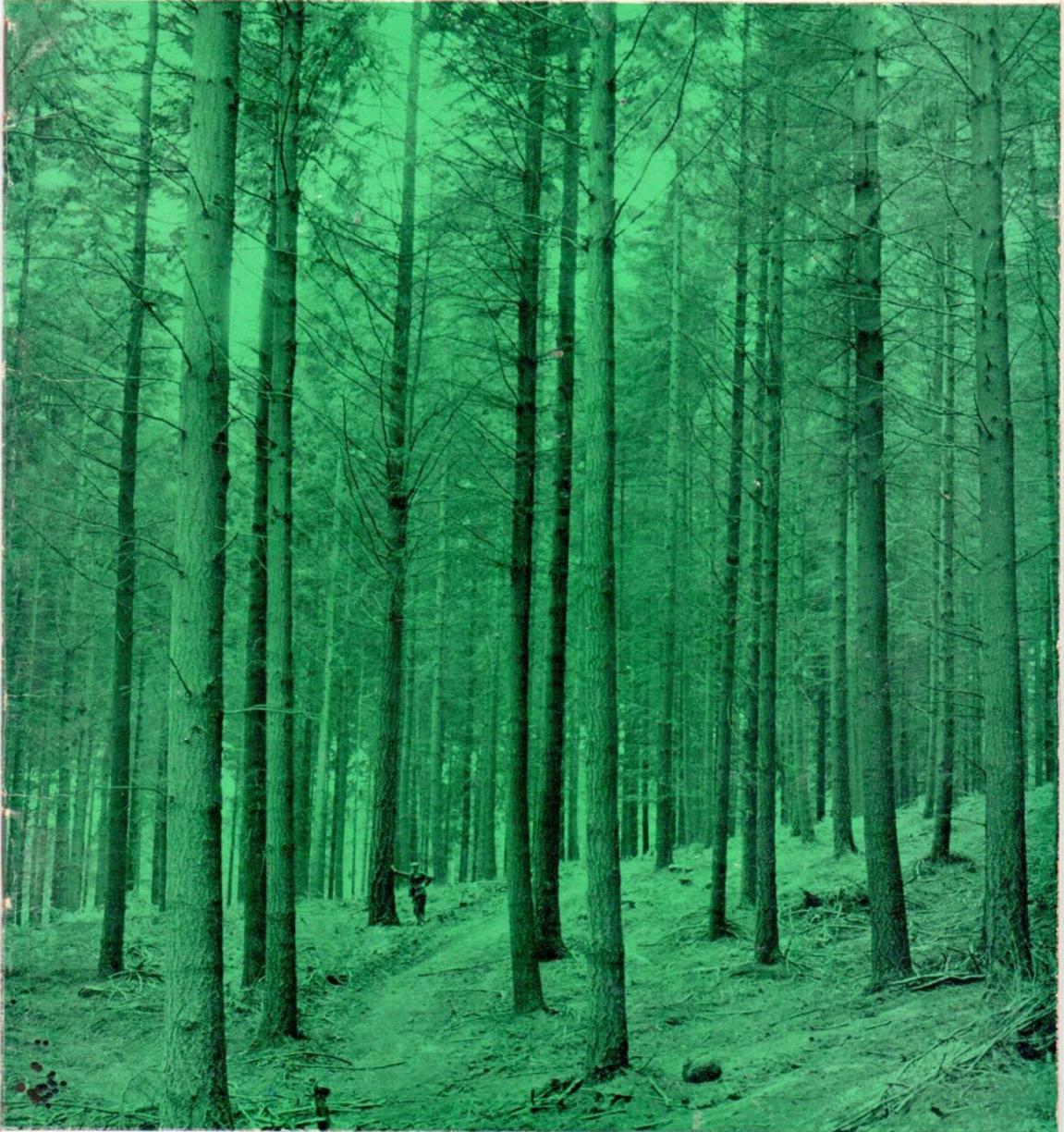


**Home-Grown Timbers**

# **Douglas Fir**



**Forest Products Research Laboratory**

Department of Scientific and Industrial Research  
Price 2s 0d net

*Front Cover.* A 50-year-old stand of Douglas fir in the Forest of Dean.  
(By courtesy of the Forestry Commission)

