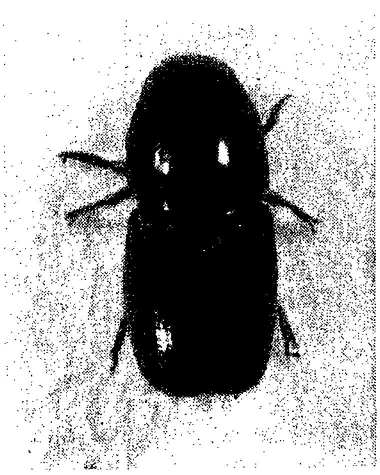
These other considerations should also be applied when assessing the acceptability of timber sizes after shrinking.

Summing up, although it is possible for timber, particularly hardwood, to shrink by relatively large amounts, *a piece of timber that is undersize only because it has shrunk is still structurally equivalent to a full-size piece in the green condition.* However, other factors must also be considered when judging the acceptability of any particular piece of timber.

Dutch Elm Disease Beetle in Australia

By A. Rosel and J. R. J. French, Preservation Group

In January this year live specimens of the smaller European elm bark beetle, *Scolytus multistriatus* (Marsham) (Coleoptera: Scolytidae), were collected by one of the authors from elm branches in Melbourne. The discovery of this insect is extremely important as it is one of the main vectors or carriers of the Dutch elm disease fungus, *Ceratocystis ulmi* (Buism.) C. Moreau. Dutch elm disease is one of the most devastating tree diseases of our age and annually causes the loss of many thousands of valuable elm trees in the Northern Hemisphere. The presence of the beetle in Australia is thus of considerable significance although, fortunately, at present it does not appear to be carrying the pathogenic fungus.



Adult of Scolytus multistriatus (3mm).

Distribution of the Beetle

The beetle is found in the Northern Hemisphere throughout Europe and North America. The name, Dutch elm disease, was coined by research workers in the Netherlands to describe the symptoms of attack caused by the fungus *C. ulmi*. Since World War I there have been three major epidemics of *C. ulmi* in Europe, in 1931, 1937 and the present one which broke out in 1971.

In Australia elms infested with *S. multistriatus* have been found in a number of parks and gardens within a seven-mile radius from the centre of Melbourne. Whether the beetle is more widely distributed in Australia is as yet not known. However, there are no records or specimens of *S. multistriatus* collected in this country in any Australian museum and none have been received from Australia by the British Museum.

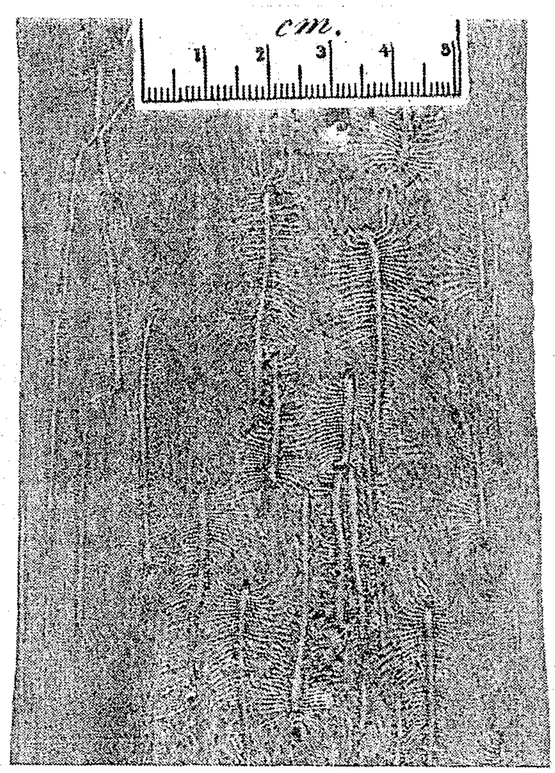
Hosts

This beetle only feeds and breeds in all native and naturalized species of elm (Ulmaceae) and in Japanese Zelkova, a close relative of the elm.

Life History of *S multistriatus* and Spread of *C. ulmi*

The beetle has two complete generations a year in the Northern Hemisphere, although egg-laying extends over a considerable time and adults may be present from May to September (or December to April in the Southern Hemisphere).

Larvae of *S. multistriatus* overwinter at the ends of their tunnels which form a fan-shaped pattern in the inner bark. The larvae pupate and emerge from these tunnels in May as small, cylindrical reddish brown beetles about 3–4 mm in length with a characteristic posterioral concave or undercut abdomen. Emerged beetles feed on twigs, often in the crotches of healthy elm branches, especially in trees that contain, or are very near other trees that contain weak, injured or sickly portions. However, the female beetles construct their brood chambers or parental galleries (up to 63 mm long) only in the cambium of weakened, dying or recently dead wood. These galleries run lengthwise with the branches and the fan-shaped larval galleries run across the grain and under the bark.



