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THE DIVISION OF FOREST PRODUCTS,

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION,

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REPRESENTATION

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Secretary - A. P. Wymond.

CONTENTS

ITEM 1. WOOD STRUCTURE

Item 1(a)

REVIEW OF RESEARCH ACTIVITIES*

In the periodic reviews of work of this Section presented to the Forest Products Research Conference it has been unnecessary to present any generalized statement of the scope and aim of the work, since the results presented concerned the extension or elaboration of well established lines of investigation. Although this is still true, recent changes in the organization of the Section following the appointment of a new Chief of the Division, make the present Conference an appropriate time to outline the general scope and aims of the Section's work, in addition to describing new lines of work which have commenced since the last Conference, and the status of those upon which investigation has continued.

In general, the Section's work is directed to carrying out a programme of research designed to provide fundamental structural and physiological information on the development and structure of wood in terms of which its behaviour during its utilization can be understood. In addition, investigations of a specialized nature in which the structural, microchemical and biochemical techniques employed in the Section are of value are carried out.

Current lines of work are listed in the table. It will be appreciated that any division of the work in this way is largely arbitrary and that the various lines of work are complementary. Naturally this involves collaboration between the research groups concerned and in practice this is done wherever possible. Since the previous review of work presented in 1958, two major changes in our

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*Prepared by Dr. A. B. Wardrop.

programme have been made. The first of these results from the addition to the Section of a research group working on chemical and biochemical aspects of lignification. Such work, it is hoped, along with anatomical studies of this problem should greatly stimulate progress in this field. Secondly, it has been felt for some time that greater progress could be made in most of our projects if facilities were available for growing plants readily and in some instances under conditions of controlled environment. Accordingly, work is nearly complete on the construction of a glasshouse at Springvale which can be heated and eventually will contain two growth cabinets in which temperature and day length can be controlled. The provision of these facilities and the development of a more biochemical and physiological approach to problems such as lignification, the origin of polyphenolic constituents of wood, as well as to morphological problems such as the formation of reaction wood and the factors determining cell dimensions in growing stems, will give a greater appreciation of the nature of the factors which are significant in governing the final behaviour of the wood.

The work of the Section has been greatly assisted by the visits of a number of overseas research workers. In 1959 Dr. H. Harada of the Government Forest Experiment Station, Tokyo, worked on the development and structure of the cell wall in fibres, tracheids and ray parenchyma, and during the past 8 months, Dr. M. Hasegawa from the same laboratory has carried out investigations on the origin and synthesis of polyphenolic constituents of wood. During 1959-60 a Fulbright Fellow, Professor Vernon I. Cheadle of the University of California at Davis carried out investigations into the fine structure of phloem. In September Dr. Clinton J. Dawes, of the University of California at Los Angeles will take up studies in fine structure under a Post-doctoral Fellowship of the National Science Foundation of the United States.

(a) Identification of Wood

Some 12,000 wood specimens have been identified for individuals and Government Departments in the past 2 years. Among these have been numerous specimens of driftwood from South Georgia, Macquarie Island, Tristan da Cunha, the great majority of which have been identified as South American species of *Nothofagus*. Work on the provision of card sorting keys based on both macroscopic and microscopic features has continued. An X-ray diffraction study to determine the identity of crystalline inclusions in wood has been commenced. Details of work particularly relevent to this Conference on New Guinea timbers are included under Item I (e).

(b) Differentiation and Fine Structure

(i) Cell Differentiation

Work in this field has been greatly facilitated by the installation in 1959 of the Siemens Elmiskop I electron microscope. The nature of surface growth in fibres of *Eucalyptus* and tracheids of *Pinus* has been shown by electron microscopic and autoradiographic studies, to involve the multinet mechanism previously shown to be operative in coleoptile and root parenchyma. Secondary wall formation begins near the middle of the fibres and tracheids and extends towards their tips. Anatomical studies relating to lignification are given under section (c).

(ii) The Organization of Cytoplasm in Cambium and its Derivatives

A study of cytoplasmic organization in differentiating fibres, tracheids and ray parenchyma, as well as in the derivatives of the apical meristem in woody plants has been commenced. This work is still in an exploratory stage, and is difficult since the cambium as well as its derivatives are vacuolate and present particular difficulties in fixation. From such a study evidence of the nature of the cell wall formation and the origin of vacuolar constituents such as tannins should be obtained. Endoplasmic reticulum (E.R.), mitochondria, Golgi apparatus, and other organelles have been recognized. The E.R. appears to be concentrated and aligned parallel to the wall surface near the tips of differentiating fibres, but no evidence of the incorporation of this structure into the cell wall as reported by some other investigators has been obtained. Preliminary observations suggest that the polyphenolic constituents of ray cells arise within a double membrane limited structure.

(iii) Cell Wall Structure

Cell Wall Organization of Tracheids and Fibres.- The model of fibre structure presented previously has been somewhat modified as a result of the application of replica and ultra-thin sectioning techniques. It has been demonstrated that all layers of the secondary wall are lamellated and that, while the outer layer S_1 possesses a crossed fibrillar structure, there are a number of lamellae between this structure and the layer S_2 in which the microfibrillar orientation shows a progressive change, becoming more nearly that of S_2. The distribution of lignin in the cell wall has been investigated by interference microscopy and in agreement with overseas work it has been shown in *Eucalyptus* that probably 90 per cent. of the lignin lies in the region external to the layer S_2. This is of significance in relation to the preparation of semi-chemical pulps. The structure of pits in both softwoods and hardwoods has been investigated, and some modification of the structure of the softwood pit has been proposed. This is considered to be of importance in relation to the movement of liquids into wood. Further studies on the nature of the pit membrane in both hardwoods and softwoods has been made.

An ultra-violet and electron microscope study of the wart structure of conifer tracheids has shown that this structure consists of a membrane lining the lumen and pit chambers. It is extended into a series of diverticulae into the lumen in which is enclosed a spherical object which absorbs in ultra-violet light. The membrane does not absorb in the ultra-violet. The wart structure has been isolated from a number of species and its approximate composition determined, although so far there is little evidence of its exact chemical nature. It is extremely resistant chemically. Studies of cell wall organization have also been made on ray parenchyma. In _Cryptomeria_ the secondary cell wall has been shown to consist of some four layers enclosed by the primary wall. In each successive layer the microfibril orientation was observed to decrease with respect to the longitudinal cell axis. The cell wall was shown to contain approximately 45 per cent. lignin. _Influence of Wood Anatomy and Fine Structure on the Path of Penetration of Liquids into Wood._- The path of movement of liquids into wood is important in relation to problems of timber preservation and pulping. In preservation processes the path of movement partly determines the ultimate site of the preservative, and in pulping operations it determines the point of initial attack on the fibre wall culminating in the separation of fibres as pulp. Fundamental investigations of cell wall organization of the tissue elements of wood and of the pits between them have been extended to a consideration of how this organization is involved in the movement of liquids through the wood. It has been demonstrated that in hardwoods the initial penetration path is through the vessels and then via the pits to the rays and adjacent fibres or vertical parenchyma. In softwoods the path is from tracheid to tracheid or tracheid to parenchyma through the pits. In both hardwoods and softwoods lateral movement takes place through the rays. After the filling of the cell lumen, by a reagent, diffusion takes place through the cell wall to the middle lamella. From the path of movement demonstrated it follows that the last region of the cell wall to be reached by the pulping medium is the lignin-rich middle lamella. At least in the initial stages of pulping this would result in considerable gradients of reagent concentration through the cell wall. These factors, as well as the organization of the fibre wall, govern the differences in the manner of separation of fibres during pulping by chemical and semi-chemical processes. Further implications of these conclusions are being studied in current investigations.

(c) Lignin and Lignification

Both anatomical and chemical studies on processes of lignification have been continued in both natural and model systems.

Substances which are known to inhibit lignification in model systems have been applied to the natural system in an attempt to control the process. So far this has been unsuccessful. However, it has been shown that cambial extracts at least modify lignification in model systems since the artificial lignin formed in the presence of the cambial extract shows ultra-violet absorption, but does not give the colour reactions obtained when the extract is absent.

Chemical investigations on artificial lignins have been studied by some overseas workers as well as in this laboratory and it is felt that from the study of this material, useful information regarding the composition of natural lignin and its formation can be obtained. Examination of eugenol lignin formed on the cell walls of potato parenchyma has shown that this material is undoubtedly lignin-like, but that it differs from natural lignin in a number of respects. From a study of the conditions under which artificial lignin is produced, it is hoped to gain some indication of the way in which particular chemical groupings are produced in natural lignin.

Studies of the lignin from reaction wood have also been continued. Milled wood lignin has been prepared by fine grinding in toluene of wood from different zones of stems containing reaction wood. Tension wood from Eucalyptus yielded almost no lignin on grinding and this is believed to indicate that here the lignin is closely associated with the polysaccharide framework. Compression wood of Pinus radiata yielded about twice as much as normal wood of the same species. This is thought to indicate that the extra lignin which is known to be deposited in compression wood is not combined with the polysaccharide framework. This lignin was abnormal in that about one-fifth of its aromatic nuclei were free from methoxyl.

(d) The Study of Cell Contents

Work on the nature of wood extractives has involved the consideration of some problems of commercial significance as well as fundamental studies of the origin of these substances in woody stems. Two problems of commercial significance may be mentioned. First, the difficulty encountered in the pulping of certain eucalypts and the subsequent processing of the spent liquor was found to be due to the presence of ellagic acid and its derivatives present in the wood. Second, the reactions between tannins and formaldehyde under different conditions have been compared with the behaviour of these materials as plywood adhesives. With reference to the ellagic acid problem, there is now sufficient evidence available to suggest that the possibility of its control by employing a high percentage of logs from young stems so that the concentration of the acid is low.

In studying the basic reactions between certain tannins and formaldehyde so little is known of the complex components of tannins that it is only possible at this stage to indicate those tannins which are likely to make good adhesives, but until further information is available, it is not possible to suggest ways of improving the performance of those tannins yielding bad adhesives.

In order to remedy the deficiencies in our fundamental information of the polyphenolic constituents in trees the extractives and kinos of a number of species have been studied. The most probable explanation of the results obtained so far is that the extractives are formed <u>in situ</u> from stored and translocated carbohydrate. This conclusion is consistent with later experiments using labelled glucose. It is also consistent with work done in association with the Division of Wood Technology, New South Wales, which has shown that the extractive content of tension wood is low, and it is found that starch reserves are depleted during formation of this tissue. A further approach designed to elucidate aspects of the origin of polyphenolic constituents has been to study the distribution and formation of these substances in the leaves of species in which their composition is similar to that in wood. From these various lines of approach it is anticipated that our knowledge both of the formation and utilization of the polyphenolic constituents of wood will be considerably improved.

(e) <u>The Influence of Environmental Factors on Growth</u>

During the period while the glasshouse, referred to in the Introduction, is being erected, studies of the formation of tension wood in a variety of species has been carried out. It has been found possible to greatly expedite these studies by the investigation of the formation of tension wood in very young seedlings, where tension wood becomes recognizable within a few days. It has thus been possible to investigate most of the classical experiments on the formation of this tissue in a very short time and observations so far suggest the overwhelming importance of gravity as the stimulating factor. The effect of the application to the stems of kinins and auxins in relation to tension wood formation is currently under investigation.

ORGANIZATION OF THE WOOD AND FIBRE STRUCTURE SECTION

I. Anatomy of Wood and Bark

Identification of wood -
    Relation of microscopic features to wood properties

II. Differentiation and Fine Structure

Study of cell differentiation -
    Cell division and cytoplasmic organization
    Surface growth of plant cells
    Cell wall thickening
    Lignification

Cell wall structure -
    Cell wall structure and wood properties - pulping and mechanical properties

Physiological studies in relation to plant anatomy -
    Reaction wood formation
    Heartwood formation

III. Biochemistry of Lignin

Chemistry of Lignification -
    In normal growth
    In reaction wood formation
    In artificial systems

Enzymes involved in lignification -

Control of lignification -

IV. Study of Cell Contents

Chemical investigation of the formation and nature of cell contents -
    (pigments, tannins)

Biochemical aspects of heartwood formation -

Cell contents as in aid in wood identification -

Commercial importance of wood extractives -
    (pulping adhesives)

V. Influence of Environmental Factors on Growth

Influence of environmental factors on the anatomy and composition of plant tissues -

Influence of environmental factors on meristematic activity -

Chemical control of growth - wood quality-

VI. Structure and Properties of Wood - Tree Breeding

Study of Inheritance of Wood and Fibre Characteristics-
    Fibre dimensions and wood properties

(f) Structure and Properties of Wood

Work on the assessment of wood characteristics and their heritability has continued and is reported under Item 1(b). A device to facilitate sampling of large stems has been developed.

Discussion

Richardson: New Zealand has not done very much on the fundamental side. Some work on extractives of native New Zealand species is being continued, as variation in extractives within species is interesting, firstly as a means of identification, and secondly to find out if there is any influence of site condition on the extractives. In the future we will be more interested in the influence of environmental factors on growth and composition of plant tissues. We hold this as basic to any attempt to select or breed woody material for improved quality. Before we can be certain that there is any direct genetic control of variation we must know a lot about the influence of environmental factors on tracheid length, cell wall thickness, spring wood/summer wood ratio, etc.

There is enormous variation in environment within the one tree, especially in such factors as cambial temperature. I feel that environmental influence has not received sufficient attention in the past, and this is one of the things we hope to look at in the future.

Bryant presented the following review of New South Wales research work:-

The investigations of bark structure of the tribe Leptospermoideae have yielded data which appear of value for the purposes of identification and may have value taxonomically. The observations on fibre morphology and abundance of cork are particularly significant for the utilization of the barks.

The bark features which are useful for the purposes of identification are fibre arrangement, presence of sclereids, arrangement and type of crystal, presence of silica, type of phellem cell and arrangement and type of rhytidome. A dichotomous key based on these features has been devised for the identification of the genera and some of the species. It is planned to extend this work to other important families.

To assist in the identification of pines an attempt is being made to have sections prepared of needles of all species of Pinus planted in Australia. While two important papers have been published on this subject it is felt that for reasonable accuracy in identification authentic prepared slides should be available for comparison.

Preliminary work has established that a juvenile stage exists in the development of the hypoderm and resin canals. It is planned to report the work either in the form of an atlas or a card sorting key. Fifty species have so far been sectioned compared with the 90 or so in the genus.

Research on the relation of wood structure to properties has been mostly concerned with the work on Elite trees (see 1(c). Other work has been undertaken in respect to the penetration of various materials into wood mainly to elucidate problems of surface finishing of wood.

Penetration of a tung-oil seal and raw linseed oil into the sapwood and heartwood of a number of species has been measured. In the sapwood of P. radiata, Araucaria cunninghamii and A. klinkii the penetration of the oils was considerable. Maximum penetration was found radially occurring preferentially through the ray parenchyma. Ray tracheids and early wood tracheids of radiata and tracheids of Araucaria spp. were not readily penetrated but late wood of radiata absorbed oil readily from ray parenchyma. Longitudinal movement of oil was observed in late wood but not early wood in radiata.

With A. klinkii compression wood penetration of oil was more widespread and rapid than normal wood occurring in all cells and through intercellular spaces.

Penetration of the oils into sapwood and heartwood of Callitris hugelii and Tristania conferta and heartwood of P. radiata was found to be confined to the cells opening to the surface.

The ease of penetration of the oils into the sapwood of P. radiata and Araucaria spp. when compared with the other species examined suggests that differential treatments are required so as to avoid large loss of paint body from undercoatings and primers. The failure of paint over late wood before early wood shown in American tests is thought to be due to the differential absorption of paint body by the late wood and early wood, late wood showing higher absorption than early wood.

Jennings: Our work also tends to be concerned with immediate problems. Generally, it is following three lines; firstly, examination of prospective parent trees, secondly, an estimate from progeny trials of P. elliottii of the narrow sense heritability of the properties in which we are interested. Thirdly, what these properties are in the population from which we have drawn our parent trees, and whether our parent trees are significantly different in those properties from the rest of the population.

ITEM 1(b)

ASSESSMENT OF WOOD CHARACTERISTICS*

The Division of Forest Products has been intimately connected with the assessment of wood qualities for tree breeding in projects initiated by the various State Government Forestry Departments. In carrying out the many detailed analyses associated with these

*Prepared by J. W. P. Nicholls.

projects much valuable information has been gathered on the variation in properties and the relationships between properties and structure. Parallel with this work efforts have been made to obtain estimates of gross heritability values for certain anatomical features and to demonstrate the relative importance of these features, especially in the evaluation of pulp strength properties. The following is a brief summary of this work to date.

Specimens have been taken from selected plus trees at a height of approximately 3 ft above ground level and sampled according to the method of Brown (1958). Seven groups of trees have been examined so far, the first six of which, comprised of *Pinus* species, are as follows:-

29 trees of *Pinus radiata* from the Australian Capital Territory
11 trees of *Pinus radiata* from Tasmania
28 trees of *Pinus radiata* from Victoria
45 trees of *Pinus radiata* from South Australia
13 trees of *Pinus elliottii* var. *elliottii* from Queensland
13 trees of *Pinus pinaster* from South Australia.

The wood was examined to determine the variation through successive growth rings from the pith of such features as average fibre length, micellar angle, basic density, ring width, percentage late wood, longitudinal shrinkage, spiral grain and percentage cellulose content. The procedure for these measurements has been described previously. Significant correlation between certain of these features were found and the combined within-tree correlations are shown in Table 1.

The values obtained for micellar angle, average fibre length, percentage longitudinal shrinkage, percentage cellulose content, basic density and percentage late wood for the trees in each group were averaged according to growth ring number from the pith. Average results were then plotted against growth ring number and at the same time on the same figures, smoothed curves showing the limits of the extreme variations from these mean values were included. Observations from growth rings found to contain compression wood were excluded. From these "bands" so obtained for each feature it is possible to obtain a very good appreciation of the range of variation in the material examined.

A method was developed whereby, feature by feature, an individual tree could be assessed in relation to the mean for the group and so receive a relative figure of merit for selected characters. It was concluded that cell length and basic density were two characteristics from which sufficient information could be obtained for the evaluation of wood quality. The assessment criteria for these characteristics depends on the end use of the material so that examination was completed on two separate bases:

(i) higher than average cell length and higher than average basic density,

(ii) higher than average cell length and lower than average basic density.

In all cases it was considered necessary to reject those trees which had excessive spiral grain, as this feature is known to be a heritable characteristic.

The abovementioned populations examined for wood quality have been comprised of species from the pinaster-taedae (Diploxylon) section of the genus Pinus. Besides these a group of 14 selected trees of Agathis robusta from Queensland has also been analysed. The only previous work dealing with an indigenous coniferous species was reported by Smith of Queensland Forestry Department for 7 trees of

Araucaria cunninghamii. Because the Agathis robusta material did not exhibit distinct annual growth rings the specimens for examination were sampled at successive equi-spaced zones. The variation through successive zones from pith to bark, of such features as cell length, spiral grain, basic density, micellar angle and longitudinal shrinkage was measured. Significant correlations between certain of these features were found and are recorded in Table 2. This species forms long tracheids and exhibits great uniformity in longitudinal shrinkage so that no attempt was made to assess the trees other than for basic density. A selection based on higher than average density was recommended with the aim of improving strength properties so that they might more favourably compare with those of Agathis material grown elsewhere. No tree had to be rejected because of excessive angles of spiral grain.

A further study of the variations in wood characteristics of Pinus radiata was carried out in a joint project with officers of the Forestry and Timber Bureau, Canberra. Estimates of gross heritability for various anatomical features were sought using material from a clonal plantation established in 1948. The results were submitted to statistical analysis to separate the variation between trees into variation within clones and variation between clones. The former is associated with environment and the latter with both environment and genetic factors. Values of gross heritability for average fibre length and basic density exceeded 0.7. These figures are very encouraging as these two features were chosen to evaluate wood quality in this species.

TABLE 1

TABLE OF CORRELATION COEFFICIENTS FOR VARIOUS GROUPS OF SELECTED TREES SIGNIFICANT AT THE 1 PER CENT. LEVEL - *PINUS* SPECIES

Correlation	Correlation Coefficient - Combined Within Trees						
	Pinus elliottii var. elliottii	Pinus radiata					Pinus pinaster
	Queensland	A.C.T.	Tasmania	Victoria	Kuitpo Area South Australia	Gambier Area South Australia	South Australia
Ring width/fibre length[1]	-.61	-.68	-.36	-.77	-.55	-.62	-.78
Ring width/basic density[2]	-.63	-.60	-.65	-.70	-.60	-.73	-.49
Fibre length[1]/basic density[2]	+.80	+.60	+.44	+.72	+.73	+.79	+.41
Fibre length[1]/longitudinal shrinkage[1]	-.42	-.52	-.68	-.43	-.64	-.76	-.40
Fibre length[1]/micellar angle[1]	-.90	-.92	-.85	-.92	-.93	-.95	N.D.
Micellar angle[1]/longitudinal shrinkage[1]	+.39	+.41	+.60	N.D.	+.65	+.75	N.D.
Per cent. late wood/basic density[2]	+.81	+.42	+.55	+.47	+.61	+.75	+.58
Cellulose content[3]/fibre length[3]	N.D.	+.72	N.D.	N.D.	+.72	+.85	N.D.

1. - Refers to late wood.

2. - Refers to whole ring (extracted).

3. - Refers to early wood.

N.D. - Not determined.

TABLE 2

TABLE OF CORRELATION COEFFICIENTS SIGNIFICANT AT THE 1 PER CENT. LEVEL FOR 14 SELECTED TREES OF *AGATHIS ROBUSTA* FROM QUEENSLAND

Correlation	Correlation Coefficient - Combined Within Trees
Fibre length/basic density	-.71
Fibre length/longitudinal shrinkage	-.29
Basic density/longitudinal shrinkage	+.35

ITEM 1(b) (Cont.)

A SURVEY OF THE WOOD PROPERTIES OF RADIATA PINE IN NEW ZEALAND*

A survey of the wood properties of radiata pine using increment borings from b.h. has been completed for Kaingaroa forest, in which 1,300 trees have been examined. Not less than 50 trees are examined from each site, and so far 1,000 trees have been tested from other parts of the country. The country-wide survey is expected to be completed with the examination of another 300 trees.

Preliminary studies have shown that average values within the stem for basic spiral grain, tracheid length and late wood and early wood characteristics can be reliably estimated from b.h. samples.

*Presented by Dr. D. Richardson.

Resin content, longitudinal shrinkage and spiral grain angle appear to be too variable to be estimated from such restricted sampling.

All trees tested were in the 30-35 years age group. Within Kaingaroa forest average basic spiral grain of the mature wood (outer 10 rings) varied between sites from 0.40 to 0.46. Elsewhere average spiral grain as high as 0.52 has been recorded. This suggests that trees selected for breeding should be judged relative to the site they grow on rather than relative to each other.

Within each site the tree of highest wood density usually has mature wood with spiral grain 60 per cent. greater than the tree of lowest density. This variability has been shown to be partly attributable to differences in growth rate, but some of the remaining variability is regarded as being genetically controlled. The gradient of spiral grain across the stem is very variable and prediction of mature wood spiral grain from juvenile wood or from young trees does not seem feasible for this species.

The limits of late wood have been estimated macroscopically or by using a blunt probe to estimate the textural boundary between late wood and early wood. In some of the low density trees none of the late wood of certain growth layers would satisfy Mork's criterion. On the other hand most of the early wood in high density trees would qualify. This feature has been examined with the beta-ray apparatus for examining wood density: almost the entire range of density across an annual ring from a high density tree may lie above that for a ring from a low density tree. Both early wood and late wood density are higher in trees of high density than in low density trees.

Tracheid length has been examined by measuring 50 tracheids from the late wood of the fifth and outer growth layers at b.h., of a proportion of the trees selected as having exceptionally high or low wood density. Tracheid length was not correlated to differences in spiral grain between trees, nor could any correlation be demonstrated between tracheid lengths of the fifth and outer growth layers at b.h. At the fifth growth layer tracheid length varied from 1.7 to 3.0 mm and at the outer growth layer from 3.4 to 4.6 mm.

ITEM 1(c)

RESULTS OF WORK ON ELITE PINUS RADIATA*

Measurements of the fibre length, basic density, ring width, percentage late wood and spiral grain have been made for each ring of 21 elite trees of Pinus radiata. The results for each tree and the means for all trees have been graphed against ring number. Using the graphs of the means for each ring as a basis for comparison the individual trees have been graded so as to facilitate the selection of trees for the formation of a seed garden. From the change in slope of the graph of the fibre length against ring width an estimate of the length of the juvenile period has also been given.

The graphs of the means have been compared with graphs of P. radiata from Tasmania and A.C.T. published by H. E. Dadswell, J. W. P. Nicholls of the Division of Forest Products. The fibre length basic density and ring width agreed substantially with their results but the percentage late wood showed considerable variation, and this has been attributed to differences in technique.

A study was made of the shrinkage characteristics of 18 P. radiata trees from the southern Tableland.

The results indicate that radial and tangential shrinkage increase with the age of the tree up to approximately 20 years (the age being indicated by ring count). From this age onwards, tangential

*Prepared by H. Booth

shrinkage shows a slight increase with age while radial shrinkage shows slight decrease with age. Volumetric shrinkage as derived from the linear shrinkage shows the same tendency to increase up to a tree age of 20 years, then levelling off to a uniform value at ages greater than this. Graphs of these shrinkage values against ring number do not show a smooth increase up to a tree age of 20 years but indicate a definite wave. Additional sampling will confirm whether this is a true picture of these shrinkage characteristics.

Longitudinal shrinkage is at a maximum near the pith and decreases steadily with tree age, levelling off after about 20 years.

The ratio of radial to tangential shrinkage does not show any connection with tree age, but remains at a uniform value through the cross-section of the tree; the value being approximately 1.8.

Volumetric shrinkage was initially measured by immersion and compared with the value obtained by calculation from the linear shrinkages. As very good agreement was obtained between these two methods, it was decided that for simplicity the volumetric shrinkage be obtained by calculation.

The elite tree samples are also being examined for:-

(i) The ether-soluble content of both the heartwood and sapwood.

(ii) The tannin content of the bark.

The presence of bark on the samples appears to be fortuitous and it was not always available. The results are as follows:-

Sample No.	Ether Extractives Per Cent. (O.P. Basis)		Bark Tannin Per Cent. (O.O. Basis)
	Sapwood	Heartwood	
E59	0.45	7.68	18.7
E62	0.68	14.41	22.2
E64	0.80	8.79	not available
E69	2.41	6.11	14.8
E70	0.38	2.93	22.2
E71	0.43	7.20	25.2
E72	0.87	8.12	24.3
E75	0.46	3.91	not available
E78	1.17	5.71	not available
E80	0.77	9.87	not available
E83	0.66	13.66	27.2
E84	1.54	17.58	not available

The ether soluble material in the wood is important to pulp producers for obvious reasons. It may also be important as a measure of the ability of a tree to resist infection. The considerable variation shown by these figures is in accord with the variation found between trees during the turpentining experiments.

The tannin contents are rather higher than usual even for this location but there are not enough results to show whether this is significant. The results, however, agree with those obtained on younger trees in that rate of growth was shown to have no deleterious influence on the tannin content of the bark.

ITEM 1(f)

SOME ASPECTS OF PARENT TREE SELECTION ON WOOD QUALITY*

(a) The Existence of a Maturity Factor

It has been stated that the core of "juvenile wood" in a tree varies with species and may be affected by environmental conditions. The opinion has also previously been expressed that individual trees may attain the adult stage earlier than others of the same species. Since there is variation at the specific level in the "juvenile" period, there is good reason to believe that maturity factors are under genetic control and, if evidence of between-tree variation existed, their consideration in estimates of parental worth would be highly desirable.

During a study of wood samples extracted from 5 potential parent trees of Pinus caribaea Morelet, pith to bark trend lines for tracheid length showed that 1 tree attained a more or less constant value at a much earlier age and shorter distance from pith than the others. While the average age of "maturity" in respect of this feature seemed to be about 19 years for this group of trees, one was considered to have attained "maturity" at as early as 8 years. All trees were evenaged (24 years old) dominants from the same site and 4 of the 5 had about the same rate of growth.

From data presented, it is suggested that:-

(i) There is some evidence for the existence of "maturity factors" for characteristics affecting wood quality (in particular, tracheid length).

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*Prepared by W. J. Smith (Queensland).

(ii) Variation observed between trees in age of maturity of tracheid length and (2) extent of the core of juvenile wood suggests that they may be under genetic control.

(iii) Increased rate of growth may have the effect of retarding maturation of tracheid length.

(iv) Earlier maturity age does not necessarily mean a reduction in the core of juvenile wood, and

(v) the juvenile core may be capable of reduction without adversely affecting growth rate.

(b) Predictions from Correlations

Following the establishment of highly significant within-tree correlations between certain features and/or properties, the suggestion has been made that comparisons of the wood quality of potential parent trees can be made without measuring some of the features and properties considered desirable.

Attention is drawn to the facts that:-

(i) In tree-breeding work, a causal effect must be established between the factors involved to justify predictions for other populations from correlations derived for a particular population, and

(ii) correlation analysis is open to the danger that correlations may be interpreted as causal when actually due to some third factor exerting a common influence. When used in the study of causal relationships, it is susceptible to misinterpretation, due to the possibility of other factors being mutually correlated with those examined and giving the appearance of a higher than actual degree of correlation between the examined factors.

Evidence is presented to show that high degrees of correlation between cell length and micellar angle in discs from comparable lower-stem levels may be partly due to the intercorrelation of the common factor of distance from pith or cell cross-sectional dimensions or both. Reduction in the predictive value of length as a guide to angle with height in stem and between trees could be due to independent variation in growth rate and in pith to bark and up the stem trends for length and cross-sectional dimensions.

It is suggested that, in established relationships between an anatomical feature such as tracheid length and certain physical and mechanical properties, there is a possibility that the factors involved may be mutually correlated with a third factor, possibly another anatomical feature such as micellar angle.

In discussing the separately demonstrated relationships of tracheid length and micellar angle with the tearing strength of pulp, it is suggested that since, so far as is known, no experiments have yet been designed to show the <u>independent</u> effect of these anatomical features on this property, the degree of <u>causal</u> relationship has yet to be demonstrated and may not be as high as established crude correlations for some species may seem to indicate.

In considering relationships established between (i) basic density and crushing strength and (ii) percentage late wood and basic density, it is suggested that possible mutual correlations with other factors such as age or distance from pith, cell diameter or cell wall thickness could give a misleading impression of the degree of <u>causal</u> relationship between basic density and percentage late wood.

Again, so far as is known, the <u>independent</u> effect of density, percentage late wood and cell wall thickness on strength properties has yet to be established.

On the assumptions that (i) most of the characteristics likely to affect wood quality are heritable and (ii) at least some of the genes controlling these characteristics could interact (e.g. those controlling growth rate, cell dimensions and basic density), and considering the evidence of between-tree variation in the relationships between at least some of these characteristics, it is suggested that it may be hazardous to exclude certain characteristics from consideration in parent-tree selection despite apparently high degrees of correlation with other features used in assessment.

Inclusion of all characteristics in assessments of parental worth on the basis of wood quality is advocated, at least until either high degrees of causal relationships or sufficiently low degrees of heritability have been demonstrated to justify the exclusion of some of them. Registration of the parental worth of each and every character would make reassessment possible at any future date, whereas suitable resampling would not be possible.

Discussion on Items 1(b, c and f)

Nicholls: Mr. Smith seems to have lost sight of the fact that there is no clear dividing line between the zones of juvenile and mature wood. On the fibre length variation curves that are shown he has nominated a particular year, or a particular distance from the pith for the attainment of tracheid length maturity. Even supposing one takes this view, this does not invalidate the fact that there are between-tree age differences in respect of maturity factors for tracheid length or for any other features. Nevertheless the interpretation he has placed on this does not seem to provide the hoped for evidence that the juvenile core is capable of reduction without affecting volume production.

To include maturity factors as additional factors for selection as he has suggested, seems to introduce a needless complication. In this Division we have never used correlation factors to demonstrate causal relationships. For the level in the tree at which the samples for examination are extracted we obtain within-tree correlations between features for discreet populations. These relationships are used when necessary and if they are significant, for prediction purposes, so that wood quality may be assessed on a few rather than many features. If we were interested in applying correlations between features over complete stems, relationships would have to be obtained which include height as an additional variable.

Harding: There appears to be some need for clarification of the term "elite trees". We are endeavouring to select a tree which we regard as preferential in relation to certain characteristics of the species with which we are dealing, but to use a term "elite" tree is probably wrong. Many trees in any species may have characteristics not present in so-called elite trees, and we must not lose sight of these more or less lower grade trees. Even with our pseudo elite trees there may be better class trees for some purposes than the ones we have selected, therefore, we cannot say that we have elite trees.

Richardson: The thing that startles me about our survey is the lack of any correlation between juvenile density and mature density and, possibly, tracheid length.

ITEM 1(d)

TIMBERS FOR THE FUTURE

Bryant: In our submissions for the agenda of this Conference we listed this item as "Discussions on the Timbers we should be Growing for the Future". This carries somewhat broader implications than the official agenda title which is "What are the Wood Characteristics Needed for the Future?" because species as well as characteristics are implied.

Dr. Dadswell and his colleagues in Australia have published extensively on the desirability of certain wood characteristics for particular end uses and there is no need here to emphasize the significance of this work.

For some years past, both here and overseas, a steadily increasing amount of timber harvested has been used in a chemically or mechanically modified form as paper and cellulose derivatives of all types, fibre boards, particle boards and so on. A steadily decreasing amount on a per capita basis is being used to produce sawn and peeled products. This decrease will be sharper in Australia as high density living is forced on urban populations and fewer cottage type dwellings are built.

The planting or treatment of forests which will not mature for 40 or more years make it imperative that these utilization trends are thoroughly studied and it should be the responsibility of Conferences such as this to advise the State Forest Services in the light of intelligent extrapolation of such trends.

It is, therefore, suggested that this Conference should set up a sub-committee to examine the position here and overseas by literature surveys and by questionnaires and discussions with producers and consumers of wood. Such a sub-committee could report back to the next Conference and its terms of reference could be examined. The task will not be a simple one but if approached on a national basis it should be well worth-while.

Bednall: I would like time to think about the proposal of setting up a committee to investigate the problem.

Turnbull: I would support this suggestion actively. It is evident that we have many more species than we actually need for purposes of utilization. Four basic kinds of wood could meet the majority of our requirements. These would not necessarily be the same throughout our geographic range, but it would be better to concentrate our attention and effort on fewer species.

Dadswell: We should have some guidance in tree breeding work on whether we want, for example, high density in a certain species or not; whether we should grow Pinus radiata as a structural timber, as a utility timber, or purely as a timber for pulp. For pulp, we do not necessarily need high density, but high density would be required for structural purposes. We have never had any direction on this particular point with respect to individual species. Pinus taeda and Pinus elliottii are grown in Queensland but we do not know whether they are wanted for structural timbers or not - presumably they are. Queensland may therefore want to breed for high density. We would like to have some indication of what is wanted in the way of wood characteristics.

Huddleston: Analysis of future trends is more one of economy than of scientific fact; nothing will stop the use of timber quicker than its unavailability in the form and price that the buyer wants. This is a question of economics, not of suitability of material. Although the per capita consumption of timber is dropping in Australia and in some of the other more advanced countries, per capita consumption of timber must rise in many other countries, hence I think we are always going to have a very large demand for sawn timber. Admittedly, timber requirements for pulp and disintegration will increase, but at the present time, these take only a very small proportion of the timber crop, and the indications are that for many years sawn timber will be the main crop, and other timbers will be a minor crop.

Bryant: We have a conflict of interests attempting to supply a future market with timber; we have those groups which are interested in buying material at a very low price in very large quantities and reducing and reconstituting it, such as the paper and building board manufacturers, and we have the traditional structural demand that will always be made on timber. If we could look at trends elsewhere and develop some informed opinion on the type and characteristics of timber that we hope to grow , we could perhaps alter our planning practices to cope with a market that will exist in the future. This must also be discussed with the ultimate users.

This should not affect existing eucalypt stands, except perhaps to modify present sylvicultu al practices. In many cases it could only be an opinion expressed to the various interested organizations. People who are buying timber would welcome some intensive thought on this problem, which is going to become very acute in the near future.

Richardson: In New Zealand we have estimated trends in consumption and changes in population up to the year 2,000. The total consumption is of much more importance than the per capita consumption. We have learned that a survey such as this needs to be done by an economist, not a forester, because so many imponderables come in, it is not just a question of basing future upon present uses.

Whatever future markets we are going to have, particularly for radiata, we are always going to need straight trees without branches, so that these might be the first two properties that are considered!

Turnbull: If our population continues to grow at the present rate, we will need to double our timber output in 38 years. The important fact is not whether the per capita consumption drops a little but that much extra wood is needed in such a short space of time. It is important for us to decide what we should try to grow in that time. Fast growing conifers seem to be the only ones with any prospect of reaching the requirements, whether their characteristics are liked or not, and whether some better seed can be selected or not. We should encourage the necessary appropriations to advance the growing at the estimated rate.

ITEM 1(e)

NEW GUINEA TIMBERS*

Over the period since the previous Conference the Division has continued the identification of timber samples for the Department of Forestry, Territory of Papua and New Guinea. This has amounted to some 275 samples. Early this year an officer of the Department spent 5-6 weeks with Wood and Fibre Structure Section taking an intensive course in timber identification, involving the use of the microscope, sectioning and preparation of slides, and the identification of timbers by the use of the macroscopic card key for New Guinea timbers (recently revised and amended) and the microscopic family card sorting key. In the future it is hoped that all identifications from the Territory will be screened by this officer and only wood samples of which the identity is uncertain will be sent to the Division, thus reducing to some extent the duplication of work on the more common frequently occurring species.

The Division has also obtained some 100 botanically authenticated samples collected by officers of the Forestry Department, and a further 216 wood samples supported by herbarium material collected by officers of the Resources Survey teams, Division of Plant Industry. The Division has been able to assist in the identification of many of these. In addition, some 80 samples collected without herbarium material have been identified for these officers.

A more complete picture of New Guinea timber resources is being gained by the acquisition of duplicate wood collections obtained through the courtesy of the Forest Service, Netherlands New Guinea; several requests have been made for check identifications of a small proportion of these.

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*Prepared by H. D. Ingle

From time to time the Division is asked to assist in taxonomical problems by examination of the wood anatomy of certain genera of doubtful affinity or anomalous position. This has involved a re-examination of groups of related genera, e.g. Papuodendron and Hibiscus; Heritiera, Argyrodendron and Tarrietia; Koompassia and Pericopsis.

The acquisition and determination of all this material results in a fuller coverage of certain families with commercial species occurring throughout the Malaysian region as a whole.

Discussion

Beesley: The New Guinea Department appreciates the tremendous amount of work the Division has done in identifying New Guinea timbers. All specimens for identification now come through Port Moresby. The ones that we cannot identify there are passed on to the Division of Forest Products. We find that new timbers are constantly coming in as civilization extends into new areas.

Ingle: The number of genera represented in Australian New Guinea alone is between 450 and 500.

ITEM 2. WOOD CHEMISTRY

ITEM 2(a)

REVIEW OF RESEARCH ACTIVITIES*

The work of the Section may be considered under the following headings:-

(a) Organic Chemistry of Carbohydrates
- Constituents of the Cambium: Biogenesis
- Polysaccharides of the Cell Wall
  - Hemicelluloses of *E. regnans*
- Gum Exudates

(b) Physical Chemistry of Polysaccharides
- Spectroscopy and Structure
- Reactivity of Cellulose
- Hydrogen Bonding

(c) Pulping Studies
- The Process of Fibre Separation
  - Mild Hydrolysis of Wood
- Potentialities of Various Species
- Properties of Holocellulose Pulps

(d) Physics of Fibre-Water Systems
- The Beating Process
  - Specific Surface
- Drainage Behaviour
- Flow Properties

(e) Paper Physics and Technology
- Relationship Between Fibre and Paper Properties
  - Fibre Morphology
  - Fibre Rheology
  - Fibre Chemistry
- Theory of Paper Strength
- Anisotropy of Paper

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*Presented by H. G. Higgins

It can be seen that the activities extend across rather a wide range of scientific disciplines, from organic chemistry with a biochemical flavour on the one hand to physics and technology on the other. The research projects are approached in two ways:-

(i) With a particular practical problem as a starting-point, an attempt is made to apply basic concepts to its solution, the scientific level being determined by the requirements of the problem itself.

(ii) Attempts are made to uncover basic principles in the field of wood chemistry, pulp and paper; this approach has no direct practical objective, but possible applications are kept in mind as the work develops.

(a) Organic Chemistry of Carbohydrates

The nature of the carbohydrate constituents of the cambial zone of *Eucalyptus regnans* is being studied, with the ultimate aim of elucidating the paths whereby the polysaccharides of wood are formed in the living tree. A number of sugars and related substances have been identified and their role in the biogenesis of wood carbohydrates is being assessed.

Another project is concerned with the identification of the polysaccharides of the plant cell wall and particular attention is being paid to the hemicelluloses of *E. regnans*. It is necessary to obtain knowledge on the detailed structure of these materials so that their reactions during pulping may be more fully understood. There are grounds for believing that the differences in the properties of paper made from pulps prepared by various processes may be largely the result of physical and chemical modifications of the fibres which take place as a result of such hemicellulose reactions.

A new investigation involves the examination of the gum exudates of various species, and this will require co-operation from various State Forest Services. The structure of these materials is of considerable interest in carbohydrate chemistry, and some of the gums may be of potential economic interest.

(b) Physical Chemistry of Polysaccharides

A considerable amount of work has been carried out on the spectroscopy of carbohydrates, with the purpose of aiding in the elucidation of the structure of wood polysaccharides and of using spectroscopic techniques in the investigation of cellulose reactions. Studies have been made on periodate oxidation of cellulose, thermal degradation of cellulose and the comparative infra-red spectroscopy of cellulose, laminarin, xylan, amylose and other polysaccharides, of various modifications of cellulose and of cellulose and deuterated cellulose. Present work is directed towards the resolution of some controversial points in the assignment of the absorption bands of cellulose and other glucosans by study of the spectra of deuterated sugars, and attention is being paid to problems of chain conformation and hydrogen bonding in polysaccharides.

(c) Pulping Studies

In order to derive fundamental information applicable to the pulping process, work has been carried out with the aim of elucidating the essential changes that take place during fibre separation. Evidence has been obtained that the separation process is controlled largely by the scission of interfibre covalent bonds. Experiments have been carried out to obtain information concerning the chemical changes which occur during mild hydrolysis of wood, and it has been concluded that hydrolysis takes place within the living tree and may affect the ease of fibre separation.

Another section of the pulping work concerns the papermaking potentialities of various species. Recently particular attention has been given to various species from New Guinea and Western Australia.

Holocellulose pulps are being used to study the influence of chemical composition on properties such as beating response, water retention and interfibre bonding. The influence of lignin and alkali-soluble polysaccharides in pulp has been investigated, and the maximum yield of chemical pulp determined for Eucalyptus regnans and Pinus radiata. Marked differences in behaviour have been observed between holocellulose pulps made from hardwoods and softwoods, and the reasons for these differences are being studied.

(d) Physics of Fibre-Water Systems

With the object of improving the efficiency of the beating ndamental studies on the mechanism of beating have been veral years. Recently changes in drainage resistance and r have been used to clarify the changes taking place in the fibre during beating. Fibrillation and changes in specific surface have been investigated by various methods. A survey of the relationship between primary effects of beating and fibre, pulp and paper properties has been made. The action of the P.F.I. beater has received detailed study, variables such as stock concentration, beating load, clearance between the beating surfaces and operating speed having been examined.

Another project in the field of pulp physics is the study of the laws governing the removal of water from pulp and the drainage of water through fibre pads. The ultimate aim of this work is to apply these principles in papermaking.

The rheological behaviour of pulp systems is also being investigated. Methods have been developed for isolating some of the intrinsic variables influencing the flow of fibre suspensions, and a study of stock pumping is being initiated in collaboration with the University of Melbourne.

(e) Paper Physics and Technology

The relationship between fibre and paper properties has been the subject of considerable attention and further work is being planned. One purpose of these studies is to determine the conditions under which the properties of the individual fibres limit those of the assemblage, and to apply such knowledge to understanding the differences between papers made from pulps prepared by different processes. Equipment for measuring the rheological behaviour of single fibres is under construction.

The influence of fibre morphology on papermaking properties has also been investigated. The effects of fibre length, fibre diameter, cell wall thickness and micellar spiral angle have been studied, and the behaviour of late wood and early wood fibres in papermaking process and their influence on paper properties is being assessed in connection with tree breeding programmes.

Factors underlying the mechanical behaviour of paper have been under active study for some years, and contributions have been made towards a theory of paper strength based on hydrogen bonding. Attempts have been made to incorporate into a general theory the effects of the supermolecular structure of paper and this work is continuing.

The causes of the anisotropic behaviour of paper are of considerable practical interest, and some years ago experiments were carried out on the effect of drying tensions on rheological behaviour. An apparatus has now been developed for producing paper sheets with a preferred direction of fibre orientation, and it is proposed to evaluate the effects of fibre orientation and unidirectional drying tensions on the mechanical properties of paper, and the relative contributions of each towards anisotropy for different structural patterns.

Discussion

Richardson: We are examining woods for the following chemical properties:-

(i) Per cent. extractives
(ii) Per cent. lignin
(iii) Per cent. chlorite holocellulose
(iv) Per cent. - cellulose (based on (iii))

((ii), (iii) and (iv) based on oven dry extractive - free wood).

The extractives are qualitatively studied using the technique of paper chromatography.

The possibility of using the "chlorite holocellose" and " - cellulose" determinations, to study the variation in cellulose content within trees, and between trees of Pinus radiata, is being explored. (Compare work of Zobel et al. on e.g. Loblolly Pine.) Lignin variation in Pinus radiata is also under study.

Bryant: Our Chemistry Section has been primarily interested in plant physiology, particularly Pinus nutrition; being concerned with variable growth in some of the inner forest areas in New South Wales. The development of a good analytical method for the determination of starch has arisen out of an investigation into the death of blue gum. Some of this work was carried out in a co-operative experiment with Mr. Hillis of the Division of Forest Products.

Mr. Bryant then read the following statement prepared by Mr. Humphries:-

Starch Resorption in Sapwood

"Work on the resorption of starch in sapwood has been extended to the determination of starch concentrations in various parts of leaning and normal stems of Angophora costata.

While starch shows a fairly normal distribution around the circumference and along the length of the stem (with the exception of that portion close to the roots) in a normal A. costata tree, transversely, from sapwood to heartwood, a rapid rise in starch is followed by a steady decline to often nil in the transition zone.

In a leaning stem starch is irregularly distributed around the circumference, the upper side having a very low concentration whereas the under side has a high concentration. Tension wood was abundant on the upper side but axial parenchyma (starch storage tissue) was found to be much lower, in volume per cent., than the under side.

There was a general tendency for starch to increase in concentration in the stem near the roots.

Estimations of total free sugars have been made in normal and leaning stems but the results are not yet available for comment.

Further work is planned for the determination of threshold values of starch for attack by Lyctus. The production of starch free sapwood for experiments with Bostrychids is also contemplated."

Stewart: Concerning the use of holocellulose to measure carbohydrates, the method may give reliable results in the case of young untreated wood, but in the case of old wood (i.e. wood from near the pith of old trees), the method is unreliable, especially where hardwoods are under examination; as a result of continued acid hydrolysis within the living tree, much of the non-resistant polysaccharides dissolve during the holocellulose treatment.

Item 2(b)

PULPING PROPERTIES OF NEW GUINEA TIMBERS*

The scope of these investigations has been expanded by the introduction of semi-chemical and mechanical pulping processes in addition to the chemical processes used previously. This has been done to give a wider assessment of the pulping and papermaking potentialities of the species under investigation and also because of the great interest now shown in semi-chemical pulping.

This approach has necessitated further investigations on some of the most promising species previously examined as well as a more detailed study of those species examined since the last Conference.

Pulping of Araucaria klinkii by the neutral sulphite semi-chemical process gave pulps with yields of 70-75 per cent. which were little inferior in papermaking qualities to those prepared using the sulphate process. The high tearing strength, which was a feature of papers made from the sulphate pulps, was also obtained from the NSSC pulps. Cold soda semi-chemical pulps and mechanical pulps were also prepared. These were inferior to pulps prepared under similar conditions using convent nal softwood pulping species.

*Prepared by A. J. Watson.

Semi-chemical and mechanical pulps were prepared from Excoecaria agallocha and Camptostemon schulzii; chemical, semi-chemical and mechanical pulps were made from Anisoptera polyandra, Pasania spp., Castanopsis acuminatissima and Planchonella luzonensis. These investigations demonstrated that E. agallocha gave good quality semi-chemical and mechanical pulps in addition to the good grade chemical pulps previously reported. This is the most promising New Guinea hardwood timber yet examined. It is of interest to note that this species is now being pulped commercially in Pakistan for the production of newsprint.

The papermaking qualities of the other species are governed largely by the basic density of the wood, the lower basic density giving the better properties. This applies particularly to pulps made by semi-chemical and mechanical processes, pulps from the denser species giving a very poor grade of paper. The high tearing strengths of paper from A. polyandra was high for paper produced from a hardwood pulp. This could be attributed to the high fibre length (1.9 mm), and pulp from this species could be blended with the shorter fibred hardwood pulps to improve their tearing strength.

One interesting feature of many of the New Guinea species examined is the high pulp yield obtained by any given process. Sulphate pulp yields of 55-57 per cent. were frequently obtained whereas many eucalypts pulped under similar conditions give yields of 50 per cent. or lower.

Mixtures of the various hardwood species mentioned above have been pulped. This work indicates that pulping of mixed species would present no difficulties providing that dense species were culled from the pulpwood.

Discussion

Dadswell: Co-operation with New Guinea Forest Department has been going on for a number of years to investigate the pulping possibilities of New Guinea species. In the assessment of pulping properties of New Guinea timbers, two anatomical features may be used. First the proportion of fibres to other tissues such as rays and vertical parenchyma; and secondly, basic density.

Item 2(c)

PULPING PROPERTIES OF WESTERN AUSTRALIAN TIMBERS*

Pulping studies have been carried out on Eucalyptus calophylla R. Br. (marri), Eucalyptus diversicolor F. Muell. (karri) and Eucalyptus marginata Sm. (jarrah) collected from both pure and mixed stands growing in a fairly compact region in the south western area of Western Australia. Most of the work has been done with young wood, the samples being taken from trees with girth at breast height within the following ranges:- E. calophylla, 31-78 in.; E. diversicolor, 36-57 in.; and E. marginata, 43-81 in. Certain comparative tests have been made with samples from larger and much older trees.