Department of Scientific and Industrial Research

*Forest Products Research Laboratory*

**Home-Grown Timbers**

**Douglas Fir**

London: Her Majesty's Stationery Office: 1964

## Foreword

*This is the first in a new series of publications on home-grown timbers. It provides a concise account of the properties and utilization of home-grown Douglas fir for the information of foresters and landowners, the timber trade and the timber-using industries. It shows how this important exotic conifer compares with other commercial softwoods and includes advice on how to make the best use of the timber for various purposes by suitable methods of seasoning, grading and processing. It supplies the answers to many of the questions that are asked about the properties and uses of Douglas fir and its place in home timber production.*

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October, 1963

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# Home-Grown Timbers: Douglas Fir

## Introduction

Douglas fir (*Pseudotsuga taxifolia*) was introduced to Britain from North America in 1826–27. On good sites it is capable of excellent growth, producing up to 12 000 Hoppus feet per acre by the time the stand is 50 years old. By comparison, Sitka spruce can produce about 13 000 Hoppus feet per acre and Scots pine some 7000 Hoppus feet in the same period.

The extent to which Douglas fir is planted is limited by its site requirements; in 1963 the total area in private and Forestry Commission woodlands was some 87 000 acres. Its distribution is unusually scattered, only a few counties containing more than 2000 acres. Most of the plantations over 60 years old are in Scotland, the younger ones mainly in Wales and south-west England. A typical 50-year old stand is shown on the front cover.

The timber has been regularly imported from British Columbia and the western United States since the first World War. It is commonly marketed as Columbian pine or Oregon pine, though the more appropriate standard name, Douglas fir, is becoming more general. The properties of the Canadian and American material are well known to the timber trade. However, timber merchants and users have had comparatively little experience of home-grown Douglas fir which is now available and will be offered in steadily increasing quantities both as poles and as sawn timber for building and general purposes.

It is well to explain that, because of the wide variation with size, age and conditions of growth, it is almost impossible to generalize about a timber without specifying the grade or quality under consideration; there is a vast difference between the knotty, wide-ringed core-wood (juvenile wood), the wood formed in middle life and the clear narrow-ringed outer wood (Fig. 1). The information presented is based on the results of laboratory tests and practical experience accumulated over the last thirty years or more. The test material was mainly "thinnings" (immature trees removed in the course of silvicultural thinning operations) which comprise the bulk of the timber now coming forward. Timber from the older and larger trees which will form the final crop will be generally of better quality, especially if the trees are pruned. The comparatively rapid growth of Douglas fir makes the pruning of this species an attractive proposition.

## General description

Douglas fir characteristically has a pinkish-brown heartwood usually of fairly uniform colour throughout (apart from the stripe effect of the denser summer wood bands); it lacks the yellowish or greenish tinge of larch, the only other common softwood likely to be confused with it. The pale sapwood is quite



Fig. 1. A cross-section of Douglas fir showing the typical growth pattern and the dense character of the wood formed in middle life

distinct, from 1 to 3 inches thick, average about  $1\frac{1}{2}$  inches, and without much variation between trees of different ages. Much of the sapwood is likely to be removed in the course of conversion to square-edged stock. In bulk the fresh timber has a spicy fragrance, but the dry wood is virtually odourless.

The annual growth ring consists of a pale-coloured spring wood followed by a denser reddish-brown summer wood, the two zones being clearly distinguishable except in a few rings close to the pith. In the majority of rings the summer wood comprises a third or rather more of the total width of the ring. It is the broad bands of dense summer wood that give Douglas fir its outstanding strength and incidentally make it rather hard to nail. Usually the summer wood is sufficiently distinct from the pale-coloured spring wood to produce a prominent growth-ring figure on plain-sawn surfaces (Figs. 2 and 4) and rotary-cut veneers. The average weight of the seasoned timber is 33 lb/cu. ft with comparatively little variation between consignments from a wide range of sites. Spiral or wavy grain is occasionally encountered but in general the grain is straight. Resin ducts are a normal feature of the wood but resin exudation is not often serious.

According to Canadian figures, Douglas fir is relatively long-fibred, the average length being nearly 4 mm, that is some 20 per cent longer than black spruce, the principal Canadian species used for pulp. Limited observations on home-grown Douglas fir indicate that the fibres are somewhat longer than those of Sitka spruce of similar age (average about 3 mm).