Typical vertical galleries and fan-shaped larval feeding galleries.

The eggs which are very small (*c.* 0·3 mm wide and 0·5 mm long) are oval, round or slightly elongate and are clear or creamy white. About 80 to 140 eggs are deposited in small cup-shaped cavities along the sides of the parental galleries; eggs hatch in about one week.

The larvae are thick-bodied, legless, cylindrical and curved, white or cream-coloured with distinct heads. At first the larvae and their tunnels are very small, but both increase in size as feeding and development progress. The tunnels form a fan-shaped pattern and are always packed with excrement and boring dust which is used to imbed the eggs on each side of the gallery. Larvae develop in a few weeks and a second or summer generation of adults appears and lays eggs in August and early September (March or early April in Australia). There may be more than two generations per year in Australia and further research on the life cycle of this beetle is continuing.

Transformation to the pupae occurs at the end of the larval tunnel in a specially constructed pupal cell. The pupae are soft, white and unprotected. Antennae, mandibles, legs and wings are clearly visible which slowly darken or pigment, turning a light yellow and then reddish brown colour as the new adult form is reached.

These new adults, after a short period in which to harden their cuticle, emerge through small circular holes and fly to feed on twigs of new host trees before attacking the bark of the tree and continuing the life cycle. The emergence holes are often referred to as shot-hole damage, and as many as 3000 adults may emerge from one metre of branch (6 cm int. diam.).

If trees are affected by the fungus *C. ulmi*, beetles carry the spores in or on their bodies, and when they make feeding or breeding (= parental) galleries in healthy trees they inoculate the fungus into the fresh host which becomes infected. The fungus develops within the vessels of the outermost annual ring, secreting a toxin that causes a blockage of the vessels. The first symptoms are wilting, curling and yellowing of the leaves on one or more branches followed by leaf fall and death of affected branches. A tree may die within a few weeks of the onset of symptoms or die a limb at a time over a year or more. In cross-section the springwood of the last annual ring of an affected tree shows as a dark brown ring or a series of dark dots and dashes.

Status of the Beetle in Australia

The amount of damage, as observed by the number of emergence holes, or shot-holes, in the bark of attacked elm branches in Melbourne, and the number of live beetles collected suggest that this Scolytid has been in the area for at least two and probably several years. At present *S. multistriatus* is not causing any wholesale destruction of elms but it seems likely that very heavily infested limbs and the occasional tree will die from ring-barking caused by larval feeding in the cambial zone. However, if spores of the pathogenic fungus were introduced into Australia it is almost certain the disease would spread rapidly through the elm population in Melbourne and beyond to elms in other towns and probably in other States. The effects of the loss of elms as ornamental trees in parks, streets and gardens cannot be readily assessed in monetary terms in our present highly urbanized society, but their aesthetic value to our urban community is almost beyond estimation.

Current Investigations in Australia

This Division has contacted all State Departments of Agriculture and Forests Commissions, Australian Museums, the British Museum, the National Parks Service in Melbourne and the Commonwealth Department of Plant Quarantine and informed them of the presence of *S. multistriatus* and its potential hazard. None of these institutions had any specimens of the beetle in their collections, indicating that this is the first known record in Australia.

The beetle is being reared in our laboratory. Data on its life cycle in Melbourne compare similarly to the life cycles of Northern Hemisphere beetle populations. As well as culturing the beetle, isolations have been made from various life stages and infested elm materials to detect the presence of *C. ulmi*. So far, none of the fungi isolated has been identified as the pathogen. Although this does not mean the disease is not in Melbourne, it is the considered opinion of an American authority on this Scolytid that the disease would have manifested itself by now if present. He mentions that the situation in Australia and the west coast of North America is similar: the vector is present but not the disease.

Requests have been sent to Canada, the U.S.A. and England to obtain information on current research and control methods on the Dutch elm disease.

Control Measures

At present, there is no practicable method known by which the beetle *S. multistriatus* can be eradicated in areas where it is well established and where there are many elms. However, some degree of control is possible by a combination of sanitation felling, insecticide spraying and possibly the breeding of resistant varieties of elm. Meanwhile sanitation felling of infected trees or branches is one segment of control that can readily be carried out for little other than labour costs, as only a chain saw and a bark destroyer of some kind are necessary to effect this beetle population control method.

As dead and dying elm material is used for breeding by the beetles prompt distinction of this material is recommended. All dead and dying trees should be removed and burned. Trees that are weakened, for instance by drought conditions, are more likely to attract beetles, so all dead and dying branches should be pruned. These procedures must be thorough and repeated over the entire elm population if possible, as adults of *S. multistriatus* can be blown or will fly for considerable distances, probably several miles.