This work has shown that wood samples from the young trees were lighter in colour, contained fewer gum veins, had lower basic density and produced better quality pulp than samples from older trees of the same species.

Young woods of the three species each gave higher yields of sulphate pulp, with better papermaking properties, than old wood, and each could be pulped satisfactorily with lower amounts of alkali. In

*Prepared by F. H. Phillips.

the case of young E. diversicolor and E. marginata, the small trees produced somewhat higher yields of pulp than larger trees and the use of small trees did not detract from the papermaking properties of such pulps. Pulping of a crown log of E. calophylla of 6 in. diameter gave higher yields than did larger samples of the same species cut from various positions in other young trees. Sulphate pulping of composite samples of each species showed that E. marginata pulp had higher strength than pulp from either E. calophylla or E. diversicolor, at the same degree of beating. However, both yield and colour of the E. marginata pulp were poor. Strength properties of E. diversicolor sulphate pulp were somewhat better than those of E. calophylla pulp. The general papermaking properties of sulphate pulp from these three species were somewhat inferior to those of pulp produced under the same conditions from E. regnans, one of the best eucalypt pulping species.

No difficulty was encountered in pulping a mixture of these species by the sulphate process but, because of the poorer colour of the E. marginata pulp, separation of this wood might be desirable if a bleached pulp was to be made.

All three species gave high yields of neutral sulphite semi-chemical pulp, but the papermaking properties of the pulps from E. diversicolour and E. calophylla were better than those of pulp from E. marginata. All were inferior to E. regnans NSSC pulp prepared under similar conditions.

Cold soda semi-chemical and groundwood pulps were also made from the three species. The results indicated that these processes could be used only for the production of low grade pulp from these particular species.

Discussion

Dadswell: We are doing this work at the request of the Western Australian Forests Department to see whether certain species of Western Australian eucalypts are suitable for pulp. We have shown by these experiments that the raw material is there, to do the job is a matter of economics.

Wickett: It is a matter of getting the particular parties interested. We are very grateful to the Division for carrying out this work.

Item 2(d)

GUM EXUDATES*

Gums are obtained from a large number of plants, including many tree species. They have been an article of commerce for several thousand years. Their principal constituents are complex polysaccharides whose chemical and physical properties determine the usefulness of the gums as components of adhesives, cosmetics, drilling fluids, emulsions, foods, pharmaceuticals, paper, textiles, etc. Scores of Australian species exude gums or are closely allied, botanically, to overseas species which are known to exude gums. There is a paucity of knowledge concerning the properties of Australian gums and it is our aim to determine these properties, especially those of gums exuded in plentiful amounts. We hope to obtain samples mainly through the co-operation of the State Forestry Departments. To date we have collected gums from Acacia pycnantha growing near Melbourne, and the Forestry Commission of New South Wales has supplied samples from A. deanei and A. penninervis growing near Baradine. Preliminary work has indicated that gum from A. penninervis may be suitable as a substitute for gum arabic.

*Prepared by C. M. Stewart.

Discussion

Mr. Bryant and Mr. Trist said that they would be happy to co-operate in provision of samples for this work.

Bryant: It might be pointed out that there is a good market for sandarac resin which is of the acid type. The problem has been to get enough of it. If the Queensland people have a source of supply, we could put them on to a buyer.

Chairman: Have there been any experiments carried out to stimulate the flow of sandarac?

Stewart: In most cases in Australia, naturally occurring gums have been collected. Overseas it is common to would trees in some way in order to stimulate the flow from those that do not produce much gum under natural conditions.

Item 2(e)

THE USE OF MINOR FOREST PRODUCTS

Beesley: In New Guinea a lot of rattans are used; they have quite a possibility as a native industry. The Administration and the Forestry Department would like to stimulate such an industry, for a cash return, and have tried to develop markets for those products, through co-operatives or agencies.

Dr. Cohen: Two methods are being used in New Guinea for de-waxing rattan canes, viz. (i) soaking the cane in running stream water, followed by scouring with sand and then drying, and (ii) wiping the cane with a kerosene-soaked cloth. The former is time-consuming and not very efficient; the latter, apart from the cost of kerosene, has caused contact burns on the operator's skin. Because soaking in running water appeared to be analogous with retting some trials with the latter were made but without success. Experiments have also been carried out with alkaline treatments, with and without added detergents, but these proved to be ineffective. The cane has also been steeped in high boiling liquids with the objective of melting and dissolving the wax. Of the various liquids tried, the most promising was hot liquid paraffin which, after a momentary dip followed by wiping with a cloth, left the cane surface smooth and clean. There are two difficulties concerning cost, viz., (i) the initial outlay on the paraffin oil and (ii) its eventual consumption, especially by contamination. However, it is possible that the oil would be recoverable by precipitating the wax and removing it by filtration on sand. Trials with other high boiling liquids have not been so successful; from crude oil treatment, the cane emerged with an unpleasantly dark colour.

Bryant: There is renewed interest in fibres from our stringybarks. The following statement was prepared by Mr. Humphreys:-

Fibre From Stringybark Barks

"At an earlier Conference (i) this Division reported the preparation of fibres from the barks of a number of stringybark fibres, notably *Eucalyptus scabra* and *E. agglomerata* by retting. The following tests were carried out on this fibre:-

(i) It was made into commercial fibrous plaster (at the Narraboon Plaster Works) alone and in admixture with sisalfibre. Both products were acceptable commercially. In substituting stringybark fibres for sisal, slightly more were required to produce a board of equal strength because our fibre was not quite as strong (13 oz of fibre per sq.yd. of 7/16 in. board was required). The stringybark fibre was found to wet more readily than sisal and therefore to form a better mixture with the wet plaster. The board made from it along was less flexible than that with sisal alone. This was preferred by the trade since there would be less tendency to sag in ceilings.

(ii) Samples of the fibre were shown to an upholsterer and to the Manager of a firm using coconut and other fibres in upholstering (Laminated Plastics Pty. Ltd.) both express the opinion that it was at least as good as coconut fibre for their purposes.

The Commission publicized this work and although there were some enquiries there was no commercial development. At this time (1952) we estimated that sufficient crude bark could be collected in the metropolitan forestry district (excluding points north of Gosford) tp produce 350 tons of dry fibre per annum.

Interest has been revived in this source of fibre in New South Wales by a man named Murray who uses cold 3 per cent. caustic soda to produce fibres from stringybarks and from the leaves of the giant lily, Doryanthes excelsa. Murray has a small factory at Somersby, near Gosford and has approached a number of organizations for finance. The Division has reported favourably on Murray's process to one finance company and has been informed that the company will probably finance Murray to install efficient machinery.

We have passed this information on to the Division of Building Research, C.S.I.R.O. which is investigating substitutes for sisal in the manufacture of fibrous plaster."

ITEM 3. TIMBER PHYSICS

Item 3(a)

REVIEW OF RESEARCH ACTIVITIES*

Since the last Forest Products Conference, the work of the Section has been mainly along three lines, namely:-

(a) Sorption and swelling characteristics.
(b) Rheological characteristics including vibrational properties.
(c) Moisture content determination.

As the last is dealt with in a separate item of the agenda, this resume will be confined to the first two aspects of the work.

(a) Sorption and Swelling Characteristics

(i) Sorption Characteristics

Work has continued on the kinetics of the process of sorption of water by wood. This has been directed mainly to understanding the mechanism which determines the sorption rate. Dr. Christensen indicated at the last Conference that for wood samples less than a couple millimetres in thickness this mechanism was not diffusion. This conclusion has been confirmed and the nature of the alternative mechanism has been studied further. It is probably rheological, i.e. involves stress and time.

A practical consequence of this work is that the conditioning of wood in divided form, e.g. thin veneer, sawdust, wood flour and even paper, cannot be accelerated by reduction in size beyond a certain limit. This limiting size will depend, however, on the range of moisture content change involved.

*Presented by R. S. T. Kingston.

In addition, it should become possible to predict, for a given change in external humidity, the minimum time required for any fraction of the subsequent moisture content change to occur.

It is possible also that an understanding of the sorption process may lead to modification of some aspects of seasoning theory, particularly those relating to changes in the moisture content of the cell wall itself.

Concurrent studies of the rate of swelling of wood substance in liquid water have shown that the mechanism of loss or gain of moisture is more complicated than was originally thought. For instance, it has been found that rate of swelling in liquid water, although perhaps two orders faster than in saturated vapour, is still affected greatly by the initial moisture content.

(b) Rheological Characteristics including Vibrational Properties

(ii) Swelling Characteristics

In an endeavour to investigate the relationship between the shrinkage of wood and its structure, two lines of approach have been attempted.

In the first approach, the shrinkage of thin cross-sections of various species has been studied microscopically, and it has been established that the middle lamella shrinks much less than the more bulky cell wall, and thus restrains the total external shrinkage of the wood. However, differences in the thickness of the middle lamella in the radial and tangential directions do not appear to be responsible for the transverse anisotropy of shrinkage. The existing mathematical theory relating the shrinkage anisotropy to the micellar angle has been extended, and experiments are now in progress in an attempt to study the longitudinal shrinkage-moisture content relationship and its dependence on structure.

In the other approach, use has been made of animal cellulose, or tunicin, as a model substance to investigate the shrinkage phenomenon. In the natural state, tunicin contains about 95 g water per g of tunicin, and on normal air drying, an irrecoverable shrinkage occurs, approximately equal to the volume of the water removed. It is evident that capillary forces are responsible for most of the shrinkage that occurs in tunicin, as it is possible to reduce the volumetric shrinkage to about 10 per cent. by drying in such a way as to practically eliminate capillary forces. Similar treatments, when applied to wood, however, do not reduce the shrinkage below the normal air dry value. Most of the irrecoverable shrinkage of tunicin occurs at high relative vapour pressures, well above 90 per cent., but on drying at very high relative vapour pressures greater than 99.99 per cent., although the moisture content is reduced to about 6 g/g, the shrinkage produced is largely recoverable.

(c) Moisture Content Determination

(iii) Routine Measurements

Routine measurements of the shrinkage and density of Australian and Pacific Island species is being continued; emphasis is now being placed on the testing of Fijian species. Up-to-date values of the shrinkage and density of some hundreds of species have recently been published in a Technological Paper.

(b) Rheological Characteristics including Vibrational Properties

(i) Static Rheological Properties

The study of the rheological behaviour of wood has been continued, special emphasis being placed on the behaviour of material whose moisture content is changing during test.

A study of the effect of moisture changes on the deformation of wood under load has shown that during the first moisture content change the deformation increases greatly when the moisture content of the wood is decreased or increased. This has been observed for creep in bending where the effect is most pronounced on the compression face and has also been observed in tension; compression is now under observation. A corresponding effect of moisture changes on stress relaxation under constant deformation has been observed in bending and torsion.

During moisture content cycling of wood in bending, increases in deformation occur during all moisture content reductions and during the first moisture content increase but slight decreases in deformation occur during subsequent moisture content increases, the total deformation gradually increasing with continued cycling. Most of the increase in deformation is found to be recoverable if the wood is subjected to moisture cycling after unloading. The deformation of wood under tensile loading appears to increase only during the first moisture content change.

The rate of change of moisture content affects the rate of change of deformation but does not seem to affect the total deformation for a given moisture content change.

In view of the probable part played by swelling stresses in the mechanism of the sorption process, it is considered likely that these stresses will be important in explaining why changes in moisture content contribute to the deformation of wood under load. An understanding of these mechanisms may help us to explain and perhaps utilize the effect of changing moisture content on the rheological properties of wood.

In the case of creep at constant moisture content it was observed that creep in tension appears to remain proportional to stress even at very high stresses. This is at variance with observations in bending where the increase with stress is far more rapid. The phenomenon is now being investigated in compression in an attempt to elucidate this difference which may at least in part be due to the much lower strength of wood in compression than in bending or tension.

The effect of changing moisture content on the strength of wood under dead loads has not been found to be so important as that on deformation. So far this has only been studied for decreasing moisture contents from the green state.

At stress levels for which the time to failure is long enough for appreciable drying to occur, the time to failure was higher for material drying out under load. This may be due to the increase in strength which occurs with drying.

(b) Rheological Characteristics including Vibrational Properties

(ii) Dynamic Rheological Properties

Equipment for the measurement of elastic moduli and damping co-efficients at low audio frequencies has been perfected and an experiment is under preparation.

Item 3(a) (Cont.)

DIMENSIONAL STABILITY, SHRINKAGE INTERSECTION POINT, AND RELATED PROPERTIES OF NEW ZEALAND TIMBERS*

All the commercially important exotic and indigenous timbers have now been examined, (32 species in all; 15 as both heartwood and sapwood samples). Not less than 4 samples of each species from

*Presented by Dr. Richardson.

different sources were used, and, for major species, 20 samples of each were examined.

E.M.C. at 65 per cent. R.H. and 26°C varied from 9.2 per cent. for red beech heartwood to 13.7 per cent. for tawa. Shrinkage intersection points (average of radial and tangential values) varied from 22 per cent. for black maire to 34 per cent. for rewarewa.

Dimensional stability was examined in two ways. In the first, dimensional swelling was measured as samples in equilibrium at 65 per cent. R.H. were soaked to moisture contents substantially above their shrinkage intersection points. The second method took cognisance of the fact that stable timbers never approach their potential E.M.C. limits under fluctuating conditions of humidity commonly encountered in practice in New Zealand. To compare these timbers with less stable species, some measure of their rate of movement was required, and the dimensional swelling of samples was, therefore, measured when they were transferred for a limited peri d (24 hr) from equilibrium at 65 per cent. R.H. to an atmosphere at 95 per cent. R.H.

These experiments confirmed the stability of the heartwood of indigenous softwoods, and also showed that the heartwood of several indigenous hardwoods (notably red beech and hard beech) are very stable under short term fluctuations in atmospheric moisture despite high shrinkage in drying from green.

The practical applications of these results depend on the type of exposure to which timber is subjected. Where periodical wetting or prolonged exposure to alternately high and low humidities is probable, standard shrinkage figures, or those for maximum potential movement, are applicable. For exposure to short-term fluctuations in atmospheric humidity, the rate of movement is more important than maximum potential movement.

In samples over 1 in. thick the weight of water absorbed from the atmosphere in 24 hr was proportional to the surface area. Stability tables for 1 in. timber of the 32 species have been prepared, showing the effects of both long-term and short-term exposure to conditions of varying humidity.

Discussion

Jennings: We have observed interesting relationships between the radial and tangential shrinkage in some plantation-grown hoop pine and *P. elliottii*. This has been related to subsequent degrade; this work will be published shortly.

Item 3(b)

MOISTURE METERS*

(a) Species Correction Tests for Use with Resistance Type Moisture Meters

Electrical resistance moisture meter species correction tests have been carried out on the following species since the last Forest Products Research Conference.

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*Prepared by N. C. Edwards.

Common Name or Standard Trade Common Name	Trade Reference Name	No. of Trees Represented in Sample	Source of Material
blackbutt, W.A.	Eucalyptus patens	10	W.A.
fir, Douglas	Pseudotsuga menziesii	9	North America
fir, Douglas	Pseudotsuga menziesii	6	Victoria
ironbark, grey	Eucalyptus drepanophylla	7	Queensland
ironbark, grey	Eucalyptus paniculata	18	N.S.W.
karri	Eucalyptus diversicolor	12	W.A.
marri	Eucalyptus calophylla	10	W.A.
pine, loblolly	Pinus taeda	10	Queensland
pine, radiata	Pinus radiata	40	Victoria
tingle, red	Eucalyptus jacksonii	3	W.A.
tingle, yellow	Eucalyptus guilfoylei	3	W.A.

In addition, tests were carried out on material from 1 tree only of 8 New Guinea species and although the data from these tests are meant to be used as a guide only, the reliability will be improved as more material becomes available.

(b) Improved Sampling for Species Correction Tests

The results of past work on brush box (Tristania conferta) and radiata pine (Pinus radiata) have indicated the advisability of obtaining test material from as many areas as there are commercial quantities of a species available. A minimum tree representation of 10 has been found satisfactory for most species but three to four times this number are required for important species.

Where a species occurs in several distinct districts, an analysis of the results often shows a significant effect due to the area of growth. Therefore, it may be worth-while giving separate correction data for each region of growth for a particular species.

(c) Moisture Determination in Veneer

Work is still being carried out to determine the most suitable method for measuring the moisture content of veneer including boron treated veneer.

Preliminary steps have been taken in the development of a suitable capacity type meter. The use of needle electrodes in conjunction with a resistance type moisture meter has a lot to recommend it in some cases, while hygrometric methods are more applicable in others.

Tests will be made in the near future to assess the possible advantages of an electric hygrometer recently constructed.

(d) The Effect of Chemical Treatment

The results of tests carried out on radiata pine treated to four different retentions with three preservative salts were compared with those obtained on water treated controls. These showed that the effect of variation in retention within the range of commercial treatment was negligible.

Results of samples treated with "Boliden S25" showed no significant variation from the results of the controls in the range 8-24 per cent. meter readings, whereas those from samples treated with "Celcure A" and "Tanalith C" showed a significant increase in meter reading for a given moisture content for meter readings above 9 per cent.

Discussion

Dr. Richardson: Work in this field has centred on the effect of preservatives on the accuracy of moisture meters. Correction figures have been determined for the principal species/preservative combinations (using the Techtron). Also a study of the effect of variation of preservative loading is nearing completion. It appears that, so long as the loading from board to board is reasonably even, resistance-type meters are sufficiently accurate for many industrial needs provided appropriate corrections are applied.

Correction figures are also being determined for the Protimeter, the agents accepting that, contrary to the maker's assertion, correction figures are required.

ITEM 4.- PRESERVATION

Item 4(a)

SUMMARY OF RESEARCH ACTIVITIES*

The purpose of this review is to present a thumb-nail sketch of our preservation work since the 1958 Conference. Some important aspects will be discussed under later agenda items and I will omit these or comment only very briefly but try to spend a little more time on aspects which might not otherwise be mentioned.

(a) Commercial Developments

The pressure preservation industry has developed vigorously since 1958 and there are now some 30 commercial plants operating or soon to commence as well as several private plants. Mr. Dale has listed these plants for the information of all concerned (D.F.P. Newsletter, October, 1961).

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*Presented by N. Tamblyn.

This development and its likely early extension to the treatment of pine building timbers has posed us some very real problems which we are finding difficult to answer as they involve matters of policy as well as long range economic considerations which must be the concern of several States as well as ourselves. We have given this a lot of thought and feel that a small Preservation Committee to co-ordinate opinions and make recommendations on the more important issues would be mutually helpful to all of us. We would like your opinions on this before the Conference is concluded.

(b) Sleeper Tests

Our rail sleeper tests are a major project and over the years have involved installation of more than 12,000 test sleepers in some 30 localities in 6 States. Since the last Conference, tests of about 700 high pressure treated sleepers have been set up in New South Wales and Queensland with the co-operation of the State Railways and Forest Services. The oldest tests of high pressure treated sleepers in Victoria, Tasmania and on the Commonwealth railway have now been in service for 7-9 years with excellent results for the oil treatments which already appear to justify application in Tasmania. However, no immediate action seems likely because it is claimed that a sufficient stock pile of air dry sleepers cannot be accumulated at present in Tasmania.

In South Australia in most test sections creosoted pine sleepers have continued to give results equal to or better than those obtained with jarrah and this treatment is now coming into commercial use. However, in the Victorian test, there has been some failure of pine sleepers to hold spikes satisfactorily, indicating that more work may be necessary to obtain best results in heavy traffic sections.

Last year attention was given to the problem of increasing the life of sleepers in sugar tram lines in North Queensland. A detailed questionnaire survey was made followed by some inspections in the Cairns area. As a result, tests of pressure treated scrubwood timbers have been arranged with the Queensland Forestry Department.

(c) Other Field Tests

The marine borer test of sawn pine and round eucalypt specimens installed in four ports in 1959-60 and more fully discussed in a later agenda item is showing that copper and zinc-copper preservatives have a high degree of effectiveness against Teredine borers including Nausitora in the Brisbane River. However, until the test is older, we are hesitant to recommend these preservatives for marine work, though it now appears that blackbutt piles pressure treated with copper-chrome-arsenic may be offered for use in the Brisbane River next year.

At the last inspection of the pole test installed in North Queensland in 1958 at two sites showing Mastotermes activity, there was no sign of termite attack in any of the pressure treatments. As yet this is regarded as promising but not conclusive evidence of effectiveness.

A stake test of five proprietary metal-chrome-arsenic preservatives, commercially available in Australia, has been arranged with the Division of Wood Technology, Sydney. Approximately 450 sawn radiata pine specimens have been treated to retentions of .25 to .75 lb/cu.ft. and are now ready for installation. The low retention was included to obtain an early comparison of the effectiveness of these preservatives.

(d) High Pressure Treatment of Crossarms

When high pressure treatment of karri crossarms commenced at Pemberton, Western Australia last year, it was soon apparent that there were problems which had not occurred in the quite extensive experimental treatments previously made at this Division. At the Pemberton plant moisture contents were much higher and penetration relatively poor; many arms were cut on the half-quarter and these diamonded considerably during treatment; also treated arms did not clean up satisfactorily in storage, apparently due to the type of oil supplied by the Kwinana refinery.

In the last year we have done a great deal of work in an effort to reduce these problems with karri and our results to date are summarized in a later paper by Mr. Barnacle. In addition to work with karri, we are now starting pilot scale tests on some Victorian timbers which will be used in the projected Victorian high pressure crossarm plant. Retention, penetration, percentage rejection and cleanliness are the main factors being investigated.

(e) <u>New Preservatives</u>

The possibility of producing a fixed, non-arsenical copper-boron preservative has been investigated using ammoniacal copper- and copper-zinc-borate solutions as well as various formulations containing boric acid, copper, zinc, chromium and some additives. In all cases the copper and zinc proved to be highly fixed but the boron was readily leached suggesting that a copper-wood complex is preferentially formed.

Brown coal tar distillates obtained as a by-product of the Lurgi gasification process have also been examined for suitability as wood preservatives. The creosote fraction or "wash oil" at present used for scrubbing the gas has a satisfactory chemical composition but is more volatile than standard bituminous coal tar creosote and has proved inferior in A.S.T.M. laboratory evaluation tests. Further investigation has now shown that a brown coal tar creosote of satisfactory toxicity and permanence can be produced without adversely affecting plant operation. Tests are progressing to determine whether fine coal dust particles in this creosote will impede penetration in wood.

Tests have also shown that a satisfactory creosote oil can be distilled from the wood tar produced by the charcoal-iron plant at Wundowie, Western Australia.

(f) Permeability Studies

Tests with natural round specimens of radiata pine and mountain ash, pressure treated with both water and paraffin wax containing a red dye showed that the pine sapwood treated readily by lateral penetration even when both ends were completely sealed. In the similarly sealed eucalypt specimens lateral penetration was negligible and even when end penetration was permitted by cutting circles or crosses through the seal, the pattern of the exposed end area was traced quite sharply through the sapwood indicating that very little lateral movement had occurred. It thus appears that even in a long eucalypt pole substantially all preservative enters through the ends.

(g) Diffusion Studies

Under a later agenda item, Mr. Johanson will summarize developments relating to our patented dip-diffusion preservative. It is sufficient here to say that the latest development of a 4-component fortifier for addition to boric acid at the treatment plant is most important as it will considerably reduce the cost of the previously developed mix containing all components.

We have given much thought to diffusion treatment of radiata pine building timber and are now investigating the possibility of a pressure diffusion treatment of green pine to reduce concentration gradients in the wood and if possible to eliminate the block stacking period. Using a simple boron-arsenic preservative costing about

10d per lb, we have obtained initially promising results from pressure treatment of green boards after only a few days air drying or after conditioning in the cylinder by a short steam and vacuum treatment.

We are also investigating the relative diffusion rates of boric acid and borax. Results have been most surprising as in diffusion cell tests the diffusion rate of boric acid through mountain ash heartwood was more than double that of borax using solutions of equal boron content. If this is confirmed it may be necessary to revise our ideas on the best formula for a diffusion preservative.

(h) Termite Tests

Since the last Conference a considerable amount of work has been done both in our own tests and in those made in co-operation with the Division of Entomology, Canberra. Since Mr. Gay will be reporting on the co-operative work, I will comment only on one result from our own tests. This is simply that in the field we have not found boron compounds to be reasonably effective against *Coptotermes* spp. This conflicts with laboratory tests, but we now believe that in the jar tests, protozoa in the termite gut, essential to *Coptotermes* for digestion of wood, are killed and cannot be refurnished. In the field refurnishing presumably does occur. From these results it appears that boron compounds used alone would not give good termite protection in treated building timber. Addition of arsenic is necessary for this purpose.

(i) Tolerance of Fungi to Preservatives

Laboratory tests have shown that many wood destroying fungi are highly tolerant to copper and in some cases can grow on agar saturated with copper sulphate. Several of these fungi have also shown high tolerance to copper-chrome-arsenic preservatives and in treated wood are controlled only at loadings of 1 lb or more per cu.ft.

With one strain of Poria vaillantii loadings of 4 lb/cu.ft. of a proprietary copper-chrome-arsenic salt did not prevent decay completely. While in general these preservatives are highly effective, isolated cases of rapid decay in service seem likely to occur.

(j) New Guinea Timbers

We have arranged to make a series of scout tests on timbers from Papua and New Guinea - probably involving 70 or more species. Tests include durability of heartwood; treatability of sapwood and heartwood in pressure and diffusion treatments and susceptibility to Lyctus. Limited tests on mechanical and physical properties are being undertaken by other Sections.

Item 4(a) (Cont.)

REVIEW OF PRESERVATION WORK IN NEW ZEALAND*

(a) Processes

(i) Diffusion

The study of factors affecting the diffusion of boron into green timber continues and such factors as temperature, density, sawing angle, dipping time and surface dryness have been studied in relation to radiata pine. Temperature was found to have a pronounced effect within the range of $4^{\circ}C - 80^{\circ}C$ but the effects of the factors was small within the normal ranges of variation found. Drying out of cores of radiata was found to occur under some conditions of temperature and humidity and this is possible related to osmotic phenomena; it can be controlled by retarding all moisture loss with polythene. The greatest outstanding problem is the reason for the wide variation in loading found along the length of single boards.

*Presented by Dr. D. Richardson.

(ii) Pressure

1. Treatment of Green Radiata Pine with Boron.- Trials have shown that 1 hr steaming at 20 p.s.i. followed by 1 hr vacuum will reduce the saturation of freshly cut radiata pine (4 in. x 2 in.) from an average of 92 - 95 per cent. to about 70 - 75 per cent. Immediate pressure treatment with 4 per cent. boric acid solution results in loadings of at least 1.0 per cent. in all-sap pieces and the initial penetration of at least ¼ in. while the residual heat in the timber greatly speeds diffusion and reduces diffusion times from 8-10 weeks to 2 weeks. Heartwood is heavily treated in this process resulting in boron salt usage of about double for that in normal diffusion. Commercial trials have shown that greater steaming and vacuum times are required to obtain the same standard.

2. Oscillating Pressure Method.- All species and sizes (other than Corsican pine rounds) have produced results too variable to be commercially acceptable. With Corsican pine posts good results have been obtained provided that the posts are recently cut and peeled when treated. The formation of a dry skin produces variable penetration and retentions. Increasing the treating pressures from 8-10 kg/cm^2 and increasing the vacuum/pressure ratios have produced generally beneficial results.

3. Sap Replacements.- Preliminary tests using a dairy type vacuum pump have indicated that Corsican pine posts can be treated successfully with fixed multisalt preservatives such as Boliden S25 and K33 in about 6 hr without any great variation of salt component ratios along the post length.

(b) Preservative Testing

(i) Decay

1. Laboratory.- Threshold values tests on four waterborne preservatives (Tanalith C, Tanalith U, Boliden S25 and Boliden K33) were completed last year. The results showed that the commercial retentions used in New Zealand are generally adequate even after severe leaching, with the exceptions of Tanalith U (not now used where leaching occurs) and the fungus Poria sericeomollis. The threshold values for this fungus on leached blocks were above commercial retentions in each case, Boliden K33 being the lowest of the three fixed salts and Tanalith C the highest. This fungus has not been found to be causing decay in treated timber in service however.

Threshold values tests on domestic creosotes are now in progress using the A.S.T.M. tentative standard method with some adaptations. The adaptations are mainly similar to those developed by C.S.I.R.O. No results of these tests are yet available.

2. Graveyard.- The accelerated $\frac{3}{4}$ in. x $\frac{3}{4}$ in. stake plots established 9 years ago have now reached a stage where most of the less efficient preservatives have failed. Creosote, creosote/oil, and 5 per cent. PCP in oil at retentions of 6 lb/cu.ft. are all still 80 per cent. sound or better (on the A.W.P.A. log base rating scale) as are ammoniacal copper arsenite and three copper-chrome-arsenate formulations at retentions of 0.4 lb/cu.ft. Lower retentions of fluor-chrome-arsenate-phenol, chromated zinc chloride, zinc sulphate, zinc-chrome-arsenate and zinc meta arsenite were all found to have been severely attacked by soft rot at the time of failure.

A new series of stakes to be laid down this year covering the newer waterborne formulations will use P. radiata stakes $1\frac{1}{4}$ in. x $1\frac{1}{4}$ in. x 15 in. to reduce accidental breakages and possible reduction of moisture content per cent. below the decay activity level.

3. Service Tests.- Examination of existing service test records by our newly appointed service tests officer has shown that while telegraph poles and sleepers, are relatively well covered there is a grave shortage of service tests for treated fence posts. Priority is being given to rectifying this position.

(ii) Marine Borers

Accelerated coupon tests were carried out in seven harbours in 1957-58 for exposure periods of 3 and 6 months. Subsequently the panels have been re-exposed in the three worst harbours for a further 6 months period and the results of these are awaiting assessment. The general picture appears to be that fixed waterborne preservatives with high copper contents have considerable promise; their performance in this test being superior to that of creosote or the greenheart and turpentine controls.

(iii) Corrosion

Tests to determine any possible corrosive effects of preservatives in timber on metal fastenings were initiated using a method based on relative changes in electrical resistance in a metal strip (bolted between blocks of wet treated wood sealed in polythene bags) as the cross-section was reduced by corrosion. It was hoped that this method would give a rapid result in terms of micro-inches of corrosion per year but unfortunately the corrosion pattern was mostly "pitting" and the results therefore of greatly reduced value. Only with copper, and to a lesser extent steel, were the results reliable and with these the corrosion rate was less in each case than with untreated timber of the same species (P. radiata sapwood).

(c) Natural Durability

While continuing with the existing graveyard tests of sawn stakes 2 in. x 2 in. x 18 in., some attempts are being made to develop an accelerated test for general use and in particular to compare durability of different strains or individuals of the same timber species.

(d) Surveys

(i) Decay Fungi

The discovery that the widely distributed fungus Poria sericeo-mollis was extremely tolerant to copper-chrome-arsenate type preservatives, has demonstrated the need for more information on the distribution and tolerance of our decay fungal flora. In this respect a culture collection of any fungi found active in treated timber has been commenced. Such fungi are now being tested back for wood rotting ability and preservative tolerance. Identification will only be attempted for those species of high tolerance to preservatives.

(ii) Marine Borers

A survey is being carried out in all major ports later this year (in conjunction with a world wide Teredinid survey being undertaken by Dr. Turner of America) in order to identify all economic marine borers in New Zealand waters and to grade harbours into hazard categories.

(e) Chemistry

(i) Spot-testing of Treated Timber

Owing to the tumeric and PCV spot-tests not being entirely satisfactory, particularly from the boron diffusion operators standpoint, work has been proceeding to evolve a simple spot-test procedure of greater reliability for operator use. In addition, a test for the presence of arsenic in timbers giving a positive molybdate test when untreated is also receiving attention.

(ii) Methods of Analysis

In general, efforts in this field are directed at refining and streamlining existing methods of analysis to improve both speed and accuracy - a wet-ashing procedure for multisalt treated samples using hydrogen peroxide instead of nitric acid has recently been introduced - the method is much more rapid, and considerably less acid fumes are produced. In boron analysis, a method involving the use of aliquots only of the leach liquor has been introduced, this method has been found particularly valuable for samples with a highly coloured extract, and for samples with a high boric acid content. A drying tower, using a forced draught at ambient temperature has been found very valuable for drying boron samples to equilibrium moisture content in humid weather.

In the field of multisalt preservatives, particular attention has been paid to the possible use of X-ray fluorescence spectrography for analysis.

(iii) Heartwood and Sapwood Differentiation

Most of the work in this field has been directed towards the evolution of tests for the less common species of both indigenous and exotic timbers. A solution of dimethyl yellow (0.1 per cent.) in alcohol, originally suggested by C.S.I.R.O. for some Eucalypt species has been found useful for some indigenous hardwoods, particularly Hinau and various species of beech, the test appears to be solely a pH effect, and species giving a positive test, (heart red, sap yellow) also contain large amounts of tannins.

Discussion

Edwards: Our work has been curtailed because of shortage of staff, but the position has improved recently and a much expanded experimental programme is under way. There will be some concentration in the future on the preservation aspects of *Pinus radiata*; this will be discussed in detail at a later stage. Recently work has been done in the field of sap stain control in *P. radiata* logs. The tests have been unsuccessful, although formulations were used which were successful in the southern States of the United States and further work is planned. Sub-floor ventilation investigations have been carried out in conjunction with the Commonwealth Experimental Building Station. Studies are also being carried out on the biology of the Bostrychidae. As regards powder post beetle control, there has been a marked swing from borax and boric acid to sodium fluoride for veneer treatments. This conversion would be almost complete in New South Wales.

As regards Anobium attack in pine, attempts to gather sufficient insects for experimental work have not been successful. Anobium is not regarded as a serious problem at present, but an opinion on this would be welcomed.

Interest in preservation is increasing in New South Wales, but the coal mining industry is adopting a very conservative attitude in the use of preservative treated timbers. Co-operative investigations in the preservative field are being conducted with C.S.I.R.O. and C.E.B.S.

Jennings: Little experimental work has been done; our interest being mainly in the extension of dip-diffusion methods to North Queensland species. We know very little about the treatability of North Queensland timbers and study of this will be a major part of our work in the future. There is one pressure treatment plant operating in Queensland.

Item 4(b)(i)

DIP-DIFFUSION TREATMENTS - TECHNICAL REVIEW*

This process consists of momentary dipping of green timber in concentrated preservative solution and block stacking it for 3-6 weeks, stacks being protected against rain and excessive drying.

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*Prepared by R. Johanson.

Dip-diffusion has been applied to klinki pine in New Guinea since 1955 where it has given complete protection against decay and termites in the houses built from the treated timber.

(a) Chemicals

In this treatment it is aimed to produce an envelope with arsenical component but to penetrate more deeply with the boron component. For this reason the preservative contains boron and arsenic as active toxicants with the addition of dichromate to prevent iron tannate reaction and to help the fixation of arsenic. Sodium fluoride is also added, chiefly to solubilize boric acid components, but it is also a toxicant.

Recently a patent application was taken out to cover a newly developed formulation for a dry mix diffusion preservative. The mixture consists of five components, it does not deteriorate on standing even at elevated temperatures and retains its free flowing dry powder state. At present, for economic reasons, we are suggesting the use of a "partial" dry mix which contains four chemicals. The fifth major component - boric acid - would then be purchased separately. Three licencees have been appointed to manufacture the dry mix - Borax Consolidated Ltd., Celcure (Aust.) Pty. Ltd., and Hickson's Timber Impregnation Co. (Aust.) Pty. Ltd.

(b) Termites - Laboratory and Field Tests

In jars, under laboratory conditions (Coptotermes lacteus and C. acinaciformis are very susceptible to the diffusion chemicals which appear to be as toxic as Cu-Cr-As preservatives. However, from results of field tests conducted over the last 3½ years in a Victorian forest area, we can say with certainty that it is only arsenic containing treatments which have prevented specimens from destruction by termites. Borofluoride alone offered no appreciable resistance. The results also show that termites in the field conduct a thorough examination of treated and untreated specimens, build galleries and plaster over arsenically treated wood. They single out and destroy untreated controls adjacent to the treated specimens but leave intact the treated wood. To date, tests show that this discrimination against arsenic containing preservatives has been 100 per cent. as illustrated by the score obtained in the following tests, in which many separate stations were set up.

Treatments	Stations Explored	Stations Attacked and Destroyed
Untreated specimens	8	8
Treated specimens	10	0

(c) Decay Tests

In laboratory tests employing five wood destroying fungi (Coniophora olivacea, Daedalea trabea, Coriolus sanguineus, Poria sericeo-mollis, Fuscoporia contigua) it was found that the borofluoride-Cr-As diffusion formulation was at least as effective as a proprietary Cu-Cr-As preservative. In the case of Poria sericeo-mollis, however, dip-diffusion proved much superior. With this fungus Cu-Cr-As treatments sustained 50-60 per cent. of dry weight wood loss whereas diffusion treatments lost only 5-10 per cent.

(d) Fixation

Unfortunately there is no known method by which boron can be fixed in wood and for this reason we do not recommend borofluoride preservatives to be used in contact with the ground or in places where timbers will be exposed to continuing leaching.

(e) Penetration

Extensive tests were carried out to compare penetrations that can be obtained by dip-diffusion or pressure-diffusion in green sapwood and heartwood in the New Guinea timber Anisoptera sp. It was found that though better distribution in the sapwood was obtained by the pressure-diffusion treatment, it gave no advantage in the treatment of heartwood. For this species it was therefore concluded that dip-diffusion would be economically preferable.

In the dip-diffusion treatment, thearsenic accumulates as an envelope in the outer layers where its function is to act as a termiticide, insecticide and fungicide, and also to resist surface leaching. The borofluoride component penetrates more deeply and its main action is to increase decay resistance and to protect against borers in the inner layers.

Discussion

Edwards: We are particularly interested in the treatment of *Pinus* at 50 lb/sq.in. with pressure being maintained for 16 to 17 hr. In our scout tests, uptake in terms of boric acid was 0.25 per cent. when the pressure was maintained for 6 hr and 0.5 per cent. after 17 hr. The initial moisture content of the samples was 156 per cent. A small series of scout tests has also been carried out with 50 lb/sq.in. pressure for 17 hr and a diffusion period of 14 days. With green timber the average uptake of boric acid was 3.3 per cent.; with kiln dried timber (limited number of samples) the average uptake was 1.6 per cent.; in heartwood the uptake was .04 to .08 per cent.

Bednall: Is a momentary dip of 2-3 sec sufficient? I understand that New Zealand practice is somewhat longer.

Byrne: The common practice in New Zealand is to submerge the whole packet in a tank to obtain full surface coverage. Some people leave it in the tank for ½ min, others as long as 3-5 min before withdrawing.

Bednall: If it could be done as in an ordinary sap-stain bath, the method would be much simpler, but a 2-3 min dunking is somewhat different.

Johanson: In New Zealand short immersion is often performed in a loosely chained or cradled pack which is moved up and down in the treating tank for about 5 min. This arrangement helps to open up the pack so that each piece of timber comes in contact with the solution.

Cokley: In Queensland we have found it necessary to go to a lot of trouble in the block stacking period to avoid drying. In New Zealand published work, there has been described the use of wet hessian screens and various other types of packaging. What are the economic effects of this ?

Richardson: In climates where you have rapid drying the polythene cover slows down the rate of drying very effectively and is quite cheap.

Edwards: As far as diffusion treatments are concerned in New South Wales, we think storage sheds will be necessary. Sheds are estimated to cost £1,500 to £2,000. The necessity for these depends partly on the amount of timber being used and also on the type of treatment.

Beesley: Dip-diffusion treatments have been carried out at one plant in New Guinea over a period of 18 months and the polythene covers are still in reasonable shape.

Gottstein: I inspected the early dip-diffusion treatments in New Guinea in the period 1955-56. At Bulolo they had very severe difficulties in that the drying of treated pine prevented diffusion. Eventually, after trial of stack covers, they changed over to sheds.

This proved effective in ensuring moist surfaces and continuation of the diffusion treatment, even with pine heartwood of low initial moisture content. They used the momentary single board dip for only 1 or 2 sec.

Tamblyn: We have obtained some results for an uncovered stack which was held without any cover in a kiln to simulate drying under hot weather conditions. We concluded from this that 1 in. boards needed no protection at all. For heavier sections it would probably be better to cover the edges. The main problem is in the ragged end of the stack but if we would have a stack square at both ends the problem would disappear.

Item 4(b) (ii)

DIP-DIFFUSION TREATMENTS - ECONOMIC AND OTHER ASPECTS*

The borofluoride-chrome-arsenic diffusion preservative, patented by this Division, was developed for treatment of building timber in Papua and New Guinea. In a tropical area such as this, many potentially good building timbers do need a general purpose preservative treatment and their local utilization is dependent on it. In most places climatic conditions do not favour the drying necessary before conventional pressure treatment and transport difficulties and the insecurity of capital investment are obstacles to erection of central treating plants. In addition, many timbers have a non-durable heartwood which is most difficult to penetrate satisfactorily under pressure but which can be penetrated reasonably well by a fairly simple, cheap dip-diffusion treatment.

*Prepared by N. Tamblyn.

The position in Australia is not everywhere so technically and economically favourable to diffusion treatment and with pressure treatment facilities becoming available, our recommendations for building timbers need critical consideration. They depend largely on answers to the following questions. Our opinions are indicated (in brackets) below and we would be glad to have the considered views of the State Forest Services and other delegates.

(a) Rainforest Timbers

1. Is the present boron treatment of the sapwood of rainforest timbers adequate or would it be desirable to give better protection against decay and termite attack - probably by addition of arsenic and possibly by increasing the loading ?

(We believe better protection is desirable and that it would add very little to the present costs of treatment.)

2. Are we prepared to recommend the present boron treatments (Lyctus immunization) for weatherboards, external joinery, verandah floors etc.?

(No.)

3. Would we be prepared to make this recommendation if higher loadings were used of a better balanced but unfixed preservative containing arsenic ?

(Yes, if verandah floors are omitted, and provided the cost to the consumer is substantially less than pressure treatment with a fixed waterborne preservative.)

4. Is the alternative of pressure treatment with a fixed salt any more attractive ?

(It is more reliable but if a good multisalt diffusion treatment is less than 75 per cent. of the cost of pressure treatment we would recommend it; otherwise we would favour pressure treatment.)

5. Should we recommend diffusion treatment for interior timbers and pressure treatment with fixed salts for weatherboards etc. ?

(This would be technically sound but economically undesirable because most operators would then require to set up facilities for pressure and diffusion treatment. Also we would still have the problem of penetrating non-durable heartwood in weatherboards etc.)

6. Assuming that a satisfactory diffusion treatment at 60-70 per cent. of the cost of pressure treatment were available, could we expect this price differential to be passed on to the public ?

(We are inclined to believe that most of the cost advantage would be pocketed either by the treater, retailer or builder before the public could benefit. In this case we could be severely criticised for approving a treatment which was not the best available for the money.)

(b) Radiata Pine, Hoop Pine

1. Is treatment of radiata and hoop pine building timber undesirable ?

(With the possible exception of roof timbers, we believe that in most areas treatment against decay and insects is desirable, but would like to confirm this from the results of a survey.)

2. <u>For these timbers, is pressure treatment with fixed salts preferable to diffusion treatment</u> ?

(We are inclined to believe so, because apart from technical reasons diffusion treatment alone will not encourage maximum utilization. On the other hand pressure treatment restricted to uses other than building timber may not be sufficient for profitable plant operation.)

3. <u>Can we recommend diffusion treatment as an alternative to pressure treatment with fixed salts</u> ?

(We are finding this question very difficult to answer. These timbers are more suitable for pressure treatment than rainforest hardwoods and have important use for weatherboards and flooring where profiling and dressing is likely to remove much of the arsenic which does not penetrate well in diffusion treatments. In New South Wales where there is competition from cypress pine, costs of a diffusion treatment would probably be kept as low as possible, but in South Australia diffusion and pressure treatments might ultimately cost the public much the same. We are inclined to believe that unless legislation is enacted in South Australia, diffusion treatment will be introduced whether or not we recommend it. If this does happen, we would probably be forced to make a recommendation and set the best standard possible. Its justification would then depend largely on the relative future prices of diffusion and pressure treated timber and we would have no control over these.)

4. <u>Is dip-diffusion suitable for radiata pine weatherboards</u> ?

(If it is conceded that leaching is slight in painted weatherboards, an unfixed preservative should be satisfactory. However, because of profiling we would like to see high core loadings and this may require a pressure-diffusion treatment of semi-green timber.)

<u>Note</u>: Further discussion on (b) 1-4 under Item 5(a).

Discussion

Edwards: In reply to the Division of Forest Products' request for comment on various questions concerning dip-diffusion we have divided our answers into those relative to rainforest species and those concerning Pinus radiata. The latter we have listed under Item 5(b).

Replies to Questions (a)1-6 are as follows:-

(a)1. We feel that the present treatment with boron is adequate for the purpose for which it was introduced. With regard to protection against decay and termite attack most rainforest timbers used for building in New South Wales are employed in situations where such hazards are not serious.

(a)2, 3.

Yes, although we are not happy about the use of unfixed arsenic. We agree with the exclusion of verandah floors.

(a)4. We agree with the Division of Forest Product's comment. We feel from discussions with millers that diffusion treatments will be about 50 per cent. cheaper than pressure treatments.

(a)5. We agree with the Division of Forest Product's comments.

(a)6. The Division of Forest Product's comments highlight an important difficulty which may arise.

Beesley: In New Guinea the installation of pressure treating facilities is completely beyond the capacity of existing timber producing units and any treatments done must be made with the simplest of equipment.

In the highlands there does not appear to be much hazard from termites, the only hazards to timber in service being from decay and from the Lyctus type borers. Most of the decay in permanent structures can be prevented and in many districts such structures, which are mostly Government owned, are repainted on a 2-year cycle. Consequently, the most important hazard in the highlands against which preservative treatment is required is Lyctus and similar borers hence a diffusion treatment with boron would appear to offer adequate protection.

Where new dwellings are being constructed it is now standard practice to place them on concrete stumps or on timber stumps set on pads of concrete 2 or 3 in. out of the ground. Ventilation under these buildings is good and there is very little trouble from sub-floor decay. Additional protection is provided by setting the outermost row of stumps 6 or 12 in. back from the ends of the bearers and carrying the sheathing down over the ends of the bearers to protect them from run-off.

As the Administration Mills at Keravat and Lae have been closed, all treatment in the Territory will now be done by private enterprise, and until there is a Timber Users Act there is no regulation of treatment.

Jennings: My answers to the questions are:-

(1) Present treatment is satisfactory for Lyctus,

(2) no,

(3) yes,

(4) I would prefer to make the recommendation for diffusion treatments; the objection to pressure treatment is an economic one. If we recommend that an all-purpose preservative should be in general use we are going to add to the cost of timber in Queensland, not only because of the high cost of treatment, but because of high transport costs between the source of supply and the treatment plant. It is much more desirable to encourage a treatment which can be done at the source of production. In the North Queensland industry, I do not think pressure treatment could

be done at the source of production because no sawmill could afford the capital investment.

(5) Our answer is the same as yours. Lower treatment costs would be very acceptable. If you want to keep treatment costs down you need competition. Thus it may not, in the long run, be desirable to adhere to one preservative.

Richardson: One should consider the economic aspects pertaining to question (4). Diffusion is simpler and cheaper to set up. In New Zealand an enormous number of diffusion plants have been put in, and the cost of policing these is fantastic and must be introduced as a cost of diffusion. For example, the Timber Preservation Authority laboratory was designed to cope with 6000 analyses a year, but samples would now be coming in at the rate of 24,000 a year if the sampling intensity was up to requirements. This is a measure of the rate that plants have mushroomed in New Zealand. The cost of policing, that is the cost of collecting samples and analysing them, must be over £30,000 a year.

Bryant: The figures you quote are purely for dip-diffusion treatments ?

Richardson: No, but there is less control of pressure plants, possibly because dip-diffusion has exploded at such a rate in New Zealand.

Huddleston: This highlights the difference between control in Australia and New Zealand. In New South Wales we specify a depth of penetration and loading of preservative, and rely on the plant operator to meet these requirements. The only analyses we conduct are those which are taken by inspectors from pieces of timber about which there might be a complaint or some suspicion. We carry out certain analyses on behalf of the trade, which pays for them, but they would have to do their own if the number became too great. The situation reported by Dr. Richardson is not likely to arise in Australia unless we change our policies.

Byrne: Referring to the explosive growth of preservation in New Zealand, in 1956 we had 30 plants registered; at the moment, they are going in at the rate of 2 or 3 a month and there are now about 200 registered. Over the last 2 years these have been mostly diffusion plants. The policing is operated through the Timber Preservation Authority, and the sampling is undertaken at 5-weekly periods at some plants, at others less frequently. This work is done by Forest Service timber inspectors, who double as Quarantine inspectors. They also do check grading and routine sampling. Thus, while in reality a staff of 20 is involved, only about a third of their time is used sampling preservation material.

Jennings: In North Queensland, where the bulk of our plants are situated, there are some 40 approved plants using ordinary open tank diffusion. They are policed by one officer who makes check inspections of plants and check analyses of results on a part-time basis. This system is quite satisfactory, and we are not contemplating ever policing like New Zealand.

Edwards: We have one Inspector engaged on full-time inspection. The analyses are carried out by our Chemistry Section. There are about 70 registrations issued, and approximately 40 plants are actually working. One Inspector is perfectly able to cope with these.

Huddleston: The effectiveness of the policing in New South Wales can be shown by the fact that we have never had a complaint and have never made a prosecution for borer attack in treated timber. Our policy should be that we do not make any definite recommendation of pressure versus dip-diffusion treatment, but should aim to provide each enquiring body with the technical details of each treatment and leave them to determine which they should adopt.

Tamblyn: Concerning costs - we are trying not to deceive ourselves. We are inclined to believe that if equal approval is given to diffusion treatment and pressure treatment, there will be a tendency to make no discrimination between them. A builder will, therefore, charge both at the same price. I am afraid that the public will not receive the cost advantage of diffusion treatments. If the builder has opportunity for selling dip-diffused timber at the same price as pressure treated timber, it will put more money into his pocket. He will thus prefer to buy diffusion-treated timber, and the sawmiller will be more anxious to use the diffusion treatment because he will sell more timber. If this chain of circumstances occurs, we will have diffusion treatments ousting pressure treatments, but selling for the same price. I believe this situation did exist in New Zealand until quote recently. Only if the lower cost is passed on to the ultimate purchaser of the house would we be justified in recommending diffusion treatment. In this connection I believe that the cost of boron immunization in New South Wales has risen to over 20/- since pressure treatments became established.