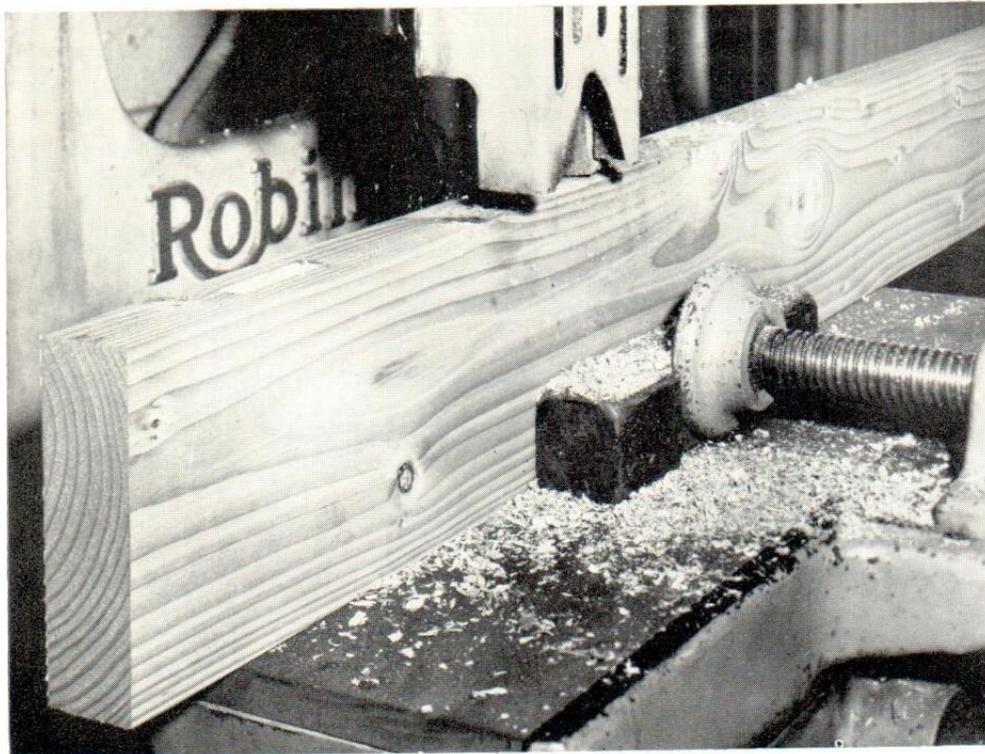


Fig. 2. A woodworking test showing the general appearance of the timber. A mortise is being cut with a chain mortiser in a piece of 6 × 2 in. home-grown Douglas fir.

## Seasoning properties

The sawn timber can readily be air-seasoned. Distortion during drying is slight, and although some end-splitting and surface checking may develop, these defects should not be serious. Encased knots have a pronounced tendency to loosen and about one-half of initially sound knots may be expected to split slightly. One-inch boards piled out of doors in the spring or early summer should dry to a moisture content of 16–18 per cent in about two months, and under average conditions two-inch material should be similarly seasoned by late autumn.

In kiln-seasoning, Schedule K\* has been found to give good results in so far as the timber seasons rapidly with relatively little degrade. There is a slight tendency for the colour to darken and for resin exudation to occur during seasoning, but not to an objectionable degree. If darkening is to be avoided a lower temperature schedule can be employed, but there is then a risk of resin exudation when the timber is put into use. With timber from mature trees little distortion is experienced, but boards cut from small thinnings are liable to cup and twist. The tendency to checking and splitting is small, but where resin pockets are numerous some of these may open during drying. Knots are generally

\* See *Forest Products Research Laboratory Leaflet No. 42, Kiln-Drying Schedules* (particulars on page 11).

the main cause of degrade in kiln-seasoning. Encased knots nearly always become loose, irrespective of the schedule employed, and a large proportion of sound knots split to a greater or lesser extent. The time required to kiln season two-inch material from the green condition to 12 per cent moisture content is about ten days when Schedule K is employed. If a milder treatment is deemed desirable on account of inferior quality or the need to prevent darkening of the timber, a rather longer drying period is inevitable.