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Reassessment of Radiata Pine for Structural Purposes

By H. Kloot, Division of Building Research

Since Langlands (1938) reported the first intensive mechanical testing of Australian-grown *Pinus radiata* D. Don, this exotic species has increased enormously in value until today it is of prime importance to the timber economy of this country. Under normal circumstances, the 24 trees tested by Langlands would have constituted a sufficiently adequate sample to provide strength data that would remain substantially valid today. This would have been the case, for example, with virtually any native species. However, as reported previously (Newsletter No. 232), radiata pine exhibits a marked increase in its physical and mechanical properties with age of tree, the further the material is from the pith the denser and stronger it is. The other species of the *Pinus* genus grown in this country exhibit a similar trait.

It was therefore to be expected that, as the average age of the radiata pine plantations increased, the physical and mechanical properties of the marketed timber would show some improvement over those recorded when the plantations were comparatively younger.

Over a period of years the species was further sampled, largely on a piecemeal basis, until Bolza and Kloot (1963) were able to publish data obtained from tests on 78 trees. These later results showed slight increases in the properties of the species over those published by Langlands (Table 1).

More recently it was thought desirable, considering the general stability in the average age of radiata pine plantations throughout Australia, to make a reassessment of the structural properties of the species. With the collaboration of the Radiata Pine Association of Australia, an extensive sampling of the species was conducted to provide material for mechanical testing. The sample of material taken from 235 trees constituted by far the largest ever essayed on any single species in Australia, and one of the largest attempted anywhere.

The method of sampling used ensured that the sample reflected as accurately as possible the relative volumes of material from the range of diameters and age classes available for conversion at the various centres of production in each of the several States. To obtain the optimum information in relation to the cost of sampling and testing, the selection of the sample trees in each area and the test sticks taken from these trees was made in accordance with the random sampling procedure discussed by Pearson (1952) and Bendtsen *et al.* (1970).

The total sample of 235 trees was designed to provide information on:

(1) the characteristics of the total population of radiata pine, i.e. including material containing pith, and

(2) the characteristics of the population of

the species excluding all material within 50 mm of the pith.

All the test material was seasoned by use of the normal kiln-drying schedule and brought to equilibrium moisture content at 65 % relative humidity before test. Apart from density, only the properties of major structural significance were measured, namely the moduli of rupture and elasticity in bending, the maximum compressive strength and modulus of elasticity in compression parallel to the grain, the stresses at limit of proportionality and at 2·5 mm deformation in compression perpendicular to the grain, and maximum shear strength.

The sampling, testing and analysis and discussion of results will be published in detail in due course by H. Kloot and his co-authors, Miss N. Ditchburne of the CSIRO Division of Mathematics and Statistics, and Mr B. L. Rumball of the Radiata Pine Association of Australia.

Because of the importance of the species and the significance of the results obtained from this assessment, it was considered expedient to present in an abbreviated form the principal conclusions of the investigation.

In Table 1 the species average results and relevant statistical data obtained from the recent comprehensive survey are shown together with the previously published data for the species. As would be expected, the results for the population of radiata pine excluding material within 50 mm of the pith are slightly higher than those for the population that includes pith-in material.

The average density is some 6 % higher than the values published from previous tests. Similarly, the values for modulus of rupture, modulus of elasticity and crushing strength parallel to the grain show a significant improvement over the corresponding values previously published.

While the standard deviations of individual results differ little from previous estimates the standard errors are significantly lower, as would be expected from a more extensive sampling. In the case of modulus of rupture, for instance, there is a 99 % probability that the true species mean for this property lies within ±3·6 % of the sample mean. For engineering purposes this is an extraordinarily high degree of precision and, without doubt, reliable working stresses could be derived specifically for this species.

However, with regard to the overall advantages of strength grouping rather than the derivation of specific working stresses, these latest data provide an opportunity to strength group radiata pine with an even greater reliability than has been possible before.

For the purposes of visual grading, it is much more convenient to consider the population of radiata pine excluding pith-in material quite separately from the population in which all members contain pith. The strength data for this population indicate that radiata pine would be correctly grouped in SD6 on the basis of its relative low stiffness instead of in SD7 as it is at present (Newsletter No. 394). Consequently, the stress grading for the four grades of radiata pine defined in the grading rules of AS 1490-1973 should be F7, F8, F11 and F14 for Standard Building, Select Building, Standard Engineering and Select Engineering grades respectively. It should be noted that the stress grades for pith-in material covered by grading rules of AS 1490 are not changed as a result of this reassessment.