Huddleston: At my last check it was 17/6 per hundred super - it could well have risen over £1.

Edwards: The cost of pressure treatment in New South Wales is about 24/- at .35 lb; 27/- at .5 lb and 34/- at .75 lb.

Jennings: We have little pressure treatment at present. The one pressure plant we have at Eidsvold is selling pressure-treated timber at the same price as non-pressure-treated timber. For the last 3-4 years in Brisbane it has not been possible for the industry to demand a treatment price on top of its normal sawn price. Hardwood treated against Lyctus attack is sold at the same price and frequently at a lower price than standard grade material which did not require treatment. In all other respects this material is equivalent to standard grade. Once you have approved a treatment, you must also approve the plant to use it, and my position in giving advice would be exactly the same as Mr. Huddleston's.

Booth: If one treatment is better than the other, it will sell at the higher price. Lending authorities will specify treatments they consider adequate to preserve a job.

Beesley: The New Guinea Forests Department has adopted a policy that where sapwood is treated to make it usable for building purposes, no extra charge for treatment is made. It is considered that the additional recovery will adequately recompense the cost of treatment. However, when a timber is treated to increase its durability for a special use, the cost of treatment would be added to the cost of the timber.

Item 4(c)

USE OF UNFIXED PRESERVATIVES FOR WEATHERBOARDS AND EXTERNAL JOINERY*

The possibility of decay in weatherboards or external joinery must depend on the climate of the region under consideration. In Victoria, untreated timbers of low durability, e.g. mountain ash, have been used for weatherboards and external joinery for many years, with only occasional complaints when decay occurred, very often at a poorly constructed or badly protected joint, such as that between jamb and sill in a window. However, when a timber of low durability and

*Prepared by F. A. Dale.

high absorptivity, namely ramin, was used some years ago for window sashes, a great deal of trouble occurred in a short time. Ramin is no longer used. Untreated mountain ash window sills also gave trouble in the wetter Latrobe Valley on a large Housing Commission project.

The fact that in this State at least the hazard is both variable and marginal suggests that only marginal protection is required. If we eliminate unpainted joinery and weatherboards as requiring permanent, fixed protection, we must then decide what degree of protection is needed in houses where paint will always be maintained, even though this may be delayed beyond the desirable period.

Unless the paint film is completely broken down, it is very hard to imagine that substantial leaching will occur and if some does occur it will be arrested when repainting is done. For this reason the Division believes that a non-fixing preservative such as the dip-diffusion mixture developed here will give adequate protection against decay and insect attack for the life of the house, provided that adequate core loadings are obtained to ensure that any cross-cutting or moulding will not expose unprotected wood.

This belief is substantiated by Harrow's tests on boron-treated pine weatherboards on a building in Auckland over a number of years. In these tests no significant loss of protection occurred in the treated boards, which were painted at the usual intervals.

It is not suggested that treatment with a diffusing preservative would obviate the need for the usual precautions taken to prevent access of moisture to exterior weatherboardings and joinery, such as adequate width of eaves, proper flashing, and grain priming and careful joint design. Where for any reason timber is fully exposed and regular painting cannot be guaranteed, e.g. in verandah floors, ramps, staircases, etc., the use of a durable timber or one treated with a fixed preservative is highly desirable.

All the foregoing implies that decay is the principal hazard in weatherboards and joinery. Insect attack in treated timber is only likely to occur where decay is already established so that provided protection against decay is given and maintained by initial treatment, there is no risk of insect attack. This means also that boron treatment alone would be insufficient, as it is not lethal to some termites. The addition of arsenic is therefore essential.

It will be argued that the decay hazard is much higher in New South Wales and Queensland. This is not denied, but we believe that even there the leaching hazard in a house given normal paint maintenance is so slight that dip-diffusion treatment with our mixture will give adequate protection.

Discussion

Jennings: I do not agree that a weatherboard must be termite proof. With present building methods in Queensland termites are not a hazard for weatherboards. For weatherboards of exotic *Pinus* species, however, some preservative treatment must be used, and we feel that provided loadings are adequate, boron treatment with normal maintenance may be adequate. There is no need at the present time to use this type of material but it is of future importance. We have some field tests with *P. elliottii* at the moment for external joinery and weatherboards. Where a naturally non-durable species is used for external joinery, the treatment of the finished article may be better preferably an oil treatment of some sort and we have done some trials with 5 per cent. PCP in oil We are at present using unseasoned hardwood for sills in Queensland and their performance is far from satisfactory.

Cokley: One Brisbane company has been using 5 per cent. PCP (up to a week cold soak) on silky oak for Lyctus control on sappy edges. They have been doing this for 8 years on the commercial production of joinery and to date we have had no complaints.

Huddleston: Both Celcure and Hickson's have told me that trouble is experienced due to decay in boron treated weatherboards in New Zealand.

Byrne: As far as I am aware, we do not use boron for the treatment of weatherboards in New Zealand, we only use fixed salts. There could be a few houses built on private finance with such weatherboards, but the State Advances Corporation will not approve boron treated weatherboards.

Tamblyn: We have heard that a preservative treatment firm was making a dossier of examples of decay in boron treated weatherboards in New Zealand.

Edwards: Our feelings on leachability are that it is something that has been much over-emphasized, and we feel that the report of Harrow gives a much more realistic assessment. Even if leaching is taking place it is probably confined to a small shell on the outside of the boards.

Bryant: We do not favour the use of arsenic on weatherboards, because we agree with Queensland in thinking that it is unnecessary.

Tamblyn: Referring to dipping of slash pine for window joinery, ultimately the man using the timber may ask why do we have to doctor this inferior material. Also, every little back-yard producer will have to treat it and control will be difficult. On the other hand, if we come out in the open and require pressure treatment with a fixed salt, people would be sure of getting good service.

<u>Jennings</u>: I do not agree that pressure treatment is inevitable or that the dipping method could mean back-yard doctoring. Satisfactory preservation does not necessarily require large-scale operation.

<u>Cokley</u>: One must think in terms of a simple method of preservative treatment. We cannot tell the average joinery shop to put in a pressure treatment plant. In many cases mills are in country districts far from technical assistance and they require a simple process and preservative technique.

<u>Huddleston</u>: Substitutes for timber which are often cheaper than the timber product, are actively promoted. It is therefore essential that manufacturers of timber products should do the job properly. The tallowwood sill which has been manufacturered widely in Australia was selected because it had certain characteristics, the most important of which was its small movement with change in atmospheric conditions. Slash pine has a smaller shrinkage, but responds readily to changes, and I believe the promotion of sills of slash and radiata pine, would be an invitation to the aluminium and plastic industries.

<u>Dale</u>: This illustrates the great diversity of conditions, and how difficult it is to get reasonable agreement between Victoria and Queensland on the likely hazards.

<u>Item 4(d)</u>

<u>RECOMMENDED RETENTIONS FOR METAL-CHROME-ARSENIC PRESERVATIVES*</u>

(a) <u>Questionnaire Survey</u>

In November 1959 a questionnaire was prepared and sent to manufacturers of various proprietary waterborne preservatives and to a number of people professionally experienced in their use. This

*Prepared by N. Tamblyn.

questionnaire listed the principal uses for treated timber with specific examples, and requested that desirable minimum retentions be stated. In all, 10 questionnaires were sent out and 10 replies were received.

The questionnaire referred specifically to sawn and round radiata pine and to round eucalypts. It was assumed that penetration would be complete or substantially so in the pine and that a sapwood of at least $\frac{1}{2}$ in. would be fully penetrated in the round eucalypts. While these specific cases do not cover all timbers, it was considered that they are typical and most suited for our basic recommendations, from which retentions for other timbers can be derived.

The questionnaire listed many categories of use and many specific examples where different retentions would be technically desirable. In sending the questionnaire it was explained that although it may not always be practicable for a commercial plant to treat to many different retentions, our purpose was to set minimum average charge retentions which in practice could be met by supplying to the nearest higher retention conveniently available.

(b) Recommended Minimum Retentions

In Table 1* our recommendations are given for the preservatives Tanalith C, Tanalith CA, Celcure A, Boliden S25, Boliden K33, Celcure (old) and Tanalith U. The formula of these preservatives is given in Table 2 +. Recommendations have been made only after careful study of the questionnaire replies, of specifications current in other countries, of field test records and of our own experiences in Australia. They are intended to apply in all Australian areas south of the Tropic of Capricorn. In most cases they should also be applicable north of the Tropic, but if in any tropical area the hazard is known to be particularly high, an increased retention may be desirable.

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*Pages 103-5. +Page 106.

(c) Reasons for Recommendations

In the discussion below the numbers used refer to the 14 classes listed in Table 1.

CLASSES 1 and 2 - BUILDING TIMBER

(a) Metal-chrome-arsenic Preservatives.

The five metal-chrome-arsenic preservatives (Tanalith C, Tanalith CA, Celcure A, Boliden S25 and Boliden K33) are sufficiently similar to be considered as a group.

If, as a starting point, it is accepted that there is good evidence that Tanalith C should be recommended for treatment of protected building timbers at a retention of 0.35 lb/cu.ft. commercial salt, then comparative retentions for the other preservatives in this group may be examined on a chemical or "paper toxicity basis". Comparisons of this type are considered to be reasonably valid for building timbers where the leaching hazard is low or negligible and the environment is not complicated by contact with soil or soil water. The toxic content must then be the main criterion and this can be assessed theoretically by giving all toxic components the same value ("toxic percentage") or by setting arbitrary values according to the estimated toxicity of each component ("toxic score"). The various comparisons which can be made by these methods are shown in Table 3.

(i) Toxic Percentage

Although the toxic percentage would normally be based on total toxic content (As + Cu + Zn), it could also be based on the arsenic content alone or on the toxic metal content (Cu + Zn). Although all comparisons are shown in Table 3, there seems no doubt that the comparison based on total toxic content would be more applicable to building timbers in Australia where there is a combined decay and insect hazard.

If this comparison were to be accepted, some adjustments may be desirable as shown in column 8, Table 3*. Reasons for these adjustments are as follows:-

Celcure A.- In mild vacuum drying (40°C) of commercial samples, the weight of Tanalith C remained almost unchanged while the Celcure A sample lost approximately 5 per cent. In air drying at 105°C, the Celcure A sample lost over 10 per cent. weight and the Tanalith C samples less than 1 per cent. It is, therefore, believed that there is at least 5 per cent. more free water in Celcure A than in Tanalith C and that the adjustment made in column 8 ($.308 \times \frac{105}{100} = .323$ lb/c should be applied, at least to retentions below 0.5 lb/cu.ft.

Boliden S25.- The toxic metal in this salt is mainly zinc which is less toxic than copper to most wood-destroying fungi. If the toxic score method of comparison (as later described) is not fully adopted, it would seem desirable for it to be applied to devalue the toxicity of zinc in this preservative. As a reasonable adjustment it is suggested that metallic zinc be given one third (1/3) the value of metallic copper. On this basis the zinc content of 9.32 per cent. would be equivalent to 3.11 per cent. copper and the toxic percentage (As + Cu + Zn) would be reduced to 23.47 + 3.11 + 3.12 = 29.70 per cent.

The comparison with 0.35 lb/cu.ft. Tanalith C would then become:

$$\frac{20.18}{29.70} \times 3.5 = .238 \text{ lb/cu.ft. Boliden S25.}$$

(ii) Toxic Score

As an alternative, and preferable, method of assessment, different weights may be given to the copper, zinc and arsenic with particular reference to their effectiveness in preventing decay. As

*Page 107.

seen from Table 3 the retentions based on arsenic alone are invariably lower than the figure based on total toxic content. Since laboratory tests (1) have shown that 0.35 lb/cu.ft. Tanalith C gives high termite resistance, there seems little doubt that the other preservatives, all of which contain more arsenic, will give adequate insect control in any comparison with Tanalith C. On the other hand, the same laboratory tests indicate that 0.35 lb/cu.ft. Tanalith C is probably a minimum loading for decay protection. In setting comparative retentions it would therefore appear that decay protection is more likely to be the limiting factor and for this reason it is proposed that the toxic score method should be based on the following values:-

Copper (Cu)	2
Zinc (Zn)	2/3
Arsenic (As)	1

The toxic score for Tanalith C would then become (Cu) 17.82 + (As) 11.27 = 29.09 and this figure has been used in the toxic score comparisons in Table 3. Adjustment for free water in Celcure A has also been made.

(iii) Comparison of Results

Retentions based on toxic content (adjusted) and on toxic score are summarized in Table 4 and compared with retentions approved in the 1960 specifications for pine building timber issued by the New Zealand Preservation Authority.

It is recommended that retentions based on toxic score should be accepted.

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(1) Tamblyn, N. Proceedings 9th Forest Products Conference, pp. 75-90, Division of Forest Products, Melbourne, 1958.

TABLE 4

SUMMARY OF RETENTIONS AS LB/CU.FT.

Preservative	Based on Toxic Percentage Adjusted Figures		Based on Toxic Score - Adjusted		New Zealand
	Commercial	Anhydrous	Commercial	Anhydrous	Anhydrous
Tanalith C	.35	.30	.35	.30	.30
Tanalith CA	.24	.22	.26	.24	.19
Celcure A	.32	.27	.34	.29	.27
Boliden S25	.24	.18	.28	.21	.19
Boliden K33	.21	.16	.22	.17	.19

(b) Celcure (old) and Tanalith U

On a paper toxicity basis these preservatives cannot be compared easily with the metal-chrome-arsenic salts and have, therefore, been considered separately on the basis of overseas standard, on evidence of various field tests, and on our own experiences.

(i) Celcure (old)

In our experience, this is a relatively inefficient, though highly permanent preservative. Because of the absence of arsenic it has low insect resistance and because copper is essentially the only toxic component, it is susceptible to copper-tolerant fungi. Although the chromium content is high it is not regarded as materially increasing toxicity to fungi or insects.

Recommended retentions in typical overseas standards are summarized in Table 5.

TABLE 5

OVERSEAS STANDARDS (AS COMMERCIAL SALT)

Specification	Preservative	Interior Timbers	Exposed Painted Timber	Exposed Unpainted Timber	Ground Contact
U.S.A. Federal Spec. TT-W-671C (1950)	Celcure	.5	.5	.5	.75
	Tanalith U	.35	.35	.35	.55
A.W.P.A. Spec. C2-59	Celcure	.5	.5	.5	1.0
	Tanalith U	.35	.35	.35	.5
South Africa SABS.05 (1949) (softwood timbers)	Celcure	.4	.45	.5	N.R.
	Tanalith U	.35	.4	.45	N.R.
British draft Standards 9043, 9044 - June, 1960	Celcure	.4 - .5*	.5	.5	.5 - .8
	Tanalith U	.25 - .35*	.25	.25	N.R.

*The higher retentions are recommended where there is severe condensate.

In the Mississippi fence posts tests (2) treated southern yellow pine posts have given the following service under a combined decay and termite hazard (Table 6).

(2) Blew, J. O. and Kulp, J. N. - U.S.D.A. For.Prod.Lab. Report 1757 (1960).

TABLE 6

MISSISSIPPI FENCE POST TESTS

Preservative	(lb/cu.ft.)	Service Life
Celcure	0.92	31 years life*[a]
Tanalith U	0.35	25 years life*[b]
Boric acid - borax	0.92	10.6 years life
Untreated		3.7 years life

*[a] Estimate based on 19 per cent. failures in 22 years.
*[b] Estimate based on 46 per cent. failures in 23 years.

Tests of treated southern pine stakes (3) also in Mississippi have given the following results (Table 7):-

TABLE 7

MISSISSIPPI STAKE TESTS - RESULTS AFTER 14 YEARS

Preservative	(lb/cu.ft.)	% Good	% Attacked	% Destroyed	Remarks
Celcure	.26		30	70	Mostly attacked by termites
	.52	30	70		
	.75	90	10		
Greensalt	.26	10	90		Decay and termite
	.50	90	10		
	.78	100			
Untreated				100	Life 3.2 years

(3) Blew, J. O., - U.S.D.A. For. Prod. Report No.1761 (1960).

In Australia, laboratory tests of treated karri plywood (4) have given results as shown in Table 8.

TABLE 8

LABORATORY TESTS OF TREATED KARRI PLYWOOD

Preservative	(lb/cu.ft.)	% Weight Loss in Decay Tests			% Weight Loss in Termite Tests		
		F.1	F.2	F.3	T.1	T.2	T.3
Celcure	.30	50	43	7	25	45	35
Greensalt*1	.28	31	19	16	33	14	10
Copper borate*2	.29	11			8	10	34
Untreated		52	48	48	61	86	68

Fungi: F.1, C. cerebella; F.2, T. lilacino-gilva; F.3, L. trabea.

Termites:

T.1, C. acinaciformis; T.2, C. lacteus; T.3, N. exitiosus.

*1 $CuSO_4.5H_2O$ 33.3 per cent.; $K_2Cr_2C_7$ 55.6 per cent; $As_2O_5.2H_2O$ 11.1 per cent.

*2 $CuSO_4.5H_2O$ 38.5 per cent. + $Na_2B_4O_7.10H_2O$ 61.5 per cent. + acetic acid.

This table illustrates the weakness of Celcure (old) in relying on one toxic component only and also incidentally shows that in Greensalt the arsenic content is too low. In tests previously mentioned (1) much better protection was obtained with Tanalith C though

(4) Tamblyn, N., Da Costa, E.W.B., Gay, F.J. Technical Paper No.6 (1959). Division of Forest Products, Melbourne.

it must be admitted that these latter tests were made on treated radiata pine which being much lighter than karri would contain a higher percentage of toxic components at the same loading in lb/cu.ft.

In New Zealand, the toxicity of Celcure to Anobium punctatum has been reported by Harrow (5) who obtained complete control in laboratory tests at 0.4 per cent. commercial salt (equivalent to about .13 lb/cu.ft. in radiata pine). To this result he applied safety factors which we would consider excessive and recommended that in commercial practice a retention of at least 1.0 lb/cu.ft. commercial salt should be required.

In summarizing the above evidence, the American field tests indicate that 0.5 lb/cu.ft. Celcure (old) commercial salt should be sufficient to control decay and termite attack in building timber. This is the recommendation of the manufacturers for Australian conditions and is not exceeded in any of the standards summarized in Table 5. However, our laboratory tests (Table 8) suggest that this retention would not give the same protection as 0.35 lb/cu.ft. Tanalith C which resulted in weight losses of less than 2 per cent. in laboratory termite tests (1) and in good decay control with all except one unusually tolerant fungus. As previously discussed these tests refer respectively to karri and radiata pine and are thus not strictly comparable.

On the above evidence it is difficult to decide whether a retention of 0.5 lb/cu.ft. Celcure (old) would be adequate in commercial practice where with some timbers the retention in individual pieces may vary considerably from the mean for the whole charge. With radiata pine sapwood this variation is usually not great and since the heartwood is relatively difficult to treat an overall retention of 0.5 lb/cu.ft. would usually result in slightly higher loadings in the sapwood.

(5) Harrow, K. M. N.Z. Jour. Sci. and Tech. Section B, 36 : 3. 278-280, 1954.

Considering all evidence it is recommended that the minimum retention for Celcure (old) for building in classes 1 and 2 timbers should be set at 0.6 lb/cu.ft. subject to review when further evidence is available.

(ii) Tanalith U

Tanalith U is an anhydrous salt with an elemental arsenic content of about 10 per cent. compared to an arsenic content of about 11 per cent. for Tanalith C. For interior building timbers it should, therefore, be expected to give good termite control at 0.35 lb/cu.ft. retention. This loading is quite widely specified abroad (Table 5) and based on field tests in U.S.A. (Table 9) should give adequate protection inside buildings.

TABLE 9

(lb/cu.ft.)	Average Life (Years)				
	Canal Zone	Louisiana	Florida	Mississippi	Wisconsin
.2	2.9	9.6	13.9	10.2	90 per cent. failure
.28 - .3	6.4	13.7	15.4	70 per cent. failure	16.3
.6 - .65	14.2	15.6	17.3	30 per cent. failure	16.0
Untreated	.7	2.9	2.8	2.9	5.7

Based on these results, it is recommended that a retention of 0.35 lb/cu.ft. Tanalith U as commercial salt should be approved for treatment of building timbers in classes 1 and 2.

CLASS 3 - SAWN TIMBERS, UNPAINTED, USED OUTDOORS ABOVE GROUND

It is considered that the comparisons based on toxic score used for building timbers in classes 1 and 2 and the low retentions recommended should be restricted to timbers protected from leaching and used under conditions where the decay hazard is relatively low.

Class 3 contains unpainted timbers used outdoors for such purposes as fence palings and rails, farm gates, steps, tank stands, exposed bridge decking etc., where leaching can occur and where the decay hazard may at times be relatively severe (e.g. at the bottom of fence palings when weed growth is high).

With preservatives of the Tanalith C type, there is good evidence that retentions of 0.5 lb/cu.ft. should give satisfactory protection under these conditions. Without reviewing all evidence it should be sufficient to record that E. sieberiana poles treated with Ascu to an average loading of 0.7 lb/cu.ft. in the sapwood have shown no decay or termite attack in the treated sapwood in 24 years at the Ballarat test site. These loadings were as low as 0.6 lb/cu.ft. for individual poles.

In comparing other preservatives with Tanalith C the following reasoning has been applied:-

Tanalith CA.- This preservative has a higher arsenic content than Tanalith C but its copper and chromium contents are almost identical. There appears no reason to question the manufacturer's recommendation that except in classes 1 and 2 it should be used at the same retention as Tanalith C.

Celcure A.- Except for a slightly lower copper content and a slightly higher arsenic content this preservative is very similar to Tanalith C. For class 3 timber it should be used at the same retention as Tanalith C.

Boliden S25.- In this preservative zinc has been largely substituted for copper and any direct comparison with Tanalith C and other similar formulations is difficult to make. For the present, and until further evidence is available, it is proposed that for class 3 timbers the Boliden S25 preservative, as commercial paste, should be used at the same retention as Tanalith C.

Boliden K33.- On the toxic score basis (classes 1 and 2) this preservative is recommended for use at 63 per cent. of the retention required for Tanalith C. There is some evidence from leaching tests and laboratory decay tests suggesting that this factor is too low for service outdoors or in ground contact. It is, therefore, recommended that this factor be raised to 80 per cent. of the retention required for Tanalith C. This decision is subject to review as more evidence becomes available.

Celcure (old).- Based on evidence previously presented (Tables 5, 6, 7 and 8), a retention of 0.75 lb/cu.ft. is recommended for class 3 timbers.

Tanalith U.- Because of its relatively low resistance to leaching and because it is no longer recommended for outdoor use by the manufacturers, it is proposed that this preservative be not recommended for outdoor use in Australia.

CLASS 4 - SAWN TIMBER USED ABOVE GROUND UNDER SEVERE CONDITIONS

It is considered that in this class (wet factories, greenhouse timbers, concrete nailing strips etc.), service conditions are not sufficiently different from some types of hazard in the previous class to justify increased retentions. No increase is, therefore, recommended.

CLASS 5 - SAWN TIMBER IN COOLING TOWERS

A distinction has here been made between heavier framing timbers and the lighter members (slats and fill structural timbers up to 1 in. thickness) which because of position and size are most liable to failure from soft rot. Retentions for slats and fill structural members up to 1 in. have, therefore, been set with the primary objective of controlling soft rot while in larger timbers control of basidiomycete fungi has been made the main objective.

(a) Slats and Fill Structural Members up to 1 in. Thickness

Copper-chrome-arsenic preservatives such as Tanalith C and Celcure A are now becoming widely used for treatment of cooling tower fill in several countries at retentions of about 1.25 lb/cu.ft. Celcure (old) has also been widely used for cooling towers in England where long service records indicate good results at about this retention.

On the evidence at present available, the copper content appears to be the main factor affecting the comparison of closely similar preservatives when used for soft rot control. The preservatives, Tanalith C, Tanalith CA, Celcure A and Boliden K33 have, therefore, been compared on the basis of copper content and respective retentions of 1.33, 1.33, 1.50 and 1.00 lb/cu.ft. recommended. Since these figures have been calculated on a mathematical basis the 5 per cent. penalty for the apparent free moisture content of the Celcure A salt has been included.

Of the remaining preservatives, the Boliden S25 salt was not recommended for cooling towers by the manufacturers and this ruling has been accepted until results of tests planned by this Division are available.

Celcure (old) has a high copper content but as it contains no arsenic and is hence not strictly comparable with the copper-chrome-arsenic preservatives, the comparative retention has not been set on copper content, but on general service records.

(b) Heavier Structural Members

Retentions for heavier structural members have not been set on copper content but on the relative evaluation of the preservatives as already discussed for class 3. Proposed retentions are the same as those recommended later for pine poles and posts.

CLASS 6 - SAWN TIMBER IN GROUND CONTACT

Comparative retentions have been based on the relative evaluation of the preservatives as already discussed for class 3. A base figure of 0.75 lb/cu.ft. Tanalith C which is considered satisfactory for ground contact (see previous comment on Ballarat pole test) has been adopted except for the special case of house stumps where a very long life is desirable and where the base loading has been increased to 1.0 lb/cu.ft.

CLASS 7 - ROUND TIMBER, EXPOSED BUT NOT IN GROUND CONTACT

In this class conditions of service are similar to those already discussed in class 3. In most other classes higher retentions have been recommended for round eucalypts than for round pine. This is regarded as generally justified because of the shallower protective band of treated wood in round eucalypts and because of their higher density which reduces the percentage retention of a preservative when loadings based on lb/cu.ft. are recalculated. However, in class 7 this distinction between eucalypts and pine has not been made because it is considered the loading for eucalypts is adequate to prevent attack in the sapwood.

CLASS 8 - ROUND TIMBER IN GROUND CONTACT

A base retention figure of 0.75 lb/cu.ft. for Tanalith C is recommended for this type of use and the discrimination between pine and

and eucalypt discussed for the previous class has been made. Comparative retentions for other preservatives have been derived according to the relative evaluations discussed for class 3 timbers.

CLASS 9 - ROUND MINE TIMBER

Under severe conditions the decay hazard in a mine would almost certainly exceed that for poles and posts in normal outdoor service. However, in general, pit props are not expected to give the same long service as a transmission pole. Taking both factors into account it is recommended that the retention for round timbers in a mine or colliery should be the same as for poles and posts if the decay hazard is judged to be high, but may be reduced for less severe conditions.

CLASS 10 - ROUND PILING, NO MARINE BORER HAZARD

Comparative retentions for all preservatives have been based on those recommended for poles and posts (class 8) except that all loadings have been raised (in most cases by 25-35 per cent.) to reduce the risk of premature failure and to increase service life, which in typical bridge piles could desirably be 50 years or more.

CLASS 11 - ROUND PILING, NO MARINE BORER HAZARD

Preservatives containing a fixed copper component are of value in preventing Teredine borer attack if very high retentions are used. It appears probable that effectiveness is related to copper content but this has not been proven sufficiently for comparative rating on this basis. It is, therefore, recommended that for the copper preservatives under consideration, the same retentions should be used irrespective of their formulation. The retentions proposed are strictly the minimum which should be permitted and in practice the highest loading consistent with economic use should be required for permanent structures.

With eucalypts a minimum retention of 2 lb/cu.ft. would be desirable but a range from 1.5 - 2.0 lb has been given in Table 1 because with timbers of high density the higher figure may not be practically obtainable.

The Boliden preservative S25 was not recommended by the manufacturers for marine use and this has been followed in Table 1. However, this preservative is so far performing well in Australian marine borer tests and its use will, therefore, be subject to early review.

CLASS 12 - PLYWOOD, INTERIOR USE

Retentions proposed are the same as those recommended for other building timbers in similar use (class 1). Comparative retentions are based on toxic score as discussed for classes 1 and 2.

CLASS 13 - WATERPROOF PLYWOOD, EXPOSED BUT NO MARINE BORER HAZARD

Where the hazard is not unduly high, retentions proposed are the same as those for class 3, but for more severe conditions higher loadings equivalent to those used for pine poles and posts are recommended. Comparative retentions have been derived from the relative evaluation of preservatives as discussed for class 3 timbers.

CLASS 14 - MARINE PLYWOOD, EXPOSED TO MARINE BORER HAZARD

Retentions proposed for plywood likely to be exposed to marine borer attack have been set at the same level as those for pine marine piling (class 11). Comparative retentions for the various preservatives have been set in accordance with the discussion under class 11.

TABLE 1

RECOMMENDED MINIMUM PRESERVATIVE RETENTIONS

	Type of Use	Examples	Timber	Minimum Retentions as lb/cu.ft. Commercial Salt or Paste						
				Tanalith C	Tanalith CA	Celcure A	Boliden S25	Boliden K33	Celcure (old)	Tanalith U
1	Sawn timber used indoors above ground	Framing timber, floors, trim	Pine	.35	.26	.34	.28	.22	.6	.35
2	Sawn timber, painted, used outdoors above ground	Weatherboards, window joinery	Pine	.35	.26	.34	.28	.22	.6	.35
3	Sawn timber, unpainted, used outdoors above ground	Fence palings, steps decking	Pine	.5	.5	.5	.5	.4	.75	NR
4	Sawn timber under severe conditions above ground	Greenhouses, concrete nailing strips	Pine	.5	.5	.5	.5	.4	.75	NR
5	Sawn timber in cooling towers	Fill timber to 1 in. thick	Pine	1.33	1.33	1.5	NR	1.0	1.33	NR
		All other members		.75	.75	.75	.75	.6	1.0	NR
6	Sawn timber in ground contact	Rail sleepers	Pine	.75	.75	.75	.75	.6	1.0	NR
		House stumps		1.0	1.0	1.0	1.0	.8	1.5	NR
		Mines or tunnels		.75	.75	.75	.75	.6	1.0	NR

cont./

TABLE 1 (Cont.)

	Type of Use	Examples	Timber	Tanalith C	Tanalith CA	Celcure A	Boliden S25	Boliden K33	Celcure (old)	Tanalith U
				Minimum Retentions as lb/cu.ft. Commercial Salt or Paste						
7	Round timber, exposed but not in ground contact	Fence rails	Pine	.5	.5	.5	.5	.4	.75	NR
			Euc.	.5	.5	.5	.5	.4	.75	NR
8	Round timbers in ground contact (excluding mines)	Poles and posts	Pine	.75	.75	.75	.75	.6	1.0	NR
			Euc.	1.0	1.0	1.0	1.0	.8	1.33	NR
9	Round Mine Timber	Pit props	Pine	.5-.75	.5-.75	.5-.75	.5-.75	.4-.6	.75-1.0	.5*
			Euc.	.75-1.0	.75-1.0	.75-1.0	.75-1.0	.6-.8	1.0-1.25	.75*
10	Round piling, no marine borer hazard	Bridge piling	Pine	1.0	1.0	1.0	1.0	.8	1.33	NR
			Euc.	1.25	1.25	1.25	1.25	1.0	1.5	NR
11	Round piling, marine borer hazard present	Marine piling	Pine	1.5	1.5	1.5	NR	1.5	1.5	NR
			Euc.	1.5-2.0	1.5-2.0	1.5-2.0	NR	1.5-2.0	1.5-2.0	NR
12	Plywood, interior use	Linings, doors, furniture	All spp.	.35	.26	.34	.28	.22	.6	.35

Cont./

TABLE 1 (Cont.)

	Type of Use	Examples	Timber	Minimum Retentions as lb/cu.ft. Commercial Salt or Paste						
				Tanalith C	Tanalith CA	Celcure A	Boliden S25	Boliden K33	Celcure (old)	Tanalith U
13	Waterproof plywood, exposed, but no marine borer hazard	Caravans, boats	All spp.	.5	.5	.5	.5	.4	.75	.5
		Silos, irrigation wiers		.75	.75	.75	.75	.6	1.0	NR
14	Marine plywood, exposed to marine borer hazard	Boats	All spp.	1.5	1.5	1.5	NR	1.5	1.5	NR

NOTES:- NR - Not Recommended.
* - Recommended only where leaching conditions are not severe.

All retentions are as commercial dry salt or in the case of Boliden preservatives as commercial paste (25 per cent. water).

Retentions are based on total volume for pins and on sapwood volume for eucalypts or similar timbers.

Pine refers specifically to radiata or hoop pine but retentions apply to any similarly permeable timber.

Euc. refers specifically to round eucalypts, but retentions apply to any other timber with a relatively narrow sapwood.

TABLE 2

FORMULAE OF PRESERVATIVES

Preservative	Formula as % Commercial Salt	Anhydrous %	% Elements Based on Commercial Salt Formula
Tanalith C	$CuSO_4.5H_2O$ - 35 $K_2Cr_2O_7$ - 45 $As_2O_5.2H_2O$ - 20	$CuSO_4$ - 22.37 $K_2Cr_2O_7$ - 45.00 As_2O_5 - 17.29 Water - 15.34	Cu - 8.91 Cr - 15.91 As - 11.27
Tanalith CA	See under anhydrous	$CuSO_4$ - 22.4 $Na_2Cr_2O_7$ - 39.0 As_2O_5 - 32.0 Water - 6.6	Cu - 8.92 Cr - 15.48 As - 20.86
Celcure A	$CuSO_4.5H_2O$ - 32 $K_2Cr_2O_7$ - 40 $As_2O_5.2H_2O$ - 21 $Na_4As_2O_7$ - 7	$CuSO_4$ - 20.46 $K_2Cr_2O_7$ - 40.0 As_2O_5 - 18.15 $Na_4As_2O_7$ - 7.00 Water - 14.39	Cu - 8.14 Cr - 14.14 As - 11.83) 14.79 As - 2.96)
Boliden S25	See under anhydrous	ZnO - 11.6 CuO - 3.9 CrO_3 - 23.0 As_2O_5 - 36.0 Water - 25.5	Zn - 9.32 Cu - 3.12 Cr - 11.96 As - 23.47
Boliden K33	See under anhydrous	CuO - 14.8 CrO_3 - 26.6 As_2O_5 - 34.0 Water - 24.6	Cu - 11.82 Cr - 13.83 As - 22.16
Celcure (old)	$CuSO_4.5H_2O$ - 45 $Na_2Cr_2O_7.2H_2O$ - 50 $Cr(C_2H_3O_2)_3.H_2O$ - 5	$CuSO_4$ - 28.77 $Na_2Cr_2O_7$ - 43.96 $Cr(C_2H_3O_2)_3$ - 4.64 Water - 22.63	Cu - 11.45 Cr - 17.45) 18.50 Cr - 1.05)
Tanalith U	See under anhydrous	NaF - 25.0 Na_2HAsO_4 - 25.0 Na_2CrO_4 - 37.5 D.N.P. - 12.5	F - 11.31 As - 10.07 Cr - 12.04 D.N.P.- 12.5

TABLE 3

COMPARISONS WITH 0.35 LB/CU.FT. TANALITH C (ALL RETENTIONS AS COMMERCIAL SALT OR PASTE)

Preservative	Toxic Percentage*							Toxic Score*		
	Based on % As		Based on % Cu + Zn		Based on % As + Cu + Zn					
	Calculation	lb/cu.ft.	Calculation	lb/cu.ft.	Calculation	lb/cu.ft.	Adjusted	Relative Score	Calculation	lb/cu.ft.
Celcure A	$\frac{11.27}{14.79} \times .35$	.267	$\frac{8.91}{8.14} \times .35$	.383	$\frac{20.18}{22.93} \times .35$	.308	.323	Cu 16.28 As $\underline{14.79}$ 31.07	$\frac{29.09}{31.07} \times .35$ + 5% adjustment for high m.c.	.344
Boliden S25	$\frac{11.27}{23.47} \times .35$	.168	$\frac{8.91}{12.44} \times .35$	.251	$\frac{20.18}{35.91} \times .35$	.197	.238	Zn 6.21 Cu 6.24 As $\underline{23.47}$ 35.92	$\frac{29.09}{35.92} \times .35$	.283
Boliden K33	$\frac{11.27}{22.16} \times .35$	.178	$\frac{8.91}{11.82} \times .35$	.264	$\frac{20.18}{33.98} \times .35$	.208	.208	Cu 23.64 As $\underline{22.16}$ 45.80	$\frac{29.09}{45.80} \times .35$	.222
Tanalith CA	$\frac{11.27}{20.86} \times .35$	.189	$\frac{8.91}{8.92} \times .35$	.350	$\frac{20.18}{29.78} \times .35$	.237	.237	Cu 17.84 As $\underline{20.86}$ 38.70	$\frac{29.09}{38.70} \times .35$	.263

* Because of the relatively low toxicity of chromuum it has not been included in the above figures.

Discussion

Edwards: We are in general agreement with the retentions proposed by the Division of Forest Products and feel they have made a most useful contribution to the rational use of the metal-chrome-arsenic salts.

For the information of Conference the following approvals for Tanalith C are in force under the New South Wales Timber Marketing Act 1945-52.

	Sawn Timber	Retention of Commercial Salt in lb/cu.ft. of Treated Timber
1	Immunization against Lyctus attack.	0.15
2	Inside use - not in ground contact.	0.30
3	Outside use - not in ground contact.	0.50
4	Mining timbers (and natural rounds).	0.75
5	Ground contact.	1.00
	Natural Rounds	
6	Ground contact.	1.00
7a	Pinus radiata in ground contact	1.00 or
7b	if based on total volume.	0.50

Note: All retentions based on sapwood volume except 7b.

There are also requirements regarding heartwood penetration in 1 to 7a to ensure that timber is not sold as preservative treated if it cannot be effectively treated.

With regard to marine piling we are somewhat hesitant to recommend the CCA salts until more evidence is available for local conditions.

We agree with recommendations of classes 13 and 14 for plywood but feel that the problem of gluing plywood satisfactorily at some of the higher retentions of these classes still remains to be overcome.

Huddleston: What concentration are we going to recommend and what do we accept as a legal minimum ? If we recommend a loading of .35 lb/cu.ft. based on the content of a charge we cannot set .35 as the minimum acceptable in a piece of timber. We must set some other lower figure as the basis for the approval. When the question arises as to how this lower figure should be determined, consideration has to be given as to the radical to be used as the basis of determination.

Cokley: What about the effect of species density on loading ?

Tamblyn: We admit that lb/cu.ft. is not a technically sound way of expressing loading; it is percentage on a weight basis which counts. Therefore, if we recommend .35 lb/cu.ft. for radiata pine we should probably recommend .70 lb for a timber of 60 lb/cu.ft. density. We have not really faced up to this problem in setting loadings.

Huddleston: Mr. Edwards' figures are approvals under the Timber Marketing Act, and thus are minimums. Basis of determination of these is different from the one used normally. The .3 lb/cu.ft. is usually based on the total volume of timber in the charge. In these approvals it is a legal minimum based on the outer $\frac{3}{8}$ in. annulus cut from the piece; the average loading could be less.

Tamblyn: That would depend on the timber; radiata pine would have a different distribution.

Note: After some discussion it was decided that this subject should be dealt with by the Preservation Committee.

Item 4(e)

HIGH PRESSURE TREATMENT OF EUCALYPT CROSSARMS*

Shortly after operations commenced at the Pemberton (Western Australia) crossarm treatment plant, two problems were encountered, namely, difficulty in obtaining the required retention, and cleanliness of the treated arms.

Analysis of 505 observations obtained from 10 per cent. sampling of various charges of crossarms at Pemberton gave the following information.

(i) Treating with 1,000 lb/sq.in. for 1 hr appears to give a significantly higher absorption than 800 lb/sq.in. for 1½ hr.

(ii) That in 9 ft x 3 in. x 3 in. crossarms with eight number 1-1/16 in. holes there is a significantly higher absorption obtained than with eight number 11/16 in. holes for a given treating pressure, i.e. either 800 or 1,000 lb/sq.in.

(iii) For bored crossarms core moisture content has a more significant effect on retention of preservative than case moisture content.

Considerable testing of treatment variables at this Division using air dried material or material partly air dried followed by kiln drying yielded little success, with mean retentions of the order of 4.0 lb/cu.ft.

Two groups of specimens kiln dried from the wet condition with and without pre-steaming and treated at 800 lb/sq.in. and 160°F for 1 hr gave mean retentions of 6.5 and 6.6 lb/cu.ft. respectively.

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*Prepared by J. E. Barnacle.

(a) Unincised Material

Kiln drying from wet gave a very significant increase in retention over material air dried for a considerable period followed by the same kiln schedule as used for green material.

Pre-steaming at 212°F for 2 hr before kiln drying from wet, also enhanced absorption of preservative. In addition, boring before kiln drying gave better preservative retention than boring after kiln drying in both unsteamed and pre-steamed specimens, although pre-steaming enhanced the difference in retention.

(b) Incised Material

The effect of boring before or after kiln drying was of little significance in material dried either from green or the partially air dried condition.

Effect of incision carried out before kiln drying was highly significant in material dried either from the wet condition or the partially air dried condition.

The effect of pre-steaming incised material before kiln drying on subsequent retention preservative was highly significant in material steamed in the green condition but was not significant in partially air dried material.

The use of oblique incision (blades at 30° to sides of specimens) resulted in only a slight increase in preservative retention over that obtained with parallel incision, i.e. blades parallel to sides of specimen.

(c) High Temperature Drying from Wet

Again in non-incised material, tests have shown that very high temperature drying from wet resulted in very high retentions. Results are as shown in Table 1.

TABLE 1

Stick No.	Kiln Schedule								
	110°F/30°F W.B.D.			200°F/50°F W.B.D.			230°F/95°F W.B.D.		
	M.C. at		Retention (lb/cu.ft.)	M.C. at		Retention (lb/cu.ft.)	M.C. at		Retention (lb/cu.ft.)
	Surf.	$\frac{3}{4}$ in.		Surf.	$\frac{3}{4}$ in.		Surf.	$\frac{3}{4}$ in.	
15	$9\frac{1}{2}$	30	5.1	–	8	8.6	8–	8–	11.0
16	9	36	5.1	–	8	9.2	8–	$9\frac{1}{2}$	11.4
17	11	40+	5.0	–	19	9.9	8–	28	12.2
18	$12\frac{1}{2}$	40+	5.5	–	8–	10.9	8–	8	14.0
19	$12\frac{1}{2}$	25	5.3	–	8–	11.2	8–	8	11.9
20	$11\frac{1}{2}$	28	5.3	–	8–	13.7	8–	8–	14.9
Mean Retention (lb/cu.ft.)			5.2			10.6			12.6

Specimens in the high temperature runs, however, were severely honeycomb checked due to tension set conditions developed during drying in the outer layers of the specimens.

While some of the increasing retentions in these specimens may be attributed to the honeycomb checking, it is considered that the retentions are too high to be explained in this way. It is possible that some change has occurred either in the structure of the wood itself or in the deposition products within the vessels, and this is currently being investigated by the Wood and Fibre Structure Section.

Another test was designed to examine the effect of moisture content on preservative retention and the effect of two different kiln conditions for drying from the wet condition. Points that have come out of this test, however, are as follows:-

(i) There is a clear trend of increase in preservative retention as moisture content decreases from greater than 40 per cent. to the vicinity of fibre saturation point, but there is no definition of the trend below fibre saturation point. Thus it may be possible to dry karri excessively before pressure treatment and only further tests can prove this point.

(ii) There was no significant difference in retention of preservative for material dried initially from wet using a kiln schedule of 110°F/30°F W.B.D. and using a schedule of 100°F/5°F W.B.D.

(iii) Moisture content is not of itself the dominant factor in the treatability of karri. This is indicated by the fact that the variation in moisture content only accounted for approximately 14 per cent. of the variability in retention.

In view of this, some very small scale observations have been made on one sample from each of the eight crossarms represented in this test, and ranking comparisons are currently being made of such features as basic density, pH, water soluble extractives, colour of wood, total extractives, porosity, amount of obstruction in vessels, etc.

(d) Oil

Considerable trouble was experienced due to sludging of the furnace oil at the Pemberton plant and this was attributed only to water being returned to the work tank. It now appears, however, that the oil itself contributes to the cleanliness problem due to a relatively high wax content. This could also be important in other preservatives such as creosote.

Discussion

Barnacle: Without incision the classical type of treatment is not possible with karri. Penetration is mainly along vessels from the ends and where grain emerges on the sides. Where grain is parallel to the side, there is virtually no penetration. However, I do not believe this is as serious as it may appear, since if we cannot put oil in the side grain at 1,000 lb/sq.in., I believe the oil film would prove adequate in crossarms to give an effective barrier to ordinary moisture.

Wickett: The present practice is to cut the arms $\frac{1}{8}$ in. full, air dry, kiln dry to 15 per cent. and then square-dress in order to get away from diamonding during drying. By this means rejects are brought down to an acceptably low level. A high-pressure cold water wash immediately upon removal from the cylinder gives considerable improvement in cleanness of the arms.

Dale: Mr. Barnacle's statement does not imply that there was not good end penetration where it was most needed. There were complications like retaining full cross-section, shape and cleanliness but the same difficulties need not be expected with other eucalypts, particularly the more permeable Victorian hardwoods. It should be borne in mind that the first commercial application is always looked at critically.

Item 4(f)

HIGH PRESSURE TREATMENT TESTS OF RAIL SLEEPERS IN VICTORIA*

This test, comprising 3,421 sleepers, was inspected this April for the first time since it was installed, from 1954 to 1956. The main part of the test is distributed evenly between three sites at Glenrowan (94 lb rail, plated), Carnegie (107 lb, plated) and Heyfield (75 lb, unplated). Traffic is moderate at Heyfield, very heavy at Carnegie and heavy at Glenrowan, with high axle loads in all cases.

Four species of eucalypt were used, namely E. eugenioides, E. obliqua, E. regnans and E. australiana. These were treated at pressures up to 1,000 lb/sq.in. with 6 different preservative oils or oil mixtures and 2 waterborne preservatives. One group was left untreated as controls while the last was surface coated only with creosote.

There are 800 sleepers at each site comprising 40 groups of 20 sleepers each of 1 species with 1 preservative. In each group of 20 there are 10 pre-bored and 10 unbored sleepers, also 10 incised and 10 not incised, i.e. 5 sleepers comprise the smallest sub-group.

Supplementary sleepers at each site include 140 Pinus radiata sleepers, of 2 sizes, treated with oils and waterborne preservatives and 40 red gum sleepers as additional controls.

At Heyfield an extra 100 pine sleepers have been installed with various fastenings because of the failure of spikes to hold the rail in unplated track.

Over 300 hardwood sleepers surplus to the main test were treated with a reduced number of preservatives, without incising, and installed at Bena in South Gippsland.

Treatment and installation of this test is covered fully in our report - Project P.3, Sub-Project P.3-10, Progress Report No.1.**

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*Prepared by F. A. Dale.

**This report is to be published shortly.

Results of the inspection have not yet been analysed, but the following trends are apparent.

(i) Waterborne preservative treatment of hardwood sleepers at high pressure, while giving satisfactory penetration and retention, is of no value in preventing weathering and splitting. One of them, copperized chromated zinc chloride, chosen at the time for want of a better alternative, in fact causes chemical breakdown of the timber and a number of sleepers treated with it have already been removed.

(ii) Mountain ash (E. regnans), although easily treated, is so easily split that even oil treated ash sleepers are showing considerable splitting and it is unlikely that this species will give the same order of service as the others in the test.

(iii) The great majority of oil treated sleepers in the test are in very good condition and at least at this stage it is doubtful whether the extra retention and more uniform penetration obtained by incising will be economically justified. The more fissile species also sustain considerable surface damage during incising.

(iv) Unplated Pinus radiata sleepers will not hold spikes in heavily loaded track and this failure occurs sooner, with attendant rail cut, in oil treated sleepers.

This test, together with those installed in other States, can be expected to give results at the next inspection in 4 years' time justifying the high pressure treatment of eucalypt sleepers as being economically sound. The Tasmanian test, installed in 1954 and inspected in July 1958, will probably be inspected next year. There is little doubt that this will show that the extra life needed there for treatment to be economic will be obtained, i.e. roughly 6 years over an untreated average life of 11 years or less.

Discussion

Richardson: What sort of variation in retentions are obtained with hardwoods ?

Dale: Quite large: aiming at 5 lb/cu.ft. or more in hardwood sleepers, we get an envelope about $\frac{3}{4}$ in. thick. In fact we get variations down to 2 or 3 lb and up to 10 lb. It is not nearly as uniform as *Pinus radiata*.

Item 4(g)

PRESERVATIVE TREATMENTS FOR PLYWOOD*

(a) Interior Plywood

Except where a termite hazard exists, the present Lyctus immunization treatments with boron or fluorine compounds are adequate for protection of interior plywood. If protection against termites is also required the addition of a small amount of arsenic pentoxide or sodium arsenate should be entirely effective. On the evidence from various co-operative tests with Mr. Gay of the Division of Entomology, Canberra, less than 0.1 per cent. $As_2O_5.2H_2O$ based on the air dry weight of the

*Prepared by N. Tamblyn.

wood should be sufficient to give high termite resistance. In practical terms we would expect that a solution containing .75 per cent. arsenic pentoxide or less would be adequate for momentary dip treatment of $\frac{1}{8}$ in. green veneer. While this has not been proven by direct dip-diffusion tests with green veneer such tests could be made quickly and if desired the extent of Lyctus protection could also be determined for arsenical solutions with and without addition of boron or fluorine. As arsenic used alone does not appear to affect gluing, a simple arsenical solution to control both termites and borers may be attractive.

(b) Plywood for Exterior Use

For waterproof plywood, which may be exposed to leaching, use of an unfixed preservative such as borax or sodium fluoride, with or without addition of arsenic, cannot be recommended except as a temporary expedient. For this purpose a fixed salt such as one of the proprietary metal-chrome-arsenic preservatives or a simple zinc-chrome-arsenic mixture would have the obvious advantage of high permanence as well as high insect and decay resistance even where the plywood was exposed to considerable leaching. Since these preservatives will give cold solutions up to 10 per cent. or more concentration, there should be no difficulty in obtaining loadings up to 0.5 lb/cu.ft. dry salt by dip treatment of green veneer. Alternatively, weaker solutions could be applied by pressure treatment of green veneer and this latter method would have the advantage of reducing the salt concentration at the veneer surface, with consequent reduction of any gluing problem. With liquid phenolic glues it appears certain that gluing problems can be overcome by attention to the treatment method, the preservative formulation and the gluing technique, probably without the necessity for any change in the glue itself.

