STRENGTH PROPERTIES OF SOME KAURIS OF THE SOUTH-WEST PACIFIC
WITH SPECIAL REFERENCE TO FIJIAN KAURI

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Introduction

The kauri pines are native to the region extending from Malaya and Borneo into the South-west Pacific. About sixteen species have been described, but some of these are so much alike that they appear to be geographical forms of one variable species with the Amboyna pitch tree (*Agathis alba*) as the type. Some of the kauris of the S.W. Pacific have been considered to bear some affinities to this species. In particular, the Solomon Is. kauri (*A. macrophylla*), Queensland kauri (*A. robusta*), North Queensland kauri (*A. palmerstoni*), Fijian kauri (*A. vitiensis*) and New Zealand kauri (*A. australis*) have been considered to be closely related ; superficially their timbers are fairly similar.

Of these kauris in the S.W. Pacific, the most important economically are the New Zealand, the North Queensland, the Fijian and possibly the New Caledonian species (*A. lanceolata*). Apart from the N.Z., and only recently the North Queensland species, very little is known about the timber properties of these trees. The extent to which *A. lanceolata* is exploited is not known and details regarding the properties of its wood are obscure, the only reference being to the fact that it is similar to the Queensland kauri (*A. robusta*). The strength properties of the Fijian kauri were also not known, but it was always considered to be fairly similar to N.Z. kauri and potentially a valuable source of supply in the event of the other known kauris not being sufficient to supply the demand.

The possibility of such a shortage occurring arose with the increased demand for kauri during the early stages of the Second World War, and in 1940 the Forest Products Branch of the N.Z. Forest Service undertook the investigation of the properties of Fijian kauri for possible use in the ship-building industry.

General

The Fijian kauri or dakua (*Agathis vitiensis* Benth. and Hook. f.) is a medium to large sized tree which varies in height from 50 to 100 ft. and has a relatively stout trunk which tapers rather more than the N.Z. kauri ; the trunk may measure as much as 20 ft. in girth at breast height. Average trees range from 8 to 12 ft. in girth. Dakua is found only in the rain-forests which occur on the south-eastern or weather sides of the main islands, in particular Vanua Levu and Viti Levu ; it ranges from sea level up to an elevation of about 3,000 ft., with an apparent optimum between 1,500 and 2,500 ft.

It is perhaps the most important forest tree in Fiji and, although seldom numerically abundant, it dominates the forest in which it occurs and constitutes anything up to 35 per cent of the total volume.

Result of Tests

Standard strength tests were carried out on five logs, three being "D bolts" 12-16 ft. in height from average trees, and two being "C and D bolts" 8-16 ft. in height from additional average trees. The girth measurement of these logs at 16 ft. ranged from 6 ft. to 9 ft. 2 in.

The results of the tests on the logs are presented in the accompanying table.

The results of the first full tests on North Queensland kauri (*A. palmerstoni*) were recently published (2), and with the results from the tests on the Fijian kauri, and previous tests on N.Z. kauri, it was of interest to compare the strength properties of the three major timber-producing species of *Agathis* of the South-west Pacific. Comparisons have previously been made of the N.Z. and North Queensland species with other softwoods. Entrican (1) has shown that *A. australis* ranks amongst the very strongest softwoods of the world and that it is equal or superior to Douglas fir and southern Finnish pine in most strength properties except compression parallel to the grain in which kauri is the weaker. Kloot (2) has discussed the strength properties of *A. palmerstoni* and has made a comparison with two other species of similar density, viz. bunya pine and Sitka spruce. On the whole the North Queensland kauri does not compare favourably with either of those, particularly in tensile strength, modulus of elasticity and impact strength. Except in compression parallel and perpendicular to the grain, and one or two minor properties, North Queensland kauri is inferior to both bunya pine and spruce.

As can be seen from the figures, Fijian kauri is superior to North Queensland kauri, and is also superior to New Zealand kauri in most properties, which indicates that the timber possesses good strength properties, particularly when it is considered that the density of *A. vitiensis* air-dry is 33 lb. per cubic foot compared with 36 lb. for *A. australis*. Similarly, a very favourable comparison can be made with a timber such as Douglas fir which has a density of 34 lb. per cubic foot.

On the whole, Fijian kauri compares very favourably in most properties with the other kauris and many other softwoods of world-wide reputation, and except in bending, appears to be generally stronger than N.Z. kauri. However, North Queensland and Fijian kauri tests were carried out on mature trees, whereas the test figures quoted above for N.Z. kauri were obtained from material cut from comparatively young trees or "rickers." Higher test values, particularly in compression and the minor tests, would be expected from material cut from more mature trees.