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Table 1. Properties of radiata pine at 12% moisture content

Property	Langlands (1938) Species mean	S.E.[A] of mean (%)	S.D.[B] of individual results (%)	Bolza and Kloot (1963) Species mean	S.E. of mean (%)	S.D. of individual results (%)	Ditchburne *et al.* (in preparation) Total population incl. pith Species mean	S.E. of mean (%)	S.D. of individual results (%)	Ditchburne *et al.* (in preparation) Total population excl. pith Species mean	S.E. of mean (%)	S.D. of individual results (%)
Number of trees	24			78			235			235		
Air-dry density (kg/m^3)	502	2½	10	506	1¼	11¾	530	¾	11¾	535	¾	11¼
Static bending												
Modulus of rupture (MPa)	78·5	2¾	15¾	80·7	1¾	19	87·2	1¼	20	89·0	1¼	18
Modulus of elasticity (MPa)	10000	6	22	10205	2¾	27	11435	1½	24½	11746	1½	22¼
Compression parallel to grain												
Maximum crushing strength (MPa)	39·0	3¾	21¼	41·9	2½	24¾	48·3	1¼	19½	49·3	1¼	18
Modulus of elasticity (MPa)				11380	4	35	12572	1¾	26½	12938	1½	24
Compression perpendicular to grain												
50 × 50 × 50-mm specimen												
Stress at L.P.[C], radial (MPa)	3·95[D]	4	23	3·24	2½	25¼	3·33	1½	24	3·33	1½	24
Stress at L.P., tangential (MPa)				3·59	3½	27½	3·89	1¾	25	3·91	1½	24¾
Maximum shear strength												
Radial (MPa)	10·1	3¾	18½	11·0	2½	18¾	11·3	1	16	11·5	1	15¾
Tangential (MPa)	10·0	3¼	20¼	11·1	2¼	15½	11·3	1	14¼	11·4	1	14

[A] Standard error. [B] Standard deviation. [C] Limit of proportionality. [D] Estimated from results from 150 × 50 × 50-mm specimens.

UTILIZATION OF WOOD RESIDUES

Despite the outlets offered for large quantities of solid wood residue by export chip projects and local pulp production, e.g. the conversion of pine shavings into particle boards, the use of dry sawdust and shavings for litter in chicken pens and the success of pine bark for mulching and decorative purposes, enormous quantities of residues from timber processing plants remain. How to utilize them economically is a major dilemma which faces the industry.

The problem is not new: the utilization of residues has been a subject for investigation by forest products laboratories all over the world for many years. Nevertheless, the need to convert residues into useful products has probably never been as critical as it is today. Apart from the increasing costs involved in the disposal of waste within the requirements set by environmental authorities, world shortages of energy and materials make it increasingly important that wastage of potentially valuable materials is avoided wherever possible.

Research workers at the Divisions of Building Research and Chemical Technology are very conscious of the importance of residue utilization and officers of both Divisions are trying to obtain optimum yield from the forest resources by:

- Investigating methods of improving efficiency in production techniques with a resultant decrease in residual materials. Included here is the longer term research aimed at the reconstitution of defibrated wood with synthetic polymers as composites for use in packaging and building.
- Investigating methods of utilizing those residues such as sawdust that are produced inevitably.

To assist in the latter aim, a committee comprising officers of both Divisions meets regularly to discuss possible utilization outlets and to ensure cooperation between the efforts of the two groups to establish possible uses. A number of investigations is being undertaken in the laboratories and, in addition, a close watch is being kept on developments overseas where residue utilization has also assumed major importance.

Development of new ideas for possible outlets is difficult since the range of uses already tried, as a result of long-standing efforts throughout the world, is very large. Many products which were made from wood residues have been superseded by alternative materials produced at lower costs. However, changing world conditions could alter this situation in a number of cases, so that even though an outlet has proved uneconomic in the past re-investigation is now warranted. For example, while there has been a tendency to replace sawdust and shavings with oil as a fuel for producing steam in many seasoning plants, increasing oil prices could well create a demand for these residues as sources of energy. Also, a wood log or briquette made from wood residue could conceivably have an outlet as a home fuel if oil and coal briquettes become more expensive or less readily available.

The optimum utilization of residue from any particular plant, however, depends not only on the possible outlets available but also on the initiative of the management in seeking possible markets for their 'waste' material. Some plants find it possible to dispose of most of their residue usefully while others can find no outlets. Often this is due to plant location and variations in local demand but sometimes it is brought about by a lack of initiative in seeking possible outlets.

It is intended to publish in this Newsletter a series of short articles on wood residue utilization. (The first of these, referring to the possible use of wood residues for oil collection, appeared in Newsletter No. 392.) Many of these articles will concern traditional uses, but others are intended to outline more recent developments which might offer promise. It is hoped that they will stimulate individual plants to investigate outlets that could apply to their particular situation.

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