Assuming that gluing difficulties can be overcome simply, the real problem with the present proprietary preservatives may be in the health hazard involved in sanding veneer where concentrations of arsenic pentoxide are as high as 0.5 per cent. on the dry weight of the wood. As previously discussed, this arsenic content is higher than necessary for termite control and it could hence be reduced considerably. However, as arsenic is also a fungicide, its reduction would probably require use of both copper and zinc in the salt to retain good decay resistance. We are prepared to do work on the formulation and testing of a metal-chrome-arsenic preservative most suitable for veneer treatment but would like an assurance that if we do develop this preservative the present approval of borax or sodium fluoride will be withdrawn.

(c) Plywood for Marine Use

With metal-chrome-arsenic preservatives the dry salt retention of 0.5 lb/cu.ft. which would probably be recommended for waterproof plywood, should be sufficient for marine grade plywood provided it is not exposed to marine borer attack. Except for this latter use, the problem is, therefore, essentially the same as in plywood for general exterior use.

Where a marine borer hazard does exist, higher retentions of metal-chrome-arsenic salts will be necessary - probably up to 1.5 lb/cu.ft. dry salt. For this particular use it may be desirable for the finished plywood to be pressure treated to obtain the desired salt retention. However, except possibly in this case, we do favour diffusion or pressure-diffusion treatments of the green veneer.

Discussion

Edwards: Considerable deterioration due to decay fungi has been found in marine and waterproof grade plywoods used in boat and caravan construction in New South Wales.

The first moves to provide the public with a rot-resistant plywood came from the Rosebery Veneer Co. Pty. Ltd., of Sydney. This firm has been granted approvals by the Commission for the preservative treatment of veneers by double bath treatments designed to give one of the following salt retentions.

(i) Copper Pentachlorphenate.- A minimum concentration of copper equivalent to not less than 0.083 per cent. w/w metallic copper and pentachlorphenol equivalent to not less than 0.56 per cent. w/w of pentachlorphenate ion, based on the O.D.W.

(ii) Zinc Pentachlorphenate.- A minimum concentration of zinc equivalent to not less than 0.085 per cent. w/w metallic zinc and pentachlorphenol equivalent to not less than 0.56 w/w of pentachlorphenate ion, based on the O.D.W.

(iii) Copper Pentachlorphenate plus Sodium Fluoride.- A minimum concentration of fluorine equivalent to 0.02 per cent. w/w of sodium fluoride copper equivalent to 0.206 per cent. of metallic copper and pentachlorphenol equivalent to 0.375 per cent. w/w of pentachlorphenate ion based on the O.D.W.

These approvals were issued in February 1959. Since that date another manufacturer has sought advice on suitable preservatives for veneers for external use and this firm is likely to apply a suitable process on a large scale.

Before making recommendations to the company the Commission seeks the views of the Conference on preservative treatments for veneers generally, with special reference to end use, compatability with glues and toxic problems associated with the use of arsenic type preservatives.

<u>Booth</u>: Gluing difficulties have been encountered with the copper-chrome-arsenic preservatives at loadings necessary for complete protection. We have had long discussions with Queensland on the question of sodium fluoride, as we use it in New South Wales for marine plywood and were responsible for introducing it. The New South Wales industry also buys fluoride-treated veneer from Queensland and we know that it glues without any problems. On the question of whether preservative-treated Lyctus susceptible wood should be allowed in waterproof plywood, we say yes. Industry has been making plywood out of non-susceptible brushwoods of low decay resistance and such material as hoop pine sapwood for many years and it has a steady market. As sellers of brushwoods in large quantities, our Commission is interested to see this trade flourish. Since the fluoride treatment has been in use as protection against Lyctus attack for many years now, we feel there is not much danger of Lyctus attack due to leaching. We have not had a single instance of attack with fluoride treated material, nor have we had to prosecute anyone because of under-treatment - and large quantities have been manufactured over the last 5 years. We have had weathering tests in progress for 10 years at 3 sites where Lyctus attack could have taken place but has not, so I do not think there is likely to be any problem in this respect.

<u>Tamblyn</u>: The best way <u>not</u> to sell plywood is to continue the way we have been going. We do not produce a product which is durable under all conditions, as we should expect waterproof plywood to be. Treatment with a fixed preservative is desirable. If leachable preservatives are used, they can get the plywood into trouble.

<u>Huddleston</u>: The question asked is "should it be mandatory to preservative treat all waterproofed plywood ?" I think we are inclined to be over anxious on behalf of the people who might use plywood. I cannot see that if an exterior door is required not to delaminate in

the weather, it need be treated against termites as well. All we can do is to advise people on the use of the type of product they are buying. If the customers want a waterproof rot-proof plywood, then the industry will probably produce it, but I do not think that we should rule that waterproof plywood should be preservative treated.

Bryant: Since Cemac Pty. Ltd. put preservative-treated waterproof plywood on the market, they have taken markets from other people. We are very conscious of the fact that if you are going to treat with a water-soluble preservative, you still have to overcome this problem of delamination.

Tamblyn: The results of tests with a zinc chloride and arsenic preservative in our weatherometer indicate that it should be possible for us to formulate a zinc-chrome-arsenic preservative that will not delaminate. We are waiting a decision from Mr. Gottstein as to whether a modified preservative is necessary or not.

Bryant: We are apprehensive about arsenic being used in veneers because of unsatisfactory conditions existing in some factories for removing dust from sanders, but this is a separate issue. Our main problem in Sydney is trying to glue veneers that have been treated. We feel that industry is not yet ready and that it will be some time before it can produce a rot-proof, waterproof plywood, treated with Cu-Cr-As, in any quantity.

Item 4(h)

VARIATIONS IN DECAY RESISTANCE WITHIN A SPECIES*

In a detailed study of the radial variation in durability in teak (*Tectona grandis*) and its relationship to growth factors regarded as having a probable influence on durability, 16 trees, ranging from

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*Prepared by P. Rudman.

14 to 180 years old were selected and up to 13 heartwood zones from each tree tested for resistance to decay (in both sawdust and block form) and to termites (in block form).

In general, the relative order of susceptibility of the zones tested was the same for all three fungi used and for Coptotermes. The association between the amount of attack produced in each type of bio-assay and the values of five different growth factors was examined by correlation analyses. The best overall correlation was that with distance of zone samples from pith (DP), closely followed by that with age of the tree at the time the zone was formed (AZ). Appreciably smaller correlations were obtained with the diametral growth rate during zone formation (GR), the age of the tree when felled (AF) and the time elapsed since transformation of the zone from sapwood to heartwood (TH).

Considering these five factors as a whole, they accounted for a much higher proportion of the variation in durability than did any of the factors singly, in fact the efficiency of the regression equation used was surprisingly high and these results indicate that none of the five factors is of overwhelming importance.

In an attempt to isolate growth rate and decay resistance from the other variables, they were studied for individual trees and these results showed a high degree of correlation for a white rot fungus, which was particularly destructive to teak, but little correlation for a brown rot fungus.

These analyses show that teak heartwood may be expected to be less durable as it comes from nearer the pith, shows wider growth rings, or comes from younger trees. The individual results also indicate that some trees may have quite large non-durable cores.

Work of a somewhat similar nature is now being carried out on jarrah and cypress pine, and additionally in the case of jarrah, dominant and suppressed trees from the same site are being compared. All the tests have not been completed as yet, so statistical analyses have not been started, but the results of decay resistance tests with two brown rot fungi clearly indicate a very wide variation in decay resistance from pith to bark in nearly all trees, the core frequently being decay susceptible.

Discussion

Dadswell: You suggest change of durability with age, especially age in the living tree. Is this in line with the theory that the acid-hydrolysis that occurs in the centre of a tree, in eucalypts in particular, may change the extractives present and reduce durability ?

Rudman: It is possible, but I would not like to tie this in with the presence of acetic acid due to hydrolysis. Heart rot in eucalypts is fairly common and we may find more species suffer from this, but we cannot really relate this to anything at this stage.

Dadswell: On the question of heritability, should we not be able to get some evidence from species where we have progeny trials ?

Rudman: To what extent is it worth worrying about this in eucalypts ? Quite a lot of these facts should come out from the study of teak which grows quickly, producing heartwood at a young age.

Beesley: In the Territory teak plantations are still being established.

Rudman: I do not believe we should plant teak in New Guinea simply because it is a durable timber, because it is doubtful if durability would be achieved due to the fast rate of growth etc., without selecting seeds from trees of known durability. Its low shrinkage properties make it an excellent furniture timber and for this reason alone it could be worth planting in New Guinea or perhaps Northern Australia.

It does appear from most results that the causes of durability in teak and eucalypts are quite different. We believe that teak can be grown quite quickly and still be durable if we use the seeds of trees of known high durability in the core. However, we have not proved this hypothesis and would like to see it tested.

Cokley: Is it Dr. Rudman's intention to extend this work to rain forest species eventually ?

Rudman: We may extend our work to jarrah, and other possibilities are cypress pine and ironbark. Whether we can do this work depends on whether it can be fitted in to our programme.

Bryant: I think this work is exceedingly important and we would be interested in collaborating with Dr. Rudman.

Item 4(i)

SOFT ROT*

Soft rot in cooling towers was discussed in detail in Newsletters 273 and 274 with special reference to its nature, history, causes and control and under these headings little will be added now. It is a decay characterized microscopically by the production of fine bore holes spirally arranged almost parallel with the length of fibres in their S2 layer. It has four forms or manifestations of which its best known is the wet mud-like surface softening common in cooling towers.

*Prepared by N. E. M. Walters.

Secondly, quite different in appearance is a deeply penetrating form common in sleepers and mine timbers that are very wet but not saturated. It is characterized by a brash, carrotty fracture and can cause poles in the wet tropics to snap off.

Thirdly, a very slow surface form in aerial woodwork, exposed to extremes of wet and dry conditions and to uneven erosion, gives rise to a condition known as the washboard effect.

Lastly, the commonest form is the co-mensal form which is simply a manifestation concealed by other organisms such as ordinary rot, borer, marine borer or termite attack. Overseas workers now believe that soft rot is present in most attacks by other organisms, and that it breaks the ground for them and may remain unobserved with them throughout. In some cases the soft rot is essential to the organism but usually is not. It is seen then that with its four manifestations this deterioration is very common and much more serious than we formerly believed.

Research has progressed concurrently here in field and laboratory for some 4 years. Early preliminary tests in the laboratory gave inconclusive results with redwood, whether leached or not and could not compare in speed of decay with that in the cooling tower itself. Overseas workers found they could only rot certain hardwoods but no softwoods in the laboratory and it was clear to us that the addition of nutrients and delignification or some pre-conditioning of the timber would be necessary to speed the tests up. Even before this we had evolved a very sensitive bending test to record changes as soon as possible. Now we have perfected a procedure for delignifying redwood with chlorine so that it will soft rot rapidly. The optimum in added nutrients and pH have still to be found for softwoods, however, since untreated radiata with our present laboratory procedure takes longer to decay than in a cooling tower. We have now advanced sufficiently to begin a large programme of finding the soft rot ability of our 350 isolates and have already completed a scout test to determine the effect of nutrients and pH and have checked the protection given by several waterborne preservative radicals (Cu-Cr-As, Cu-Cr, Zn-Cr-As and Zn-Cr).

Meanwhile, in the field, our large-scale tray test was started 2 years ago. It has now been running long enough to show qualitative results and the order of durability of timbers that has now emerged is not likely to change much as the test progresses except perhaps for the upgrading of some of the denser hardwoods. In brief, the softwoods are better than hardwoods. Some otherwise durable timbers have proved non-durable or variable (depending on the water) against soft rot. The best timber was radiata sapwood treated with a commercial copper-chrome-arsenate. It was followed by redwood. The best hardwood was teak, followed closely by wandoo. However, Vanikoro kauri, King William pine, western red cedar and oregon were all better than wandoo. The test has also shown dramatically that nutrients in the water assist soft rot.

This field work was done in conjunction with a Commonwealth-wide survey of conditions, physical and chemical, in cooling towers with an attempt at correlation with the soft rot present.

The next step will be to test non-durable timbers, treated with various preservatives at various loadings or coated with various substances. (Surface coatings may well prove the answer to soft rot later on.) This will be done in similar trays in about a dozen of the susceptible towers.

An opportunity to test a commercial double diffusion treatment in situ was seized by inserting an extra set of trays in the tower, but removing one of them for the period only of the treatment. The result showed the treatment was effective (in the time tested).

Discussion

Edwards: We have found evidence of soft rot in tallowwood slats in a tower operated for 7 years. We have between 18 and 20 towers under observation in our State, 10 of them being in power stations. We will make inspections of these towers every 2 years to supplement the information you are collecting. As regards the speed of soft rot attack in towers, what are your opinions on the possibility of combinations of bacteria and/or algae with soft rot fungi increasing the breakdown to a greater rate than is being encountered in the laboratory.

Walters: As far as combination of organisms is concerned, in a cooling tower there are so many influencing factors that it is difficult to sort out which ones are important. Our only approach can be to try them all out alone, and then in combination to see what effect they have. There is no doubt that soft rot fungi get on very well with other organisms.

Booth: We have trouble with soft rot in marine plywood on exposure racks in Sydney Harbour, particularly in Rozelle Bay which has a high level of polution. We could not keep samples on racks longer than 6 months before they were completely decomposed, and have now moved the site to Garden Island. We still get some trouble here but not as much as it is a cleaner part of the Harbour.

Rudman: It has been noticed in laboratory testing of soft rot that nutrient solution encourages decay, and this is possibly related to the concentration and the nitrogen content of the nutrient solution.

Item 4(j)

DECAY IN WOODEN HOUSE STUMPS - VICTORIAN SURVEY*

Melbourne has a very high proportion of dwellings and small buildings such as shops which are supported wholly or partly by wooden stumps set directly in the ground. In the case of wooden buildings, the whole structure is usually supported on wooden stumps; with brick veneer all interior supports are often wooden stumps, whereas with brick dwellings only the bearer supports under the floors of the rooms are wood.

This practice has in the past caused little trouble, as the life of stumps of durable species has been great enough to prevent undue concern about the economics of the practice.

In more recent years, however, two problems have emerged, both of which are causing some concern to house-owners and to housing and financing authorities.

The first of these relates to houses upwards to 30 or 40 years old, where there has been failure of sufficient stumps to cause obvious defects in the structure. In these cases complete restumping is necessary, and this, together with structural repairs, redecorating etc. usually results in costs of several hundred pounds to the owner.

The second problem concerns houses in a younger age group, where failure of stumps has occurred due to the use of poorer quality timber. This is particularly noticeable in the case of houses erected during World War II or in the immediate post war years when timber was in short supply.

As a result of the enquiries received and the fact that little authentic information was available on this subject, a survey of the

*Prepared by A. P. Wymond.

service life and causes of failure of wooden house stumps in Melbourne was conducted some time ago. This established that by the time a house was between 30 and 40 years old the chances were that some replacement of stumps would be necessary. It was also disturbing to note that, of houses between 20 and 30 years old, quite a number had stumps which had decayed to the point of failure, indicating the necessity for early replacement.

Further, it would appear that the quality of timber being used for stumps today is as far as can be gauged by visual inspection not as high as it was 30 or 40 years ago, hence many of the stumps being placed today may not last 30 years.

As a life of 80 years at least may be required from houses being erected today (opinion of leading architects), and as the cost of restumping is considerable, serious thought should be given to this whole question of wooden stumps.

Discussion

Muir: Did the survey reveal the use of any other species than red gum ?

Wymond: The only two species present were red gum and a much lower percentage of jarrah, which incidentally exhibited a higher failure rate. Our first survey was of houses being restumped, in other words, houses in which the stumps had started to fail. The second survey was done on a statistical basis and covered a random sample of wooden houses. The results from this were almost the same as for the first.

Benallack: The results of Mr. Wymond's survey are not unexpected. We also have this problem of what to recommend for house stumps. We usually say that wooden stumps will be safe enough if they are of mature red gum, that is, deep red coloured material. The position is serious in Victoria, because at the time the survey was conducted I had talks with Housing Commission architects and tried to find an answer to this problem. They were adamanant, however, that you could not rely on the sawmillers, and, therefore, the Housing Commission was not prepared to take the risk and will not specify red gum.

Tamblyn: It should be pointed out that the survey showed an average life of about 40 years for red gum house stumps. There was variation of course, some were as low as 20 years. This average of 40 years means that these stumps went in about 1910 and 1920, when quality was, presumably, beyond suspicion. I think that Mr. Benallack's suggestion that only mature red gum be used is, therefore, not a complete solution. Even if high quality red gum is obtained, the house-owner will probably have to restump within the useful life of the house. The best answer seems to be concrete stumps, because we do not have a cheap method of pressure treating durable eucalypts. We, therefore, cannot offer 80 to 100 years life. We might be able to offer pressure treated radiata which could give a life of 50 years, but we have little evidence to back up this estimate.

Rudman: Mr. Benallack mentioned that he recommended that people should select the dark red coloured red gum. We have not done any work on correlating decay resistance with colour in red gum, but we have in jarrah and karri, and in our experience colour cannot be related to decay resistance. Some few years ago we had some extremely light coloured karri which had a relatively high durability.

Jennings: Why shouldn't we say straight out that concrete stumps are superior. As far as we are concerned, we are quite prepared to tell people to use concrete.

Further discussion indicated that other States are quite prepared to accept the use of concrete for house stumps, or at least for the portion in the ground. As concrete stumps are at present a little cheaper than red gum in Victoria, it was felt that it would be doubtful whether good quality radiata pine could be given a high loading of preservative and still be competitive with concrete, but that would be for the consumer to consider.

Item 4(k)

NEED FOR ENCOURAGEMENT IN USE OF ROUND FENCE POSTS

Wymond: The position concerning the use of treated round posts is improving very rapidly in Victoria and South Australia, also parts of New South Wales. In other States, although there is obviously a great deal of interest, various factors have tended to slow down the general acceptance of these posts.

In Queensland and parts of New South Wales where durable split posts are available at reasonable prices, it will be difficult for treated round posts to compete, but there are many areas of Australia where durable species are not readily available, but where there are ample supplies of round posts suitable for treatment. We would like to think that when we refer an enquirer to his local or nearest forestry officer, he will be given some help in obtaining suitable material for this purpose.

Dale: We are not so concerned with encouragement of use of round fence posts in Victoria; that is now snowballing and is looking after itself. An awareness of the value of these posts is becoming widespread and we have one or two genuine enquiries each week from people wanting to treat them commercially. Is there any interest in other States in the commercial treatment of round timbers, as distinct from the farmer do-it-yourself type of treatment ?

Jennings: Not in Queensland.

Edwards: An active sales programme is to be pursued in New South Wales by the firms concerned so far as the sales of radiata pine posts are concerned.

Cokley: We are hoping to encourage the use of brigalow for this purpose, mainly in one particular area where there are heavy stands. We have sent some to the Division of Forest Products for tests. In other areas it is a matter of economics and supply of durable fence posts may be just as profitable.

Wymond: We have no means of knowing how many posts are being treated privately, but from sales of creosote and waterbornes in small lots we do know that the number must be fairly considerable.

Bryant: There is a considerable sale of fixed salt preservatives in New South Wales for treatment by sap displacement, but we do not know how many posts are being treated.

Item 4(1)

RESULTS OF MARINE BORER TESTS*

The Marine Borer Test has now been installed for approximately 18 months.

The project was planned in co-operation with the New South Wales Maritime Services Board and the Queensland and Western Australian Forestry Departments to test the resistance of a number of preservatives against teredine and other marine borer attack.

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*Prepared by D. R. Pfitzner (D.F.P.).

The treated specimens and controls were installed on the following dates:-

(a) Western Australia

(i) At the British Petroleum jetty, Kwinana on October 28th, 1959.

(ii) At the Port Hedland jetty on October 15th and 16th, 1959.

(b) Queensland

Upstream from the Queensland Cement and Lime Co. in the Brisbane River on October 27th, 1959.

(c) New South Wales

At Goat Island in Sydney Harbour (temporary site since moved) on January 26th, 1960.

To date, inspections have been carried out as follows:-

(a) Western Australia

The first annual inspection was carried out at Kwinana on December 1st and 2nd, 1960, and Port Hedland on November 17th and 18th, 1960.

(b) Queensland

1st Inspection on February 5th, 1960.

2nd Inspection on May 31st, 1960.

3rd Inspection on November 3rd, 1960.

4th Inspection on February 27th, 1960.

(c) New South Wales

The specimens have been relocated but no comprehensive inspection has been carried out.

A summary of the 4th Queensland Inspection and the 1st annual Western Australian Inspection is appended.

SUMMARY OF 4TH INSPECTION - QUEENSLAND

Preservative	lb/cu.ft. (nominal)	Sawn Radiata					Round Eucalypt				
		No. Specimen	Sound	Attacked	Destroyed	% Attacked	No. Specimen	Sound	Attacked	Destroyed	% Attacked
K55 Creosote	10	5	5			Nil	3	2	1		33
	20	5	5			Nil	3		3		100
Marine Creosote	10	5	5			Nil	3	2	1		33
	20	5	5			Nil	3	2	1		33
Creosote:tar (75:25)	20	5	5			Nil	3	2	1		33
Boliden S25	1.5	5	5			Nil	3	2	1		33
Celcure (old)	1.5	5	5			Nil	3	3			Nil
Celcure A	1.5	5	5			Nil	3	2	1		33
Tanalith C	1.5	5	5			Nil	3	2	1		33
Boliden K33	1.5	5	5			Nil	3		3		100
Untreated Controls		5			5	100	3			3	100
Turpentine Controls							9	2	4	3	78

NOTE: Attack in round eucalypt specimens mainly in heartwood end grain.

SUMMARY OF 1ST ANNUAL INSPECTION - WESTERN AUSTRALIA

Preservative	lb/cu.ft. (nominal)	Port Hedland										Kwinana									
		Sawn Radiata					Round Eucalypt					Sawn Radiata					Round Eucalypt				
		No. Specimen	Sound	Attacked	Destroyed	% Attacked	No. Specimen	Sound	Attacked	Destroyed	% Attacked	No. Specimen	Sound	Attacked	Destroyed	% Attacked	No. Specimen	Sound	Attacked	Destroyed	% Attacked
K55 Creosote	10	5	5			Nil	3	2	1		33	5	5			Nil	3	1	2		66
	20	5	5			Nil	3				Nil	5	5			Nil	3	2	1		33
Marine Creosote	10	5	5			Nil	3	3			Nil	5	5			Nil	3	3			Nil
	20	5	5			Nil	3	2	1		33	5	5			Nil	3	3			Nil
Creosote:tar (75:25)	20	5	5			Nil	3	1	2		66	5	5			Nil	3	3			Nil
Boliden S25	1.5	5	3	2		40	3	3			Nil	5	5			Nil	3	2	1		33
Celcure (old)	1.5	5	3	2		40	3	2	1		33	5	5			Nil	3	2	1		33
Celcure A	1.5	5	4	1		20	3	2	1		33	5	5			Nil	3	2	1		33
Tanalith C	1.5	5	4	1		20	3	2	1		33	5	5			Nil	3	3			Nil
Boliden K33	1.5	5	3	2		40	3	2	1		33	5	5			Nil	3	2	1		33
Silica	1.5	5	2	3		60	3	2	1		33	5	5			Nil	3	2	1		33
Untreated Controls		5			5	100	3			3	100	5			5	100	3			3	100
Turpentine Controls		5	5			Nil	3	2	1		33	5	5			Nil	3	3			Nil
Jarrah Controls		5	3	2		40	3	1	2		66	5	3	2		40	3	1	2		66

NOTE: Attack in round eucalypt specimens mainly in heartwood end grain.

At this stage no firm conclusions have been drawn from these results.

A standard inspection procedure has not been adopted by the three States and this causes some ambiguity in interpreting results.

Discussion

Edwards: The Maritime Services Board has asked me to inform the Conference that they have carried out inspections of the samples, but they have not yet prepared the results for presentation. What is the current situation regarding the taxonomy of these species ?

Beesley: The Conchologist at the National Museum of Victoria is studying marine organisms and is very interested in the taxonomy of Molluscs. Also, someone in the University of Western Australia is interested. The University of Sydney has indicated that it might be interested in this work.

Item 4(m)

TERMITE INVESTIGATIONS*

(a) Natural Durability of Western Australian Commercial Timbers

The *Nasutitermes exitiosus* tests have been completed, the following species tested being arranged in order of decreasing resistance:- *Acacia acuminata*, *Eucalyptus marginata*, *E. redunca*, *patens*, *calophylla*, *gomphocephala*, *jacksoni*, *guilfoylei*, *astringens*, and *diversicolor*.

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*Prepared by F. J. Gay.

Cross checking tests are now being made with <u>Coptotermes lacteus</u> and <u>C. acinaciformis</u>.

Field tests of matched material in the Riverina district of New South Wales show after 3 years the following order:-

<u>A. acuminata</u>, <u>E. redunca</u>, <u>marginata</u>, <u>patens</u>, <u>guilfoylei</u>, <u>jacksoni</u>, <u>astringens</u>, <u>calophylla</u>, <u>gomphocephala</u>, <u>diversicolor</u>. Termite species present include <u>C. acinaciformis</u>, <u>Microcerotermes</u> sp. and <u>Amitermes</u> sp.

(b) <u>The Eight Preservative Test</u>

In this test, eight preservatives each at five concentrations are being tested against <u>N. exitiosus</u>, <u>C. lacteus</u> and <u>C. acinaciformis</u>. Both leached and unleached specimens are being tested. The magnitude of this test can be judged from the fact that over 500 colonies, totalling more than 3 million termites, are needed.

The following table shows the preservatives and concentrations being tested.

Boliden S	0.01	0.03	0.06	0.10	0.30
Celcure (old)	0.20	0.30	0.50	0.80	1.00
Celcure A	0.03	0.06	0.10	0.20	0.50
Tanalith	0.03	0.06	0.10	0.20	0.50
Pentaborate	0.10	0.20	0.30	0.50	1.00
Fluoborate	0.10	0.20	0.30	0.50	1.00
Fluoborate and Arsenic	0.06	0.10	0.20	0.30	0.80
Arsenic pentoxide	0.003	0.006	0.01	0.03	0.10

Results to date indicate (i) that preservatives containing arsenic are definitely superior to those based on boron or copper-chrome mixtures, (ii) <u>N. exitiosus</u> is much more tolerant to boron based preservatives than is either of the two species of <u>Coptotermes</u>,

(iii) the reaction of the two species of Coptotermes is very similar and (iv) leaching appears to have very little effect on the performance of these preservatives.

(c) Arsenic Discrimination Test

N. exitiosus was tested with five levels of As_2O_5 in Geissois benthami. Loadings (on A.D. basis) were 0.001, 0.002, 0.004, 0.008, 0.016, 0.032 per cent. There was no discrimination of treated or untreated timber below 0.008 per cent. Discrimination was evident at the 0.008 per cent. level, and showed a linear increase as the loading increased. Similar results were obtained in relation to toxic action, i.e. toxicity was first evident at 0.008 per cent. There is, therefore, no discrimination until the arsenic reaches a level at which some toxic action occurs.

(d) Termite Proofing of Plywood by Treating Glue Line

Karri plywood glued with PF glue was used with 5 : 10 : 15 : 25 parts As_2O_3/100 resin in glue line and 5 : 10 : 20 parts Chlordane/100 resin in glue line.

All treatments conferred complete immunity to attack by both N. exitiosus and C. lacteus and were rapidly lethal to termites. All treatments appear to be overdoses and it is probable that adequate protection could be obtained with much lower loadings of toxicants. Additional tests to check this are about to start.

(e) Surface Treatments - Box Tests

The 10 per cent. sodium arsenite dip (P. radiata) is still 100 per cent. sound against C. lacteus after 3 years. (Four out of six attacked by N. exitiosus in 4 years.) Creosote and 1 per cent. dieldrin solution: five out of six sound.

N. exitiosus tests with alpine ash, best results obtained with 5 per cent. pentachlorphenol, four out of six still sound after 5 years.

(f) Soil Treatments

5 per cent. PCP - appreciable failure in 9th year (C. lacteus).

Creosote - failed in 9th year (C. lacteus).

5 per cent. DDT - still effective after 11 years.

Lindane 0.1 and 0.2 per cent. - O.K. after 6 years.

Dieldrin 0.1 and 0.2 per cent. - ineffective against N. exitiosus after 6 years. O.K. against C. lacteus after 7 years.

0.5 per cent. - O.K. against both species after 4 years.

Aldrin - same results as dieldrin.

Chlordane 2 per cent. - O.K. after 7 years.

TCB (tetrachlorbenzene) - O.K. after 6 years.

(g) Hardboards

Standard and oil tempered boards treated with 0.1 per cent. aldrin or 1 per cent. PCP, both with the addition of 1 per cent. paraffin. The 0.1 per cent. aldrin treatment is superior to the 1 per cent. PCP, giving almost complete protection and being very lethal to termites. Subsequent tests were carried out with:-

0.02, 0.1, 0.25, 0.5, 1.0 per cent. NaPCP - added to pulp.

0.01, 0.05 aldrin - sprayed on back of pressed board.

0.01 aldrin + 0.02 NaPCP.

0.25 Na arsenite - added to pulp.

0.05, 0.50 CuPCP (no date on incorporation).

Results show that 1 per cent. NaPCP is completely effective against N. exitiosus, 2 per cent. NaPCP is attacked by C. lacteus. 0.01 per cent. aldrin was as effective as 0.05 per cent. aldrin and were approximately as effective as 0.1-0.25 per cent. NaPCP.

0.01 per cent. aldrin + 0.02 per cent. NaPCP mixture is no better than 0.02 per cent. NaPCP alone.

0.05 per cent. CuPCP is ineffective, 0.5 per cent. is approximately as effective as 0.25 - 0.5 per cent. NaPCP.

0.25 per cent. Na arsenite gave complete protection against C. lacteus, permitted 2 per cent. attack by N. exitiosus. Only Na arsenite was toxic at the levels tested. The difference in results with aldrin as compared with the previous test is attributed to the method of incorporation, *viz.* addition to slurry V. spraying.

(h) Stramit Strawboard

Laboratory tests with N. exitiosus, C. lacteus and C. acinaciformis of untreated and 0.1 per cent. dieldrin treated Stramit:-

Untreated readily attacked, treated unattacked (N. exitiosus dead in 7 days, C. lacteus dead in 13 days, C. acinaciformis declining after 3 weeks).

(i) A modified laboratory colony method is being used for evaluation of quinones and allied compounds. The sample is exposed to an initial population of 4 g of termites and the test period is 4 weeks.

In this time a 2 in. disc of untreated chromatograph paper is completely destroyed.

This method is useful for the rapid screening of a large number of compounds and for evaluation of materials available in minute quantities only, *e.g.* extractive fractions.

(j) Paccal Tar

Results after field testing for 4 years:-

E. regnans treated at 200 lb/sq.in. - 90 per cent. show attack by N. exitiosus.
E. regnans treated at 500 lb/sq.in. - 90 per cent. show attack by N. exitiosus.
E. regnans treated at 1000 lb/sq.in.- 100 per cent. show attack by N. exitiosus.

P. radiata - 50 lb/sq.in. 30 min 200 lb/sq.in. 10 min - 20 per cent. show attack by C. lacteus and C. acinaciformis.

P. radiata - 50 lb/sq.in. 30 min 200 lb/sq.in. 22 min - 10 per cent. show attack by C. lacteus and C. acinaciformis.

P. radiata - 30 min unit vacuum 200 lb/sq.in. 40 min - all sound.

(k) Termite Proofing of Concrete

Aldrin at 0.5 per cent. is just as effective as dieldrin 0.5 per cent. when substituted for normal mixing water.

This reduces cost of treatment by half.

Discussion

Edwards: There has been an upsurge of interest in New South Wales over the last 18 months or so in connection with soil barriers around houses, particularly in connection with dieldrin but also with aldrin.

Cokley: Has Mr. Gay reached any conclusions as regard to the breakdown in time of aldrin and dieldrin; secondly, what is your comment on loadings versus species of termites ?

Gay: We have no information on the rate of breakdown in timber. In the soil, it depends on the type of soil, and also on the loading. As the results indicate, we have already got failure of some species in both aldrin and dieldrin after about 6 years. Aldrin oxidizes readily in the soil to dieldrin. With regard to the second question, to be on the safe side, one should base the loadings on the level which will control the most resistant species of termites. We can do this quite satisfactorily for the southern species, but not with Mastotermes, which we cannot handle in the laboratory, but only in the field.

Item 4(n)

HYLOTRUPES SURVEY

Jennings: In Queensland, 2,600 houses were fumigated with methyl-bromide. Since that date, an examination has been made of 2,300 other structures in adjacent areas and only four cases of infestation found. These have now been fumigated. To date the treatment appears to be 100 per cent. effective.

Irvine: There have been no further reports of infestation in Housing Commission houses in Victoria.

Beesley: The Victorian Railways have investigated all their imported houses. Their effort was most commendable.

Jennings: What extent of infestation has been found in Victoria and what action has been taken to control it ? Queensland has spent £¼ million to eradicate infestation and is vitally interested.

Irvine: The only infestations found were in seven Housing Commission houses which were then fumigated. In every case infestation was confined to one or two pieces of timber as far as could be confirmed on visual examination. The Housing Commission has instructed their maintenance people to look for any signs of damage from Hylotrupes.

Edwards: Inspections in 1956, and later inspections in 1959 of imported prefab houses have failed to show any signs of infestations in New South Wales. Better exchange of reports of infestations between States and various Government bodies would be most desirable. The situation regarding packing cases and similar imported items is a matter which is always with us.

Jennings: As regards the follow-up period, if there is no evidence of the insect at this stage, it is improbable that there was any original infestation. Another inspection in 2 to 3 years time would be desirable to confirm this point. Our infested areas will be watched for some time yet.

Dadswell: I think the proposed Preservation Committee could be used to convey this information to various interested bodies.

Byrne: New Zealand experience with H. bajulus is limited to infestations found in imported cases from Europe, the Mediterranean area and South Africa.

In 1952, 1,000 pre-cut houses were imported from the Continent. Five-hundred of these were erected at Tamaki, Auckland and the remainder at Titahi Bay, Wellington. A close board-by-board inspection revealed no signs of Hylotrupes infestation, although many other wood boring insects were found. Subsequent inspections of visible timber undertaken at 4-5 year intervals have failed to show any signs of Hylotrupes attack.

The principal source of trouble has been imported wine and spirit cases, mainly from France. There is only a small wine industry in New Zealand and, therefore, fairly large quantities are imported. Large stocks are carried in bond stores all over New Zealand and some of the slow moving lines have been known to remain in bond for upwards of 20 years. Many thousands of these cases were destroyed or fumigated for Hylotrupes attack and the Australian authorities were kept fully informed of the affected brands. There has been no indication to date that the insect has spread from bond stores.

Item 4(o)

CODE OF PRACTICE FOR INSPECTION OF POLES IN SERVICE

We are interested in two main aspects of this problem:-

(i) The development of a rational code of practice for pole inspection mnd maintenance, and

*Prepared by D. Edwards and H. Booth.

(ii) the development of reliable non-destructive tests for the assessment of pole condition.

Provided we are agreed on suitable maintenance methods for a given area, and provided some rational objective criteria can be specified for the acceptance or rejection of a pole, the problem resolves itself into one of operational research. It is felt that a critical study is needed of the training of pole inspectors, and of the chain of command involved in pole rejection or maintenance.

We have examined X-ray, radio-active isotope and sonic methods for the assessment of the internal condition of standing poles, but have either been dissatisfied with the methods developed or were unable to continue promising leads due to lack of staff or funds. There is no doubt, however, that considerable quantities of sound poles are rejected annually because of present inspection methods such as the traditional and completely useless sounding of poles with an axe; and we suggest that further work on this problem would be well worth-while.

The economic cost of pole replacement is so great that some thousands of pounds could well be spent in order to thoroughly study present methods and from this lay down more rational ones. This would involve considerable field work with pole using authorities together with strength testing of condemned poles.

Discussion

Booth: The problem came up when we were working on detecting faults in poles. We tried co-operative work with pole-using authorities, and found the overall situation unsatisfactory.

Large amounts of money are being wasted by poles being taken out of service although there is nothing wrong with them. The economic loss involved in this practice is staggering and the situation obviously calls for improvement. As a forest authority we cannot do much without the co-operation of the pole users, but we would like to know (i) if other States have similar experiences, and (ii) whether anyone in the Division of Forest Products or elsewhere has any ideas for co-operative work to study the problem, or even some educational effort to acquaint pole users with the magnitude of the problem. Unless we can make the wooden line more economical, we shall lose that share of the business. Pole-using authorities are very ignorant of the factors involved on the wood side, at least in New South Wales. We should be stepping up our propaganda on the method of making the decision to remove a pole. Often rejected poles, when examined back at the depot, appear to have nothing much wrong with them at all. Some testing of condemned poles should be done to see what percentage of strength remains.

Jennings: We have provided some training for inspectors of the pole-using authorities, particularly in south-east Queensland.

Beesley: Some years ago when doing cross-arm inspections, I found that pole inspectors do not necessarily have any training at all. Since then, however, Mr. Keating has prepared some training instructions for pole inspectors, and he does make some attempt to indicate what sort of deterioration may be permitted for a pole before it is condemned. I do not know how this works in practice.

Dale: Sooner or later the question of the condemning of a treated pole will arise and we must know by then something of the mechanism of assessment of whether a pole is safe or not.

Chairman: I think it would be reasonable to see what the attitude of the Pole Strength Joint Research Committee is. What we can do after that may depend on the amount of work involved and the staff available. If the pole-using authorities consider that this is a serious matter, then they may decide that something should be done about it. We will undertake to make this approach to the Committee.

Item 4(p)

CONSIDERATION OF MORE RIGID PLANT QUARANTINE REGULATIONS CONCERNING FUNGAL PATHOGENS IN TIMBER*

The title is somewhat of a misnomer. What was intended was a plea for a critical review of the bodies represented here of the inherent dangers to Australian forests from the introduction of fungi along with imported timbers.

It is realized that this item is more the concern of foresters than of forest products research but the matter so often first comes to the attention of the wood technologist who advises on imported timber.

The note prepared by our Forest Pathologist, Mr. Hartigan, draws attention to the potential threat to Australian softwood plantations from the red rot fungus, Fomes annosus (Fr.) Cooke.

Again, the Preservation Section of this Commission is frequently asked to advise on the problem of moulds, decay and sapstain occurring before and during shipment of timbers to Australia. In this regard we have noticed Ceratocystis (blue stain fungi) on a number of occasions, and less frequently see logs bearing Schizophyllum or Poria sporophores.

It is reasonable to suppose that new fungal species or more virulent strains of local species can be introduced into the country in this way, and I suggest that a real potential danger does exist. Conference is no doubt fully aware that softwood plantations like any other monocultural crop are peculiarly liable to the development of so-called "explosive epidemics" of fungal pathogens. The ability of

*Prepared by D. Edwards, Division of Wood Technology.

introduced fungi to destroy natural stands of timber should not, however, be lost sight of and such examples as the ravages of chestnut blight in North America are constant witness of the hidden danger.

It is not suggested that there is cause for alarm, but rather that the potential dangers warrant some assessment.

Note Prepared by D. T. Hartigan

This note has been prepared for consideration under the agenda item dealing with Quaranting practices and desirability of excluding potential pests from Australian forests.

The fungus Fomes annosus is an example of a fungus pathogen which affects both living trees and lumber. To the knowledge of the writer no work has yet been done in this country on the potential of such a fungus.

FOMES ANNOSUS

This fungus is not recorded in Australia or New Zealand. Cleland, (1), describes the genus as "perennial fungi (fruiting bodies) often large and heavy with hard, woody or corky texture and with the tubes arranged in strata representing annual additions. Most Australian species, some of which are quite common, have the substance yellowish - brown in colour. Several are destructive parasites of forest trees".

Fomes annosus (Fr.) Cooke has come into prominence in recent years in North America, U.K. and Europe. It is accepted as a disease of rising importance in areas where replanting is taking place and particularly where some degree of species adaptation is necessary.

The U.K. Forestry Commission (2) has described the fungus in general terms in a leaflet and describes it as a "major cause of disease in British forests". A detailed description is given by

Cartwright and Findlay (3). The fungus attacks all species of conifers causing death of forest trees and damage to the timber as well as indirect damage by destruction of roots in less severe attacks. Murray (4) pointed out in a paper delivered at the 5th World Forestry Congress that "this is a build-up disease to be measured in terms of crop rotations rather than decades". Nevertheless, once infection has been established the losses in second rotation can be serious.

In terms of quick rotation P. radiata crops it is impossible to be categorical since there is no data to go on. It would be reasonable to expect that exposure of cut stumps at comparatively frequent intervals might help the spread of such a fungus but on the other hand Australian summers might be a limiting factor.

In this connection, it is worth noting that in another paper delivered at the same Congress, Offord (5) speaks of the "epidemic spread of root rot (Fomes annosus) in Slash pine and White pine plantations particularly after thinnings".

And again Spaulding (6) refers to Fomes annosus as not being important "until late years" but now that it has appeared in plantations it will become more serious in future.

He also notes that thinning of infected stands increases damage.

Control measures used in U.K. include:-

(i) Stump treatment with creosote.

(ii) Complete removal of stumps after felling.

(iii) Sylvicultural rotations to limit natural advantages of the fungus.

At present we do not appear to have this problem in Australian conifer plantations and it is obvious that protection of uninfected sites is easier than eradication from infected sites.

A list of recorded infections from Europe prepared by Spaulding is as follows:-

<u>Abies balsamea</u> - Denmark, Norway.

<u>A. grandis</u> - British Isles, Norway.

<u>A. procera</u> - British Isles, Denmark, Norway.

<u>Chamaecyparis lawsoniana</u> - British Isles.

<u>Juniperus communis</u> - Belgium.

<u>Picea glauca</u> - Denmark, Norway.

<u>P. pungens</u> - Norway.

<u>P. ritchensis</u> - British Isles, Denmark, Germany, Norway.

<u>Pinus banksiana</u> - Denmark.

<u>P. contorta</u> - Denmark, Finland, Norway.

<u>P. palustris</u> - Denmark.

<u>P. strobus</u> - Belgium, British Isles, Szechoslavakia, Denmark, Germany, Switzerland.

<u>Pseudotsuga menziesii</u> - British Isles, Denmark, Norway.

<u>Sequoia gigantea</u> - British Isles.

<u>S. sempervirens</u> - British Isles.

<u>Thuja occidentalis</u> - Denmark.

<u>T. plicata</u> - British Isles.

<u>Tsuga heterophylla</u> - British Isles, Norway.

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Discussion

Dadswell: The question of diseases of softwoods in Australia is very important. Last year I heard Dr. George Hepting of the U.S. Forest Service give a lecture on the dangers of monoculture. He referred to what had happened in the case of Dutch elm disease and several others, and also to the possibilities in New Zealand and Australia of diseases of *Pinus radiata*. He came out to New Zealand after the World Forestry Congress as a consultant to N.Z. Forest Products. I think he found that there was some evidence of what he called "little leaf" in *P. radiata* there, and I think we must watch very closely the danger of some disease getting in and wiping out plantations in Australia.

Richardson: In a report to N.Z. Forest Products, Dr. Hepting said that he found what he thought was "little leaf" in *P. radiata* in shelter belts on clay soils; he found no evidence of "little leaf" on well drained soils.

<u>Harding</u>: Has <u>Fomes annosus</u> come in to Australia ?

<u>Richardson</u>: There is some doubt as to whether the American <u>F. annosus</u> is a true identification.

<u>Hansen</u>: How can you quarantine fungal spores and keep them out ?

<u>Walters</u>: I think it would be very much easier to keep out the pathogens than the wood destroyers. Wood destroyers do not need the living tree. I do not know what steps you would take. I do not think <u>F. annosus</u> occurs in Australia; at least no specimen has ever come to us.

<u>Edwards</u>: We have also made a search of the literature in this regard and we have not found any convincing positive identification of <u>F. annosus</u> for Australia.

<u>Irvine</u>: I think this item raises something which is not directly forest products research, namely, quarantine, but I think it would be turning a blind eye if any of us were satisfied with the quarantine operations at the present time. Victoria has quite a keen quarantine service as far as plants are concerned, but it is operated by the Department of Agriculture and the quarantine service is paid for by the Department of Health. The actual quarantine inspectors are State officers given Commonwealth powers. They are also fruit inspectors. During the fruit inspecting season there may be only one or two officers engaged part-time on quarantine at the Port of Melbourne. They are willing, but the quarantine inspection at best is a partial sample, and perhaps not even a good sample, as far as living material is concerned. We have been told that no coniferous material at all will be allowed in, except by prior arrangement, and then only for research purposes, or for use or benefit of forest services. I know of no port, or have been told of no port, where the quarantine service

operates effectively. If this Conference could do anything to increase the effectiveness of quarantine the people concerned would be only too pleased.

Muir: One of the most elementary precautions that should be taken by quarantine is the exclusion of any material with bark on. During the Hylotrupes scare there was evidence that material with bark on was suspect, and presumably this would apply also to introduction of dangerous pathogens.

Irvine: Any material entering the Port of Melbourne with bark on is automatically fumigated with methyl bromide.

Chairman: I suggest we might refer this to the attention of the Forest Services.

Item 4(g)

LEGISLATION REGULATING THE SALE AND USE OF PRESERVATIVE-TREATED TIMBER

Beesley: The purpose of having this item included in the Agenda is to inform the States of Queensland and New South Wales that the Territory of Papua and New Guinea will soon have legislation very similar to that already existing in those States for this purpose and to give them an opportunity of expressing an opinion on the value of "approvals" given in the Territory for timbers imported into those States.

The legislation proposed by the Department of Forests will follow the New South Wales Legislation in providing for standard trade names for the commoner commercial timber species, in limiting the amount of untreated susceptible sapwood which may be used in buildings and manufactured articles and in regulating the preservative treatment of timber. Unlike the Australian legislation, the Territory legislation provides for a Timber Preservation Authority, whose function will be to set standards for preservative treatments which may be approved by the Director of Forests. The Authority will not have power to approve either treatments or the treating plants. Its function will be purely advisory, hence it will require no staff. Both the Public Works Department and the Commonwealth Department of Works (the two biggest construction Authorities in the Territory) will be represented on the Authority and, therefore, these two Departments will seek to encourage the use of timber treated to the prescribed standards.

In view of the fact that three separate Departments will soon have Legislation regulating the sale of preservative-treated timber, some machinery should be arranged to ensure that uniform standards of approval are adopted, so that a treatment "approved" in one State will be acceptable in each of the others.

Discussion

Jennings: We cannot license a plant which is outside the borders of Queensland.

Huddleston: Similarly we cannot license any plant outside New South Wales but we have got over it by allowing agents to register a brand in their own name. We regard these agents as being the person owning or controlling the timber, and in that way they have been able to comply with the Act to sell their timber in New South Wales. We do not anticipate that for any practical purposes this arrangement will be challenged.

Jennings: If the treatments are effective, which I have no doubt they will be, the New Guinea material could be sold in Queensland as not susceptible to Lyctus attack.

Trist: There would be no grounds for any action by Queensland, unless the timber were susceptible. I do not think there is any fear so long as New Guinea is satisfied that treatment is effective.

Bednall: I am looking for guidance myself. It is inevitable that South Australia will have to consider legislation soon concerning the use of preservative-treated timber. One of our chief dangers is the unnecessary treating of timber; I would like to hear some discussion on this point and I think the Division of Forest Products should publicize the dangers inherent in unnecessary treatment. I do not think that is a matter for legislation, although in the interests of the consumer, particularly of radiata, some legislation may be necessary in South Australia.

Note: It was decided that this subject would be further discussed by the Preservation Committee.

Item 4(r)

PRESERVATIVE TREATMENT OF SLASH PINE*

The use of Slash pine (*P. elliottii* var. *elliottii*) as a constructional timber has been outlined in another report presented to this Conference.

The opportunity thus afforded was taken to conduct observations on the need for, and the comparative effectiveness of, various treatment schedules for the preservation of Slash pine used as external sheeting and exposed joinery.

The schedule which follows sets out the treatments used:-

1 in. Boards

- B. - Treatment 1(a) - 30 per cent. boron.
- B.R. - Treatment 1(b) - Boron + water repellent 0.5 per cent.
- R.1. - 1.0 per cent. water repellent - Treatment 1(c).
- C. - Untreated Control.

*Prepared by K. V. Cokley.

Joinery

P. - Treatment 2(i) - Pentachlorophenol 5 per cent.
P.R. - Treatment 2(ii) - PCP + 0.5 per cent. W.R.
R.1. - Treatment 2(iii) - Water repellent 1.0 per cent.
C. - Untreated control.

Analysis of treated material showed core retentions in excess of the minimum requirements of 0.2 per cent. as boric acid.

Actual average core retention was 0.31 per cent. as boric acid.

For external sheeting, each treatment including controls, was replicated four times on all sides of the building at different heights on each side.

For exposed joinery (window frames), full replication of treatments was not possible.

Normal painting practice was done, a priming coat, undercoat and oil base finishing coat being applied.

The building has been in service for 12 months.

Discussion

Trist: We shall have to devote a fair proportion of our exotic softwood plantations to general building purposes, on the estimates we have of Queensland's requirements in that direction.

Tamblyn: We have given some thought to water repellent pentachlorphenol treatments. Based on conclusions by Verral, as published in a recent Forest Products Research Journal, it appears that a 3 min dip in water repellent PCP does not give long-term protection if the hazard is at all high. In some cases there have been 20-30 per cent. failures after a number of years. On the basis of these results the treatment seems inferior. From the economic angle we have tried to cost PCP treatment of weatherboards for a 12-square house and found that the cost of treatment with water repellent penta would be about £15 as against £18 for pressure treatment with a fixed waterborne. Since we are only dealing with a timber which is easily pressure treated, the balance is very much in favour of treatment with waterborne rather than with dip treatment in penta. I understand that in America water repellent penta has carried its own penalty. To make it water repellent so much wax is necessary that there are painting problems. I feel that if we want to keep selling wooden siding, we must remove every objection to it, otherwise it will be superseded by other material. I do not think any treatment which carries any obvious disadvantage such as the difficulty of painting or having to do it on the job is really what we want for the future.

Jennings: Treatment does not have to be done on the site, we hope to get enough loading in the first instance to obviate any difficulty with cut ends.