Unlike Scots pine and Corsican pine, Douglas fir gives no trouble with the development of blue-stain or mould during seasoning.

The average shrinkage values for timber kiln-seasoned from the green to 12 per cent moisture content are:

Tangential . . . . .	about $\frac{1}{2}$ in/ft or 4.0 per cent
Radial . . . . .	about $\frac{5}{16}$ in/ft or 2.5 per cent

The movement of the seasoned timber in use is classified as small, the actual values being as follows:

Moisture content in 90 per cent humidity . . . . .	21 per cent
Moisture content in 60 per cent humidity . . . . .	13 per cent
Corresponding tangential movement . . . . .	$\frac{5}{32}$ in/ft or 1.3 per cent
Corresponding radial movement . . . . .	$\frac{1}{8}$ in/ft or 1.0 per cent

The small movement of this timber together with the virtual absence of longitudinal distortion render it suitable for purposes where relative stability are important.

## Strength and specific gravity

Douglas fir is the strongest and most dense of the softwoods commonly grown in this country with the exception of larch. The results of laboratory tests (Table 1) show that clear home-grown material is comparable to the imported Canadian timber except that it is appreciably less stiff (see the figures for static bending strength). Though similar to Baltic redwood in density it is appreciably stronger. These differences are reflected in the basic stress values of the timbers for structural use, as given in Table 2. These comparisons are on a "grade for grade" basis; the general run of home-grown Douglas is of course more knotty and yields a smaller proportion of high-grade timber than does the comparatively clear material cut from Canadian logs.

Extensive laboratory tests have also been carried out on Douglas fir thinnings in the round. The significance of the results in demonstrating the suitability of this species for pitprops and poles is discussed on p. 8.

The typical pattern of variation in specific gravity within the tree is much the same in Douglas fir as in other home-grown softwoods. From the central core of juvenile wood outwards there is a steady increase for twenty years or so, after which specific gravity remains fairly constant, though there is a tendency for it to decrease in the narrow-ringed wood formed in later life (Fig. 1).

TABLE 1

Summarized results of standard tests on small clear specimens (green and air-dried) of home-grown and imported Douglas fir and Baltic redwood (for comparison with other species see Forest Products Research Bulletin No. 45).

Description	Moisture content %	Nominal sp. gr.	Weight at		Bending					Compression		Hardness		Shearing		Cleavage	
			50 % m.c.	12 % m.c.	Static			Impact	Max. crush. strength	Side	Radial	Tangential	lb/2cm width	lb/2cm width	Radial	Tangential	
					Equiv. fibre stress at max. load	Modulus of elasticity	Work to max. load										Total work
Canadian Coast Douglas fir*	green 12	0.46 0.50	43	35	8 100 14 000	1590 1920	8.5 13.3	22.7 28.5	24 34	3930 7990	510 730	1030 1680	1050 1630	38 40	38 40		
Home-grown Douglas fir: (a) from mature trees	green 12	0.41 0.43	38	30	7 500 12 600	1240 1540	9.7 13.3	30.3 27.0	27 27	3470 6840	500 760	960 1660	1050 1480	38 40	38 40		
(b) from thinnings	green 12	0.42 0.44	39	31	7 900 13 700	1190 1510	13.0 14.7	36.3 22.9	29 28	3680 7170	580 790	1020 1970	930 1610	38 46	38 46		
Baltic redwood	green 12	0.41 0.43	39	30	6 400 12 400	1120 1470	10.1 14.4	27.1 17.2	27 26	3040 6810	430 580	870 1100	850 1000	30 45	34 50		

\* Tested at the Forest Products Laboratories of Canada.

TABLE 2

Basic stress values for home-grown and Canadian Douglas fir and Baltic redwood. The figures provide a basis for calculating working stresses for structural timbers. The method of deriving basic and working stresses from the results of tests on small clear specimens is explained in Forest Products Research Bulletin No. 47.