AVERAGE PHYSICAL AND MECHANICAL PROPERTIES OF SOME KAURIS OF THE SOUTH-WEST PACIFIC

Property		GREEN			AIR-DRY		
		Fijian Kauri	N.Z. Kauri	North Queensland Kauri	Fijian Kauri	N.Z. Kauri	North Queensland Kauri
Moisture content—per cent		85	72	48	12	12	12
Basic specific gravity (weight oven-dry, volume green)		0.440	0.480	0.401	—	—	—
Density-weight per cubic foot—air-dry.....lb.		—	—	—	33	36	29
Shrinkage—green to oven-dry—							
Volumetric—per cent		12.9	11.9	—	—	—	—
Radial—per cent		4.8	—	4.0	—	—	—
Tangential—per cent		7.0	6.3	5.6	—	—	—
Static bending—							
Fibre stress at proportional limit	lb./sq. in.	4,620	4,410	—	8,830	8,240	—
Modulus of rupture	lb./sq. in.	7,630	7,790	6,710	12,220	13,070	9,210
Modulus of elasticity	lb./sq. in.	1,360,000	1,570,000	990,000	1,550,000	1,890,000	1,130,000
Work to proportional limit	in. lb./cu. in.	0.9	0.7	—	2.9	2.1	—
Work to maximum load	in. lb./cu. in.	8.7	9.0	—	15.2	14.5	—
Compression parallel to grain—							
Crushing stress at proportional limit	lb./sq. in.	2,580	2,770	2,810	5,030	4,060	3,430
Maximum crushing stress	lb./sq. in.	3,650	3,370	3,510	6,640	5,600	5,580
Compression perpendicular to grain—							
Crushing stress at proportional limit	lb./sq. in.	510	490	480	1,250	1,080	710
Hardness—load required to embed a 0.44 inch ball to one-half its diameter—							
Side	lb.	550	480	530	710	780	520
End	lb.	520	530	—	1,034	880	—
Shear parallel to grain—							
Maximum shearing stress	lb./sq. in.	830	940	810	1,900	1,220	1,120
Cleavage—load to cause splitting	lb./in. of width	190	140	170	540	250	260
Tension perpendicular to grain—							
Maximum tensile stress	lb./sq. in.	260	130	—	1,110	300	—

Properties other than Strength

The dakua or Fijian kauri can, like N.Z. kauri, be ranked amongst the very strongest and most valuable softwoods of the world. It is similar to the N.Z. species in having a pale yellowish brown sapwood and a slightly darker heartwood, the one merging gradually into the other. Growth rings are not well defined and are marked by very narrow bands of dense wood. The innumerable small rays give the wood that dappled or flecked appearance characteristic of N.Z. kauri. This similarity in appearance makes it difficult to distinguish between the two woods, but the lower density of Fijian kauri, and the taste and extract reactions (4) allow recognition with reasonable certainty.

The wood is of regular straight grain and close fine uniform texture. It seasons well and, although moderately hard as softwoods go, is easy to work. It nails with the greatest ease without splitting and possesses excellent nail and screw-holding properties. It saws easily, works readily under hand-tools, machines with exceptional ease and turns satisfactorily. It finishes to a surface of silky smoothness and should take both natural finishes and paints with ease.

Fijian kauri should be a useful building and construction timber, and is apparently widely used for house building in the Islands. It is as a boat and ship-building timber that it should be, like N.Z. kauri, pre-eminent; its lower density should make it excellent for sheathing, planking, decking, and interior finish, and even for masts and spars where its lighter weight would compensate for its lower bending strength.

For more general purposes it has been found very successful for high-class internal joinery, furniture, handicrafts and turnery. Like N.Z. kauri it should be a suitable timber for tanks and vats, although some adverse reports have been made on its attractiveness for this purpose.

Logs have been exported from Fiji to Australia for manufacture into veneers, and with the exception of spiral grain in occasional logs gave a very good product. This trade apparently suffers from some competition from Queensland and New Caledonian kauris.

In general, Fijian kauri must rank as one of the most generally useful softwoods, and should not only be a satisfactory but a valuable substitute for N.Z. kauri in a wide range of uses. There appears to be considerable support for Mead's statement (3) that "Fiji kauri is as good as, if not better than, the imported New Zealand kauri."

References

1. Entrican, A. R. The Properties and Uses of Kauri (*Agathis australis*). New Zealand State Forest Service. Leaflet No. 26 (1935).
2. Kloot, N. H. Tests on Small Clear Specimens of North Queensland Kauri (*Agathis palmerstoni* F.v.M.) Journal of the Council for Scientific and Industrial Research, Commonwealth of Australia. Vol. 20, No. 3 (1947).
3. Mead, J. P. The Forests of the Colony of Fiji. Report for Legislative Council, Fiji. Council Paper No. 4 (1928).
4. Phillips, E. W. J. The Identification of Coniferous Woods by their Microscopic Structure. The Linnean Society's Journal—Botany. Vol. II (No. 343) (1941).