ITEM 5. RADIATA PINE

Item 5(a)

NEED FOR PRESERVATIVE TREATMENT OF PINE IN BUILDINGS*

This subject was reviewed at length in a paper[1] submitted at the 1958 Forest Products Research Conference. The contents of this paper and the ensuing discussion are still relevant and may be considered as forming a background to the present item.

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*Prepared by N. Tamblyn.

[1] Tamblyn, N. - Proc. 9th For. Prod. Res. Conf., pp. 75-90; Div. For. Prod. Melb., 1958.

Since 1958 our views on the need for preservative treatment of radiata pine building timber have not changed materially, except that we have become more convinced that such treatment is economically justified and believe that this justification extends also to hoop pine. On the other hand there is still no strong evidence in our possession indicating that treatment of baltic pine is desirable and we have not reached any conclusion for this timber.

Until a survey is made we cannot fully substantiate our opinions and in this connection attention is drawn to our proposal[2] at the last Conference for a survey to assess the extent of insect and decay damage in buildings with particular reference to radiata pine but also including other softwood timbers. Unfortunately this survey has not yet been commenced though last year we were urged by the Radiata Pine Association to obtain a rapid indication of the extent of deterioration occurring in radiata pine. An approach was then made to the Division of Wood Technology, Sydney; Woods and Forests Department, Adelaide; Forestry and Timber Bureau, Canberra; the Victorian Forests Commission; the Tasmanian Forestry Commission and our Division of Entomology, Canberra. We sought comments, suggestion and co-operation in organizing the survey from these Departments, but with one exception did not receive enthusiastic replies, while in one case there was opposition on the grounds that a survey restricted to radiata pine could be damaging to that timber.

By September 1960, agreement was reached that the survey should proceed, but that baltic pine should be included for comparison with radiata pine. Unfortunately, before this could be commenced, Mr. Beesley of this Division, who was organizing the survey, left for New Guinea on extended leave of absence.

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[2]Beesley, J. - Ibid. pp. 122-124.

A survey of the type envisaged is difficult, but we are willing to attempt it, first in Victoria and then to extend it to other States where co-operation and active participation can be arranged. Until this survey is made it is believed that decisions on the best treatments for weatherboards, flooring, or other uses cannot be made at the best technical level.

Discussion

Tamblyn: A section of Item 4(b) dealing with radiata pine was deferred to this stage. We asked four questions, on which we would like some discussion:

(i) Treatment of radiata and hoop pine: is treatment for building material desirable ? We believe so, but we would like to confirm this from the results of a survey.

(ii) Is pressure treatment with fixed salts preferable to diffusion treatment ? We believe so, but we recognize that diffusion treatments will have, or do have, economic merit.

(iii) Can we recommend diffusion treatment as an alternative to pressure treatment with fixed salts ? This is a question we are finding extremely difficult to answer. We recognize that radiata pine is particularly suitable for pressure treatment and that it is one of the few timbers which can be penetrated completely. We also recognize that in diffusion treatments, there is a fairly sharp gradient in the preservative concentration from the surface of the wood to the core. Although we regard this as quite satisfactory for timber which will not be machined, we are hesitant to recommend diffusion treatments where timber has to be profiled fairly deeply, as in the case of weatherboard. A critical review of our results indicates that distribution of boron in a weatherboard after 28 days block stacking is probably satisfactory. However, the addition of arsenic to the preservative is not very satisfactory because the arsenic is slow in diffusion and tends to be concentrated in the outer layers where it would be largely dressed off. We have been trying pressure diffusion treatments, and results so far suggest that this could be better than dip-diffusion, but a considerable amount of work will yet be necessary before we can make any recommendation. Treating fairly green pine 2 or 3 days off the saw, or conditioned by steam and vacuum treatment in the cylinder, we have been able to get solution absorptions in the vicinity of 15 lb/cu.ft. Specimens which we dried rapidly after treatment in a kiln did not show satisfactory distribution, so some block stacking period may still be necessary, or at least some change in the process before the core would be adequately treated. Unless we can develop a diffusion treatment which largely obviates block stacking with pine, we should give a good deal of thought to the merits of the pressure treatment of the dried timber. In South Australia, the higher cost of the pressure treatment with a fixed salt may well be acceptable, but in New South Wales the economic situation may make it necessary to use cheaper diffusion treatments.

The final question - is dip-diffusion suitable for radiata weatherboards ? We have already discussed this; I understand the opinion of the States most concerned is that they would accept a diffusion preservative for weatherboards, providing the penetration is satisfactory. In other words, we are not going to penalize diffusion treatments in weatherboards, because of leachability. We feel the paint system, if reasonably maintained, is sufficient guarantee of long life.

Edwards: In answer to the questions raised by the Division of Forest Products under Item 4(b)(ii) the desirability of treatment of Monterey Pine has already been discussed.

On the question of diffusion versus pressure treatments we feel from a purely preservation angle that there are great advantages in using a fixed salt with a wide range of uses. However, the economics of the softwood milling industry in New South Wales are such that both methods are likely to be adopted; diffusion treatments in smaller mills and either diffusion or pressure treatment in the larger mills.

We do not at this stage advocate the treatment of pine building timbers other than weatherboards, roof decking, and external fixings. It is further considered that treatment of scantlings is not at present warranted nor is there, in any case, sufficient Monterey Pine scantling available.

We are well aware that Monterey Pine flooring and other building timbers are liable to attack by Anobium, Hylotrupes, termites and other insects; given the right conditions. We have not yet demonstrated to our satisfaction in New South Wales that the danger is a serious one which warrants treatment of all Monterey Pine building timbers. The matter, however, is kept under close and constant review and we will act promptly whenever the situation demands it.

The relative costs of diffusion and pressure treatments have been discussed in detail with the management of one of our larger mills. From these discussions we have arrived at a figure of 15/- per 100 su.ft. for diffusion and 30/- per 100 su.ft. for pressure treatment of 1 in. boards. When the relative cost of equivalent sized Cypress Pine and Monterey Pine boards are compared the difficulties of New South Wales' industry become apparent.

Relative cost of treated and untreated 4 in. weatherboards:-

Treatment	Retail Cost/100 su.ft.
Cypress Pine - untreated	165/-
Monterey Pine	175/6
Monterey Pine - dip-diffused	190/6
Monterey Pine - pressure treated	205/6

It is at the moment a question of whether the industry can afford to treat pine weatherboards; whether the cost can be adjusted against other forms of treatment (e.g. pressure treatment of pine posts in the same plant); or whether the industry will cease to produce Monterey Pine for this purpose.

We would point out that for New South Wales conditions, diffusion storage sheds will probably be necessary and this, together with the considerable capital investment on timber held in diffusion storage makes a diffusion plant more expensive initially than a pressure plant of similar capacity. Diffusion treatments, however, eliminate costly redrying and this together with its adaptability to very small throughputs may suit the small mills.

Finally, in reply to the last question, we agree that leaching of unfixed preservatives from weatherboards will probably be slight but like the Division of Forest Products are concerned about the loss of non-fixed salts because of profiling.

Bootle: In the past year many cases of decay have been discovered in the Pinus radiata weatherboards on 2 and 3 year old dwellings in the central coastal area of New South Wales - mainly Sydney suburbs, but also Wollongong (43 out of 128 in one Sydney group housing estate see table). The breakdown has occurred mainly, but not exclusively, on the southern exposures; in most cases the ends of the boards are the areas affected, as would be expected, but infection quite remote from ends has also been observed. The use of building paper adjacent to the backs of the boards has been noticed on many of the affected buildings and it seems necessary to discourage the use of such non-permeable membranes in this position. Objections were lodged with Australian Sisalkraft Ltd. which makes 80 per cent. of the building paper used at the moment, some time ago at their promotion of the use of this material on the outside of the frame. Despite the agreement of the Company's technical staff with our viewpoint, their advertising copy remains unchanged at present.

End and back priming was absent in many cases but the blame cannot be attributed entirely to this. Rotting has occurred on boards used in a 3 year old painting test carried out by ourselves, in areas away from the ends of boards when primed all round and on the ends.

The matter is an embarrassing one fot the New South Wales Forestry Commission. People who have only been in their home for a few years are faced with considerable expense already; perhaps in a few years they may have to replace most of the weatherboarding. Their builder refuses to pay the cost because he used the timber in good faith.

Instances of decay have been reported in sheltered exterior doors, garden furniture, etc. and the news is spreading quickly of the timber's non-durability.

It has been claimed that the cost of preservative treatment will lose radiata pine its weatherboard market because of the competition of cypress pine. This may well be so, but the rapid decay experienced has meant the loss of this market anyhow. The Division of Wood Technology has recommended to the Commission that timber for weatherboards should be treated against decay and the need for preservative treatment was discussed recently by the Commission with representatives of New South Wales, South Australian and New Zealand pine interests, and further meetings will be held. Delegates from New South Wales will be interested in the views and recommendations of this Conference regarding the desirability (and methods) of preserving this species when used as weatherboards in coastal climates such as those on our eastern seaboard.

Suburb	Age of House(s)	No. of Houses	Remarks
West Pymble	4 + years	43	Survey by War Service Homes Division. Rot or incipient rot.
Matraville	2-3 years	4	High side on sandy soil. Two houses badly rotted even away from butt joints
Caringbah	3 + years	1	Unprimed timber. Rot on south and east sides near stopmoulds.
Revesby Heights	2-3 years	3	Rot in primed butt joints on 5 sides.
Berkeley (suburb of Wollongong)	Not known	1	Reported by Commission timber inspectors. Rot at butt joints.
Roof on Division of Wood Technology	$3\frac{1}{4}$ years	Painted boards	Painted boards exposed as part of painting test. Primed all round plus undercoat and finishing coat. Rot in centre and on ends of boards.
Era Beach 30 miles south of Sydney	3 years	External door	Painted boards of P. radiata rotted but adjacent boards of Baltic unaffected.

Cokley: Was there any difference in types of paint used ?

Bootle: No - painting is important, but there has been a lot of confusion by blaming all the trouble on paint. Although paint may have been contributary it is not the major cause and should not influence us in deciding for or against treatment. Paint has broken down on cypress pine also, but there was no sign of decay in that species.

Jennings: We have never been in any doubt that radiata or almost any softwood species should have treatment for external use. Experience with imported softwood in Queensland exactly parallels New South Wales experience. There is no doubt that if we want to use these timbers for external use, preservation is necessary. These species are not recommended for external use without preservative treatment in Queensland and softwood for external use in Queensland will not find a market in competition with hardwood weatherboards unless it has been treated. We feel that preservation of the species should be directed to specific uses, and not be a general overall practice. Interior flooring is not regarded as a risk in view of the building practices applying in Queensland.

Bootle: I would be loath to recommend the use of radiata pine flooring in many buildings I have seen erected today. I think the question of treatment of flooring may well arise in the near future, at least in New South Wales coastal areas where I think conditions are favourable for under-floor decay.

Benallack: I have heard of no serious trouble from decay in weatherboarding or in exterior use of radiata, but we do not have the extensive usage of this species that they have in New South Wales. We are interested, however, because some of our pine does go into New South Wales, and so will be affected by whatever is decided in that State.

Bednall: I would not like to see the Conference recommend treatment irrespective of use. The cost of treatment itself might price us out of the market. In any case, we have several hundred houses built entirely of radiata in the south-east over the last 30 years; we do not have decay trouble in weatherboards or flooring, but we do have trouble with the outside verandahs. Termites are a problem in some situations, but that is not sufficiently serious, at least in South Australia, to justify preservative treatment of radiata.

Harding: I endorse Mr. Bednall's remarks and point out that weather conditions on the site are important. In this regard the Mediterranean climate of South Australia differs from that of areas in New South Wales and Queensland.

We feel that preservative should be used for specific purposes only and this means intelligent use of the timber by builders, architects and others. We do not want the whole radiata industry placed in jeopardy. There are other softwoods which have similar troubles and in these connections the term softwoods should be used instead of singling out radiata as though it were "the bad boy of the softwoods", which it is not.

If the area in which the timber is to be used is considered in a commonsense way, then it is apparent that high humidity areas such as parts of New South Wales and Queensland are quite different from large areas of Australia which have dry mediterranean climates. We do not want to raise costs to consumers nor do we wish to further the interests of preservative firms. We are considering legislation to control preservative practice so it will be necessary to be specific on the use of preservatives. There are many positions in structures where preservative is quite unnecessary, and there are other positions where it is desirable to treat. Good maintenance and a minimum of preservative treatment will avoid much of the trouble under consideration.

If affected timber is looked at, predisposing reasons can be found for the troubles concerned and such factors should be dealt with other than by condemning radiata.

Tamblyn: I do not fully agree with Mr. Harding's remarks. I think he has glossed over the termite hazard in Adelaide which we believe to be sufficient to warrant the treatment of radiata pine. It is difficult to termite-proof many houses effectively. With regard to Mr. Harding's comments on softwoods in general, we think radiata pine is a special case because of its higher moisture absorption, which is very much higher than spruce. Spruce sapwood is very impermeable, and even in pressure treatments it does not absorb at all well. Almost all imported weatherboards at present appear to be spruce. We are inclined to regard radiata pine as the "bad boy".

Jennings: We must consider the usage to which softwoods are going to be directed. Over 90 per cent. of the hoop pine plantation material will never be directed to external use. The situation is different of course in regard to southern yellow pine. The Department is not willing to recommend treatment, except for a specific use.

Wickett: The Forest Department has a number of houses sheeted with radiata pine weatherboards. There has been no mention of decay in any of these and it is not a problem with us at present.

Byrne: New Zealand is not interested in the weatherboard market in New South Wales or anywhere else. We have a shortage in New Zealand of weatherboard material. We would not have sold more than 30 or 40,000 ft of weatherboard material in New South Wales, particularly as there is a duty of 16/6 per 100 on weatherboards. I only heard of this problem a few weeks ago, and I examined some of the houses with Mr. Bootle. I agree with him that failure is occurring, but, from a New Zealand viewpoint, we prefer to regard this as a domestic problem and do not want to get too deeply involved. I estimate that between 4 and 5,000 houses have been sheathed in radiata; of the houses which are infected, I would estimate that 30 to 40 board ft of timber would have to be replaced in each case. "Building timbers" is a big classification, and I would like to endorse Mr. Harding's remarks - every section of a house has to be looked at very carefully, it would be most unwise to give a blanket recommendation for all Australia or to regard building timbers under the one heading.

Muir: The Commission has this week been advised by War Service Homes that in view of the reports to date, they are not at all happy with the use of radiata weatherboards, and are not prepared to recommend their continued use unless appropriate corrective action can be taken. We arenow faced with the possible loss of one major customer.

Gay: I have no information at all on the decay hazard in Canberra. We have had one or two instances of termite attack on radiata flooring, and this is the major insect hazard in any area in which radiata is likely to be used. Radiata is very susceptible to attack by Coptotermes which is a very widespread genus in Australia. With regard to the disappearance of Anobium from these areas in south-eastern South Australia, this is associated with the fact that the main limiting factor in establishment of Anobium is closely linked with humidity. If the relative humidity at the time the eggs are due to be hatched is consistently below 40 per cent., the egg will not hatch, and this is why Anobium does not establish itself in dry areas. If the micro climate does rise so that the moisture content is above 40 per cent. in the summer period when eggs are hatching, then Anobium can become established.

Bootle: Radiata has only been used in the last few years to any extent in the metropolitan and coastal strip. All we have to go on are the houses built in say, the last 5 years, and the extent of damage is rather alarming. About 10 to 15 per cent. of our total production of 30 million a year in New South Wales is going into weatherboards. I would say this problem will have a very considerable effect on the utilization of radiata for many years ahead. I feel that we must make a decision fairly quickly, and act, and can do so without being accused of panic.

<u>Bednall</u>: Concerning the survey mentioned by Mr. Tamblyn, I would like to assure him that provided it covers all softwood utilization we would be prepared to co-operate.

<u>Tamblyn</u>: The reason we did not carry out the survey is the amount of effort involved and the need for enthusiastic co-operation from everyone. Probably we can go ahead and decide on treatments without the need for this survey.

<u>Bryant</u>: One difficulty with a survey is that you immediately draw attention to the undesirability of the material that you are investigating.

<u>Tamblyn</u>: For many years, I have been labouring the point that radiata pine is different from the other softwoods we use in buildings, in that it is substantially all sapwood with a very high capacity for absorbing moisture. Because of this, I have always been worried about untreated radiata pine for weatherboards. We have two problems with regard to radiata pine: first, weatherboards; second, flooring. I do not believe much radiata is going into framing timbers and we can shelve that side of it for the time being. With regard to weatherboards, we have seen enough decay in baltic pine weatherboards in Melbourne to convince us that we will get a lot of decay with radiata pine. I think we should accept the need for treatment of weatherboards without further argument. With regard to radiata pine floors, I am firmly convinced we would be foolish to neglect the need for their treatment. Floors of

radiata pine are very subject to termite attack and from Brisbane to Adelaide we pass through many areas of high hazard, with Melbourne as a possible exception. Adelaide has a sufficiently high termite hazard for much trouble to develop in radiata floors in mazonary type buildings where the building construction methods favour termite attack. There is also the danger of Anobium attack in flooring, particularly in the type of brick house built in Adelaide, in fact in any house where high humidity conditions prevail in the sub-floor area. This is accentuated by use of rubber-backed carpets, rubber and lino. Also, apart from termites and Anobium, there is some decay hazard and I suggest that if we don't treat radiata pine flooring, we will get enough trouble to jeopardise its future.

Jennings: Whether you recommend treatment for a floor depends entirely on the building practice. In Queensland a suspended floor must have a minimum of 2 ft clearance from ground to the bottom of the sub-floor members. In regard to Calymaderis we have used hoop pine, principally flooring, in literally thousands of houses in the past. Calymaderis is restricted to a comparatively small area of south-east Queensland. A simple surface spraying of creosote on the under surface of the floor would stop it, or even paint. I see no necessity for a blanket recommendation. When the house is built a simple brush or spray treatment is quite sufficient to stop trouble by stopping oviposition. I see no necessity to recommend a general treatment of flooring atainst this attack.

Bryant: I am convinced that we will have to treat flooring and weatherboards. Sooner or later the New South Wales Commission will have to lay down regulations within New South Wales.

Edwards: We have two problems to consider: first of all the initial construction of the house - unsatisfactory methods of construction are widespread in New South Wales; second, advice to the public regarding corrective treatments. In New South Wales building regulations are often unsatisfactory in this regard and the builder or architect frequently does not appear to have any conception of the essential features of proper decay and termite resistant construction.

Our experience is that sub-floor inspections are carried out only when termite attack or decay has occurred and considerable damage has been done. The situation strongly indicates that preservative treatments of flooring requires urgent consideration.

Cokley: Would it be possible on your survey to ascertain what are the moisture and decay conditions in these modern type homes.

Tamblyn: If we do such a survey, we would try to get all possible information and would list other things than decay. In connection with the treatment of radiata pine, we have been attracted to the idea of a pressure plant for each radiata pine producer. It would use two preservative tanks - one containing a fixed waterborne preservativ and the other containing borax, arsenic, or some similar cheap diffusible formulation intended for treatment of interior building timbers. This would be a cheap salt - costing about one third of the price of copper-chrome-arsenic. We would envisage treatment of radiata pine with this diffusible preservative while the pine is substantially green. Under these circumstances, treatment of a building timber might be done for about 12/- as compared with 20/- to 25/- for a fixed salt.

The Chairman closing discussion said it appeared that it would be the ultimate user of the material who would dictate whether the material had to be preservative treated or not. The suppliers of radiata will, therefore, have to have available treated as well as untreated material. In advising the consumer, we can say that these conditions are likely to produce certain decay hazards and we can recommend certain treatments for certain areas.

Item 5(b)

DIFFUSION TREATMENTS AND PRESERVATION GENERALLY

Bryant: I suggest that further discussion is not necessary, but I would like some of my people to come down and work with Mr. Tamblyn to expedite the treatment and the obtaining of results.

Beesley: Some thought has been given at Port Moresby to using the suggestions made by Mr. Tamblyn, but I do not know what decision has actually been made. They may be putting in the two tanks - one for a waterborne fixed preservative and the other for a diffusing salt.

Chairman then raised the question regarding the Committee on Preservation, as suggested earlier by Mr. Tamblyn.

Tamblyn: The Committee would try to co-ordinate the opinions of the States, but would not necessarily make the decisions.

Bednall: }
Jennings: } Agreed to being represented on the Committee.
Bryant: }

Benallack: I do not think Victorian representation is necessary, but will fully support such a Committee.

Wickett: I would like to be kept informed but do not think it necessary for Western Australia to be represented.

Crane: Similarly for Tasmania.

Beesley: New Guinea will very shortly have legislation governing preservation treatment, and should, therefore, be represented.

Item 5(c)

RAIL SLEEPER TESTS IN SOUTH AUSTRALIA*

The South Australian sleeper test, which is now 24 years old, includes *Pinus radiata* sleepers pressure treated with creosote, creosote plus oil (60:40), zinc chloride plus arsenic trioxide, Tanalith U, control sleepers being untreated *P. radiata*, *Eucalyptus rostrata* and *E. marginata*. Certain definite conclusions may be drawn from the results obtained so far, and it is also possible to make additional reliable predictions.

As would be expected, untreated pine failed largely from decay, but in the remaining groups, mechanical failure was far more important than failure from decay. Unplated pine sleepers suffered from rail cut and the results indicate that plates are desirable in most cases, preferably those which have protrusions on the base.

The accompanying table gives either the mean lives, where 100 per cent. failure has been recorded, or minimum mean lives, where sleepers still remain in test. Clearly, zinc chloride plus arsenic trioxide treated pine sleepers are not in the same class as the pines treated with oils. Both the creosote and the creosote plus oil treated pines behave extremely well, and appear to be better than either the red gum or the jarrah available in 1936. Further analysis of these results suggests that these differences will become even more marked as the test proceeds.

All treated pine sleepers were laid heart down, and so it is not possible to make comments on the effect of heart being uppermost on sleeper life, though the results for red gum and jarrah, some of which were laid with heart uppermost, suggest that this would lower sleeper life.

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*Prepared by P. Rudman.

Locality	Timber	Preservative	Percentage Removals 1–6 (Years)	7–12 (Years)	13–18 (Years)	19–24 (Years)	25–30 (Years)	30 (Years)	Minimum Mean Life (Years)
Naracoorte- Mt. Gambier Narrow gauge	P. radiata	Creosote	0	0	100*				
	"	Creosote + Oil	0	0	100*				
	"	$ZnCl_2 + As_2O_3$	0	0	100*				
	"	Tanalith U	0	6	94*				
	"	Untreated	60	38	2*				5.6**
	E. rostrata	Untreated	0	0	100*				
Gladstone- Port Pirie Narrow gauge	P. radiata	Creosote	0	0	0	42	5	53	26.0
	"	Creosote + Oil	0	0	0	22	5	73	27.8
	"	$ZnCl_2 + As_2O_3$	0	0	43	45	12	0	19.2
	"	Untreated	85	13	2	0	0	0	4.4**
	E. rostrata	Untreated	0	0	10	62	0	28	22.7
Peterborough- Cockburn Narrow gauge	P. radiata	Creosote	0	0	0	7	5	88	29.2
	"	Creosote + Oil	0	0	0	7	5	88	29.2
	"	$ZnCl_2 + As_2O_3$	0	7	63	20	10	0	17.0
	"	Untreated	95	5	0	0	0	0	3.3**
	E. rostrata	Untreated	0	0	2	13	30	55	27.6
Tailem Bend- Pinnaroo Broad gauge	P. radiata	Creosote	0	0	0	0	12	88	29.6
	"	Creosote + Oil	0	0	0	2	7	91	29.6
	"	$ZnCl_2 + As_2O_3$	0	2	0	10	83	5	26.1
	"	Untreated	95	5	0	0	0	0	3.3**
	E. marginata	Untreated	0	0	0	2	74	24	27.6
Belair- Mt. Lofty* Broad gauge	P. radiata	Creosote	0	55	35	10	0	0	12.3**
	"	Creosote + Oil	0	50	27	23	0	0	13.4**
	"	$ZnCl_2 + As_2O_3$	0	63	32	5	0	0	11.6**
	"	Tanalith U	5	75	20	0	0	0	9.9**
	"	Untreated	100	0	0	0	0	0	3.0**
	E. marginata	Untreated	0	51	28	21	0	0	13.2
Snowtown- Kadina Broad gauge	P. radiata	Creosote	0	2	2	0	0	96	29.1
	"	Creosote + Oil	0	0	10	0	0	90	28.5
	"	$ZnCl_2 + As_2O_3$	2	5	43	7	43	0	20.0
	"	Untreated	96	2	0	0	2	0	3.8
	E. marginata	Untreated	2	2	0	6	37	53	27.2

*Removed due to regauging.
**Mean life.

It is believed that these relative results are indicative of what may be expected in most other States of Australia, though in high rainfall areas, particularly where hot dry seasons are not encountered, it is believed that sleepers treated with the more recently developed waterborne preservatives will be as effective as those treated with oil borne preservatives.

Provided treated pine sleepers are not used where sharp curves and steep gradients are encountered simultaneously, they should give excellent service. This Division now feels that more attention should be devoted to studying the acceptibility of sleepers with certain defects, rather than further testing of preservative treatments.

Discussion

Bednall: I am glad to hear that the matter of defects in sleepers has been taken up with the Railway Department. The size of sleeper which can be accepted is also an important matter. I think this should be detailed more carefully. On the Mt. Lofty line our figures have indicated that creosote treated pine is a shade better than jarrah.

Rudman: It certainly appears that they are at least equal, but as the test was not completed due to relaying of the track it would be dangerous to make too firm a prediction. Plating certainly appears to be essential on important lines. As regards size of sleeper, the second test started in South Australia covers different sizes of sleepers. The tests have only been proceeding for a short time but it appears that a 9 x 5 sleeper is a little freer from splitting and end checking.

Bednall: The supply position is quite satisfactory, but our main problem at present is the question of price. The price for a radiata sleeper is 23/- with, I think, 12/- for the plate.

Bryant: Is the quality of the creosote being used today the same as the quality of the creosote being used to treat the pine sleepers when the experiment was commenced ?

Rudman: I cannot say whether the creosotes were identical, but an analysis of the sleeper failure shows very little difference with regards to creosote. Once sufficient preservative is present to overcome the decay hazard, the extra amounts of creosote appear to make little difference. These points will be discussed in a progress report which will be issued shortly.

Item 5(d)

RADIATA PINE SCANTLINGS*

Analyses have been made of the results of bending tests on two parcels of dry radiata pine scantling, one from South Australia and the other from Victoria, to check the efficacy of S.A.A. Int. 376 and Int. 377. The first analysis yielded the following results:-

South Australian Material (4 x 2 in. Scantlings)

2 per cent. of pieces accepted by Int. 377 had a strength below 30 per cent. of that of the matched clear specimen.

77 per cent. of pieces rejected by Int. 377 had a strength above 30 per cent. of that of the matched clear specimen.

47 per cent. of pieces accepted by Int. 376 had a strength below 60 per cent. of that of the matched clear specimen.

20 per cent. of pieces rejected by Int. 376 had a strength above 60 per cent. of that of the matched clear specimen.

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*Prepared by N. H. Kloot.

Victorian Material (4 x 2 in. Scantlings)

20 per cent. of pieces accepted by Int. 377 had a strength below 30 per cent. of that of the matched clear specimens.

54 per cent. of pieces rejected by Int. 377 had a strength above 30 per cent. of that of the matched clear specimens.

64 per cent. of pieces accepted by Int. 376 had a strength below 60 per cent. of that of the matched clear specimens.

8 per cent. of pieces rejected by Int. 376 had a strength above 60 per cent. of that of the matched clear specimens.

On the basis of these results, both Int. 376 and Int. 377 appeared to be quite inadequate, in that their grading rules failed to ensure that "no acceptable piece had a strength less than 60 and 30 per cent. respectively of that of a clear piece".

That these standards may, in fact, be satisfactory was demonstrated by a second analysis in which a check was made to determine whether the strengths of the individual pieces exceeded a particular stress value for each grade. The appropriate stress values are derivable directly from the recommended working stresses for Strength Group D timber to which Int. 376 and Int. 377 refer. With suitable modifications, these stress values for short-time loading are 1,190 lb/sq.in. for material graded to Int. 377, and 2,380 lb/sq.in. for material graded to Int. 376. The results obtained in this particular analysis were as follows:-

South Australian Material

- 3 x 2 in. scantlings - none graded to Int. 377 had strength below 1,190 lb/sq.in.
- 3 x 2 in. scantlings - 3 per cent. graded to Int. 376 had strength below 2,380 lb/sq.in.
- 4 x 2 in. scantlings - none graded to Int. 377 had strength below 1,190 lb/sq.in.
- 4 x 2 in. scantlings - none graded to Int. 376 had strength below 2,380 lb/sq.in.

Victorian Material

- 4 x 2 in. scantlings - 1½ per cent. graded to Int. 377 with strength below 1,190 lb/sq.in.
- 4 x 2 in. scantlings - 9½ per cent. graded to Int. 376 with strength below 2,380 lb/sq.in.

This gives quite a different picture to the first analysis. On this basis, Int. 377 appears to be quite satisfactory, and Int. 376 slightly less so.

Two other factors of importance were high-lighted by the analysis of these scantling tests. The recovery of graded material to the two sets of grading rules proved to be rather poor. Of the total of 308 sticks tested in both parcels, 25 per cent. passed Int. 376, 42 per cent. passed Int. 377 and 58 per cent. were rejected. The second point relates to the modulus of elasticity of the scantlings. The average value of this property for the South Australian material graded to Int. 377 was 1.25×10^6 lb/sq.in. whereas the corresponding value for the Victorian material was only 0.6×10^6 lb/sq.in. These figures are to be compared with the working stress figure for modulus of elasticity for Strength Group D of 1.5×10^6 lb/sq.in.

Summarizing, the results to date indicate:-

(i) Without consideration of distortion as a defect, the recovery of material acceptable to Int. 376 is likely to be of the order of only 25 per cent., and to Int. 377 of less than 50 per cent.

(ii) The grading rules do not limit the strength of the weakest piece to the specified percentage of the strength of matched clear material.

(iii) Int. 376 and Int. 377 are reasonably efficient in eliminating material of unacceptable strength. However, they both reject a high proportion of material that has a satisfactory level of strength. For example, 98 per cent. of the South Australian 4 x 2 in. material rejected by Int. 377 would have passed the stress level for common grade, Strength Group D, green timber. The corresponding figure for the Victorian material was 93 per cent.

(iv) Material otherwise acceptable to the standards may have a very inferior stiffness. This, for material graded to Int. 377 and thus intended for such purposes as house-framing, may be critical.

(a) Finger-Jointed Radiata Pine Scantlings

A number of dry 4 x 2 in. scantlings, some from South Australia and some from Victoria were docked free of all significant defects and finger-jointed into 10 ft lengths. These were subjected to bending tests similar to those reported on the normal sawn scantlings. Further work requires to be done but the results of the tests to date are of considerable interest.

Summarized these results were:-

(i) Recovery of finger-jointed scantlings was approximately 70 per cent. of the original material.

(ii) Distortion in the finger-jointed scantlings was less than 25 per cent. of the distortion in the original scantlings.

(iii) The strength variation between individual pieces was considerably reduced.

(iv) From the tests done to date, all specimens including those containing pith material had strengths in excess of the stress equivalent of standard grade, Strength Group D, green timber. For scantlings from which pith material is excluded, it would seem likely that working stresses for dry timber could be used.

(v) The average stiffness of the material was significantly higher than that of the sawn scantlings, the South Australian pieces averaging 1.6×10^6 lb/sq.in. and the Victorian material approximately 1.2×10^6 lb/sq.in. In the case of the latter this represents a 100 per cent. increase over the corresponding value for the sawn scantlings.

There is some indication that the finger-jointed scantlings of radiata pine could be an economic proposition and the attractiveness of scantlings machined to size, straight and stable, virtually free of defects and of guaranteed minimum strength hardly required underlining.

Discussion

Bednall: Will you now frame recommendations for the Standards Committee regarding revised specifications ?

Kloot: I have not yet given any thought to what we should do regarding Interim Specifications 377 and 376. I think perhaps more testing should first be done. Int. 377 appears to be satisfactory, but Int. 376 could possibly be tightened up. Reports that have come to my notice suggest that it may not be economically practicable to grade to these specifications.

Bednall: It is somewhat unsatisfactory that both specifications reject material that appears to have a satisfactory level of strength.

Kloot: We have considered this matter; it seems likely that it may be possible to use a simple stiffness test to mechanically grade scantlings; but it would be a rather costly business and at the moment does not appear to be very practicable.

Booth: In highly redundant frames of the ordinary house type, it seems to me that material which is given almost no grading is, in general, satisfactory. As 376 and 377 do not discriminate rationally on a strength basis, the use of this graded timber for house construction, is likely to be very limited. This can be a serious matter for people wishing to develop the rational utilization of radiata in truss type structures.

Kloot: One of the problems in the use of ungraded radiata scantling is the enormous differences in stiffness, and in a structure the stiff members will have to carry more of the load than they are designed for. I would not like to see the general use of ungraded radiata in house structures.

Item 5(e)

STRENGTH PROPERTIES OF GREEN 1st THINNINGS RADIATA PINE*

The strength properties of 1st thinnings radiata pine from two plantations, namely Green Hills and Nalbaugh, have been obtained.

Simple statistics have been calculated for the distribution of the more important strength properties.

There appears to be a significant difference between the mean strength properties of the two plantations, but this has not been tested statistically in all cases.

Of the simple regressions calculated, none have been found powerful enough for prediction purposes. Simple regressions calculated include:-

(i) Log. Modulus of Rupture on Log. Maximum compressive strength.

(Modulus of Rupture) = 15.6 (Maximum compressive strength)$^{0.76}$.

Significance 0.1 per cent.

(ii) Maximum compressive strength on Basic density.

(Maximum compressive strength) = 91.2 (Basic density) - 46.9

Significance 1 per cent.

(iii) Stress at proportional limit (compression parallel) on Basic density.

(Stress at proportional limit) = 54.6 (Basic density) + 215

Significance 1 per cent.

(iv) Stress at proportional limit (bending) on Basic density.

(Stress at proportional limit) = 77 (Basic density) + 920

Significance 1 per cent.

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*Prepared by H. Booth.

It was found that on discarding one particular result this regression became:-

(Stress at proportional limit) = 49 (Basic density) + 1,540 which was not significant.

The shrinkage characteristics of material from these two plantations has not yet been investigated.

Major Results Obtained (Mean Values)

Property		
Static Bending:		
Stress at p.l.*	2,870 lb/sq.in.	3,335 lb/sq.in.
Modulus of rupture	5,581 "	6,609 "
Standard deviation	1,171 "	730 "
Standard error	210 "	136 "
1 per cent. lower probability point	2,815 "	4,781 "
Modulus of elasticity	0.99×10^6 "	1.25×10^6 "
Shear stress at maximum load	371 "	
Compression Parallel Grain		
Stress at p.l.*	1,439 lb/sq.in.	1,883 lb/sq.in.
Maximum compressive stress	1,996 "	2,579 "
Standard deviation	394 "	419 "
Standard error	55 "	62 "
1 per cent. lower probability point	1,070 "	1,557 "
Modulus of elasticity	0.79×10^6 "	1.10×10^6 "

*p.l. = proportional limit.

Compression Perpendicular to Grain

Stress at p.l.	Radial	244 lb/sq.in.	257 lb/sq.in.
	Tangential	211 "	245 "
Stress at 0.1 in. deflection	Radial	353 "	405 "
	Tangential	328 "	404 "

Shear Strength (Maximum)

Radial	859 lb/sq.in.	974 lb/sq.in.
Tangential	869 "	974 "

Resistance to Impact

Denison	Radial	105 in.lb	113 in.lb
	Tangential	84 "	93 "
Izod		5.5 ft.lb	5.4 ft.lb

Tension Perpendicular to Grain

Radial	371 lb/sq.in.	407 lb/sq.in.
Tangential	286 "	361 "

Mechanical testing has been completed on air dry radiata pine sampled from the National Sawmills, Gilmour.

The material was tested at a moisture content near 12 per cent.; final correction of figures to 12 per cent. moisture content were made using the Division of Forest Products formula.

The following mean results were obtained:-

Four pt Static Bending

Stress at p.l.	6,740 lb/sq.in.
Modulus of rupture	11,160 "
Modulus of elasticity	1.64×10^6 "

Compression Parallel to Grain

Stress at p.l.	4,050 lb/sq.in.
Maximum compressive stress	5,970 "
Modulus of elasticity	1.38×10^6 "

Compression Perpendicular to Grain

Radial direction	590 lb/sq.in.	Stress at p.l.
Tangential direction	500 "	

Shear Parallel to Grain

Radial plane	1,890 lb/sq.in.	Maximum shear stress
Tangential plane	2,000 "	

Tension Perpendicular to Grain

Radial direction	480 lb/sq.in.	Maximum tensile stress
Tangential direction	380 "	

Resistance to Splitting

Radial direction	225 lb	Cleavage lb/in. width
Tangential direction	220 "	

Resistance to Impact

Radial direction	84 in.lb	Denison toughness value
Tangential direction	68 "	
Tangential direction	3.8 ft.lb	Izod impact value

Hardness

Radial direction	710 lb	Janka hardness valve
Tangential direction	620 lb	
End direction	860 lb	

Density 30.3 lb/cu.ft.

The results obtained appear to be in general agreement with the strength properties expected for seasoned radiata pine, with the exception of the moduli of elasticity. In this batch of material the modulus of elasticity in bending was higher than the modulus of elasticity in compression, when generally the converse is true.

Discussion

Richardson: I think we need to know the cause of the variation before we could solve these problems. We have found significant differences in the strength of radiata with region and with site.

Kloot: When we consider the structural use of radiata pine, it must be remembered that we are dealing with a species of which most people in Australia have had no previous experience. It is totally different in strength characteristics from that of hardwoods and the other common softwoods. I believe that radiata pine could become as important to Australia as Douglas fir is to North America.

Huddleston: Mr. Booth's investigation arose out of an S.A.A. investigation relating to specification 377. The programme envisages the investigation of first and second thinnings from various plantations, and we hope to be able to use this information for drawing up specifications.

Kloot: We received material from various age groups from the Penola and the Mt. Burr districts. The 10 and 20 year old material was totally different from the 30 and 40 year old material. It may be that plantations even close to each other might show marked differences; whether this is due to seed source or other factors I do not know.

Booth: There are two aspects to the problem, the long-term point of view and also the immediate requirement for the use of the timber as a structural material. Mr. Kloot's work has shown that in the use of radiata pine for structural work, there is nothing more important than attempting to correlate the visual defects with their effect on stiffness. Other factors can have a long-term importance on the variation in strength, but will have no relation to the immediate problems.

Kloot: The timber of radiata pine is obviously highly variable and contains various defects. We are attempting by our finger-jointed scantling investigations to overcome all difficulties at once. Such an approach could obviate the necessity for carrying out a vast amount of investigation that would appear to be necessary proceeding along the normal lines.

Item 5(f)

UTILIZATION OF *PINUS RADIATA* IN NEW SOUTH WALES

At present weatherboards comprise 10 per cent. of local production, and one Sydney firm is selling 50,000 su.ft. per week. Snowy Mountains engineering contracts have at times absorbed a considerable amount (perhaps 25 per cent.) of Tumut production for formwork, etc. but due to the early completion of contracts there will be a lack of demand until fresh contracts are commenced at the end of the year.

The rapid expansion of Canberra has created a strong demand for radiata flooring from Tumut.

The operations of the C.S.R.'s particle board ('Pyneboard') at Oberon, on the central tablelands, has largely solved the Forestry Commission's disposal of thinnings problem. In addition, pine has replaced sugar cane 'bagasse' in the production of "Caneite" insulating board.

Pine is well accepted in furniture carcassing and built-in fitments. The P.M.G.'s Department is now permitting it in preservatized form for telephone poles. There seems to be good future possibilities as fence posts. Some posts have been processed by Hickson's at Queanbeyan but no market promotion has yet been carried out. A small amount has been finger jointed mainly for flooring use. Knot plugging is being carried out at the National Mill, Tumut.

No Discussion

Item 5(g)

LOG GRADING STUDIES FOR *PINUS RADIATA* (NEW SOUTH WALES)

About 18 months ago some studies were carried out at Tumut in an endeavour to secure a more effective basis for log grading of pine for royalty purposes.

The presence of large encased knots invisible to external inspection made the assessment of the larger logs very difficult. The main defects used in the assessment were size of individual knots, size of knots in cluster, frequency of cone holes. It was not considered a practical proposition to try and distinguish between green and dry knots. Interim grading rules were suggested and have been in use for about 15 months.

Discussion

Bednall: Does New South Wales specify a minimum for a board log ?

Bootle: We have based the grades purely on dimensions, and have tried to get away from the question of end use.

Benallack: We have attempted to introduce a similar programme, but we have run into the problem of defects and we have not prepared any definite standards at the present.

Hansen: A mill study was carried out using the New South Wales grades to see whether they were applicable to the Australian Capital Territory. We had difficulty in getting any correlation between their grades and the grade of output. It was only a small study and we propose to repeat it.

Item 5(h)

RADIATA PINE SEASONING (NEW SOUTH WALES)

Pending completion of the Putney kiln alterations, nothing has been done this year on the kiln drying of 1 in. radiata pine. However, the drying of light framing material (in 4 in. x 2 in. sizes) graded according to S.A.A. Int. 377 has been investigated in our small laboratory kilns.

For various reasons, this schedule was attempted working on a time basis, and not based on moisture content change points. These include the following:-

(i) Difficulties in the selection of sample boards.- Such boards may include sapwood (moisture content above 150 per cent.) or heartwood (moisture content 60 per cent. - 70 per cent.) or mixtures, and as such may or may not be representative.

(ii) When the charge is dry, the moisture content range is very wide.- (We found ranges from 6 per cent. to 22 per cent.) As such, some conditioning is required. This applies no matter which drying method is used.

(iii) Saving in time in preparation of sample boards.- The dry charge can easily be checked with a moisture meter, which would be probably necessary even when sample boards are used.

It is assumed the material will be dried from the green state.

A tentative schedule is as follows:-

1st day - 200° - 10°
2nd day - 200° - 16°
3rd day - 200° - 30°

A final steaming of over 4 hr is also recommended.

It is considered that this idea of a constant dry bulb temperature throughout also has possibilities.

As this has only been developed on laboratory samples, degrade due to spring or twist has not been evaluated.

Discussion

Wright: The seasoning of radiata pine was discussed at considerable length at the last Conference - the recommendations made are still operable as far as we are concerned.

Item 5(i)

PAINTING AND FINISHING OF PINUS RADIATA

Seasoned radiata pine would seem to have quite satisfactory paint holding capacity, from tests carried out in New South Wales comparing it with cypress pine and blackbutt. No significant improvement in paint retention was observed from the use of aluminium primer or shellac over the knots.

Complaints have been received from numerous sources, especially group housing projects, about poor paint retention but they have been caused by:-

(i) Poor paints and painting techniques brought about by excessive price cutting.

(ii) The use of unseasoned New Zealand pine imported as case junk and subsequently converted into special profile boards. Considerable breakdown, especially on westerly exposures, occurred in the summer months due to resin bleeding. We are carrying out some tests to determine what degree of improvement kiln drying imparts to highly resinous timber in respect to paint hooding capacity and freedom from exudation.

Colour finishes which do not obscure the grain have been given some publicity by the Forestry Commission for internal linings, etc. Colours in oil, diluted with turpentine and oil based paints of desired hue are applied to a few boards at a time and after a few moments the excess material is wiped off. After drying wax or glo s finishes may be applied. Enamel type paint is unsuitable due to its speed of drying.

This type of finish is actively promoted by the Western Pine Association in the United States.

Discussion

Cokley: Did you find any difference between the oil-base paints and the plastic paints ?

Bootle: Three different painting systems were used externally, but no difference was noticed. Internally, it is essential to use paint or finish that dries slowly.

Richardson: As regards the question of clear finishes, D.S.I.R. in New Zealand has developed an ultra-violet filter colour which can prevent the discolouring of radiata by U-V. In Australia is this yellowing considered to be objectionable or not ?

Bootle: We do not consider that radiata should be clear finished, because of the non-durability of external clear finishes. We have done no work on the use of the colour change inhibitor for inside finishes. We have not had very extensive experience of the use of radiata lining in Australia.

ITEM 6. TIMBER MECHANICS - TIMBER ENGINEERING

Item 6(a)

REVIEW OF RESEARCH ACTIVITIES*

(a) Standard Tests

Although standard species testing is now considered secondary to our timber engineering research, a considerable volume of this work is still being carried out. Apart from tests on a number of Eastern States species, tests have been done on wandoo, marri, tuart and Western Australian blackbutt and on immature jarrah and karri. A number of New Guinea timbers have also been examined and a start has been made on the testing of Fijian timbers in a co-operative project with the Fijian Department of Forestry. Altogether some 364 trees representing 82 species have been tested over the past 2 years.

Since Bulletin 279 was published 4 years ago, a large body of information on timbers not listed in the Bulletin has been accumulated. A supplement is now being prepared which will give data on some 130 species including extra information on some of the timbers already given in the Bulletin.

By now you will be familiar with Technological Paper No. 12 - issued earlier this year - which lists the properties of a variety of imported timbers. I shall be interested to hear comments on this publication - whether you have found ti serves a useful purpose and whether the method of presentation of the information is satisfactory so far as the average user in the timber trade is concerned.

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*Prepared by N. H. Kloot.

(b) Plywood

To date, 128 sheets of plywood supplied by the Plywood Board from a number of mills have been tested to determine maximum spans for the use of the plywood in domestic and industrial flooring, roofing and concrete formwork. The plywood was intended to be typical of material that could, if necessary, be supplied for structural purposes. The prime purpose behind the work is firstly to see if the material is of structural value and, secondly, to classify the material if possible into strength grades. Although plywood has considerable potential in the structural field, two things holding back its widespread promotion for this purpose are (i) the lack of suitable quality specifications for structural plywood and (ii) the tendency to mix species of widely differing properties within a sheet. We appreciate the difficulties that force manufacturers to mix species, and it is for this reason that we are trying to see what use can be made of what is actually produced.

At the same time, we have not given up trying to persuade the plywood manufacturers of the desirability and advantages of producing plywood to a structural quality specification and with uniform strength grade within the sheet.

(c) Poles

The pole testing programme, as originally planned, has now been completed. It will be, however, some time before the supplementary tests to examine the effect of various preservative treatments on strength properties are finished. The present position of the reporting of the pole tests is that:-

(i) The report on messmate stringybark has been forwarded for publication;

(ii) draft reports on jarrah and radiata pine are practically finished;

(iii) all the necessary tables for the reports on ironbark and yellow stringybark have been prepared;

(iv) a draft report dealing with the principles involved in deriving working stresses for poles has been prepared but is likely to be modified somewhat before being presented for publication.

Because of the interest of pole users in the results of this work, each species report will include a list of recommended pole design stresses. It is intended, when the series of reports already mentioned has been completed, to prepare a paper setting out design stresses for Australian timbers generally for use as poles.

The question of testing red gum poles has been discussed with the Division of Wood Technology, and I presume that further reference to this will be made under Item 6(b).

(d) Structures

The major work of the Section now lies in those projects relating to structural timber design. Over the past 2 years we have designed, amongst other things, a series of light trusses - called for simplicity the W type, referring to the appearance of the bracing - for spans from 20 to 35 ft, from 10° to 25° pitch, and loadings ranging from the equivalent of a galvanized iron roof without ceiling, to a tiled roof with ceiling. There has been quite a wide demand for these designs, and one Melbourne contractor is using a large number of these trusses in housing estates. Other designs extend the range down to 5° pitch and to 15 ft span.

Proof-testing of trusses built to these designs has been carried out in the laboratory and some 20 trusses are currently being examined under long-time loading conditions on a field site. From these tests we not only hope to get confirmation of the adequacy of the designs but also to obtain more information on the effect of time on structures under load.

Portion of the adjacent buildings has been set aside as a structures testing laboratory and recently we had constructed a 120 ft reaction beam of reinforced concrete in the floor of this laboratory. This beam and the auxiliary equipment being purchased at present will not only make it easier to test structures but will allow us to test structures very much larger than we can cope with at present.

Whilst on this matter of structural design, I wish to mention a point which is rather important, and I think should be brought to your attention, as from time to time the Forest Services may be involved directly or as intermediaries with contacts desiring to use our designs. Whenever we issue a blueprint to a builder or anyone else for that matter, we always take particular care to emphasize that the design is developmental, and although we think it will be satisfactory we cannot guarantee it nor assume any responsibility, and that any deviations from the design are likely to cause trouble. The reasons for this are two-fold. Firstly, the designs are in fact developmental - until long-time loading tests are completed we cannot be absolutely certain of the adequacy of the design. Secondly, and what is even more important, we are particularly anxious not to encroach on the preserves of the consulting engineer not only because of the ethics involved but also because of legal implications.

By issuing designs directly to the building trade, we are brought into close contact with the practical side and this certainly has its advantages. However, we are essentially a research laboratory, and the more of this contact work we do, the less research work gets done.

We would rather not have to provide this design service. But if we don't, who will ? Of all the consulting engineers in Victoria, there are perhaps not more than half a dozen who take even a passing interest in timber. I suspect the position in other States is equally as bad. We have been trying to interest the Timber Development Associations in taking over this design service along the lines adopted by the English T.D.A. I don't know what the exact position at the present moment is but I believe the T.D.A.'s in the various States are considering the idea.

Apart from encouraging builders to use timber structures by supplying them with designs, the second prong of our attack on the whole problem of trying to lift timber engineering in Australia up to a level somewhere comparable with that of other countries is an attempt to educate engineers and architects in this field. In 1959, a series of post-graduate lectures was given to engineers, architects and other interested parties at the Melbourne University. This was followed in 1960 with a similar series at the Queensland University, and my colleague, Mr. Pearson, completed in May a highly successful repetition of this series at the Sydney University. The interest and enthusiasm aroused are not only gratifying to us but suggest that this approach may start to pay dividends in the not too distant future. A third prong to the attack has been suggested to us, namely lectures aimed at educating the timber trade itself. We are giving this idea some serious thought.

In conclusion, I should like to mention briefly two or three further items of interest. Pamphlet 112 is being reviewed. A final revision will not be possible until current discussions in the Standards Association on the loading code are satisfactorily concluded. In the meantime we have commenced extending some tables and also have circularized the municipal engineers in Victoria to obtain their comments on how Pamphlet 112 might be improved. Some 130 replies to our questionnaire have been received and these are being collated.