	Bending and tension parallel to grain	Compression parallel to grain	Compression perpendicular to grain	Shear parallel to grain	Modulus of elasticity	
					Mean	Minimum
Canadian Douglas fir	2200	1600	260	250	1 500 000	850 000
Home-grown Douglas fir .. .. .	2100	1500	250	200	1 300 000	650 000
Baltic redwood ..	1700	1200	220	200	1 100 000	600 000

TABLE 3

Ultimate design values for home-grown Douglas fir, Scots pine and European larch poles obtained from F.P.R.L. tests. The values for Scots pine and larch are quoted in B.S. 1990: 1953, *Wood Poles for Overhead Lines*.

	Ultimate extreme fibre stress	Modulus of elasticity
	lb/sq. in	lb/sq. in
Douglas fir .. .. .	9 100	1 860 000
Scots pine .. .. .	7 800	1 520 000
European larch .. .. .	10 000	1 640 000

## Durability and preservative treatment

In the log, Douglas fir, like most softwoods, is subject to attack by ambrosia beetles (pinhole borers) and longhorn beetles. It is possibly less susceptible to furniture beetle (*Anobium punctatum*) which attacks seasoned timber. It appears to be attacked only rarely by the house longhorn beetle (*Hylotrupes bajulus*).

Limited test results indicate that converted material is a little less durable than the imported Canadian timber. It is classed as non-durable which means that in the standardized field tests, using 2 × 2 inch specimens, it has had an average life of between five and ten years. Other common softwoods in this class are Scots pine and Baltic redwood, the spruces and western hemlock.

It is probable that the home-grown timber is not inherently less durable than the Canadian; the slight difference shown by test results may be attributed to the difference in the age of the trees which furnished the test material. The wood laid down early in the life of a tree tends to be less durable than that produced later on, so material from the much older Canadian trees would be expected to have a somewhat higher average durability than that obtained from the comparatively young trees available in this country. It is to be expected that the general run of timber from mature trees will compare more favourably with the imported material in this respect.

Home-grown Douglas fir is resistant to impregnation with preservatives, although on the average it is easier to treat than the Canadian material. It is one of the species used in the Laboratory's field tests on wood preservatives and the results have shown that when treated with an efficient preservative, such as creosote or a copper/chrome/arsenic formulation, it will remain in perfectly sound condition for at least 30 years, indicating that its useful life in service will generally be considerably longer than this.

## **Working properties**

The timber converts easily and boards have little tendency to spring on leaving the saw. A tendency to sweep and crookedness in the butt length and a rather pronounced taper in the upper part of the stem sometimes limits the length of logs where a good yield in conversion is required.

The working properties of the timber vary with the ring width and with the number, size and type of knots. Clear, straight-grained material with about six or more rings to the inch works readily and finishes well in most machining operations. Rapidly grown material with four rings or less to the inch, as commonly found near the centre of the tree, is somewhat milder in working but the spring wood tends to drag up in planing unless the cutters are sharp and to crumble in rip-sawing, producing a corrugated surface. The knots are hard and often loose; they are liable to make the use of hand tools rather difficult, are often troublesome in sawing and tend to cause damage and severe blunting on planer cutters with the normal sharpness angle of  $35^\circ$ . This damage can be largely prevented by providing a stronger cutting edge with a larger sharpness angle as formed in the jointing or tracking operation carried out on planing and moulding machines.

In general, the timber works readily with hand and machine tools but with a little less ease and a somewhat greater dulling effect on cutting edges than Scots pine of similar quality. Satisfactory results are obtained with circular plate rip-saws having 54 spring teeth with  $25^\circ$  hook. There is a tendency to chip-bruise in planing and moulding, and tearing occurs where the grain is disturbed by knots, but a reasonably good finish is obtained provided sharp cutters are employed. The use of dull cutters not only increases the amount of tearing but may result in grain-raising by compressing the soft spring wood which later expands and produces ridged surfaces. The timber is inclined to splinter and break away at the tool exit where the cut is across the grain and requires a little extra care to avoid splitting in nailing. It takes stain, varnish and paint satisfactorily.

## **Bending properties**

The results of limited laboratory tests indicate that the bending properties of home-grown Douglas fir can be classed as moderate; that is, the radius of curvature of specimens one inch thick, supported by a metal strap, is within the range 11 to 20 inches. Being a softwood, however, it is unlikely to be used for solid bends for furniture, sports goods, etc. Reasonably clear straight-grained material can probably be used satisfactorily for producing certain types of glued laminated structural bends (roof arches and the like) for which imported Douglas fir is employed.