Forest Services will be interested in a set of tables of round timber stringer sizes for highway bridges prepared at the request of the Forestry and Timber Bureau. The Bureau will publish the tables in a handbook for forestry officers.

In response to requests for tables instead of the charts in the Timber Engineering Design Handbook, we have published safe loads for beams and columns in tabular form, and reprints of these are freely available.

Discussion

Richardson: Three methods of developing shearing resistance in composite timber-concrete have been tested with radiata pine. Three-member "shear units" were loaded in direct shear. Assessment of the results is not complete.

Cantilever tests of poles are at present confined to plantation grown exotic softwoods. To obtain the quickest indication of strength and variability the majority of tests have been on green poles, in most cases commercially produced, with trimming and peeling by hand-tools. The test breaks most frequently are either at knots, or are influenced by them. Stresses are being computed from "effective circumferences", i.e. by eliminating local swelling from the measurements, and it seems advisable to ensure that such poles will, in practice, be measured likewise for classification purposes, especially the pine species. Subsidiary tests on all green poles have yielded growth data, specific gravity, and the modulus of rupture of green small clears 2 x 2 cm in section. Tests of radiata pine include 72 green poles from four North Island stands of differing age and location. Preservative treatments had no serious effects on some poles from one source. The effect of portion of stem used is being studied for Corsican pine by testing two poles per tree from 16 trees on one site. Comparative tests of green and treated, butt soaked specimens of Douglas fir and European larch show that modification of the Rueping treatment schedule has reduced, to acceptable level, the strength degrade previously detected. A few tests of green ponderosa pine have also been made.

Pressure creosoted butt soaked fence posts of larch, fir, radiata and Corsican pines have been tested by the cantilever method, together with a range of concrete posts to provide a basis for assessment. The weakest wooden posts encountered, a 4 in. diameter machine-shaved fir, was as strong as the strongest concrete post tested.

Booth: Most of our activities over the year have been centred on the testing of radiata and the results of this have already been presented. In addition to this work we have carried out the usual standard species testing on timbers which are of interest to us.

We have endeavoured to develop more rational use of timber in structures in our State by providing an advisory service on design to persons interested in this field. We have assisted in the design of two types of timber shell roofs and these are being constructed. We also examined the economics of various structural timber systems in relation to competitive materials.

We have carried out fairly extensive testing of types of plywood offered in Sydney for use as concrete shuttering in construction of multi-storey buildings. With the co-operation of plywood manufacturers and a large building contractor we have been able to correlate the performance of plywood in standard strength tests with its performance on the job. We have collected a considerable amount of useful data on the requirements for concrete shuttering plywood and this data will be summarized and published.

Among the more interesting findings of this survey are, firstly, the relatively high deflections which can be tolerated in shuttering plywood, secondly, the overriding economic importance of the fact that the concrete shuttering on any particular project must be written off on that particular job.

Jennings: We are looking forward to the development of custom manufacture in timber engineering. One firm is almost ready to commence this work. We have been interested in developing nailed portal frames for use with exotic species as a competitor with steel welded pipe frames.

Booth: A number of engineers who will design timber structures have been in contact with us. However, following the death of Mr. Stanley, there is no-one really interested in this work.

Jennings: A very similar position exists in Queensland. However, a number of structures have been designed, particularly since the lectures given at the University; the big problem is getting custom manufacture of structures. We are not happy about designing a job and giving it to the normal builder.

Huddleston: A firm at Regents Park, New South Wales, Timber Structures Incorporated, is manufacturing roof trusses and is backed by proper engineering design. They retain a consulting engineer who prepares designs when requested. Although they provide a service in timber design, they also try very hard to sell the complete article.

Beesley: In New Guinea there is no design service in the Department, nor are there any private bodies competent to do design work. As many buildings are manufactured or pre-fabricated prior to being flown into the Highlands, weight is an important factor and there is an urgent need for light-weight timber design. The Department of Works in Melbourne does a lot of design for Territorial structures, others are designed by the New Guinea Department of Public Works at Port Moresby.

Wickett: We also have one or two consultants who are mildly interested in designing timber work; however, the Timber Development Association has taken it on enthusiastically and they are working on the design of trusses for farm buildings in particular. The aim is to prepare designs which allow for pre-fabrication of trusses and buildings on a line similar to the procedure adopted by the steel people. In the Forest Department we have done a little work on bow string trusses. Trusses ranging from 23 up to 52 ft span of nailed-laminated type have been incorporated in our own buildings and are behaving satisfactorily.

Jacobs: In Canberra, the Department of Works is doing a considerable amount on the basis of Division of Forest Products designs, and our own staff who have close contact with the Division of Forest Products are helping them particularly with roof trusses which are being used more and more in Canberra buildings.

Booth: It is not hard to see why the timber engineering industry has not developed in Sydney as it has on the west coast of the United States, when you look at the relative costs of steel in buildings in the two areas. We costed several different ways of carrying the roof of small factory buildings and found that glued laminated wood, or the connected truss, were not cheaper than standard welded steel trusses. The relative price of steel and wood is partly the explanation. On the west coast of America, steel is relatively dear compared to wood, but in Sydney it is the reverse. We conclude, therefore, that the place for timber engineered structures will be in the domestic field.

Wickett: In Western Australia we can do the same job with a Division of Forest Products "W" design timber truss costing £9 as with a steel truss available locally for £16.

Jennings: The firm I mentioned earlier erected their factory to their own design. They asked bids for construction on the basis of both steel and wood. The design was essentially a 50 ft (span) portal frame. The actual cost in wood was half that of the steel quote, the latter for a welded pipe type frame.

Booth: Steel must be much cheaper in Sydney than in other States.

Huddleston: The aluminium industry is also interested in light roof trusses and they claim to be able to build an aluminium truss at a figure below the cost of a steel one.

Item 6(b)

STRENGTH TESTING OF RED GUM POLES

Booth: Our Commission has agreed to supply poles for Mr. Kloot and Mr. Boyd for strength testing. We hoped that there would be a market for preservative treated red gum poles, but we are now advised that as the result of testing by Hickson's, they are not enthusiastic about the proposition. However, the Commission feels it is worth-while to have the poles tested, because it could aid, ultimately, to market them, both in small quantities which we can dispose of now and also in the future market. Do the Victorian people have any comments on this proposal - are they interested in red gum poles ?

Irvine: As far as I know, we cannot sell red gum poles to the P.M.G. Victoria, but we can to the P.M.G. in New South Wales. I understand that the administration here will not accept red gum poles because of the fact that fatalities or near fatalities have occurred due to sudden failure in the region of the crossarm. The development of a market is of interest, despite the fact that full length creosoted messmate poles are being installed in lines running through box-ironbark forests, from which could be obtained a more than adequate supply.

Item 6(c)

STRUCTURAL USE OF SLASH PINE*

Plantations of Slash Pine (Pinus elliottii var. elliottii) in south eastern Queensland are approaching a size where it will be economical to mill scantling sizes from the butt logs. These butt logs are pruned to a height of 22 ft 6 in. above the ground.

Because of the availability of this material it was decided to mill a sample of these logs into scantling sizes and use the material to construct a laboratory at the Beerwah Forest Station. This building will be used as an experiment to determine the suitability of this timber under South Queensland conditions.

Logs from a 27 year old plantation in the Beerwah State Forest were the source of the building timber.

(a) Log Data

The range of log size from which the material was cut was.- Centre girth under bark 14 in. - 39 in. and length 14 ft - 30 ft.

(b) Sawing Details

All logs were taper sawn to a board and scantling schedule. Where possible the scantling was cut free of pith to eliminate seasoning stresses. All scantling was seasoned to 18 per cent. and boards to 10 per cent. to 15 per cent.

Some degrade occurred during seasoning, the major degrade occurring in material from the knotty core, excluding material that contained pith. Outside the knotty core, the higher grades of sawn timber have seasoned with no degrade.

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*Prepared by N. C. McConochie.

The schedule used for the seasoning of this material was:-

Green-off-saw 150°F. Wet bulb depression 10°F.
Finish 180°F. Wet bulb depression 30°F.

(c) Construction

The laboratory design was for a building of 20 ft clear span with a length of 40 ft. The building is made up of portal frames placed at 5ft centres. The factor limiting the spacing of these frames was the use of 4 in. x 2 in. purlins, the maximum size readily available. The frames were made of 4 in. x $1\frac{1}{2}$ in. and 3 in. x $1\frac{1}{2}$ in. members with $\frac{1}{2}$ in. webbing. The construction was of the nailed type with the frame being made in two sections for easy transport, the two sections being fitted together with a self locking apex joint. The portal frames are fixed to the reinforced concrete foundation with angle plates. Intermediate studs between portal frames in the external wall were 3 in. x 2 in., fixed to 3 in. x 2 in. top and bottom plates with Teco Double Grips, no checking being required. The roof purlins were 4 in.x 2 in. and were fixed to the portal frames with Teco Triple Grips. All external wall sheeting is 4 in. x 1 in. dressed chamfer boards. The internal lining is hardboard and 4 in. x $\frac{5}{8}$ in. [illegible] jointed. All window frames were cut from 4 in. x 2 in. and 3 in. x 2 in. material. Two laminated window sills were also included in the construction. The material used was 6 x 13/16 pine glued with RF900 resin and No.900 hardener. After gluing, the pieces were placed in the kiln and heated to 100°F with a 10° depression for 3 hr. The remainder of the sills are the only hardwood used in the construction. Internal battens for the hardboard were 2 in. x 1 in. All material was seasoned and dressed, giving a uniform and stable product and a saving in construction time.

Discussion

Booth: The fact that you could only get 4 x 2 purlins must have had a profound effect on the economics of the building. Could you get deeper sections by lamination or use hardboard nailed purlins ? The economics of the building would then be much better.

Jennings: We were interested in using slash pine. The portal frames could stand a wider spacing if a larger purlin size had been available from the materials we had. The building was about 800 sq.ft. and cost complete, including painting, but without installation of internal equipment, £1,200.

ITEM 7. TIMBER SEASONING

Item 7(a)

REVIEW OF RESEARCH ACTIVITIES*

Our present seasoning research programme comprises some 8 or 9 projects of more-or-less major importance, and a number of more minor studies. Some of them are the subjects of separate items, and so will get no more than passing mention from me in this review. All of them, however, fit into our programme for one or more of the following reasons:-

(i) They are likely to lead to faster, or more economic drying,
(ii) they will improve the drying behaviour and usefulness of difficult, or marginal species at present avoided,
(iii) they will reduce drying losses, or improve dried quality,
(iv) they will simplify drying methods or lead to the development of better drying equipment, or
(v) they will add to our technical knowledge of the drying process, or of phenomena which arise from drying - such as drying stresses, warp, collapse or splitting.

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*Presented by G. W. Wright.

(a) Drying Studies

Considering our present drying studies of a more general nature, I should mention under this heading our work on -

(i) karri crossarms,

(ii) timber sawn from young eucalypt regrowth and thinnings, and

(iii) pole, post and sleeper timbers.

(i) Karri Crossarms.- The work on karri, in crossarm sizes, is being done in association with our Preservation Section, to improve the acceptability of this species as a crossarm timber, find out what kiln drying conditions, or pretreatments, give optimum dried quality (i.e. least splitting and diamonding), and shortest drying time, consistent with maximum retention and penetration of a preservative when treated by our Preservation colleagues under high pressure conditions. So far, we have examined a wide range of drying conditions, and developed a schedule which meets requirements in the comparatively short drying time of about 28 days. Although diamonding has been a problem a particular virtue of the schedule is that it helps retain fairly good squareness of cross-section.

As a side issue of this study, we have designed a crossarm predryer, with several novel features, for Western Australia, to give an annual output of about 160,000 arms p.a. This will reduce the lag between green procurement, and supply to users, by many months, and should reduce stock holding and capital invested in stock very considerably.

(ii) Timber from Juvenile Eucalypts.- Work to improve the acceptability and behaviour of timbers sawn from small-diameter, juvenile eucalypts has been kept moving. One purpose of this work is, of course, to enable a widening of supply from native timber sources by improving the marketability of this class of material. So far, most attention have been given to young messmate stringybark, mountain ash and silvertop ash supplied by the Victorian Forest Commission.

We have confirmed that, if pith is excluded, this material can be satisfactorily dried, but that it has a greater tendency to spring, bow and twist than mature material, and requires a higher standard of stacking practice.

Perhaps further work of this nature should also be done on young karri, Sydney bluegum, and such other species as the Forest Services consider important in this respect. We would appreciate comment on this.

(iii) Round and Large Sawn Timbers.- Work on the drying of round and large sawn timbers, including sleepers, has not moved as fast as we had been hoping, mainly because of problems in getting our equipment for this working as we wanted to. However, most of the problems are now solved, and we should make a great deal of progress with this study over the next 12 months.

As you may remember, our objectives in this work are to ascertain the technical suitability and relative costs, of a number of possible methods such as boultonizing (boiling-in-oil under vacuum), steaming and vacuum, vapour drying and kiln drying - for partially drying these large section timbers before preservative treatment. So far, greatest progress has been made with boultonizing, and we are now fairly satisfied we can dry "ash" eucalypt pole material by this method in from 12 to 24 hr. Steaming and vacuum drying was not so satisfactory for this material, but indications are that it could be appropriate for softwood poles. Kiln drying, or predrying, is also a possibility for round pine products, as we found no difficulty in kiln drying radiata pine, 6 in. to 8 in. at mid-diameter, without end splitting and very little barrel checking to well below 25 per cent. moisture content in about 11 days.

Under this particular project, however, one of our most urgent tasks is to find out what can be done to improve the serviceability, and hence, the acceptability of a number of fissile species available in large quantity, and of a suitable size and shape, but at present rejected for pole purposes because of their predilection to split during drying. The pole using authorities are anxious to use them and the Forest Services to supply, but they are at present unexploitable because of the heavy end and surface splitting that develops during drying.

High on the list of species of this type are young karri, young mountain ash and young manna gum.

Both the Western Australian Forests Department and the Victorian Forests Commission have emphasized the comparative urgency of studies on this problem, and we have now almost completed a Working Plan for work in this field.

We would be glad to hear if any other species are in this category.

(b) Predrying and Presteaming

Predrying has now become an important feature of seasoning operations in the southern States; e.g. charge capacity in Tasmania alone is now something over 1 million su.ft., and additional units are under construction. Predrier charge capacity would, therefore, be somewhat greater than kiln capacity in Tasmania.

Work on predrying, particularly for the difficult, Tasmanian species, is accordingly being given a good deal of attention by us, especially with respect to schedules, sampling techniques, and conditioning treatments to reduce moisture gradients (wet spots), and improve recovery from collapse.

This work is being carried out in close collaboration with Tasmanian interests, and since my last review, two Predrying Conferences have been held in Tasmania, with industry, to discuss the results of the work and its application. We have been particularly pleased with a by-product of these Conferences, in that 8 Tasmanian Companies have since put in hand research programmes which we were asked to plan, and which we are supervising - a further Conference is proposed in 2 or 3 months' time.

I should add that it has been as a direct result of predrying studies that we have been able to make what I think I can call a major research contribution, or 'break-through' to solving some of the problems of drying the southern eucalypts and, possibly, other impervious, slow drying timbers. I refer to the presteaming process as it is known in industry. I will not outline our work, or the industry follow-up in this review, as it is the subject of a separate item, but should mention that, as indicated, the process may well have application to other Australian species, and we plan to investigate this: species which may respond to presteaming could be myrtle beech, Sydney bluegum, karri and jarrah.

(c) Collapse and its Removal

Our recent work on collapse and its removal is also the subject of a separate paper so I will not discuss it at this stage.

However, I would like to say that it remains an important project with us, as we believe problems associated with collapse and its removal are likely to increase rather than diminish in the future, because it is unlikely that the hardwood forest growth can sustain selective utilization of only the better quality material - or rather, more readily seasoned material - on the scale that has been possible in the past. We must be careful to recognize the fact that, because a species collapses, this does not necessarily make it an inferior wood, although, of course, its utilization can be seriously affected if we cannot remove the collapse.

(d) Moisture Movement in Wood

Work has also been started to try and clarify the mechanisms of the movement of moisture in hardwoods, and the effects of the factors concerned.

As most of you know, our lack of knowledge in this field has been a stumbling block to the development of all processes concerned with the movement of moisture in hardwoods - this applies particularly, of course, to the drying and preservation processes - so that we are very pleased to be in a position to be moving on this.

As you will remember from Dr. Wardrop's review, other work in this general area is also in hand in this Division, especially work on the influence of morphological factors, and I feel we are very fortunate that this complementary work is going on in this important field.

I shall not discuss this work further as it is also the subject of a short separate item.

Our remaining major fields of research are (i) our Equilibrium Moisture Content project, and (b) a very much stepped-up programme on Air Seasoning.

(e) Equilibrium Moisture Content

You will recall that one of its main purposes is to establish a correlation between wood moisture content and the associated determining meteorological conditions, the object being to establish moisture content prediction methods, so that e.m.c. values for any required site throughout Australia, or New Guinea, can be rapidly obtained, simply from a knowledge of the site's meteorological history. The suggestion for this study arose, of course, from a previous Forest Products Research Conference. Practically all Forest Services, and a number of other government authorities, have since been participating, and we would like to pay tribute to the way in which the twice weekly observations in all States have been regularly made and sent on to us.

You will also recall that the need for this work stemmed from a recognition that existing Australian information on this subject was now not enough for either the technical needs of industry, or for specification purposes, or such legislative needs as consumer-protection Acts. In addition, of course, the work also has a special research interest as a study of wood-water relationships.

Most of the field work on this study has now been completed, or is nearing completion - observations at the Brisbane station finish this month - and an analysis of data on $\frac{1}{4}$ in. thick material is now well in hand. We have not, as yet, commenced analyses on the $\frac{3}{4}$ in. and $1\frac{3}{4}$ in. material.

This study is also the subject of a separate item, so this review will give no details of progress, except to say that radiata pine and klinki pine have consistently shown the highest mean yearly e.m.c. readings and the largest seasonal variation (about 3-4 per cent.) although jarrah and Queensland maple are not far behind. Spotted gum has shown the lowest mean annual e.m.c. value, and tallowwood the least response to weather changes (about 2 per cent.).

(f) Air Seasoning

Our increased activity in this field was originally stumulated by observations on industry operations in Victoria and Tasmania over the last few years. Since then industry surveys in Western Australia in collaboration with the Western Australian Forests Department, and in New South Wales in association with the Division of Wood Technology, have strengthened our convictions on the need for this work.

There is no question in our mind but that industry's present far-less-than-effecient operations in air seasoning, and the repercussions this has in later kiln drying, and on the general productivity and economics in this area of operation can be very greatly improved if we, as technical specialists, first find out what is necessary to enable industry to establish optimum yard conditions, and then can submit data to confirm our opinions. I am convinced this is a field in which industry is waiting for a lead.

I think this will be a very rewarding project. However, I shall not attempt to elaborate on results in this review, as we shall also be discussing this work as a separate item.

(g) Miscellaneous

In rounding off this review, I should mention we also have on hand work to (i) improve the dimensional stability of wood when subject to moisture changes our approach is mainly with bulking agents. If the technical and economic problems concerned can be solved the position of wood as an engineering and constructional material would, of course, be immensely strengthened.

In the case of alpine ash, for example, we were able to reduce shrinkage and swelling to about 1/3 by a comparatively simple soak treatments with polyethylene glycol 1,000, and to under ½ with sugar and urea solutions. We are also looking into the effectiveness of silicones and glycerine.

As a future field study for the coming summer we are also hoping to determine the extent to which (ii) the drying out of logs in mill dumps or other assembly areas can be prevented during summer months. Present losses suffered from barrel and end splitting in some species have been reported to be as high as 10 per cent. We shall be looking into the alternatives of (i) a water spray system, (ii) complete sheathing of dumps in a plastic sheet, such as polythene, and (iii) spraying with a water resistant coating.

Item 7(a) (Cont.)

NEW ZEALAND SEASONING RESEARCH*

(a) Redistribution of Preservatives

Boron compounds have been found to be redistributed during both kiln drying and air drying of sapwood of radiata pine and rimu with greatest effect in rapid kiln drying. In timber treated by diffusion, the core retention may be reduced below the minimum specification, particularly in 2 in. timber which normally has a lower core loading than 1 in. timber at the end of diffusion. These results have been confirmed in samples taken from commercial charges, but further testing is planned to gauge its seriousness in commercial practice. It is presumed that any non-fixed chemical in sapwood tends to move towards the surfaces during drying; fixed preservatives such as copper-chrome-arsenate are not redistributed.

(b) The Drying of Radiata Pine

With the provision of a 2 ft laboratory kiln, a start has been made to determine the drying characteristics of radiata pine. The purpose of the work is to compare the wide range of schedules currently used in commercial practice, to study the effect of variation in physical properties (material from high density and low density sites) on drying, to determine the effect of variation in stack weighting or distortion in 1 in. and 2 in. timber and to compare steaming (at 212°F) and high humidity treatment in the kiln as means of reducing distortion. These tests will be extended to commercial runs.

(c) The Drying of New Zealand-Grown Eucalypts

One in. boards of 55 year old *Eucalyptus regnans*, *E. obliqua* and *E. fastigata*, and 30 year old *E. gigantea* have been dried using a combination of preliminary air drying followed by kiln drying. Results

*Presented by Dr. D. Richardson.

have been encouraging - only slight checking in flat-sawn boards, slight collapse (worst in the core) and warping which was much less than the limits for dressing grade.

Other species dried recently or in course of drying are E. saligna, E. botryoides, E. pilularis and E. resinifera.

The average density of New Zealand grown material of the ash species was towards the bottom of the range quoted for mature Australian material; net shrinkage was about the same.

The most critical factor affecting utilization of plantation eucalypts is growth stresses, therefore, further research will concentrate on the effects of silviculture as affecting the development and internal readjustment of growth stresses. From the small amount of work carried out to date, it appears that maximum size for age appears desirable in the growing of sawlogs.

(d) Drying of Beech Spp

Red, hard and silver beech from further sources has been dried. Apart from silver beech which even at high density (up to 50 lb/cu.ft. from Taranaki), dries rapidly in theair, the other species dry very slowly. Prolonged air drying down to 20-25 per cent. m.c. before kiln drying is the only means of ensuring an even final m.c., economically. There may be scope for the application of pre-steaming techniques developed recently by C.S.I.R.O.

Discussion

Jennings: We are very interested in the efficiency of air drying, and have concentrated our efforts on getting people to follow the general principles laid down years ago in the Division's Trade Circular. Where we have been successful it has made a substantial reduction in costs.

I have no doubt that the Division's work on the technique of air drying will pay remarkable dividends. We are interested in determining air drying rate curves, moisture content variations and shrinkages for North Queensland species, about which we know very little, beyond those for maple, silky oak, etc. There are several hundred species involved and this work will have to be continued for a considerable period. It has been surprising how quickly 25 per cent. moisture content is reached. Sometimes in less than a week even in the wet season. We are also interested in reducing air drying times and a paper on this will come later.

Wright: Are the Forest Services interested in further seasoning work being done on the timber of juvenile trees of the major species ? We would like to know whether they would like us to look at this, or do the work themselves. Furthermore, do they feel anything should be done on species other than those mentioned in my Review which should make good pole timbers, but split in drying ?

Bryant: Even in species which do not check or split, some spring does take place and blackbutt concerns us because of its behaviour after treatment. For critical work, such as high tension wiring, our Electricity Commission should not take blackbutt poles because of splitting in service and exposure of non-durable heartwood. It seems that this is an important contribution because if you can solve it for a typical splitting species, perhaps the same measures could be applied to other difficult species.

Wickett: Work is being done in Western Australia on young karri and we will be happy to send karri to Mr. Wright when he is ready to receive it. We have conducted tests on the salt water soaking and seasoning of karri without any satisfactory results. The approach at present is to pressure treat the poles in the green condition. What effect this may have on subsequent seasoning and checking we do not yet know, but we have for example treated one log almost green from the stump, retention being $7\frac{1}{2}$ lb/cu.ft., as against 12 lb required. After 5 weeks drying from the stump, moisture content in the sapwood was 40 per cent. and absorption was 11.4 lb.

Turnbull: In North Queensland, logs deteriorate during storage, the losses of some species being very serious indeed and they are classed as perishable. This is a problem needing attention. It may even transcend in importance some of the other things that are actually on the programme of various organizations.

Beesley: The Territory of Papua and New Guinea has no kiln drying facilities at all, and air drying is very primitive. The wastage of timber in storage in some instances is in excess of 50 per cent. due to faulty stacking practices. This seems to call for some extension work.

Item 7(b)

PROGRESS IN RESEARCH ON COLLAPSE AND RECOVERY*

Collapse remains a major factor in the technique and economics of timber seasoning in Australia. Research since the early 1920's by this Division and other organizations has yielded satisfactory and efficient procedures for the processing of collapsing material, but many problems are still unsolved. Prominent among these are the possible control of collapse by stabilizing agents, and the influence of chemical transformations and the acidity of wood on collapse, both of which may have application to industrial seasoning practice. Research

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*Prepared by W. G. Kauman.

on the detailed mechanisms of liquid tension collapse and reconditioning recovery helps to improve understanding of these phenomena. Work in all the above fields is being actively pursued in this Division and some encouraging progress has been made during the last 2 years.

Several extensive experiments on the value of a number of inorganic salts, sugars, polyethylene glycol and glycerine for collapse control have been concluded. Worth-while reductions in total shrinkage can be obtained, but the economics of any process involving bulking agents are not promising.

The effect of thermal degradation on collapse and shrinkage of three species has been examined. Thermal degradation of green wood increases collapse during subsequent drying and reduces reconditioning recovery. These changes were shown to be correlated with increase in the acidity of the wood during the heating treatment.

The kinetics of liquid tension collapse have been studied, and plots of collapse development against moisture content obtained in this work may prove of value for drying control. Replacement of sap by various liquids has confirmed the dependence of liquid tension collapse on surface tension. However, other properties of the liquid used also seem important, and further work is in hand to examine this problem.

Other projects are dealing with collapse in radiata pine, collapse in specimens dried and resoaked several times, and collapse after short steaming treatments.

Research results which are now well accepted in industrial practice include the "holding period" which enables successful reconditioning of "difficult" material, a testing technique to recognize this material, and water injection into reconditioner steam lines to improve performance.

Discussion

Cokley: Do you feel that treatment with borax solutions at temperatures ranging from 160-200, and for as long as 4 hr, is likely to accentuate collapse ?

Kauman: I do not think the effect of this is significant, but collapse might be increased because of the high moisture content after the treatment. I have noticed in North Queensland that if the timber is pulled out of the treating tank and then immediately placed in the midday sun, very severe checking can occur.

Cokley: They are usually advised to give a minimum temperature drop and to protect from surface effects and rapid drying. On one occasion we had a 30 per cent. degrade on $2\frac{1}{2}$ in. carabeen due to that very hazard. The recommendation is to leave it in the chamber to cool off.

Wright: This surface checking may be accentuated by this semi-dry material absorbing moisture on the surface during treatment and swelling. On redrying it is then even more subject to shrinkage, and hence checking.

Cokley: We have sometimes experienced difficulties in reconditioning, when mills have been in the habit of using steam at 50 or 60 lb pressure for reconditioning. On the other hand, other mills use 7 to 10 lb pressure. Has any work been done on limiting temperatures or pressures of the steam coming in.

Kauman: Some work has been done on reconditioning using live steam at high temperatures expanded down to atmospheric pressure. If you have dry steam, you could very well super heat it when expanding and then run into difficulties.

Wright: Our recovery is always better from exhaust or low pressure steam.

Item 7(c)

PROGRESS WITH RESEARCH TO ESTABLISH A RELATIONSHIP BETWEEN EQUILIBRIUM MOISTURE CONTENT AND METEOROLOGICAL CONDITIONS*

An equilibrium moisture content study was commenced in 1958 at the request of this Conference to determine whether a relationship could be established between wood e.m.c. and meteorological factors. It was recognized that, if a specific relation could be expressed, it would enable a ready prediction of equilibrium moisture content for large areas of Australia for which information is not available. The study provided for the exposure of eight species in three thicknesses at eleven sites in Australia and New Guinea.

Moisture contents and specimen widths have been measured twice weekly at each site, and daily values for mean dry bulb temperature, mean wet bulb temperature, rainfall and wind travel obtained for each site: vapour pressure, relative humidity and wet bulb depression values for each observation have been calculated. In the early stages all data were punched on to Hollerith cards, but this system was subsequently abandoned because the number of significant variables became too great for the equipment available in Melbourne. All data have since been taped for analysis on the C.S.I.R. A.C. Electronic Calculator at the Melbourne University.

Tests for significance made on the first 12 months' weather data have shown relative humidity and temperature to be dominant factors. Subsequently, an examination of various conditions of relative humidity and temperature showed that relative humidity (by itself), and the product of relative humidity and temperature, gave the best prediction of moisture content.

*Prepared by R. Finighan.

Meteorological data for various groups of days have now been examined, including 3 days, 7 days and double groups of 7 days prior to the moisture content measurement. Significance has been found in the relative humidity effect up to about 7 days, so this has been selected as the group to be used in the development of regression equation. The product of relative humidity and temperature showed significance for a greater period than 7 days, but 14 variables was the limit of the calculating equipment available.

To date, an analysis has been largely completed on the $\frac{1}{4}$ in. thick material for four species. The regression equations developed give a moisture content prediction of an individual specimen to an accuracy of $\pm$ 1 per cent., and a prediction of the monthly average to an accuracy of $\pm$ 0.3 per cent. for all sites. While this accuracy is adequate for practical purposes, there are some peculiarities about the form of the equation, in that the significance of the product of relative humidity and temperature does not fall off appreciably with time as would reasonably be expected. The reason for this effect is not clear as yet, but it is probably due to the complex relationship between relative humidity and temperature.

A regression equation based on monthly means of relative humidity, and also the product of relative humidity and temperatures gives a prediction for monthly mean moisture contents to an accuracy of $\pm$ 0.7 per cent. for all sites.

Concurrently, with the outdoor study, an indoor study is being carried out in three capital cities. In this case the eight species used are exposed in one thickness only. Unheated rooms in domestic dwellings are used as exposure sites, and moisture contents and determinations are measured fortnightly. Data from this study are incomplete and no analysis has yet been made on this material. It will be used to obtain a relationship between outdoor and indoor e.m.c. values.

Discussion

Booth: Have you any idea as to how you will be able to use this data in relation to species not included in the survey ?

Finighan: I think we will be able to do this on the basis of the characteristics of the timber, particularly basic density, as we think this property can be related to moisture variation.

Bryant: We have observed that the moisture content of jarrah showed some variation. In the outdoor experiment, the $\frac{1}{4}$ in. and $\frac{3}{4}$ in. thicknesses had very similar moisture contents to the other dense hardwoods, tallowwood, spotted gum or brush box. The moisture contents of the $1\frac{1}{2}$ in. thicknesses were consistently about 2 per cent. higher than the other hardwoods.

In the indoor experiment, those in group No.7 were consistently 2 per cent. high, in No.8, about $1\frac{1}{2}$ per cent. higher, and No.9 about 1 per cent. higher than the other hardwoods. These were all $\frac{3}{4}$ in. thick. In our experiment in air-conditioned buildings, the moisture contents of $\frac{3}{4}$ in. jarrah were similar to the other hardwoods.

The suggestion is that this is due to variable deposits of kino, which may be more hygroscopic than the normal constituents of timber. Apart from the physical characteristics of wood (density, permeability, etc.) these must be a factor in its varying e.m.c.'s.

Finighan: We did find the $\frac{3}{4}$ in. jarrah considerably higher in e.m.c. values, but corrections may have to be applied when oven dry weights are checked.

Huddleston: We will have to be very careful in working from the relationship between basic density and moisture content for moisture content variation. There are some notable variations, for instance white beech and bollywood. Timbers are very inconsistent in the rate at which they lose and absorb moisture, and unless we take account of these individual species we may be in difficulty in working from the general relationship.

Richardson: Is not this a good reason for analysing the reasons for basic density variations ?

Wright: We expect to take into account the diffusivity of the timber as well. It obviously comes back to the number of sorption sites available and the accessibility of these sites; this may be affected by the presence of gums, resins and various occlusions.

Item 7(d)

THE VALUE OF PRESTEAMING FOR DRYING SOME COLLAPSE SUSCEPTIBLE EUCALYPTS*

The steaming of green timber has been practised occasionally in many countries for a variety of purposes but, as far as can be ascertained, suggestions of accelerated drying rates following the treatment have never in the past been confirmed.

To investigate the effect of presteaming on "difficult" material of several collapse-susceptible ash-type eucalypts, 1 in. and 2 in. thick green or near-green boards were subjected to steaming treatments ranging from 2 hr to 48 hr at a temperature of 212°F.

It was found that reductions in drying time of 20 to 35 per cent. of that required for unsteamed material could be obtained by presteaming green material from 2 to 4 hr. Longer treatments failed to effect any further improvement in drying rate but tended to accentuate collapse. The effect of presteaming on total shrinkage, checking, colour and strength properties has been studied. A short presteaming treatment appears to favour reduction rather than increase in drying degrade and has no deleterious effects on strength.

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*Prepared by G. S. Campbell.

In Australia, reconditioners are already available at most timber seasoning plants for the purposes of recovering loss of dimension and shape due to collapse which develops during either air or kiln drying. Presteaming treatments can be carried out in the same chambers, the additional expense of the treatment being more than offset by factors such as greatly reduced drying time, hence reduced drying costs, by the reduction of steep moisture gradients, and by improved recovery of collapse on final reconditioning.

Preliminary trials with the predressing of green timber followed by a short presteaming treatment indicate that further reduction of drying time may be possible beyond that obtained by presteaming only.

Discussion

Bryant: Why is this presteaming treatment so effective in certain species ?

Campbell: It may be that the heat treatment in the early stages produces enough modification of the cell structure to improve the diffusion characteristics.

Wright: Dr. Kauman has carried out some scout tests on diffusion rates in presteamed material. He has shown that the diffusion coefficient is increased by presteaming, but the work is still in its preliminary stages.

Bryant: Has the presteaming treatment been tried on timber which has been dried down to about 30 per cent. moisture content ?

Campbell: Yes - we have tried it at lower moisture contents, and while the effect is still there to some extent, we cannot see any point in delaying it to that stage because we lose the main advantage. Recent laboratory tests have shown that the drying rate of black bean is increased as a result of presteaming.

Wright: We are hopeful that many of the denser, impervious timbers will respond to this treatment.

Booth: What temperature does the core reach in the steaming treatment, and as regards predressing, is it just a case of removing some of the section, which otherwise has to be dried ?

Campbell: The temperature reached is that of the conditioning chamber or just a few degrees below. We are of the opinion that predressing will help overcome the boundary layer condition, therefore, with the increased permeability from presteaming, we are able to take advantage of improved boundary layer conditions. We are investigating this matter at the present stage.

Wright: The boundary layer effect could be significant with rough sawn material, where the rough surface holds a humid layer right at the surface of the wood.

Harding: Has any work been done on radiata pine ?

Campbell: A report from South Australia indicated that the drying time could be reduced by 8 hr by using this presteaming treatment; I have not found that to be the case from my experience using 1 in. boards.

Huddleston: I do not think the statement that they will have to take less off in the final dressing is a true statement. You still have to allow sufficient margin to allow for the variation in shrinkage of the individual boards, and that is catered for at the present time by allowing a very light dressing on the back of the board. If you are going to dress down before seasoning, you still have to allow a little more tolerance to make certain that you have sufficient timber to dress off to give the required profile. The advantages become ones of straight out economics; predressing will save the cost of operation from a kiln viewpoint, but it involves extra machining costs. Green dressing will probably be just as expensive as the dressing after drying. Consequently, for the predressing to be economic the saving in kiln drying must be at least equal to the cost of predressing the timber. Also, if you have a timber which is inclined to check during air seasoning, predressing will reduce the quantity of material available to permit the checks to be dressed out.

Wright: These points will have to be examined in considerable detail. From Victorian experience, we know that the machining of dry material can be speeded up very considerably after a prethicknessing - this is because material of irregular thickness no longer hits the planer at speed. Hence, final machining economics could, perhaps, be greatly improved by predressing, and compensate for its cost. Checking will certainly have to be watched very carefully.

Item 7(e)

RESEARCH ON AIR SEASONING*

Despite the long history of air drying, most of the accumulated data on it are empirical and are now inadequate for the requirements of technologists concerned with present needs to accelerate drying rates and improve air drying efficiency. The Division has, therefore, stepped up its programme of research in this field. The programme provides for studies on the basic unit - the drying stack, and on aggregates of units - the drying yard.

*Prepared by G. W. Wright and R. M. Liversidge.

(a) The Drying Stack

At this stage studies on the drying stack are concerned with:-

(i) The influence of stack construction on air movement - the principal drying medium within a stack,

(ii) the effectiveness and economy of stack roofing on -

1. drying speed and uniformity
2. drying losses, and

(iii) the influence of seasonal conditions on drying rate and material availability.

So far, for the southern Australian area, studies on factors (ii) and (iii) with 1 in. thick "ash" eucalypt timbers have demonstrated that:-

For Stacks Erected in Summer (December).- The presence or absence of stack roofing does not significantly effect drying rate while the weather remains comparatively dry. For example, the moisture content of matched covered and uncovered packs dropped from 87 per cent. to 13 per cent. in 3 months in the Melbourne area over this period, irrespective of the extent of stack protection.

However, for material held into the following winter, stack covering is of great value as re-wetting commences with the onset of autumn rains. For example, by late autumn the mean moisture content of uncovered packs had reverted from 13 per cent. to 27 per cent. (to a condition it had been 5 months previously) and remained so throughout the following winter. On the other hand, the moisture content of matched covered packs did not rise above 17 per cent.

<u>For Stacks Erected in Autumn (early April)</u>.- From the outset, covered packs dried much faster and more uniformly than uncovered packs. After 6 months' air drying - by early spring - the average moisture content of uncovered packs had dropped from 76 per cent. to 35 per cent. only, but that of the matched covered packs to 21 per cent.

Even more important, the moisture content at the centre of the uncovered packs had dropped to 49 per cent. only, whereas that at the centre of the covered packs was down to 22 per cent.

<u>For Stacks Erected in Winter (late July)</u>.- Again, study evidence showed the covered packs drying at a much faster rate than the uncovered. After 2 months' drying (by September) the uncovered material had dropped from a moisture content of 92 per cent. to 60 per cent. but the covered material to 35 per cent. Over this stage, the covered material dried almost 50 per cent. faster than the uncovered material.

After $3\frac{1}{2}$ months, the uncovered packs had dropped to 30 per cent., the variation ranging from 14 to 81 per cent. On the other hand, the covered packs had dropped to 20 per cent., their moisture content variation ranging from 14 to 29 per cent.

<u>For Stacks Erected in Spring (late October)</u>.- Data from this material showed little benefit from covering. For example, after 2 months' air drying the average moisture content of both the covered and uncovered packs had dropped from approximately 90 per cent. to 34 per cent., and after $3\frac{1}{2}$ months both averaged 16 per cent. In this respect, results confirmed the data for the studies carried out on stacks erected in summer.

General conclusions from this work are that stack covering is of considerable economic and technical value during wet periods, and that even though it may not contribute to improving drying rate during dry weather its use at this stage could, in many cases, prevent the re-wetting of large stocks of low moisture content material inevitably carried over into wetter periods.

(b) Yard Design

Studies demonstrating the extent to which site conditions and yard design influence the performance of air drying yards were reported at the Ninth Forest Products Research Conference in 1958. However, these studies also demonstrated the extent to which external factors, beyond the control of the investigator, can influence results in field studies of this type. Investigations showed many advantages from a model study approach, and research into factors influencing yard efficiency has, therefore, commenced using this technique.

To date, work has been directed, in the main, to -

(i) establishing the study procedure, and

(ii) construction of a calibration wind tunnel, and stack models on a 1:10 scale, for tests on similitude with full scale stacks. Pressure, velocity and evaporation instrumentation techniques are at present being investigated.

Some preliminary *ad hoc* tests on stack arrangements have been carried out in a water channel and a wind tunnel.

Discussion

Jennings: I have no doubt that covering stacks in Queensland would give very great economic advantages.

Bryant: So far, we only have information on stacks of brush box drying at Coff's Harbour. More areas will be included shortly. Two stacks were stripped out on 8th February, 1961, with ten matched sample boards in each, one covered, one uncovered. The stacks lie in an east-west direction. Covers showed little effect on the initial drying rate, during the later summer months. However, with the advent of the rainy season, their use is showing advantages. So far, the covered stack has dried from 59 per cent. to 21 per cent. in 18 weeks, with the uncovered stack reduced from 56 per cent. to 23 per cent. This is considered rapid drying compared to many mills where stacking is not so good, and stacks may be out 9 months or more.

The moisture content variations initially were 31 per cent. for the uncovered stack and 25 per cent. for the covered stack. These are now respectively 11 per cent. and 6 per cent. Incidentally, these initial and final variations were measured on different sample boards. The uncovered stack showed both the highest and lowest moisture contents. As the rainy season has started, weekly readings show increases in both stacks after rain. However, the cover has reduced the increase in this stack to about ½ to 1/3 that of the unprotected one. Very worth-while results are expected at the end of a 12-18 month period.

Wright: The economics given were based on a calculated assessment, substantially confirmed by a firm which built permanent covering over part of its yard area. This cover consisted of 5 in. x 5 in. posts supporting a skillion roof framework covered by galvanized iron - no guttering, and no sides, but with substantial eaves. The results given were obtained with stack roofing using galvanized iron on timber frames.

Stashevski: Experience gather in Queensland veneer air drying racks shows prolonged drying times in sheds accommodating more than two rows of veneers. The drying time can be extended by as much as 1/3 in four row sheds as compared with two row sheds. Open air racks are giving fastest drying but the veneer is degrading for other reasons.

Wright: It may be, of course, that the drying load for veneer is much heavier than with sawn timber, and where there is little wind you could really be in difficulties in highly humid conditions. We hope to design stack roofs so as to encourage air flow through the stacks.

Elliot: Could it be also that the method of stacking referred to by Mr. Stashevski had interfered with the air flow ?

Wright: Yes - with large veneer sheets, and the wind in a particular position, you may not get very much air movement into a shed; for example, if the wind direction was at 90° to veneer sheets.

Jennings: In stacks of sawn timber in North Queensland we have found little difference between drying rate curves for stacks under complete protection and covered stacks without side protection.

Huddleston: In connection with the yard drying studies, is consideration being given to the effects of neighbouring installations? For example, how far must we be away from a factory before the yard can be considered as an entity ?

Wright: We are taking that matter into account.

Liversidge: Initially, the aim is to ensure that we get a good circulation throughout the yard, but the question of internal circulation through the stack will be looked at using the wind tunnel. In obtaining basic information on the flow through stacks, we hope to examine the effect of various sticker thicknesses.

Bryant: Our facilities and staff assistance are available if you are working in Sydney.

Item 7(f)

AN APPROACH TO THE STUDY OF MOISTURE MOVEMENT IN WOOD*

The study of all facets of moisture movement in wood is of obvious importance for the understanding of drying and impregnation processes. Considerable theoretical and practical research has been

*Prepared by W. G. Kauman.

done on movement of fluids in porous materials generally, but work on wood in the past has been largely confined to gymnosperms. Research in this laboratory is, therefore, being concentrated on moisture movement in angiosperms, which still furnish the major part of the timber used in Australia.

From the point of view of timber seasoning, one of the most important aspects of moisture movement is the combination of water vapour diffusion and adsorbed water transport below fibre saturation point. An apparatus has been designed to investigate this process, and a prototype has been constructed and tested.

In this apparatus, a gradient of water vapour pressure is established across a thin disc of wood. This is achieved by exposing the two faces of the disc to streams of air at different controlled humidities. Water vapour diffuses across the disc and is picked up by the air stream on the low humidity side. The rate of diffusion is determined by measuring the increase in the humidity of the air stream as it passes the disc.

Tests with the prototype equipment have shown that the method is practicable. Using Eucalyptus regnans at an average moisture content of 14 per cent., the equivalent diffusion coefficient in the radial direction was found to be of the order of 10^{-6} cm^2 sec^{-1}.

Approximate measurements of water vapour permeability of wood have been made by a simple cup method, and experiments on the diffusion of stabilizing agents through wood are in progress.

Item 7(g)

FORCED AIR DRYING*

The method is likely to have appeal for small sawmill operators who feel that it is economically impossible and impractical for them to install suitable kilns at their mill. In this State,

*Prepared by N. C. McConochie.

however, many mills are in localities where, with properly stripped and set out air seasoning stacks, it is possible to satisfactorily air dry timber to the equilibrium moisture content. To overcome poor drying which is caused by poor air circulation and also to reduce the actual drying time, experiments have been carried out in this State and overseas on the use of fans to force air currents through timber stacks.

To date information has been received of three independent studies being carried out in America.

(i) Tests carried out by Carlton Smith of the Hardwood Dimension Manufacturer's Association of Tennessee led to the establishment of the Fan Air System. In this system drying time of four hardwoods was reduced from 4-8 months to 5-10 days, also the degrade which occurred in air seasoning was considerably reduced.

(ii) At the South Eastern Forest Experiment Station Research Centre at Athens in Georgia, experiments were carried out on Southern yellow pine. The pine was dried from green-off-saw to 15 per cent. moisture content in 4-8 days.

(iii) The Seasoning Section of the Forest Products Research Centre at Corvellis, Oregon carried out tests on three species up to 2 in. thick. The results here proved satisfactory also. Shipping charge savings from \$1.87 to \$5.30 a 1,000 board ft were made.

Following the studying of these reports it was decided to set up our own experiment. The test chamber consisted of a container 4 ft x 4 ft x 6 ft long. One end is open to the atmosphere and the other end has a Woods 24 in. diaphram mounted propeller fan. This fan can be run at five different speeds.

A thermograph hydrograph was installed alongside the unit to record weather conditions. A watt/hr meter was installed on the fan motor to record power consumption.

(a) Method of Charging

A stack approximately 18 in. high was built up on the bottom of the chamber. One in. boards were used with $\frac{3}{4}$ in. strips between for this 18 in. layer. The test stack of 6 layers was then built up on this and the remaining space on top filled as for the bottom.

(b) Moisture Content Check

Two copper nails were driven into a sample board in each stack and leads taken out to a terminal block. One removable standard sample board was also included in the stack. This was used as a check on the moisture meter at the higher moisture content. When a charge was removed the moisture content of each sample board was checked by the oven dry method to test the meter accuracy.

(c) Operation Cost

A watt hr meter was included in the supply line to the fan motor. From the drying time the cost per hr per 100 su.ft. was then calculated. Graphs have been drawn of power consumption and time and cost in pence and time from which it has been possible to deduce the most economical fan speed.

To date tests have been carried out on 1 in. hoop pine.

The following results are available and have been analysed using regression analysis:-

Charge No.	Fan Speed	Air Speed	Initial m.c.	Time to 20% m.c.	Power
1	490 r.p.m.	350 ft/min	84%	216 hr	46.8 kWh
2	575 "	450 "	67"	96 "	25.8 "
3	730 "	550 "	92"	192 "	61.5 "
4	850 "	650 "	94"	120 "	50.7 "
5	942 "	750 "	63"	192 "	71.4 "

Indications are that the two most efficient fan speeds are:-

(i) 575 r.p.m. Air Speed 450 ft/min.

(ii) 850 r.p.m. Air Speed 650 ft/min.

On estimated costs these speeds are the most economical in that order. Further work is planned to test the accuracy of the equations developed.

It was noticed that when the R.H. exceeded 85 per cent. little or no drying occurred. Overseas practice has been to shut down plants of this nature when the R.H. exceeds 90 per cent.

At present a firm near Brisbane is experimenting with this type of drying of slats up to $\frac{5}{8}$ in. thick. The material is spotted gum, blackbutt and rose gum. The spotted gum is used in the manufacture of meat skewers while the blackbutt and rose gum are used for dowelling and small mouldings. The drying unit consists of a small shed open at one end. A 6 ft propeller from a Gypsy Moth Aircraft is fitted to the other end. This is being driven at 480 r.p.m. The shed holds approximately 2,000 su.ft. in each charge. This unit is being used as a predrier for a small electric kiln. Charges have been dried from green-off-saw to approximately 30 per cent. moisture content in 60 hr.

Discussion

Wright: We are very interested to hear that this work is being done and think that it is very necessary. The results indicate that a very considerable reduction in operating cost has been achieved.

Huddleston: In Malaya, research work is being done on air drying with some interesting results. Based on their work, I was partly responsible for making an installation at the depot for drying 12 in. x $2\frac{3}{4}$ in. keruing crossarms for preservative treatment. They were getting them down from green to about 20 per cent. moisture content in something under 3 weeks. This was certainly helped by the even temperature throughout the day - about 80°F.

Campbell: A timber dryer at Vermont indicated that he was going to use one of these fans to improve drying procedures. He has flue gas heated kilns and he wishes to air dry his material down to 25 per cent. before putting it into the kilns and he proposes to use fans located in his building to increase the rate of air drying.

Wright: In the southern States, I think that one needs an enclosed structure and added heat for our impervious southern hardwoods - that is why we have concentrated on the development of heated predriers for this area. When treating less impervious species in areas with higher ambient temperatures, fan circulation without added heat would probably be quite satisfactory. Selection of method would largely be governed by prevailing climatic conditions.

ITEM 8. UTILIZATION

Item 8(a)

REVIEW OF RESEARCH ACTIVITIES*

The Sectional work continues to be mainly advisory together with applied investigations. About 2,000 enquiries are dealt with annually on general utilization subjects, but we are spending less time on enquiries and moving more towards experimental laboratory work.

(a) Properties and Uses

The Division continues to be approached for information on timbers and their suitability for certain uses. Information from other

*Presented by R. F. Turnbull.

Sections of the Division is sought for the most reliable up-to-date data as to strength, shrinkage, durability, seasoning behaviour or other property that may be relevant to the question being answered. Among the numerous uses the following have been recently prominent:- boatbuilding, bowling alley floors, bowling pins, cooling towers, flooring, handles, skis (water and snow), and window walls. Properties relating to 120 to 160 species are the subject of enquiries annually. Descriptions of species are published in the F.P.N.L. Other references, accumulated records and acquired knowledge help us to give rapid service in these fields.