## **Pulping properties**

Douglas fir is not generally considered suitable for acceptable grades of groundwood pulp, mainly because of the colour. It is successfully converted by a variety of mainly mechanical processes to pulps suitable for hardboard, insulating board and packaging board. In these applications certain constituents of the bark have been shown to impart particularly good properties of water-resistance to the finished product.

There is no definite information available on the pulping of home-grown Douglas fir for paper making. The fibres are long enough to give a paper with adequate strength properties (see page 2) but the large proportion of stiff summer wood fibres and the presence of coloured extractives are a disadvantage. However, bleached pulps suitable for printing papers, etc. may be made by means of the sulphate process. The species is relatively difficult to pulp by the acid sulphite process, but with some modified techniques, for example two-stage processing, pulps of acceptable quality are obtainable.

## **Summary of properties in relation to uses**

Most of the home-grown Douglas fir coming on to the market would be graded as suitable for carpentry, structural work, packing-cases and similar purposes, or for use in the round as poles, pit-props, fence posts, etc. There is little clear joinery-grade timber being produced today, but the proportion of this material will increase as greater supplies of large logs become available.

Douglas fir is appreciably stronger than Baltic redwood and is particularly useful for structural work. Its high compression strength in the round makes it suitable for pit-props. In this respect it is well above the usually accepted limit of 2240 lb/sq. in for pit props of standard proportions.

Traditionally the best timbers for transmission poles are Scots pine (including Baltic redwood) and European larch. Douglas fir, though slightly below larch in bending strength, is appreciably stiffer than larch and is both stronger and stiffer than Scots pine. In respect of strength, therefore, Douglas fir is excellent for poles. The main obstacle to its acceptance is that the sapwood is much less permeable than the sapwood of Baltic redwood, which is the standard timber for the purpose, so that the poles take longer to creosote and are more subject

to bleeding in service. The development of a method of treatment for Douglas fir poles which will overcome these difficulties is part of the Laboratory's current research programme.

Provided it has been given an adequate preservative treatment, for example, by pressure or the open-tank hot-and-cold process, small-diameter material from thinnings or tops makes excellent fence posts. Tests have shown that posts creosoted by either of the above methods can be expected to have a life of over 40 years.

Service trials have shown that, when properly creosoted, home-grown Douglas fir is satisfactory for railway sleepers. An incising treatment reduces the tendency to split (Fig. 3). It compares favourably with Scots pine and Baltic redwood, and although no direct comparisons have been made, it is believed that it would compare quite well with the Canadian timber.

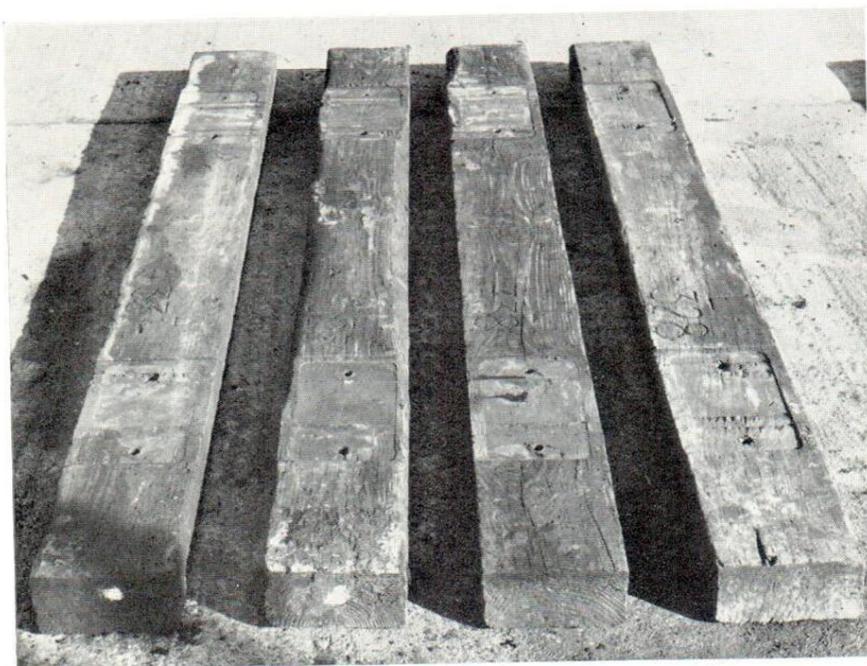


Fig. 3. Home-grown Douglas fir railway sleepers (creosoted and incised) after 18 years in the track

The sawn timber dries with relatively little degrade and is fairly stable; that is to say the dimensional changes under varying atmospheric conditions are small—less than in Scots pine and Baltic redwood.

The general run of the timber presents no special difficulties in sawing and working. In wide-ringed material, especially plain-sawn, the machined surface tends to be rather rough. Home-grown Douglas is slightly harder to work than Scots pine of similar grade and has a somewhat greater dulling effect on cutting edges.

Whether home-grown or imported, Douglas fir is harder to nail than most commercial softwoods, especially wide-ringed material with broad bands of dense summer wood, and has a tendency to split if nails are driven too near

the edges or ends. Splitting may be reduced by using smaller-diameter or blunt-pointed nails. Nails made of high-carbon steel are less likely to bend in driving and would be particularly useful in machine nailing, as in box-making, pallet-making, etc., and for nailing structural timbers on large contracts. When nailing by hand splitting is reduced if the point of the nail is blunted with a hammer blow as in general carpentry practice. For rough work the tendency to split in nailing can be overcome by using unseasoned timber.

Woodworking tests at the Laboratory have shown that selected material is suitable for joinery; the selection for this purpose aims at freedom from large or loose knots and a fairly slow rate of growth—eight or more rings to the inch, as required by *British Standard 1186, Quality of Timber and Workmanship in Joinery*. The proportion of joinery-grade material coming forward at present is small but it will increase as greater supplies of large logs become available.

The pronounced contrast between spring wood and summer wood makes Douglas fir specially suitable for shuttering (formwork) for *in situ* cast concrete where it is desired to improve the appearance of the finished work by imparting a texture to the surface. The characteristic growth-ring figure of the plain-sawn timber is accentuated by weathering, which erodes the soft spring wood; a similar effect can be obtained by machining with a specially prepared blunt-jointed cutter-block. The appearance of textured concrete cast against Douglas fir shuttering prepared in this way is shown in Figure 4.