We have heavy commitments in the lecturing field. Every year we give 10 lectures on timber to third year architectural students, Melbourne University, 12 lectures on utilization to forestry students at Melbourne University, 4 to students from Australian Forestry School, and 4 to students of the Victorian School of Forestry. At A.U.S.T.I.S. Conferences we are usually committed for 1 or more papers. During a year we commonly give talks to groups from technical colleges, apprentice schools, Education Department, trade organizations and professional associations.

(b) <u>Sawmilling</u>

Interest in all phases of forest products production has been maintained. Assistance is continuing to industry on sawmill design and sawing techniques. The subject is discussed in general terms with personal callers or correspondents. Layouts are prepared on request, and since last Conference we have supplied these for 17 new sawmills, 10 for improvement of existing sawmills, 3 planing mills, 2 joinery plants, 1 case plant and 4 distributing yards. No standard has been developed for all conditions, but types are emerging that may have fairly wide application. We are attempting to cover a gap in consulting services that nobody else appears able at present to deal with, and we would withdraw whenever consultants indicate their ability to take over the work.

Recommendations made at lectures and Conferences of the timber industry concerning the replacement of breaking-down by headsawing seem to be bearing fruit. Several riderless carriages have been brought into operation on hardwoods, other carriages with high class mechanisms for accurate setting have also been installed, and all are cutting dimensioned flitches. Improved recoveries and better production rates are reported.

Developments in equipment and their performance are kept under observation. Framesaws, log edgers, bar turner, Simonson turner, one-man resaws, band mills, mechanical barkers and improved conveyors have appeared or increased in number in recent years.

Formation of productivity groups in the timber industry has been under discussion, and we have suggested topics that the groups might discuss. If formed, the groups could become channels through which results of research could be disseminated.

Preliminary steps have been taken in preparing courses on sawmill engineering. Outlines for the course have been submitted for the consideration of A.U.S.T.I.S. Council and sawmiller organizations in Queensland, Tasmania, Victoria and Western Australia. Some progress has been made in assembling texts and demonstration material. Starting of the courses in Melbourne is preferred, with extension to other States after early experience is reviewed.

Sawmill studies will be undertaken in North Queensland to establish recoveries and production rates for the range of North Queensland species at the request of the North Queensland Sawmillers Association and the Queensland Forestry Department. These will possibly start in September. A visit of an officer to Western Australia has been promised to survey sawmill practice and possibly suggest improvements.

Broad fields in sawmilling remain to be covered as productivity continues to be low. Pine conversion is increasing in importance, and better guides to milling efficiency are desirable as bases for planning conversion.

Attention is turning to small logs to attain highest yield relatively to dimensions and quality, and to control spring and other distortions. A log edger has been received on loan with which we can test sawing patterns. Instrumentation of our breaking-down equipment has proceeded.

(c) Saws

Laboratory investigations on saws are being reported under Item 8(c) by D. S. Jones who will also refer to studies on circular saws in industry, and under Item 8(b) by W. M. McKenzie who will discuss fundamental studies on cutting.

Since last Conference the Division imported a chain saw of advanced design, and the interest stimulated with it led to the importation by industry of modern chain saws for testing. A Timber Industry Chain Saw Advisory Committee organized the import, and the Division provided its Secretary and played an active part in collaboration with Commonwealth Forestry and Timber Bureau in planning, conducting and reporting on tests, and disposing of the saws after test. No more work is specifically planned. We will endeavour to keep abreast of developments and give advice when requested.

(d) Grading

Collaboration with the Standards Association of Australia actively continued, and Standard specifications are prepared and reviewed for timber and timber products. Recently considerable time has been spent on Standards for radiata pine sawn and milled, sleepers, structural timber, decking, sawn and milled hardwoods generally, parquetry, and on a code for the guarding and safe working of sawmill and woodworking machinery. Progress is reported on a specification for the sanding of wooden floors, and on the revision of a Standard for flush doors to allow introduction of honeycomb core. Interest in boatbuilding timbers is reviving. A first draft of grading rules for Douglas fir has been decided in committee. Work on revision of the nomenclature of timbers has been transferred to the Commonwealth Forestry and Timber Bureau, and on terms and definitions to the Headquarters of the Standards Association.

(e) Waste Utilization

Encouragement to briquette sawdust and shavings has had some influence on a commercial development in South Australia. Sawdust and shavings as fuel is the subject of many enquiries, and following preliminary advice interested parties are referred to firms experienced in the design and construction of appropriate furnaces. Studies on sawdust as a mulch and additive to the soil are not at present active. Charcoal production and briquetting have been matters of lively interest recently.

Finger jointing has become a subject of major interest experimentally and industrially in the last 3 years, and we have devoted a large portion of our experimental resources to this subject. Our work will be reported under Item 8(e) by M. W. Page.

(f) Immature and Small Logs

Small logs of hoop pine and flitches from small logs of radiata pine have been sawn and fabricated in various ways into 4 x 2 and 3 x 2 light framing sections. Cores of pithy 2 x 2 sections from the centres of the flitches from fast grown radiata when combined with 2 x 1 covers from slabs of larger trees have given strengths greatly exceeding that of a full 4 x 2 section containing pith. When the

2 x 2 has been so distorted as to interfere with laminating it may be crosscut at intervals along its length, the pieces brought together end to end and 2 x 1 covers glued on without apparent sacrifice in strength. The final products have attractive appearance.

When laminae from small hoop pine are glued together distortion is noticeably reduced and strengths of assemblies of full length pieces and finger jointed pieces are greater than that of the one piece section.

Item 8(a)(Cont.)

REVIEW OF WOOD USE AND GRADING (N.Z.)*

(a) Standards Work

(i) Building By-Laws (Model Code)

Revision of NZ.SS 95 Pt.IX.- "Light Timber Construction", was completed and distributed for comments. Working committee is now on final draft, but very serious differences of opinion are being expressed, *e.g.* on proposal to require framing to be dried to about 25 per cent. moisture content before it is enclosed.

Preparation of "Timber Design Code".- Comments received on draft are now providing the basis for final form. Working committee has been increased from three to six. Data on glued laminated construction was omitted but it may be possible to incorporate this as the Code of Practice for Fabrication (a prerequisite) is taking shape. Plywood data is also excluded because necessary testing has not been done. It is proposed to provide for inclusion of "Diaphragms" (along lines of Californian Code). Stress values tabulated for timbers are

*Prepared by J. S. Reid.

now only for "unseasoned", interpreted as below 30 per cent. but above 15 per cent. moisture content.

Structural grades are required as a prerequisite to use of Design Code. Early drafts need amendment. Radiata 60 per cent. grade for joists is fairly soundly based on tests but beams, planks and columns need testing.

Glued lamination.- Committee convened by the New Zealand Institution of Engineers is tackling code of practice. First draft sent to co-opted members is now receiving comment.

Revision of National Grading Rules for Building Timbers, NZ.SS 169.- In place of the four native softwood timbers on which the rules were based, we are now concerned with six native softwoods, three beeches, seven other native hardwoods, Pinus radiata and Pinus spp. providing comparable timbers, the early heartwood-forming exotics comprising a separate group. The lastmentioned, including Douglas fir, larch and macrocarpa, is not yet covered by grading rules but the rest are. The format, machinery clauses, definitions, etc. developed 25 years ago are no longer acceptable and committee is drafting a new volume.

Plywoods.- Requirements for top grades (interior) tightened up.

Doors.- Standards altered in regard to number of standard types. Stub tenons now admissible under restrictions.

Pallets.- Attention is being devoted to one or two basic types but the Forest Service is also assisting in specifications for other types for private firms.

(b) Wood Use - General

(ii) Exterior Uses for Preservative-Treated Timber

With the policy for use of locally available materials, wood is given a wonderful opportunity to establish itself itself with all help from us. Items include -

short-span bridges (superstructure)
wharf decks
highway guard rails and posts
oil rig mats
cribwork
sleepers, posts and poles and
stave reservoirs and geothermal vent surrounds.

Buildings.- Certain commercial, educational and hospital buildings have posed problems at the specification stage; it is a lot more satisfactory giving help at this stage than the alternative of being brought in when troubles occur - the familiar items are grading, moisture content or poor choice of timbers or timber sizes.

Ladders.- Ladder failures have drawn attention to -

(i) Difficulty in specifying imported Douglas fir to avoid a surprising variation in density.

(ii) Need for grain detectors as a standard tool in ladder manufacture.

(iii) Avoidance of unreasonable acceptance tests involving deflection under heavy load.

Wood Wool and Wood Flour.- Revival of interest.

Tanks and Vats.- Heart kauri and heart totara are very difficult to replace in some Australian as well as New Zealand industries.

(c) Paints and Coatings (in Co-operation with D.S.I.R.)

Projects include:-

(i) Causes and prevention of yellowing of radiata pine for interior natural finish.

(ii) Paint coatings for radiata pine (exterior).

(iii) Paint test fences for climatic variability.

(iv) Natural finishes (exterior and interior) small scale.

(d) Silvicultural Relations (with Conservancy and Mill Co-operators)

The various facets being studied include:-

(i) Sawn conversion and grade assessment of exotic softwoods not yet in commercial production or special studies on commercial species.

(ii) Node studies without sawn conversion to determine defect development and zonation in immature exotic softwood trees as an aid to silvicultural prescription.

(iii) Studies of industrial needs for various grades within the several species.

The principal objective is to achieve balance in sawn grade production. Another objective is to establish saw log grades and values based on average yield of the several grades.

Failure to appreciate certain variables have seriously reduced the value of two major early studies with radiata pine.

(i) A study designed to show the effect of spacing of trees on the nature and size of defects and consequent sawn grade failed to yield the required data because the basis for grading of the product was formulated to admit a widely variable bracket of timber. An experienced grader could have noted variations within the grades but there is an obvious need for recording data on the critical defects affecting each piece.

(ii) A mill study of 30,000 board ft of boards designed to provide a reservoir of information on which to base improvements to grading rules entailed recording of position, nature and size of all defects. The nature of defects encountered was found to change materially within a few years in that proportion of boards (spread over several grades) sawn from the outside of logs.

Progress has been made with:-

(i) Improved mill study procedure.

(ii) Node studies using saw and axe to delineate existing and potential grade, and to provide effective illustration of defect zonation in longitudinal (full log) section and in cross-sections.

(iii) Appreciation of the limitations of the node study method in merchantable size logs; i.e., the determination of the effect of sweep, butt curvature, resin pockets, sloping grain, etc. implies sawing of sample lots.

Item 8(a) (Cont.)

REVIEW OF RESEARCH ACTIVITIES (NEW SOUTH WALES)*

(a) Exposure Tests on Tempered Hardboard

Experimental painted (Dulux and Bergermaster) weatherboards of hardboard have now been exposed for 5 years on a Sydney roof-top. Paint retention has been very good except for the bottom edges where it

*Presented by Mr. Bootle.

has peeled off in many instances. There has also been some lifting of the fibres of the boards. It is understood that C.S.R. are working on the improvement of the boards, so they may be promoted for weatherboarding in the not too distant future.

(b) Polyurethane Clear Finishes

After 2 years' exposure all test finishes except one were in poor condition. The exception benefitted from some shading and cannot be considered superior. Polyvinyl acetate sealers under the polyurethane proved unsatisfactory as they promoted mould growth and blistering. Brush box held the finishes quite well, but blackbutt and alpine ash performed poorly. The use of so-called "ultra violet absorber" gave no improvement in durability. The only clear finishes worthy of use externally are long oil alkyds, spar varnishes, and polyurethenes, but all require regular maintenance annually for good appearance under normal Sydney exposure conditions.

(c) Finishes for External Wooden Flooring

This is a very exacting requirement for a finish and at present no compound can be recommended as being worth-while. Tests were carried out with a number of products (e.g. creosote, bitumens in solvent, coumarone resin, microcrystalline wax, ester gum, pentaerythritol resin, petroleum resins, styre co-polymer resin, low viscosity mineral oil, long oil alkyds, and pigmented linseed oil. Of these only the latter was present to any extent after several months' exposure.

(d) Sealers for School Floors

In an endeavour to keep its floors in good condition, particularly those in the many new schools now being built, the New South Wales Department of Education has enlisted the assistance of the Forestry Commission in testing a range of floor sealers. Sealers tested include tung oil based material, spindle oil, epoxy esters, styrenated alkyds, styrene co-polymers.

Tung oil based material, with the addition of resin modified wood varnish, showed the best results on timber and is now being used on all the new floors.

This formulation has good wear resistance, is easily applied and recoated (in contrast with the harder urea-formaldehyde and polyurethanes), is of low cost, does not emit offensive fumes, and produces a non-slip surface. Waxing is not necessary and is not recommended.

(e) Floor Sweeping Compounds

In cleaning large areas of flooring, as in schools, it is very desirable to use a material that will assist in gethering all the dirt particles and allay dust while sweeping is being carried out.

At the present time compounds based on sand and sawdust are being used to a limited extent but they have not all been carefully formulated. We have carried out investigations to determine the most suitable formula for use on all types of flooring, simple to manufacture and low in cost.

Tests on sealed and unsealed panels of common hardwood and softwood timbers showed that the surface obtained was of pleasant appearance, was not slippery, oily, or gritty, did not hold scuff marks or black rubber marks and was easy to wax polish if required. Any odours in the mix were masked with a small amount of pine oil. The recommended formula is sand 25 per cent., oil blend 25 per cent., sawdust 38-45 per cent., water 5-12 per cent. The oil blend contained 48.5 per cent. automotive distillate, 47 per cent. red naphthenic mineral oil (2,500 sec viscosity), 3 per cent. dark green petroleum jelly and 1.5 per cent. pine oil.

(f) Natural Finishes

The U.S. Forest Products "Natural Finish", based on linseed oil with the addition of pigment, wax and pentachlorphenol is being marketed to a limited extent in New South Wales and gives a life in excess of that of the clear finishes. One drawback is the difficulty of applying two coatings initially due to the considerable amount of wax present. Tests in which the second coat of finish has been applied shortly after the first, before the wax has migrated to the surface, are being carried out at present. Intervals varying from 3 hr to 3 days have been tried.

Discussion

Wickett: We have done some work on sawmill design, construction and management, and have been assisting T.D.A. with design and construction of buildings. Some clear finish tests and some mill studies have also been carried out to assist the trade. Details of our clear finish tests appear under Item 8(g).

Thomas: We have conducted some studies on the production of clear or prime quality timber from unpruned trees and have some results but they are not ready for criticism or comment yet as there is further work to be done. Indications are that we have either not pruned early enough, or we have not pruned heavily enough.

Crane: We have carried out one mill study on radiata thinnings and have had some work in progress for some 4 years now on the value of pruning against topping. Preliminary indications are that 60 per cent. reduction of crown could cause a serious reduction in growth, but we are not getting any unfavourable effects on 40 per cent. pruning.

Beesley: The New Guinea Forest Department is trying to develop a market for lawyer vines and this occupies one staff member almost continually. Another officer is engaged almost full-time collecting and identifying timber samples. Several sap replacement treatments have been attempted recently and with this treatment it is hoped to utilize some of the hoop pine thinnings, as well as bamboos.

Sawmilling also comes under the Utilization Division and one project in this field is the machining of Anisoptera, which has a high silica content and is hard on planer knives. In cutting Anisoptera carbide tipped saws have been tried and have lasted 4-6 times as long as ordinary saws, but the carbide tips cannot be resharpened in the Territory.

A great deal of education is necessary in all parts of the Territory among people handling timber. The Division of Utilization is having a large workshop built and fitted with a number of woodworking machines for the purpose of demonstrating the use of New Guinea timbers.

Benallack: We have no staff specially engaged on research in utilization activities. The main aspects of our work are trade enquiries; we get a lot more of those now that Forest Products has shed some of that work. There has been a lot of co-operation with the trade this year in connection with the utilization of peeler logs from radiata and hardwood of slicing quality. A firm is now producing both radiata plywood and hardwood veneer, and is satisfied with a much lower quality log in both cases than we believed would be possible. Supplies are now becoming a problem but we are meeting it at present.

Jennings: The Department's work is concerned with two aspects:- (i) the efficiency of the sawmilling industry, and (ii) the effect of various practices in the field of utilization technique. We have done our best to eliminate low grade production; that requires a knowledge of the values of various sizes and qualities of trees, which is the link between the two forms of our activities.

Item 8(b)

FUNDAMENTAL RESEARCH IN WOOD CUTTING*

Historically, research in wood machining has progressed from investigation of a particular problem of a certain machining process to study of the problems basic to a particular process, as exemplified by the work of Franz in planing, Reineke in sawing and Leney in veneer cutting. It is apparent that the more fundamental such work becomes, the less it is concerned with the details of the machine or the tool, and the more it is concerned with the action of a highly simplified cutter on a work-piece of wood. Attention is focussed on thebehaviour of the material of the work-piece rather than that of the tool.

To carry this trend further, it is logical to ask "are there problems basic to all wood machining processes ?" and further, "are such problems vital ?" If the answers to these questions are affirmative, there remains the question, "how effective can a general approach be in providing the information required for the many and varied machinery processes ?"

The answers to these questions are discussed in an article "Fundamental Aspects of the Wood Cutting Process" by W. M. McKenzie. In answer to the first two questions, it is claimed that a problem basic to all wood machining processes concerns the action of a simple wedge-shaped cutter on a work-piece of wood, and that it is a vital one. The work reported in the article was the result of attempts to answer the third question, and is summarized as follows:-

(i) The intrinsic effect of velocity is small and predictable, and cutting can be studied at very low speeds.

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*Prepared by Dr. W. M. McKenzie.

(ii) The anisotropy of wood is such as to necessitate the study at one time, of a limited range of directions relative to the grain.

(iii) An indentation process, related to the cellular nature of wood, is important, especially in cutting across end-grain as in rip sawing.

(iv) Deformation and damage occurring in this process can be alleviated firstly, by lateral vibration of the edge. This applies also to the cutting directions relevant to planing and veneer cutting. Secondly, lubrication may have a favourable effect.

Subsequently, in pursuit of the ultimate aims concerning the cutting forces and the nature of the chip formation, the following result has been achieved:-

(i) A model, using the theory of a beam on elastic foundations, has been developed to provide a useful estimate of the cutting force, from certain physical and mechanical properties of the wood, for cutting across end-grain (as in rip sawing).

(ii) This model is in principle, applicable to the other main cutting directions, which represent the important processes of planing and veneer cutting, among others.

(iii) A similar model has been developed which is partially successful in predicting the type of chip formation in end-grain cutting.

(iv) Important properties involved in cutting across end-grain appear to be tensile strength parallel to the grain, elastic moduli perpendicular to the grain, and coefficient of friction, all of which are not obtained by standard testing programmes, so existing data are very sparse.

To carry the practical possibilities a little further, cutting forces computed from theory were compared with tooth loads computed from sawmill power studies. The available data on properties were meagre, but the theoretical values were in most cases about 60-70 per cent. of the observed tooth loads, which is in reasonable accord with Reineke's observation that fibre severance accounts for about 75 per cent. of sawing energy. This illustrates the possibility of predicting power requirements of species from their mechanical properties, and of eliminating the need for cutting tests for this purpose.

(a) Work Proposed

The work done to date has revealed the importance of bluntness, especially in cutting across end-grain, but like that done elsewhere, has been unable to cope with this aspect fully so that the effects of blunting on forces and chip formation can be predicted. It is, therefore, considere that a study of blunting, from this point of view, is the most urgent need, and such a study is being planned.

Another aspect of theoretical importance in connection with lateral vibration and bluntness, and of practical importance for sawing, concerns the effects of inclining the cutter edge to its direction of movement. This creates a three-dimensional problem, and for its study a three-component force dynamometer is being developed.

Both these lines of work should lead to better understanding and control of the fundamental wood cutting process.

Discussion

McKenzie: The difficulty and time consumed in this work should not be under-estimated, and I hope that too much will not be expected.

Bryant: George Canaway was very impressed with this paper.

Booth: We were very impressed to see this fundamental work being done. If it is going to be continued in Australia, what species are you going to use as your local model ?

McKenzie: No particular species, but I want uniform texture and a range of densities.

Item 8(c)

FIELD AND LABORATORY STUDIES ON SAWING*

In November and December of 1959, a sawmill study was conducted in a Queensland sawmill with the following objectives:-

(i) To determine the practicability of using thinner circular saws in a No. 1 bench sawing a selection of south-eastern Queensland species.

(ii) To determine the influence of saw speed on the use of thinner saws.

(iii) To determine the influence of swage-setting and spring-setting on the use of thinner saws.

Four species were sawn. They were blackbutt, (E. pilularis Sm.), ironbark (probably E. panicaulta Sm.), brush box, Tristania conferta R. Br.) and hoop pine (Araucaria cunninghamii Ait.).

Saws were 38 in. diameter with 54 teeth, blade thicknesses being 10, 11 and 12 gauge. One set of saws was sharpened in the conventional manner with the teeth spring-set, bevelled and hogged, and the other set was swage-set as for wide band saws. In addition, a 36-tooth, 10-gauge swage-set blade and a 44-tooth, 10-gauge tungsten carbide tipped blade were included in the tests.

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*Prepared by D. S. Jones.

The saw rim speeds employed were 6,000 ft/min, 7,000 ft/min, 8,500 ft/min and 9,800 ft/min.

Measurements of power input to the saw motor and saw blade deflections were made for a variety of depths of cut and feed speeds for each of the 80 chosen combinations of the above variables.

Work on the final report is still in progress, but a summary of the most interesting conclusions reached to date follows. It should be noted that these conclusions are provisional, as further studies of the data may throw new light on some points and may even force different conclusions. The results given hereunder apply mostly to the sawing of brush box, as the other three species have not yet been studied in full.

(a) General Trends when Sawing Brush Box

The 12-gauge saws were of little practical value under any sawing conditions, although at the slowest saw speeds in light cuts they operated well.

The 11-gauge saws were satisfactory in depths of cut up to 4 or 5 in. at saw speeds up to 8,500 ft/min, and were sometimes satisfactory in deeper cuts when no bark was present. At 9,800 ft/min the 11-gauge saws were unsatisfactory.

The 10-gauge saws operated well under all conditions, except at a rim speed of 9,800 ft/min.

It would thus appear that when sawing brush box at saw speeds of 8,500 ft/min or lower, a reduction in saw thickness of 1 gauge is practicable provided depth of cut is limited and bark eliminated by preparing dimensioned flitches on the breaking-down machine. Under these conditions, an additional advantage may be obtained by reducing saw diameter.

(b) Differences between Swage-set and Spring-set saws in Brush Box

The swage-set saws consumed more power than the spring-set saws. For example, at a saw speed of 8,500 ft/min and a feed speed of 160 ft/min the 10-gauge swage-set blade drew a mean total (cutting plus idling) power of 35 h.p. in 4 in. deep cuts, while the spring-set saw drew 30 h.p.

Because of the higher power demand, the swage-set blades suffered heavier deflections than the spring-set. For example, the mean left hand (away from the fence) deflection of the 10-gauge swage-saw blade under the conditions described above was 0.13 in., while the spring-set blade had a mean deflection of 0.11 in. The difference is not great, but these small differences occurred sufficiently often to create significance and indicate a trend.

The power and deflection values of the swage-set saws were reduced to values comparable with the spring-set when the number of teeth was reduced from 54 to 36.

Only at the slowest saw speed of 6,000 ft/min, when tooth loads were heavy, did the swage-set teeth of the 11-gauge and 12-gauge saws show any sign of deflecting or vibrating.

At both 7,000 and 8,500 ft/min the spring-set teeth of the 11-gauge and 12-gauge saws deflected or vibrated and adversely influenced cutting efficiency. Thus, the full benefit of thinner spring-set saws will not be realized until stiffer tooth profiles are developed.

There is evidence to indicate that the tooth deflections of the spring-set saws magnified the blade deflections.

When operating at the border line of performance, the 54-tooth spring-set saws usually showed an advantage over the 54-tooth swage-set saws, because of their lower power demand. This did not apply to the 36-tooth swage-set saw, which equalled the performance of the spring-set saws.

(c) Differences Between Saw Speeds in Brush Box

Power demand fell as saw speed fell for both the swage-set and spring-set saws. For example, the 10-gauge swage-set saw in 4 in. cuts at 120 ft/min feed speed drew mean total (cutting plus idling) powers of 31, 27 and 23 h.p. at 8,500, 7,000 and 6,000 ft/min respectively. However, with the 11-gauge and 12-gauge spring-set saws, tooth deflections or vibrations at 7,000 and 8,500 ft/min sometimes obscured the saw speed effect.

The blade deflections of the 54-tooth swage-set saws were roughly similar at saw speeds of 7,000 and 8,500 ft/min, but were significantly reduced at 6,000 ft/min.

The 10-gauge spring-set saw deflected significantly less at both 7,000 and 8,500 ft/min than at 9,800 ft/min, and the 11-gauge saw deflected least at 7,000 ft/min.

(d) Saw Blade Deflection Characteristics of the No.1 Bench for all Species

The saws always deflected away from the fence. For example, the 10-gauge spring-set blade sawing at 7,000 ft/min in 4 in. deep brush box had a mean deflection away from the fence of 0.13 in., while the mean deflection towards the fence was only 0.04 in.

When the fence was not used, saw blade deflections were not only more uniformly balanced on either side of the saw centre, but were relatively lower. Without the fence, the corresponding deflections to those given above were 0.05 in. and 0.03 in. respectively.

This effect is due to the fact that the saw in a No.1 bench is set up to provide the forces necessary to hold the timber against the fence. If this were not done, the timber would tend to leave the fence and scant dimensions would result.

This deflection effect was most marked with the 11-gauge and 12-gauge saws, which were less resistant to lateral forces than the 10-gauge saws.

It is clear that with the present design of No.1 benches the saws are operating at a disadvantage and never give their best performance.

Furthermore, the fullest use of thinner saws cannot be made under these conditions. Saws should be relieved of all loads except sawing loads by providing an independent means to hold the timber in the sawing line.

Discussion

Hansen: I agree wholeheartedly with Mr. Jones' remarks. Surely in any cutting operation, the sending to the bench of properly sized material is one of the greatest advantages that a bench can have in its role of production. I congratulate Mr. Jones on the equipment which is simple to use and very robust.

Jennings: There has been much interest aroused in Queensland by this work; we are hopeful of getting our own equipment so that we can carry it on as quickly as possible.

Item 8(d)

HARDFACING SAWS TO IMPROVE SERVICE LIFE (NEW SOUTH WALES)

The need to overcome the abrasive action of some island species of Nyatoh and Anisoptera, led to a joint project between a Sydney sawmiller and the Division to study the possibilities of hard-facing of bandsaw blades with Stellite.

The following is a report on the techniques and equipment used and some information on blade life and time involved in the process.

Stellite or "Cobalide" as it is known locally is a chromium-tungsten-cobalt alloy with a Rockwell hardness of C42 as used for wood cutting tools having a high melting point (1,200°C) and retaining its cutting properties even at red heat.

(a) Equipment

The equipment required to hardface bandsaws is usually present in the average toolroom, the main items being -

(i) A standard oxy-acetylene welding plant with an equal pressure blowpipe and a set of swaged tips (No. 2 used). It is recommended that the best valves and gauges be used on the welding gear.

(ii) Automatic grinding machines (for bandsaws).

(iii) Standard grinding wheels (A46 MVBE). Some overseas authorities suggest a grain size of 60 gives better grinding than 46.

(iv) Grade 3 (Silver) 3/16 in. diameter Cobalide rods.

(b) Preparation of Saw

The bandsaw used is prepared for hardfacing by using the standard techniques of swaging, side dressing and checking of the set.

The sawdoctor hardfaces ever second tooth on his log bandsaw blades and the in-between tooth is left 1/32 in. below the cutting tooth. He claims that his cuts are very little different to when he uses every tooth and that he has only half the work to do on the saw. Every tooth is faced on the band resaw.

It is essential that the saw teeth and swaging dies be free from grease, oil, rust and dirt, as this will prevent proper adhesion of the Stellite to the steel.

(c) Method of Application

When ready, the oxy-acetylene mixture is turned on at a low velocity of approximately 5 lb/sq.in. oxygen and 10 lb/sq.in. acetylene and the flame regulated so that the flame cone is roughly three (3) times the length of the inner flame cone (about 2 in.).

Next play the flame cone on to the tooth face at the same time protecting the tip of the tooth with the Stellite rod which is held at an angle of about 45° to the tooth face. Care should be taken to see that the tooth point is not overheated as it will be damaged.

When the tooth becomes bright red, play the flame cone on to the Stellite until it drops and spreads over the indentation, care being taken not to have the drop too large or too small as the former requires too much grinding and the latter weakens the tooth resistance to wear.

(d) Tempering, Grinding and Sharpening the Tooth

Should the teeth be brittle after the process is completed it will be necessary to heat to 450°C with a low velocity neutral flame until blue colour passes through tip of tooth.

The methods used in grinding and sharpening are similar to those used in normal bandsaw sharpening operations.

Also equalizing wheels are used to grind the Cobalide to approximate shape on saw sides before swage shaping takes place with another cup grinder.

(e) Regrinding and Refacing

Regrinding of bandsaws should be done on the clearance face more often than the cutting face to save the Stellite and maintain a sharp edge.

The time taken to swage, tip, sharpen and side dress the log bandsaw is 3 hr and this allows 8-12 sharpenings of 20 min each whereas with the ordinary saws the swaging and resharpening process takes about 1 hr, and a regrind 45 min.

(f) Blade Life

The firm using the blade appear to be quite satisfied with the process and are continuing to use it.

They work a 10 hr day cutting 30-35,000 su.ft. log per day custom sawing.

Before hardfacing, four (4) saws were used per day on the bandmill now they require only one (1) saw every $1\frac{1}{2}$ days whilst the life of the resaw has been extended from four (4) hr to sixteen (16).

(g) Further Work

Interest shown in hardfacing by New South Wales South Coast sawmillers cutting turpentine has prompted the Division to study the problems concerned with introducing this process to sawmills using circular saws in that area.

Discussion

McKenzie: In conjunction with this attempt at reducing wear by Cobalide, was attention paid also to speed, on the lines of the work done by Mr. Jones in improving the wear situation by slowing the saw down ?

Booth: I understand the saw was run at conventional speeds.

Jones: In this particular mill the saw doctor was keener to cut out every second tooth than to reduce the saw speed, because that was cheaper. Thus, only every second tooth on the log saw blade was tipped. On the band resaw blades, every tooth was tipped, and there could be additional benefit in reducing the speed of that machine.

We have received a number of enquiries from North Queensland, particularly where they saw very abrasive species, on the practicability of hard-tipping both bandsaw blades and circular saw blades. The New South Wales work will be of considerable advantage to those sawmillers when it is made available to them.

Item 8(e)

FINGER JOINTING*

There are now 12 finger jointing plants operating in Australia, with a total capacity exceeding 30,000,000 linear ft per year, jointing species ranging in density from radiata pine to ironbark. Our programme of work includes the following, most aspects of which are still under investigation.

(a) Development and Testing of Profiles to Suit Australian Species

For various reasons it has been necessary to study the influence of the individual details of joint profile on joint strength. We still feel that our knowledge on the mechanism of joint failure is inadequate, and investigations are continuing. It is believed that the generally accepted relationship between scarf angle and the efficiency of scarf and finger joints is not directly applicable to the full range of our indigenous timbers because of the suspected influence of the strength level of the species being jointed.

The dimension of the tip of the finger is important as it constitutes a loss of tensile load carrying section but its reduction can cause an increase in the rate of cutter blunting. The rate of blunting of a tip 1/16 in. wide is, for example, twice that of a tip 3/32nd in. wide while the application of "Stellite" to the face of the cutter appears to reduce the blunting rate by half.

With the denser species joint failure usually occurs in the glue line but little is understood of the actual mechanism of failure or of the influence of the strength properties of the glue on the strength

*Prepared by M. W. Page.

of the joint. Present belief is that the criterion of glue failure is some function of its tensile strength. An effort has been made to evaluate this property by using bending specimens containing a central vertical glue line. The results, shown in the table below, give figures fairly close to those obtained by Marra (University of Michigan) for the tensile strength of glue using thick cross lap specimens.

Species	PVA	Urea Formaldehyde	Resorcinol Formaldehyde	Melamine Formaldehyde
Radiata pine	977 lb/sq.in.	950 lb/sq.in.	1148 lb/sq.in.	1030 lb/sq.in.
Mountain ash	1500 "	1145 "	1255 "	1060 "
Brush box	1112 "	1143 "	1155 "	1270 "

On the basis of these figures it was postulated that the glue in a finger joint acts inefficiently and that the reason for this is inadequate pressure between the mating surfaces during cure. To check this hypothesis, specimens were cured under side pressure and a 16 per cent. increase in strength resulted. Further work on this aspect is planned.

(b) <u>Effect on Joint Strength of Gluing at Various Moisture Contents</u>

Cypress pine flooring stock is not usually kiln dried and as such material for finger jointing is likely to vary fairly widely in moisture content it was decided to investigate the effect of this on strength. Because of certain difficulties in conditioning specimens to the exact moisture contents required, and of obtaining clear specimens, the test tended to be unsatisfactory but the results indicated that the most suitable range for gluing lies between 8 and 16 per cent. moisture content.

(c) Finger Jointing at Moisture Contents above Fibre Saturation Point

Approximately 50 per cent. of the hardwood timber produced in Australia is used green for such purposes as scantlings and because such timber cannot be glued the benefits of finger jointing are not applicable. It has been shown that resistance to moisture movement in medium to dense hardwoods is sufficiently high to allow time for a skin dried surface to be glued with a waterproof adhesive. Jarrah and messmate stringybark have been finger jointed in the laboratory at moisture contents of approximately 90 per cent. and joint efficiencies in excess of 60 per cent. achieved. A bunsen flame was used to obtain the dry surfaces and a patent application has been lodged covering this technique. Present investigations include closer study of the temperature-time relationship in a flame dried and glued joint, rate of moisture recovery, depth of drying, other methods of rapid skin drying and the temperature-time requirements for glue cure. It has not been possible as yet to develop a satisfactory commercial method of rapid skin drying which will tolerate the variations of moisture content found in mill run production.

(d) Application of Finger Jointing to the Up-Grading of Timber

(i) In conjunction with the Section of Timber Mechanics the possibility of using finger jointing to produce an acceptable grade of radiata pine scantlings has been investigated. Results to date which are reported elsewhere (Item 5(d)) indicate -

1. Greater reliability in strength,
2. significant reduction in distortion, and
3. important increases in the yield of acceptable material from mill run production.

It is predicted that the increase in yield from less than 50 per cent. to 70 per cent. and better will more than off-set the cost of jointing and data is being collected to test this point.

(ii) The volume of select quality material likely to be recovered from run of the mill jarrah shorts by finger jointing has been studied and recoveries of 60 per cent. as full length select quality material found possible.

(e) Effect of Weathering on Finger Joints

Finger joints in 3 species and glued with a range of adhesives are being cycled in a weatherometer. The criterion of failure is delamination of both edges on the exposed faces. Results to date, given below, while incomplete, illustrate the weather resisting properties of melamine formaldehyde. This adhesive has a number of advantages.

(i) It is available at approximately the same price as PVA, the adhesive now being commonly used.

(ii) It gives a colourless glue line.

(iii) The manufacturers claim that it can be cured at temperatures as low as 50°F.

This latter claim is justified for low density species such as radiata pine but is not confirmed with medium to dense species.

(f) Finger Jointing of Preservative Treated Timber

Radiata pine and hoop pine for a number of uses may need preservative treatment and as those treatments are normally carried out at moisture contents above the glueable range any finger jointing should preferably be done after treating and drying. A study of the effect of treating chemicals on joint strength has commenced but to date no results are available.

Adhesive	Radiata Pine	Mountain Ash	Red Gum
Resorcinol formaldehyde	No delamination after 114 days	No delamination after 114 days	Results not available
Melamine formaldehyde	No delamination after 114 days	No delamination after 114 days	No delamination after 114 days
Urea (separate application)	Failure after 14 days	Failure after 40 days	Failure after $5\frac{1}{2}$ days
Urea (mixed application)	Results not available	Failure after 21 days	Failure after 20 days
PVA No. 1	Failure after $4\frac{1}{2}$ days	Failure after $4\frac{1}{2}$ days	Failure after 5 days
PVA No. 2	Failure after $4\frac{1}{2}$ days	Failure after 4 days	Failure after 4 days

Discussion

Page: In New South Wales, Victoria and South Australia, housing authorities do not differentiate against finger jointed flooring, and in Western Australia they actually specify it. In Queensland, the attitude of the Housing Commission is that finger jointed flooring is inferior to full length.

Jennings: We were not aware of this position regarding the Housing Commission. I shall look into it and am confident that a satisfactory solution can be reached.

Booth: There was objection to finger jointed weatherboards being used in New South Wales, and as a result of its poor behaviour, some lending authorities refused permission for finger jointed material to be used. There is some jointing of cypress and radiata pine, using straight urea. In our opinion, with adequate painting, This will probably perform all right as weatherboards only. Is the melamine a straight melamine formaldehyde adhesive ? I doubt if it would be as resistant to weather as resorcinol, judging from overseas testing.

Page: I believe it is a straight melamine formaldehyde manufactured by Aero Research Ltd., England, sold here as Selleys 308.

Gottstein: We have no information on the extent to which it is a urea blend. Aero Research have indicated that it is high in melamine, without actually saying so. It has behaved quite well in our laboratory tests, and withstood a 72 hr boil test. It appears from weatherometer tests that it has very good weathering characteristics, and for finger jointing it has given excellent bonds.

Page: We have not been able to get room temperature curing with some of the denser species, but radiata cures excellently at 70°.

Turnbull: What is the significance of weatherproofness in the joint in a weatherboard ? So long as it holds together up to the time it is nailed to the studs it cannot come apart.

Page: In the weatherometer tests, failure has been due to the outside fingers lifting away, if that happened in practice it would be unsightly.

Item 8(f)

PAINT FAILURES IN GOVERNMENT HOUSING PROJECTS IN NEW SOUTH WALES

Bootle: An inspection of any large housing project in the Sydney area (e.g. Housing Commission, War Service Homes Estate) will reveal widespread paint breakdown on weatherboards, often within a year of construction. The failure is very manifest to the passer-by and is obviously a very poor advertisement for the use of timber, so much so that the Housing Commission's officers favour the construction of fibro-cement and brick-veneer dwellings because of the lessening of the early high maintenance charges involved.

An inspection of the buildings shows that the paint breakdown is not due to any inherent fault in the timber, for breakdown is occurring on metals and to a less extent on the more tolerant fibro-cement sheeting.

The fault lies in the present system of sub-contract building, by which tenders are cut "to the bone", much of the painting is done by unskilled labour, and to compete, the qualified tradesmen have to adulterate the paint to secure the contract. From the prices tendered it is quite obvious that nobody could do the job satisfactorily and make a living from it. Supervision on these large projects is extremely difficult. It is suspected that the number of coats and the intervals between coats are not in accord with good practice.

The matter is viewed very seriously by the New South Wales Forestry Commission as it has undoubtedly influenced lending authorities against timber cladding and has created many worries concerning the durability of radiata pine boards subjected to such poor surface finishing.

The matter has been taken up with the New South Wales Building Industries Congress, but little real progress seems to have been made.

Discussion

Jennings: There have been no painting problems on Housing Commission properties particularly, but weatherboards in imported houses have given a lot of trouble. The Housing Commission is very strict about painting practices. The lowest tender is accepted, but we are not having any particular trouble with paint failure.

Bootle: This applies to our Commission also, but the lowest tender often means that the work is poor.

Turnbull: We have been asked often to be trouble shooters in paint failure cases, particularly Housing Commission work. We are not sufficiently informed to be of much help. Certainly many paint failures occur at an early age.

Bryant: Paint companies point out, quite rightly, that after they have sold paint they are no longer responsible, as they have no control over how it is applied.

Item 8(g)

CLEAR FINISHES AND STAINS FOR WEATHERBOARDS, LINING AND FLOORS. (NEW SOUTH WALES)

The incidence of use of clear finishes for weatherboards has declined very considerably in New South Wales due to their poor life (1-2 years). Despite work by local and overseas manufacturers, there seems little likelihood of the development of a durable clear finish in the near future. The U.S. Forest Products Laboratory's "material finish" formula, really a pigmented linseed oil, has been accepted with favour by some Sydney architects and is expected to give a better service life. However, it has a matt surface which holds dust much more readily than gloss finishes, and there is some doubt as to its moisture insulating capacity when the wax concentration diminishes with service. The one Sydney manufacturer of this product is carrying out experimental work for its possible improvement.

Further new products are being marketed for use on floors and it is proposed to test these in the immediate future. From earlier experimental work urea-formaldehydes, modified urea-formaldehydes and polyurethanes all gave good service. However, they are not cheap, are unpleasant to apply and rather difficult to patch, so we have recommended the application of wax to areas of heavy wear so as to obviate the necessity of refinishing.

Where a non-slip floor is required (as in a home with elderly occupants) it is suggested that a floor sealer finish be used. This finish is generally based on tung oil, is easy to apply and patch, and cheaper than the abovementioned "plastic" finishes. It is quite a bit less resistant to wear, but its ease of replacement makes up for this.

Non-obscuring stains are finding favour for use on interior panelling. Radiata pine lends itself well to oil colour finishes rubbed on the surface (see 5(j)) and the attractive effects obtainable should assist considerably in the sale of pine for this purpose.

The colour finishing of plywood is being actively promoted by the Australian Plywood Board and one of the main paint companies. Particularly attractive effects can be obtained, for example, tulip oak and a pale blue finish makes an outstanding background in Farmer's, Sydney, furniture department. Tubed colours are added to a "satin clear" varnish, and a very wide range of colours is offered.

Discussion

Wickett: A test of 5 clear finishes over 12 primers set up at Como on 23rd April, 1958, has now been in progress for nearly 3 years. Most of the panels have now failed to a very unsightly degree, but a few are still reasonably acceptable from the points of view of integrity of surface and retention of gloss.

The best jarrah panel is probably Forminex/PVA/Raw Linseed + 5 per cent. PCP closely followed, or perhaps equalled by Estapol/ Timbakote (Walpamur).

The best primer tested for jarrah is Timbakote, and the next best is PVA/Raw Linseed + 5 per cent. PCP.

The best radiata pine panel is Silicone Alkyd/PVA/Raw Linseed, and the next best is Estapol over the same priming treatment.

The best pine primer tested is PVA/Raw Linseed and the second best is PVA/Raw Linseed + 5 per cent. PCP.

The test has shown that a priming treatment is very necessary, that there are great differences in the suitability of primers and that water repellent preservative primers containing 2 per cent. paraffin wax, some of which give good results for up to 12 or 18 months cause rapid failure thereafter. It has also shown that a fungicide is not necessary to control blue-stain in pine as long as the clear finish remains intact, and if the finish fails 5 per cent. PCP does not prevent bad blue-stain in any case.

Turnbull: We have been approached by a leading firm to do some work on clear finishes, particularly for floors. For our canteen floor we chose a finish, a polyurethane, which has not received a great deal of support from the trade. We have not committed ourselves as yet to a programme, as we do not have the staff.

Bootle: We will be testing this finish in the near future and will keep you advised of results.

Bryant: We have submitted two articles to the journal of the Australasian Consumers' Association on timber, and we propose to use this journal to give results of tests on various brands; we will submit these articles anonymously. We will do the tests, and the Commission has approved this as a policy.

Gottstein: We have done some work on finishing of plywood, particularly the outside of this lecture room. We have used a number of coatings, and I can only support Mr. Bootle in his findings. All the clear coats in our tests failed in a very short time; some failures being completely irrepairable. The polyurethane type proved the most durable, but it is difficult to repair.

Item 8(h)

HARDWOOD MILL STUDIES IN SOUTH-EAST QUEENSLAND*

In 1953, mill studies were conducted in 13 hardwood mills in south-east Queensland as a co-operative project by the Queensland Forest Service and the Queensland Timber Stabilization Board.

The results of these studies were published as Research Note No. 1 "The Milling of Hardwoods in south-east Queensland". It is this report that is referred to when the 1953 studies are mentioned in the following text.

The studies in 1960 were undertaken by the same organizations to check on the developments in the hardwood sawmilling industry of the same region during the 7-year period.

The same 13 mills were again covered by the studies. Various changes in mill equipment and organization have occurred, e.g. one completely new plant was in operation, another plant was re-organized and some new equipment installed, others had minor changes.

Sawn recovery from a log was again satisfactorily determined in terms of its gross hoppus volume and defect.

The regression equation developed for sawn recovery against log volume and log defect accounts for 93 per cent. of the variation

*Prepared by N. S. Hinson.

between species. The remaining 7 per cent. is due to species differences, to differences between mills and to experimental error.

Contrary to the 1953 studies, milling time was found to be significantly influenced by defect. More efficient disposal of defect, usually in the form of heart defect (pipe), is considered to be the major reason for this.

Mill efficiency overall has increased. This is evidenced by increased recoveries, (despite the fact that log defect increased,) and more volume throughput was achieved in lesser productive time than in 1953, with smaller average mill crews.

Pertinent figures are -

(i) Increase in production rate from 40.8 to 62.0 su.ft. solid sawn per man hr (excluding reject material basis).

(ii) Log defect increased from 23 per cent. to 31.4 per cent.

(iii) Recovery increased 3.7 per cent. on G.H.V. and 12.9 per cent. on N.H.V. (excluding reject material basis).

(iv) Average mill crews decreased from 12.3 to 9.6 men.

Apart from more efficient heart disposal methods, other reasons for increased efficiency are considered to be the more effective use of log breaking-down equipment, installation of modern equipment and improved facilities and layout.

In the sawn material produced, major changes were observed in external sheetings. The production of rough sawn weatherboards decreased sharply whilst the production of sawn sizes for chamfers (seasoned weatherboards) rose even more sharply. Production of scantling sizes remained remarkably steady. Flooring sizes showed a slight decrease

All data from these studies was recorded on punch cards which allowed rapid tabulation of the information. Details of the method are given in full in the text.

Discussion

Jennings: The increase in efficiency shown since the first survey is not only due to the Department's extension activities but also to the trade itself, where improved practices have been adopted.

Richardson: Are the results at individual mills made available to other mills ?

Jennings: No, they are confidential.

Bryant: I think Queensland is to be congratulated on this work. How many people were involved, and over what period ?

Hinson: The average mill crew ranged from 3-5 members for the study group, the time spent at each mill was approximately 1 week. The whole study took 13 weeks; at the end of each week, the field sheets were sent back to the office and were recorded on cards during the following week, so that a week after field work finished, all the analyses would be collated. They were then sent to the Commonwealth Bureau of Statistics where the tabulations were done. The last study was finished in September, and the report was available 3 months after that.

Huddleston: What are the main reasons for the increased efficiency ?

Jennings: The most important contribution to increased efficiency was the disposal of hearts straight off the breaking-down equipment, and not having to put them through the mill, and generally the introduction of modern type carriages, or good mechanical condition of the old type. Also, a streamlining of the whole production right along the line.

Huddleston: Would it be that the sizing of the flitches was a major contributing factor ?

Jennings: It is a contributing factor to the increase in recovery. A sized flitch on No. 1 bench means that No. 1 is doing more actual productive work, but the prime reason is the elimination of heart defect all down the line.

Richardson: To what extent are the mills and the staff representative of those in the States ? Don't you find the more efficient ones are more agreeable to co-operate ?

Jennings: They are quite representative of the mills in the State and all were inefficient originally.

Turnbull: This is an example of the improvement being brought about in the industry; improvement of something like 50 per cent., which is highly commendable. I think we can set our sights on further targets. While the improved production reported in Queensland is 62 su.ft. per man hr, many medium sized mills in Europe and North America produce 620 su.ft. per man hr, and the best I know of in the world produces 1,600 su.ft. per man hr. Accordingly, there is still a great deal to be done in Australia and I think it should be supported right to the hilt.

Item 8(i)

THE EFFECT OF SAWING PATTERNS ON GRADE RECOVERY AND QUALITY OF HOOP PINE*

The effect of sawing patterns on grade recovery was investigated in 22 ft pruned butt logs. The following patterns have been considered in this survey.

(i) Commercial pattern (in effect gang sawing).

(ii) Patterns which remove a 2 x 2 or 6 x 2 central core.

*Prepared by V. Balodis.

(iii) Sawing round the log.

(iv) Patterns using a 6 in. central flitch followed by taper or square (i.e. parallel to pith) sawing.

A general discussion on production costs of sawn material arrives at the conclusion that conversion costs are minimum for commercially used pattern, with "square sawn" patterns next, followed by "taper sawn" patterns.

Using graphical models it was established that patterns using 6 in. central flitch produce superior sawn material to patterns listed under (i) and (iii). A further advantage was gained by taper sawing the 6 in. central flitch.

A detailed investigation of taper sawing versus square sawing (6 in. central flitch patterns) was carried out on a sample of pruned hoop pine butt logs. Analysis of results showed that taper sawing may increase sawn value by up to 20 per cent., the maximum increase being in the smaller butt logs. This improvement in sawn value was due to increased proportion of top grade material in sawn output.

The effect of seasoning on sawn material resulting from taper sawing and square sawing was investigated on a sample batch of 25 hoop pine stems. (Stems to 4 in. top diameter under bark.) Spring and twist was measured on the air seasoned material and the measured values adjusted to a 10 ft standard board.

	Taper Sawn	Square Sawn
Spring	.187 in.	.231 in.
Twist	6.25°	7.31°

Detailed analysis showed that maximum reduction in distortion took place in small top logs.

Thus, taper sawing increases value of sawn timber from pruned butt logs and reduces distortion in seasoning in material from top logs.

Discussion

Turnbull: The actual results of this sort of work are greatly influenced by price differentials between dimensions. They are not the same in Queensland as elsewhere. In Victoria there are greater increments, as the width increases; attention should be given here to achieving the greatest possible width.

Jennings: I agree. Our work has been very much influenced by the very high premiums for clears; this is so throughout the whole world. This situation has clearly influenced our silvicultural practices, it is the reason why we prune and thin at the same time to maintain the dominance of the primed trees. In times of reduced demand or over-supply, the margin between good quality and poor quality becomes important, as you cannot sell poor quality material.

Richardson: This is not true to the same extent in New Zealand where we have controlled timber prices.

Huddleston: Every case must be taken on its own individual merit. Some logs, for example, may tend to spring. Sawing practice that is satisfactory in one place, may not be in another. While we can use the work in Queensland as a guide, it is up to every operator to devise his own sawing pattern to yield the most economic results.

ITEM 9. VENEER, PLYWOOD AND ADHESIVES

Item 9(a)

REVIEW OF RESEARCH ACTIVITIES*

The Australian Plywood Board has increased its contribution towards plywood research since the last Conference and is endeavouring to maintain this despite recent trade difficulties. Work in the Section

*Presented by J. W. Gottstein.

has been primarily directed towards factors affecting plywood manufacture, i.e. peeling and peeled quality, drying and gluing. However, attention has also been directed towards distortion in veneers and plywood assemblies and to finishing difficulties, especially those associated with obtaining really smooth surfaces for high finishes.

Over the past 3 years manufacturers have imported a considerable quantity of drying and other equipment in order to minimize the labour costs involved in production and to produce a better end product, but in many end uses the plywood industry is facing serious problems because of the relatively high costs of its raw material and the high cost of labour.

A course in plywood technology, covering 10 working days, was given to members of the industry in April of this year. In addition, officers of the Section have visited plants in all States to give assistance where possible and to cover experience gained in overseas visits and work.

(a) Peeling

The industry, generally, now appreciates the value of accurate control of lathe settings and many firms are using dial gauges for setting up, and some use these for final control of nosebar location. Both Mr. McCombe and I found that the importance of control of lathe settings is gradually being realized in overseas practice.

In our laboratory, lathe operation has been improved by the installation of a Ward-Leonard drive combined with a heavy duty gear box. This arrangement permits speed control over a range of about 40-1.

Additional gears have been provided for peeling veneers 0.004 in. and 0.007 in. in thickness and a simple reeling system is being developed for laboratory work.

The peeling qualities of about 20 species received from Australia, New Guinea and several Pacific Islands have been studied and the correct peeling conditions appropriate to desired quality have been established.

Methods of veneer quality evaluation have been studied and developed. The combination of transverse tensile strength, together with an examination of the form and depth of peeler checks, together with a surface smoothness evaluation, now appears the most satisfactory laboratory technique.

Effects of knife wedge angles ground between 18°-25° have been studied on short knives and micro-bevels of various widths have been tested. In some species an effect of high moisture content on optimum nosebar settings has been clearly established.

Knife studies have included the effect of wear on veneer quality and the type of wear occurring on knife edges. For these studies logs were usually off-set with the pith approximately 2 in. away from the peeling axis.

Studies have also been completed on the peeling of <u>Pinus radiata</u> knot whorls to determine knife wedge angles and micro-bevel settings which result in minimum knife damage with adequate veneer quality. This, of course, is associated with properties of the cutting edge and a number of different knife qualities were included in these tests.

Effects of temperature and time on veneer quality were studied in several species and an improvement to surface smoothness and peeler check depth was found with several conifers.

In addition to improved speed control the Ward-Leonard drive has permitted better estimations of torque and power consumption.

Improved veneer quality through better nosebar use has increased veneer thickness control problems and factors involved in thickness variation and build-up have been studied. Slackness in lathe bearing and carriage feed clearly play a part, but loss of dogging pressure has been found to play a major part both on our own lathe and in many commercial peeling installations. Awareness of this has resulted in much more uniform veneer thickness in several plants.

It has been found on the laboratory lathe that under certain conditions of good and stable peeling, a change of as little as $\frac{1}{2}^{\circ}$ in knife pitch angle can nearly double power consumption and completely upset the consistency of veneer thickness. Initial studies indicate that this behaviour is associated with instability of the position of the knife edge relative to the nosebar.

The horizontal component of nosebar loads has been measured under a number of peeling conditions. Deflections of about 0.005 in. at maximum peeling loads can usually be tolerated in 1/16 in. veneers.

(b) Drying

A laboratory drier with a drying compartment in the form of a 3 ft 6 in. cube has been developed to provide air-flows from about 100-2,000 ft/min. In its present form it is being operated as a medium temperature drying unit with plywood walls and performs satisfactorily up to about 220°F. Results of this medium temperature high velocity compartment drying have proved satisfactory with a number of species and show that the screened drier could be used with advantage at even higher air-flow speeds than are being used at present. This would require rather costly modifications to aerodynamic design since cost of pumping air at high velocities tends to rise rather rapidly. Studies are being made of drying rates around and in knotty areas in Pinus because of the troubles being experienced with both live and dead knots in commercial drying.

The use of the temperature difference methods to estimate moisture content, both in compartment and mechanical driers, as reported at the last Conference, has developed rapidly and many screened and mechanical driers now use galvanometers for this purpose. A number of field studies have been undertaken of mechanical driers. The use of the latter is increasing rapidly because of the trend to thin face veneers and the increasing proportion of narrow and sometimes relatively cross-grained timber that must be used for veneer production.

Field studies of new jet driers show that this design has a very high drying potential relative to the humidity and temperature conditions in the drier, and also that these driers provide an improved zonal humidity control. This gives improved dried quality in some species.

(c) Preservatives

Work carried out on glue line additives and green diffusion dip treatments will be referred to later.

(d) Glues and Gluing

Work on tannin adhesives will be reported separately.

In commercial adhesives the washability of U.F. glues has been improved and addition of shell flour to improve gap filling has become fairly general. Phenolic glues with greater reactivity have become available. Several new glue formulations have appeared recently, including a cold-setting melamine.

A number of PVA glues have appeared which laboratory tests have indicated to be rather variable in quality. Special "highly moisture resistant" formulations still show low creep strength and have been found inferior to U.F. working in weatherometer tests.

Laboratory work on U.F.'s have included trials of carboxymethylcellulose. The use of unextended resins at very low glue spreads (30 lb/100) on well peeled veneers has given very good results.

Work was carried out on gluing properties of solid karri, jarrah, red gum and tallowwood with several commercial adhesives. Cold-setting resorcinols were found to be troublesome with jarrah.

Studies on surface inactivation (case-hardening) has given further evidence that the presence of water facilitates its development.

Conditions for the successful gluing of several species to other materials including aluminium, lead, asbestos cement and iron were examined.

Sonic and supersonic methods were tried for the non-destructive testing of glue lines, and simple tests have been developed for glue line penetration. Several species are being examined for suitability for high strength joint evaluation.

The importance of the doctor roll position in relation to the spreader roll was pointed out at the last Conference. Improvements have now been effected in many commercial plants, and also by commercial spreader manufacturers. The secondary "pinch" effect of the spreader rolls has also been clearly established, while more recent work has shown that smooth or furry veneer surfaces usually have surprisingly little effect until the spread conditions approach or exceed the maximum appropriate to a particular roller grooving. Laboratory equipment has been modified to study the effect of different roller grooving and three-thread forms are now available.

(e) <u>Exposure Tests</u>

After $3\frac{1}{2}$ years' weather exposure in Melbourne, unprotected plywood panels glued with phenolic and tannin based glues show no appreciable delamination. In weathering tests on this building polyurethane proved slightly better than other clear finishes, but all failed in $3\frac{1}{2}$ years. All pigmented finishes used are still serviceable.

(f) Finishing and Crazing

The tendency of veneer surfaces to craze following humidity and temperature changes is well-known, but its causes are not completely understood.

Preliminary studies have been made examining the contribution of the surface finish towards inducing or restraining the development of the craze pattern. It has been found that reduction in the rate of moisture content change appears to have a distinctly beneficial effect, but the limiting values of moisture content, veneer quality and species effects are not known. Work is being developed.

Additional facilities, including conditioning rooms and cabinets and a finishing are being provided. Gluing techniques to minimize craze development are also contemplated as are various types of sizing, sanding and other pretreatments.

(g) Particle Board

Requests from industry have required a limited amount of plant work on factors involved in particle board production, especially in respect of gluing, pressing, moisture content and thickness and distortion.

Item 9(a) (Cont.)

NEW ZEALAND*

(a) Scarf Joints

The properties of scarf joints of slope 1 in 10, but having differently prepared surfaces, have been studied by incorporating them in small laminated beams which were matched in other respects. Some

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*Presented by Dr. D. Richardson.

of the scarf joints had machined surfaces, some were fine-sawn, and some were fine-sawn but had a small locating dowel inserted. The properties of beams with joints of each type were identical with those of unjointed controls except that beams with locating dowels had an average M.R. which was only 81 per cent. of that for the others.

(b) Glue-Reservative Compatibility

Using 3 indigenous timbers, and the heartwood and sapwood of radiata pine, a comprehensive series of tests has been carried out to find out whether the immediate bond strength of glued joints formed with each of several glues, is affected by pretreating the timber with one of three waterborne preservatives. Only 9 of the 60 combinations showed an average loss of bond strength exceeding 20 per cent.

(c) Durability Trials on Treated Radiata Sapwood

Long term trials, designed to run for 20 years or until bond strength has diminished by 50 per cent., have been established. Joints will be withdrawn at intervals for testing.

The material for the outdoor test is mounted on a fully exposed fence, and that for the indoor test is enclosed in a roof enclosure with strictly limited ventilation. Appropriate glues and preservatives were selected for the two exposure conditions; all the preservatives were waterborne.

(d) Accelerated Tests on Radiata Sapwood

Sapwood treated with waterborne preservatives, was used to form joints which were exposed in a weatherometer or subjected to boil/dry cyclic testing. Appropriate preservatives and glues were selected for the two cases.

Joints were selected at suitable intervals for testing and a striking feature of the results was the initial increase in bond strength exhibited by most glues; degrade then occurred. The melamine-urea-formaldehyde glue subjected to boil tests showed a remarkably high resistance.

(e) Tests on Finger Jointed Material

Randomly selected 4 x 2 was used, the finger joint being effected between unmatched pieces. Some of the material was tested in static bending, edgewise, some flatwise and some in compression parallel to the grain. Matched unjointed control material was also tested, and in certain cases there was a high correlation with the properties of the jointed pieces.

The properties of the jointed material were superior to those of No.1 Framing Grade radiata.

Item 9(a) (Cont.)

NEW SOUTH WALES*

The main activities at the Division of Wood Technology under this heading are concerned with solving problems of using New South Wales brushwoods in high grade plywood products - particularly marine plywood.

We have recently been successful in solving the phenolic bonding problems which the species yellow bean, white birch and negro-head beech present. In this we have found out a lot about the fundamentals of phenolic bonds in wood. A paper on this work has been written for publication.

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*Prepared by H. Booth.

Briefly, the species concerned began to show trouble in glue-line durability just after we thought we had overcome the industries boron troubles by developing fluoride dipping. At first sodium fluoride was blamed but we proved that this is not the case. The essence of this puzzling effect was that some species which gave excellent dry bonds with phenolic glue gave very low strength and zero wood failure on boiling and soon delaminated on weathering. We were able to show that the trouble was caused in practice by two factors.

(i) The presence in the wood of pyrogallol type water soluble tannins.

(ii) The use of a resin of functionality less than 3. The trouble could be overcome by removing the tannins by extraction or using a trifunctional resin.

In an extended study of the problem it was found that -

(i) The bonding trouble occurs in all woods tested which contain soluble pyrogallol tannins.

(ii) These tannins exert their effect with trifunctional resins but at a lower temperature.

(iii) Woods which do not show this effect form good bonds at a lower temperature than the species which do.

(iv) By extraction of the soluble tannins from a wood such as yellow carabeen with methanol or hot water it is converted in gluing properties to a wood such as coachwood.

(v) Extraction of coachwood with methanol has no effect on its gluing properties.

(vi) It has been possible to simulate exactly the gluing behaviour of a difficult wood such as yellow carabeen by treating a good gluing wood such as coachwood or brown alder with a solution of tannic acid.

(vii) We have been able to correlate the gluing behaviour of timbers with a simple $FeCl_3$ colour test performed on a boiling water extract of the wood. Correlation is 100 per cent. on 30 woods tested.

(viii) The process involved has been explained in terms of known chemical reactions of phenolic resins, tannins and lignin.

(ix) This work is continuing with the use of model substances.

Discussion

Jennings: All the Department has been doing and is likely to do is providing testing service to Standard specifications.

Dadswell: Do you attribute the poor gluing of karri and other timbers to low pH or extractives ?

Gottstein: In dense timbers like karri we seem to get glue failure for purely mechanical reasons, and the problem of gluing dense species will probably remain independent of extractive or pH effects. I will be happy to hear results of this very interesting New South Wales work on these difficult timbers.

Hillis: I am interested in the work reported by Mr. Booth, particularly in that tannic acid can cause the trouble. I would like to ask Mr. Gottstein if the extractives in E. regnans and other eucalypts give trouble, for example, is there any trouble with the gluing of mountain ash with these phenolic type adhesives ?

Gottstein: The amount of trouble is largely a matter of degree. Ash eucalypts are fairly heavy and more difficult to glue than soft species, but otherwise results have been reasonably satisfactory.

Booth: This tannin extractive trouble does occur in the ash type eucalypt. It must be remembered we need a combination of two things: the right extractives and the low resin functionality. If you glue mountain ash with a resin of functionality 3, this trouble does not appear.

Plomley: We have done a small amount of work on karri, testing the effect of extraction on bonding; so far, no benefit from extraction processes has been observed. We have not obtained any great difference in bond strength between heartwood and sapwood of that species.

Booth: Our tests on karri show it is not subject to this trouble.

Item 9(b)

WATTLE TANNIN ADHESIVES*

At an early stage in our investigations of wattle tannin as an adhesive base it was discovered that simple formulations of tannin formaldehyde could give a satisfactory bond with a number of veneer species. With other species in this experiment, it was necessary to add a small proportion of a special synthetic resin (a resorcinol phenol formaldehyde) in order to obtain uniformly good results. Resorcinol phenol formaldehyde, when added at the rate of 10 to 15 per cent., greatly increased the number of species which could be bonded satisfactorily, but even so there were still a few difficult ones.

Since the last Conference we have been working on this problem. Attempts to increase the adhesive properties of the tannin have not resulted in any great improvement; methods of accelerating the tannin-formaldehyde reaction have been found, but no very substantial

*Prepared by K. F. Plomley.

increase in bond strength has been achieved. Recent investigations, therefore, have been mainly concerned with fortifying resins.

Bond strength in a number of species can be improved by increasing the proportion of fortifying resin, but unfortunately the cost of the resorcinol phenol formaldehyde resin does not permit this to any great extent. We have, therefore, turned our attention to phenol formaldehyde resins, which were also used in our early work with mangrove tannin. With these resins there is a major problem in combining dispersibility at the desired conditions with a sufficiently short cure time to suit commercial production, but the results of some recent work indicate that the problem may be capable of solution. At the same time we are arranging to carry out commercial trials with suitable veneer species using our resorcinol phenol formaldehyde fortifier.

Laboratory tests have shown that unfortified tannin formaldehyde is a satisfactory bonding agent for particle board when a flat pressing technique is used. A commercial trial at a plant producing an extruded board was only partly successful as the bonding of the thicker boards was not completed in the press. Methods of accelerating cure developed in the laboratory were very successful in experimental flat pressed boards, but other properties of the adhesive were changed and caused difficulties in making the extruded board. Viscosity and tackiness were largely affected. (See Table on P.288.)

Discussion

Booth: Radiata tannin is a valuable reactive material, cold-setting waterproof joints can be made with it. In co-operation with the Division of Forest Products, Mr. Hertzberg from our Division made plywood up under semi-commercial conditions using the Division of

EFFECT OF VARYING CONCENTRATIONS OF FORTIFYING RESIN ON THE BOND STRENGTH OF A TANNIN ADHESIVE WITH DIFFERENT VENEER SPECIES

Species	Shear Strength (lb/sq.in.) and Wood Failure (%)							
	Tested Dry				Tested Wet*			
	Unfortified	Resin 10%	Resin 20%	Resin 30%	Unfortified	Resin 10%	Resin 20%	Resin 30%
Hoop pine	388- 93	370- 97	362- 92	378- 89	250- 92	305- 86	290- 90	300- 90
Borneo cedar	293- 88	321-100	309- 92	313-100	233- 87	302-100	307- 94	277-100
Karri	307- 34	289- 34	305- 44	345- 48	+ +	212- 45	213- 64	246- 48
Ramin	314- 62	356- 63	373-100	387- 92	259- 73	274- 64	238- 65	259- 80
Coachwood	347- 43	- -	420- 89	409- 92	300- 80	- -	340- 98	405- 96
Mountain ash	330- 91	324- 71	344- 93	361- 97	248- 99	241- 98	250- 98	242- 99

*After boiling for 72 hr.

+Delaminated.

Forest Products equipment. This test embraced a number of species and other factors. Summarizing the preliminary evaluations; in general, the tannin formaldehyde adhesives performed equally with a phenol formaldehyde resin tried alongside it. There were some differences; phenol formaldehyde was better on some species than the tannin, but both adhesives were unsatisfactory on karri. An interesting point is that the radiata tannin formaldehyde adhesive as we have formulated it, is not suitable for the gluing of radiata veneer. In the semi-commercial tests there were no problems in spreading and handling. Exposure tests on radiata tannin plywood have been commenced, but have only been exposed for about 18 months.

Bryant: There is quite an amount of Pinus radiata bark being burnt in Australia, and it is about time the industry started thinking of extracting it. To date everyone seems too busy with other problems to devote time to this work. I would suggest that Mr. Hillis, Mr. Booth and myself endeavour to interest a few people and try to get them to extract a few tons of this material on a semi-commercial basis.

Hillis: I would like to see Pinus radiata bark used but we should remember that a large production of extract is necessary with the usual method of production in order to keep the costs competitive. At present, the process is not economical when the production of extract is below 2,000 tons p.a., and we do not have the resources of pine bark in one area to produce this amount of extract. Attention will have to be given to other methods of producing the tannin extract.

Bryant: As far as I know the paper companies are making no effort to investigate methods of extraction.

Hillis: Another thing which would hinder this question is the patent problem.

Plomley: We have had satisfactory results bonding radiata with unfortified wattle tannin, and reasonably satisfactory results bonding karri with a fortified wattle tannin adhesive.

Item 9(c)

DISTORTION IN VENEERS AND PLYWOOD AND ITS REMOVAL*

(a) Effect of Moisture Content Changes During Bending of Veneers along the Grain

When veneers are dried without physical restraint a change of form tends to occur to accommodate the differences in shrinkage which may take place for various reasons. In commercial practice the final distortion present is a function of the veneer qualities, drying conditions and the amount of physical restraint applied by fingers, rollers or belts during drying.

The forces required to hold cross grained veneers flat during drying have not been fully investigated, but it is known that the restraining force necessary is only a fraction (perhaps 1/5 or 1/10) of that required to flatten a sheet after distortion has developed. Late in 1958 preliminary studies of flattening of buckled veneers by hot pressing techniques led to an investigation of the reverse problem - that of development of bends in veneer parallel and at right angles to the grain direction when moisture content is changed. Experimental conditions were established by bending 12 in. long samples of 1/16 in. veneer in 10 in. frames and measuring the amount of residual deflection remaining after release from these frames following various treatments.

It was found that at constant moisture content conditions the veneers accepted deformation more slowly than when moisture content was falling. In experiments conducted at 120°F, the residual deflection expressed as per cent. of maximum preload was 39 per cent. after $2\frac{1}{2}$ hr treatment in material maintained at constant 7 per cent. and 51 per cent. for material maintained at constant 20 per cent. e.m.c. conditions.

*Prepared by J. W. Gottstein and A. Stashevski.

After the same treatment time some material which was dried from 15 per cent. to 7 per cent. moisture content showed a deflection of 79 per cent. The "setting" reached a maximum rate of 5 per cent. per min over the first 5 min of redrying, whilst the moisture content fell 2.2 per cent.

It was observed right throughout this work that the increasing residual deformation was closely correlated with loss of moisture. During the cycling of veneers from 5 per cent. to 15 per cent. moisture content at 120°F, all veneer strips have shown that with the exception of the first absorption cycle most of the increase in deformation occurred during desorption. Every subsequent adsorption caused slight relaxation and every subsequent desorption a further increase.

At 150°F, however, the maximum residual set obtained after one complete cycle was approximately 10 per cent. greater than the maximum set obtained after multiple cycling at 120°F level, bringing the residual deformation within less than 5 per cent. of the maximum possible preload deflection of 3½ in. There was no increase with further cycling and there was also no further increase in the amount of permanent set in veneers treated in a reconditioner at 212°F saturated and redried at 180°F even with repeated cycling.

It was also shown that once set veneers will accept further deformation when the stress is increased. Veneers previously bent in 10 in. wide frames have accepted an additional 35 per cent. set while going through a second stage of bending in 5 in. wide frames. The cycling was conducted at 150°F and the final set reached 98 per cent. of the new maximum preload. No further increase in bending stress was attempted on these veneers, but it is felt that the limits to which the veneer specimens could be bent was not reached.

Scout studies on transverse sections have indicated a similar moisture loss-set relationship, but 1/16 in. veneers loaded in tension and measured over 24 in. spans have shown relatively small deformations, not of a permanent nature and with little similarity between species. It seems likely that most of the set acceptance is occurring in compression.

(b) Effect of Longitudinal Shrinkage on the Stability of Plywood

A common distortion observed on plywood assemblies from mixed species was a longitudinal bow. This type of distortion suggested an effect of differential hygroscopic movement along the grain and a survey was undertaken to determine the extent of shrinkage or swelling which can be expected in this direction.

The results of the survey (see appendix) based on species which are frequently used as face material have shown that the magnitude of the movement varies quite considerably between species but can be of the order of 0.45 per cent. in straight grain and superficially normal material. Against this some of the species have shown only 0.1 per cent. movement over the whole hygroscopic range of moisture content. Measurements were made on a 50 in. span.

Unlike tangential or radial shrinkage, which is in lineal relationship to the moisture content below the fibre saturation point, almost all of the longitudinal shrinkage occurs below 15 per cent. moisture content, and in most of the hardwood specimens tested a high proportion occurs below 10 per cent.

The presence of compression wood in some conifers, and cross grain in hardwoods seems to change this pattern towards the normal transverse shrinkage.

Some tests were also conducted to determine the rate at which the longitudinal movement occurs in swelling. These tests have shown that low and medium density species in 1/32 in. thickness will complete their total swelling movement in approximately 20-30 min, provided one face of the veneer was maintained saturated. More dense species required 1 hr or more.

(c) Unstable Reversible Twist Distortion "Twang" and its Removal

The name "twang" was given by the industry and describes the facility with which the direction of this distortion can be reversed with the appropriate sound. It occurs chiefly in hot pressed plywood.

Investigations have shown that this form of buckling does not necessarily appear immediately after hot pressing. It may appear some time later and quite often is first observed when the plywood is released from bundles by the consumer.

Since change of stress pattern during and after hot pressing was suspected as the cause of this distortion, a careful analysis of stress distribution was carried out which has shown that in a "twanged" sheet the central area is in a state of tension with the periphery in compression.

This distortion has been found most prevalent in species showing large longitudinal shrinkage movement and pressed at high temperatures which cause appreciable moisture content reduction. It has been shown earlier that sets can develop along and across the grain as moisture is lost, so that under severe hot pressing conditions in which moisture gradient pattern is developed over the sheet area set patterns must occur which produce the conditions of peripheral compression when moisture contents are equalized.

Since the twang distortion is caused mainly by stresses working in the surface area of plywood and the basic symmetry of construction is usually sound in twanged material, it was reasonable to assume that the results of the veneer bending and flattening study could be used here for the flattening of distorted sheets. This idea was tried out under laboratory and commercial conditions with good results.

Twang problems can be minimized and sometiess eliminated by -

(i) the use of minimum suitable temperatures,

(ii) the use of minimum suitable pressing cycles,

(iii) wetting of all edges immediately after pressing and prevention of edge drying during block stacking.

Note:- See longitudinal shrinkage tables on pp.295-6.

Discussion

Cokley: The mills will very shortly work on the lines of extreme selection of species as far as these properties are concerned. Just how practical do you think this is going to be ?

Gottstein: Troubles are being experienced and this work will show which species can be used best in combination, and is proving that people with a variety of species are able to choose better combinations and avoid troubles that they had before.

Booth: I would like to emphasize the importance to the industry of this work on longitudinal shrinkage of species. In these days, plywood and solid core products are being used under more critical conditions in air conditioned buildings. Often they are used as barriers between areas with air conditioning on one side and not on the other. The use of fancy veneers with little distortion is desirable but selection is becoming increasingly difficult. Any methods to reduce the longitudinal shrinkage of species which are prone to it, for instance Queensland maple, even if such methods were somewhat expensive, could prove to be economical in the high grade architectural field.

(Continued on p.297.)

LONGITUDINAL SHRINKAGE OF VENEERS

Species	Thickness (in.)	Grain	Moisture Content Change	Movement in 50 in.	Movement (%)	Per Cent. of Total Movement
Sliced ash eucalypt	.032	Straight	0 - 8%	3/64	.09	75
			8% - wet	1/64	.03	25
			wet - O.D.	1/16	.12	100
Sliced maple	.040	Straight	0 - 8%	15/128	.23	80
			8% - wet	1/32	.06	20
			wet - O.D.	19/128	.30	100
Rotary Borneo cedar	.064	Straight	0 - 8%	3/32	.19	85
			8% - wet	1/64	.03	15
			wet - O.D.	7/64	.22	100
Sliced Sapele	.027	Straight	0 - 8%	1/16	.13	90
			8% - wet	1/128	.01	10
			wet - O.D.	9/128	.14	100
Sliced Guarea	.027	Straight	0 - 8%	9/128	.14	45
			8% - wet	3/32	.19	55
			wet - O.D.	21/128	.33	100
Sliced Guarea	.027	Curly	0 - 8%	5/32	.31	70
			8% - wet	1/16	.13	30
			wet - O.D.	7/32	.44	100
Myrtle beech sliced	0.032	Straight	0 - 8%	0.13	0.26	67
			8 - 12%	0.02	0.03	9
			8 - wet	0.06	0.12	33
			wet - O.D.	0.19	0.39	100
Queensland walnut sliced	0.033	Straight	0 - 8%	0.09	0.18	80
			8 - 12%	0.01	0.02	9
			8 - wet	0.02	0.04	20
			wet - O.D.	0.12	0.24	100
Silky oak rotary	0.063	Straight	0 - 8%	0.09	0.19	80
			8 - 12%	0.02	0.04	17
			8 - wet	0.02	0.05	20
			wet - O.D.	0.11	0.23	100
Anisoptera	0.035	Straight	0 - 8%	0.08	0.17	80
			8 - 12%	0.01	0.02	10
			8 - wet	0.02	0.04	20
			wet - O.D.	0.10	0.21	100
Silver quandong	0.061	Straight	0 - 8%	0.11	0.22	71
			8 - 12%	0.03	0.06	20
			8 - wet	0.05	0.09	29
			wet - O.D.	0.16	0.31	100

LONGITUDINAL SHRINKAGE OF VENEERS

Species	Thickness (in.)	Grain	Moisture Content Change (%)	Movement in 50 in.	Movement (%)	Per Cent. of Total Movement	Remarks
Radiata pine	.064	Straight	0-8 8-12 8-wet wet-O.D.	0.08 0.01 0.04 0.12	0.15 0.02 0.09 0.24	63 10 37 100	
Bindang (Island Kauri)	.064	Straight	0-8 8-12 8-wet wet-O.D.	0.07 0.02 0.04 0.11	0.14 0.37 0.08 0.22	62 17 38 100	
		Straight	0-8 8-12 8-wet wet-O.D.	0.08 0.08 0.23 0.31	0.17 0.15 0.46 0.63	27 24 73 100	Compression wood present
North Queensland Kauri	.064	Straight	0-8 8-12 8-wet wet-O.D.	0.08 0.03 0.09 0.17	0.16 0.05 0.17 0.33	47 15 53 100	
		6° grain deviation	0-8 8-12 8-wet wet-O.D.	0.06 0.04 0.16 0.22	0.11 0.07 0.31 0.42	27 17 73 100	
		Straight	0-8 8-12 8-wet wet-O.D.	0.12 0.07 0.30 0.42	0.24 0.14 0.60 0.84	29 16 71 100	Severe compression wood present
New Guinea Klinki Pine	.064	Straight	0-8 8-12 8-wet wet-O.D.	0.07 0.01 0.03 0.10	0.13 0.03 0.07 0.2	67 13 33 100	Heartwood
		Straight	0-8 8-12 8-wet wet-O.D.	0.07 0.01 0.04 0.11	0.14 0.03 0.08 0.22	66 13 34 100	Sapwood
Yellow Walnut	.064	Straight	0-8 0-12 8-wet wet-O.D.	0.04 0.006 0.03 0.07	0.09 0.01 0.05 0.14	64 9 36 100	
		Curly grain	0-8 8-12 8-wet wet-O.D.	0.09 0.03 0.09 0.18	0.19 0.07 0.18 0.37	51 18 49 100	

Gottstein: We have done some work in regard to the elimination of transverse shrinkage, and everyone is aware of the problems involved. On the question of reducing longitudinal shrinkage, I think it is an interesting point but the best approach could probably be through a better understanding of the differences in longitudinal shrinkage pattern between species. On the longitudinal shrinkage we have not got linear movement from 0 to intersection point of about 30 per cent., but we have something very different with an intersection point of about 16 per cent. It is possible that an awareness of this in handling the species will do a lot to obviate these particular difficulties. As Mr. Booth points out, where air conditioning is used, surface e.m.c.'s may fall. Under such conditions, the use of some shrinkage control by a material like polyethylene glycol could be very desirable.

Stashevski: Another aspect we want to look into is the actual forces developed when longitudinal shrinkage or swelling are restrained. We have done some preliminary tests on the Wood Chemistry rheometer, but more work is necessary. I am sure positive results could be obtained by measuring the forces in different thicknesses of veneer and different species under changing conditions.

Booth: I think it would be better to eliminate longitudinal shrinkage by eliminating hygroscopicity of the wood or by using some material like polyethylene glycol.

Item 9(d)

NEW SOUTH WALES PLYWOOD PROBLEMS IN RELATION TO OVERALL RESEARCH*

The New South Wales plywood industry consists of two broad groups of manufacturers -

(i) Those who manufacture plywood in Sydney from imported logs, and

(ii) those who make plywood from logs purchased from the New South Wales Forestry Commission.

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*Prepared by H. Booth.

There are instances of overlap of the two types.

Practically all manufacturers with one notable exception are members of the Australian Plywood Board and thus contribute to and receive benefits from the research carried out by the Division of Forest Products for the Board.

It is this Division's aim to assist the manufacturers of Class (ii) who use our raw material in order to assure continuing profitable sale of this raw material to them.

We are anxious to ensure that -

(i) The New South Wales firms receive the maximum assistance in overcoming local problems of raw material use.

(ii) This research and assistance by the New South Wales Commission is not seen as a substitute for but as something extra to the Plywood Board research. For this reason it is necessary that some sort of liaison in research programme planning be attempted. At present, we cope with this by personal contact with the manufacturers concerned to try and prevent overlap but if some better liaison could result we would be happier, without encroaching on the desire of the Plywood Board to keep results within its own membership.

Discussion

Booth: What is the position about using information in Plywood Technical Notes ?

Elliot: I can see no difficulties in this regard.

Gottstein: The Division of Wood Technology already gets Technical Notes, but does not get the 6-monthly reports to the Australian Plywood Board, but this information is largely the same as our Quarterly Report which New South Wales does get.

Item 9(e)

PARTICLE BOARDS*

Manufacture of particle boards is now established in two States of Australia and captive plants making particle board panels are running or projected in several other instances.

We are interested in promoting the use of radiata tannin as an adhesive for particle boards and have carried out some preliminary research on these lines at the Division. This work shows that radiata-tannin formaldehyde is generally suitable for making particle boards by the Behr process. Compared with U.F. boards made under the same conditions modulus of rupture is about the same and internal bond strength appears to be higher. There are some problems to be overcome in devising sensitive tests for use in improvement of the product under laboratory conditions.

We are also faced with the problem of chipboard testing from the users point of view particularly as imported boards are flowing into the country from such diverse places as Ireland and Dutch Guiana. We have equipped ourselves with apparatus for A.S.T.M. tests on particle boards but there appears to be need for some thoughts on standardization of test methods for Australian conditions.

We thus present for discussion at the Conference:

(i) To what extent should fundamental research on particle boards be initiated in Australia.

(ii) How best can the use of radiata tannin be promoted as a bonding agent for chipboards?

(iii) What methods of acceptance testing for chipboards should be used in Australia.

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*Prepared by H. Booth.

Discussion

Gottstein: With respect to research on gluing problems with particle boards, there is no doubt that work is desirable; for example, the tremendous gluing surfaces raise interesting problems and such work would be of value to industry.

Wright: I am not so sure about the urgency of work on the seasoning equipment side as there has been some fine work done overseas on driers. I am concerned, however, about the inadequacy of methods for determining moisture content and the lack of knowledge on moisture content effects, as these are major factors in production. At present, we just do not know the best way to control moisture content.

Turnbull: How much should we commit ourselves in this field ? If you want to look into questions of manufacture of particle board, several organizations in the particle board field with a large background of experience can give you enough information to get you started. If economic factors favour this, detailed investigations may be justified to correlate properties with procedures of manufacture. However, I am interested in the question of standardization and I am sure that the S.A.A. would cover particle boards in its programme if it is requested to do so.

Bryant: We have already been asked by C.S.R. to help them with some of the problems associated with using this young pine at Oberon. The stability of the board does not equal the stability of the boards they originally introduced into Australia before they put their own on the market. Since in Australia we will be concerned with using young pine thinnings to make this material to an increasing extent, then research people should concern themselves with how best they can use this locally produced material.

Crane: A particle board industry utilizing radiata pine thinnings is being established in Tasmania and anything that can be done to establish this product on the market will be of interest to us.

Richardson: When particle board first came into Britain, foresters were particularly delighted - this was the answer to all their problems with early thinnings. But as things turned out, it was not the answer and they soon discovered that you cannot use any rubbish for particle board. There are quite high requirements in the wood substance used, and I think the same is true in New Zealand. There is one particle board plant in New Zealand producing an inferior product that is not helping to develop a market. I think we need to recognize that particle board does require a specialized material. We do not know nearly enough about it, particularly about the wood structure requirements for the material. We should, therefore, be inquiring just what are the wood properties necessary for good particle board as opposed to low quality particle board.

Elliot: I would like to hear some ideas on the potential of certain eucalypt timbers for particle board.

Bryant: I think I can say that at the moment there would be no possibility of using eucalypts successfully in place of pine - purely on a weight basis.

Gottstein: I think there are definite indications from overseas experience. Some American plants have got into trouble through not using species of appropriate density classes.

Chairman: Are you planning to do some basic research Mr. Bryant ?

Bryant: Not necessarily, we plan to explore the field. We were helping C.S.R. as regards tannin formaldehyde - in the exploitation of tannin bark, but in regard to dimensional stability - I do not think we will be able to help them. A more fundamental approach is desired.

Chairman: I think you will agree that we should watch that aspect of it as far as possible in connection with our own programme to see if something can be done on the fundamental side - especially on the wood structure side.

Gottstein: I feel that apart from the actual species effect, there are a number of rheological problems associated with the formation of particle board; those associated with the stress pattern and moisture content change during pressing that I mentioned this morning.

Item 9(f)

THE NEED FOR BASIC RESEARCH ON ADHESION*

The trend in wood utilization is more and more towards reduction of the solid wood to a chip or pulped form and reconstitution of the material either by self bonding or with the use of an added adhesive.

While a certain amount of research on adhesives is carried on by adhesives manufacturers in Australia and by overseas affiliation, this research pursues generally the aim of selling a particular chemical product to the wood industry. Thus there arises the conflict of interest in the rational development of tannin adhesives.

Likewise, the performance of adhesives such as urea formaldehyde is hedged with mystique and commercial secrecy.

It is unreal to think that the plywood industry to say nothing of the chipboard industry can really flourish when basic research on one of its basic raw materials, viz. urea formaldehyde resin is not being carried on in a fundamental way. We are working

*Prepared by H. Booth.

actively on the fundamentals of one of the raw materials - wood, but we are forgetting about the other one, the adhesive, and yet it is equally as vital in the final utilization.

We have done some work reported earlier on the process of gluing wood with phenols and we propose to continue and develop this work as far as we are able. We have also carried out some similar work on adhesion of other glues to wood.

To pursue this work further we need studies on polymerization phenomena in mixed wood substance - resin systems. Studies of hydrogen bond formation in model systems, etc. Adhesive research on wood needs to be lifted from the empirical chemistry field where it now is to the field of physical chemistry.

Discussion

Chairman: We were doing some work in this field some years ago, but it has been restricted since. However, we are now planning to get back into this field and the question of adhesion will be looked at by our Special Investigations group. We hope that we may be able to report some progress at a Conference 2-5 years hence.

Wickett: Bunnings are having trouble with the gluing of karri in their glued laminated constructions and any work that can be done on this question will be of considerable interest to us.

Item 9(g)

PRESERVATIVE TREATMENT OF VENEERS*

(a) Additions to Gluelines

(i) Dieldrin

Dieldrin was added as an aqueous slurry at the rate of 0.5, 1.0 and 5 parts per 100 parts of liquid phenolic resin. Even at the

*Prepared by J. W. Gottstein.

lowest level a slight decrease in strength occurred and at 1.0 and 5.0 parts, strength reduction was serious.

Dieldrin in three forms - a wettable powder, a homogenized suspension and a colloidal suspension - was added at the rate of 0.35 and 0.7 parts per 100 parts of a liquid urea resin. There was no significant difference between controls, the wettable powder and the homogenized additions, but the colloidal material gave a significant decrease.

(ii) Chlordane

Chlordane added at up to 4.0 parts per 100 parts of liquid phenolic resin did not reduce bond strength, but earlier tests gave reductions at 5 parts addition.

(iii) Arsenic

Previous work has shown that arsenic as the trioxide can be used safely up to 5 parts per 100 parts of liquid resin with several adhesives without deleterious and sometimes with beneficial results.

(iv) D.D.T.

Plywood assembled with D.D.T. added to casein glue has given no borer infestation in a laboratory office after 10 years' exposure.

(b) Gluing of Treated Veneers

(i) Boron

Small additions of borax to a number of commercial phenolic resins produced remarkable changes in both pH and gelation characteristics. It is possible that this activity could be used in glue formulation.

(ii) Sodium Fluoride

No report of difficulties with borer attack have been received since the extensive use of this chemical for exterior grade plywood in New South Wales. One or two reports of gluing difficulties were associated with mixed species in the plywood assemblies.

(iii) Copper Borate

Coachwood veneers treated by instantaneous dip-diffusion gave significant reductions in bond quality.

(iv) Ammonium Phosphate

Shorea veneers treated to $2\frac{1}{2}$ lb retention by a single instantaneous dip-diffusion gave satisfactory bond quality with liquid and film phenolics, but retentions of 4 lb/cu.ft. obtained by double dipping reduced bond strength.

(v) Copper-Chrome-Arsenicals

Work on the influence of several variables on the bond strength obtainable by instantaneous dip-diffusion treating methods was initiated. Good bonds have been obtained with hoop pine, coachwood and Shorea at retentions up to 1.4 lb/cu.ft. in 1/16 in. and 1/10 in. veneers. Moisture content was the most critical variable.

Discussion

Edwards: I would like to ask Mr. Gottstein if there are any special techniques that have been found necessary to get a satisfactory adhesion with copper-chrome-arsenicals at concentrations in excess of 0.75 lb. Secondly, I would like to ask his opinions on toxic hazards, as far as arsenic is concerned during sanding operations.

Gottstein: On the first question, within the species and tests that I have mentioned, the indications were that with Shorea spp. good bonding can be obtained with good control. Very bad bonds may be obtained with poor control, but up to 1.4 lb we were satisfied with the result. On the question of toxicity in sanding, one imagines that much must depend on the solubility of the copper-chrome-arsenicals, how well they are fixed, and how well the dust extraction is carried out.

In regard to the fluoride question, we have a request from the Plywood Board asking why sodium fluoride is rejected in Queensland; would Queensland like to comment ?

Jennings: This is not an approved treatment in Queensland. The Department is not willing to go against the Department of Public Health's advice.

Item 10(a)

STANDARDS FOR UNDERFLOOR VENTILATION*

Complaints regarding poor underfloor ventilation average about two per week in this Division. As most of these are concerned with the appearance of mould, apart from cupping of floors, it would seem that present recommendations as entailed in the Local Government Act (Ordinance 71 in New South Wales) are too low or not sufficiently precise to be properly applied.

Apart from the poor utilization of timber in such positions, the use of wood itself as flooring faces a continued threat from concrete. This has been suggested as being an attractive alternative in the case of large halls and office blocks where the architect has had such difficulty with timber.

As an example of the vague type of specification in this matter, the following are the relevant paragraphs in Ordinance 71 (Clause 33 (a)(i)), which has been amended as late as 1951.

"Lighting and Ventilation Under Floors

33.(a)(i).- For the purpose of ventilation every shall be so erected that there shall be, between the underside of every joist upon which the lowest floor of such building is

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*Prepared by P. Marshall and D. Edwards.

laid, and the ground surface or upper surface of the asphalt or concrete with which the ground or site of the building may be covered, a space of 12 in. at least clear, except for bearers, in every part; and such space shall be thoroughly ventilated and cross ventilated by means of suitable and sufficient air-bricks or other effectual method to be set out in detail on the plans which will not permit the harbouring of rats: provided that where the lowest floor is so constructed (by filling with concrete, asphalt, or other approved material) as not to permit the harbouring of rats this provision shall not apply.

(ii). In cavity wall construction terra-cotta air-bricks shall be built into both sections of the wall and the wall shall be suitably sealed around the access opening to prevent the entry of rats into the cavity."

With such a specification, it is not uncommon, therefore, to find that architects, who appear to dislike the appearance of wall vents, leave them out especially along the front of a building. Elsewhere, there are only a few built into the sides and back, and these may, in cavity walls, have the two openings staggered horizontally or vertically. Internally, central solid dwarf walls, or filled solid floors may also render the vents totally ineffective.

The following results have been obtained in an experiment on subfloor ventilation. These are the moisture contents on sample boards placed just under the floor level in several adjacent subfloor spaces, 8 ft long, 18 in. wide.

Effective Vent Area	Vent Arrangement	Maximum Moisture Content of Side Boards	
		Cypress Pine	Tallowwood
47.25 sq.in.	One T.C. vent* each end, + 1 in side wall.	20 per cent.	16 per cent.
Nil	-	28 per cent.	31 per cent.
31.5 sq.in.	One T.C. vent* at each end.	19 per cent.	17 per cent.
Nil	-	32 per cent.	47 per cent.
33.0 sq.in.	28 circular holes in floorboards, 14 at each end. No wall vents.	38 per cent.	43 per cent.
E.M.C. of room proper		15 per cent.	15 per cent.

*Effective vent opening, 15.75 sq.in.

For effective venting of these areas, the following are the recommended opening sizes:-

Institution	Opening Size
C.S.I.R.O., Division of Forest Products	76 sq.in.
U.S. Federal Housing and Home Finance Agency	60.5 sq.in.
U.K. Building Research Station	28.5 sq.in.

C.S.I.R.O.	4 sq.in./lineal ft
H.F.A.	$2\frac{1}{2}$ sq.ft./100 lineal ft
U.K.	$1\frac{1}{2}$ sq.in./lineal ft

Suggestions.- Some standard be drafted for minimum vent areas for normal hazards. If the C.S.I.R.O.'s figures are taken, then for the ordinary T.C. vent, size 9 in. x 6 in., open area $4\frac{3}{4}$ sq.in. this would require almost a complete row of these around the building. In Sydney, many houses having about one vent per 6 ft appear to be sufficiently ventilated.

Such a standard would appear to depend on -

(i) Underfloor volume rather than area, and

(ii) number of air changes required per day, to maintain R.H. below say 70-75 per cent.

Discussion

Tamblyn: Although we have made recommendations from time to time on sub-floor ventilation, I have always regarded this as being more or less out of possible control, because there are so many factors involved, such as wetness of the site, shielding by other buildings, shrubs around the house and other impedances to air flow. While I sympathize with Mr. Edwards, I do not feel that a standard as he suggests would be the complete answer to it.

Bryant: We are trying accepted techniques, talking to Councils, writing articles for journals and so forth, and if there were enough intelligent inspectors, it could probably be policed quite adequately. A lot of timber rots because of inadequate ventilation and we are very concerned about it. We raised it not because we felt we could get any decision, but because we felt this committee which Mr. Tamblyn will be chairing can give some continuous thought to it. We can handle it on the ordinary public relations level in Sydney, but I do not think we would get very far.

Wymond: Mr. Edwards has mentioned that if this Division's figures are taken, almost a continuous row of terra cotta vents would be required around the building. That figure was set with the object of cutting out the use of these terra cotta vents and introducing the woven wire or steel type. Many terra cotta vents do not have the $4\frac{3}{4}$ in. free air space at all; some examined by us have had as many as 75 per cent. of the holes completely plugged.

Tamblyn: Woven wire or pressed metal ventilators are now very commonly used in Victoria. The woven wire type has a free air space of approximately 50 per cent. and are used as a spacing of 7 ft or more.

Jennings: After the war, the principal trouble in Queensland has been the use of these terra cotta vents. There has been a tendency lately to use aluminium louvres which have done a good job; they are attractive and also vermin proof. The Department has given considerable publicity to this question.

Huddleston: Some indication of the magnitude of this problem can be obtained from the Coff's Harbour shopping centre, where I was told that it was necessary to replace timber floors every 4 years, and these were out of what we regarded as durable hardwood. With regard to the question of trying to standardize on vents, spacings and types, I think we have an almost impossible task, as each has to be designed for the individual job.

Beesley: Some years ago we made a collection of over 50 different ventilators. Some were good, some fair, most of them were poor. That collection is still in the Division and is available for reference.

Item 10(b)

THE NEED FOR A NEW EDITION OF "BOAS"

Chairman: Regarding "The Commercial Timbers of Australia", there have been two editions and a reprint but it is now out of print again. We have definitely decided not to reprint it in its present form as it is out of date and has to be rewritten.

Bootle: The various Forest Services have a fund of information in pamphlet form but Education Authorities and industry want something available in book form which they can buy or use in schools. There is the very good C.S.I.R.O. design handbook on timber engineering, and also the Australian Timber Handbook which is about to be re-issued, but there is a very critical need for a thorough technical survey of timbers that are available in Australia. I feel that timber, because of this lack of information is losing to rival materials, and while I appreciate the difficulties, I feel that it is something that if Forest Products are not able to do, then somebody else should do in the near future.

Chairman: We all agree that we should do something about rewriting this text book, but we seem to need more than one book, the first to cover the fundamental side and the other the more applied side. In addition, in a third book we could include identification methods and the card sorting key. We have a small committee in the Division which will decide what is the best thing to do, and which members of the staff will have the job of preparing chapters for one or more books.

Item 10(c)

STANDARD NOMENCLATURE OF AUSTRALIAN TIMBERS

Hanson: We feel that before we can go any further with this nomenclature, there are some policy matters to be settled. For instance, should this nomenclature be a check list for all tree species or confined only to commercial species ?

Turnbull: I feel it should cover commercial timbers only. To cover every species that has been identified would be a much larger job than this particular project warrants. A check list is more in place in botanical literature than as a Standard and I would strongly support confining the latter to commercial species.

Muir: Some allowance should be made for potential use.

Jennings: We regard as being potentially useful any tree that reaches 1 ft diameter at breast height. A large number of Acacia species have potential use and it is surprising the number of them that are in fact used.

Bootle: At the present time we need a revision to bring the names up to date, with further revisions from time to time. To try to make it too comprehensive now would mean that much of it would not be used; additions can come when the species are actually used.

Turnbull: The original standard was first published in 1940. The first revision was nominal, the opportunity being taken to reinstate coachwood and alter some other names that had not become accepted. In 1948, the Standards Association agreed to the basic principle that if new names are added we endeavour to reduce rather than increase the confusion that is associated with calling timbers walnut, oak, mahogany, etc. when they are not really these timbers, and try to get fairly distinctive names attached to various genera. No definite ruling was made but people associated with the preparation of log lists appear to be following the principle as their proposals extend the use of satinash, quandong, wattle, etc.

Huddleston: Another problem we should not overlook concerns the New South Wales Marketing Act and Queensland Timber Users Protection Act. Some of the species listed in the schedule to the New South Wales Act are under trade names different from those listed in the standard. With other States contemplating the introduction of similar Acts, they will have the problem of including those timbers in the schedule to their Acts. Where we have legislation of that nature, we should use the same name and for that reason we should contemplate including some species which otherwise would not be regarded as being commercial species.

Jennings: In relation to the Queensland Act, the Department is considering listing those species that are not susceptible.

Beesley: There will be two schedules in New Guinea, one will be a list of botanical names and corresponding trade names, the second will be a list of either susceptible or non-susceptible species. The practice so far has been to use Australian trade names where possible for genera for which there is no local trade name so that the question of standardization of trade names is of vital importance to the Territory.

Chairman: Mr. Hansen, you have a list of commercial species to which a number will have to be added - some may have to be deleted. The States should provide a list of those they think should be added.

Hansen: Should species which are used for fence posts, oil production, gums, etc. be included ?

Chairman: No.

Turnbull: It is up to the States to prepare a list of what occurs in their forests; what are commercial and what are non-commercial, and try to get some reasonable agreement by correspondence to avoid duplication.

Jennings: Are the Standard Trade Reference names necessary ?

Chairman: I do not think we should continue to use the Standard Trade Reference names.

Jennings: There is general agreement on this.

Item 10(d)

CONFERENCES

(i) World Eucalyptus Conference.

(ii) British Commonwealth Forestry Conference.

In discussing the latter Conference, the Chairman asked whether there were any matters which should be brought to the attention of the Forest Products Preconference. Dr. Richardson mentioned several items which were being submitted by New Zealand.

(iii) Forest Products Research Conference

Bryant: With regard to the form of future Conferences, I suggest that the various States should suggest to the Division of Forest Products in advance the items which they wish to discuss, and that before the Conference starts an opportunity should be given for those who have specific interests to discuss them in the various Sections personally with the people concerned. Then, towards the end of the week, sessions should be held where the people who must make the decisions at the Conference consider relevant material which has arisen from the discussions within the Sections.

A Conference of this kind which takes a lot of time and costs a lot of money would pay more dividends if we gave more thought to these within-Section discussions.

Jennings: Visiting delegates certainly should have the opportunity at various stages of making contact with the Division of Forest Products officers, but the general form of this Conference has been suitable to us.

Benallack: We appreciate the opportunity to attend the Conference and like to retain the liaison between our Department and the Division.

Crane, Wickett and Richardson: Happy with present form of Conference.

Chairman: Called for comment re time of next Conference - 2 years suggested.