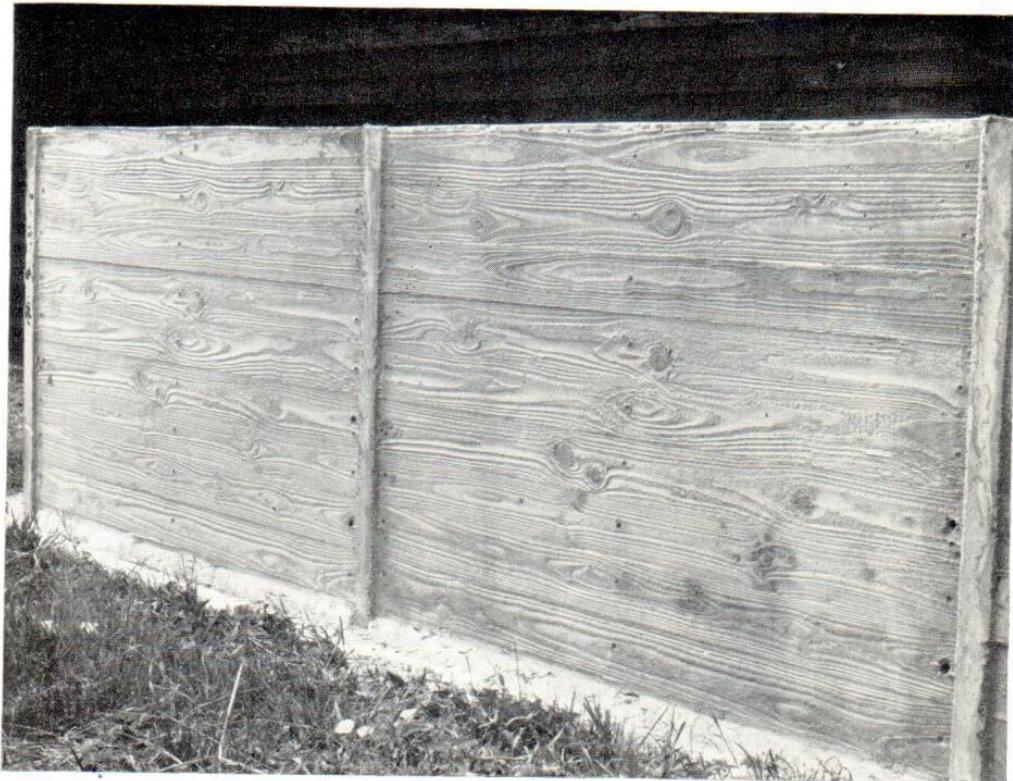


Fig. 4. Textured concrete cast against home-grown Douglas fir shuttering, showing the prominent growth-ring figure ("grain") of the plain-sawn timber

The home-grown timber is satisfactory for domestic and light industrial flooring. Quarter-sawn timber is to be preferred for this purpose as it wears more evenly than plain-sawn or random-sawn material.

Douglas fir from British Columbia is widely used for vat-making. The specification usually calls for clear quarter-sawn timber in long lengths, free from sapwood. Home-grown timber of this description would probably be equally good for the purpose but the quantity at present available is small. The same consideration applies to the use of the home-grown timber for the manufacture of plywood. The results of limited laboratory tests indicate that in the green condition the clear material forming the outer layers of large well-grown logs peels quite well, giving a smooth veneer.

For use in permanent structures exposed to the weather, in contact with the ground or in any other situation favourable to decay, Douglas fir should receive a suitable preservative treatment.

## Further reading

Further information on the properties and uses of home-grown Douglas fir and on methods of seasoning, preservative treatment, etc. is contained in the following publications obtainable from H. M. Stationery Office at the addresses on the back cover or through any bookseller. Prices in brackets include postage in the U.K.

### Seasoning

- The Treatment of Timber in a Drying-Kiln. *Forest Products Research Laboratory Leaflet* No. 20 (Revised 1957). Price 6d. (9d.).
- The Air-Seasoning of Converted Green Timber. *Forest Products Research Laboratory Leaflet* No. 21 (1942). Price 6d. (9d.).
- Kiln-Drying Schedules. *Forest Products Research Laboratory Leaflet* No. 42 (Revised 1959). Price 1s. 3d. (1s. 6d.).
- The Movement of Timbers. *Forest Products Research Laboratory Leaflet* No. 47 (Revised 1958). Price 6d. (9d.).
- Kiln Operator's Handbook—A Guide to the Kiln-Drying of Timber. Price 21s. (21s. 10d.).

### Strength

- The Strength of Nailed Joints. *Forest Products Research Bulletin* No. 41. Price 2s. 6d. (2s. 10d.).
- The Strength Properties of Timber. *Forest Products Research Bulletin* No. 45. Price 5s. (5s. 4d.).
- Working Stresses for Structural Timbers. *Forest Products Research Bulletin* No. 47. Price 1s. 3d. (1s. 7d.).
- Working Stresses for Structural Laminated Timber. *Forest Products Research Special Report* No. 15. Price 4s. (4s. 5d.).

**Durability and Preservative Treatment**

The Natural Durability of Timber. *Forest Products Research Record* No. 30. Price 2s. (2s. 3d.).

Non-pressure Methods of Applying Wood Preservatives. *Forest Products Research Record* No. 31. Price 2s. 6d. (2s. 10d.).

The Hot and Cold Open Tank Method of Impregnating Timber. *Forest Products Research Laboratory Leaflet* No. 11 (Revised 1958). Price 3d. (6d.).

The Preservative Treatment of Timber by Brushing, Spraying and Immersion. *Forest Products Research Laboratory Leaflet* No. 53 (1962). Price 8d. (11d.).

**Woodworking**

Handbook of Woodcutting. Price 3s. (3s. 4d.).

Circular Saws. *Forest Products Research Laboratory Leaflet* No. 23 (Revised 1959). Price 1s. (1s. 3d.).

**Uses**

Grading of Sawn British Softwoods. *Forest Products Research Laboratory Leaflet* No. 49. Price 6d. (9d.).

Timbers for Flooring. *Forest Products Research Bulletin* No. 40. Price 3s. 6d. (3s. 10d.).

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