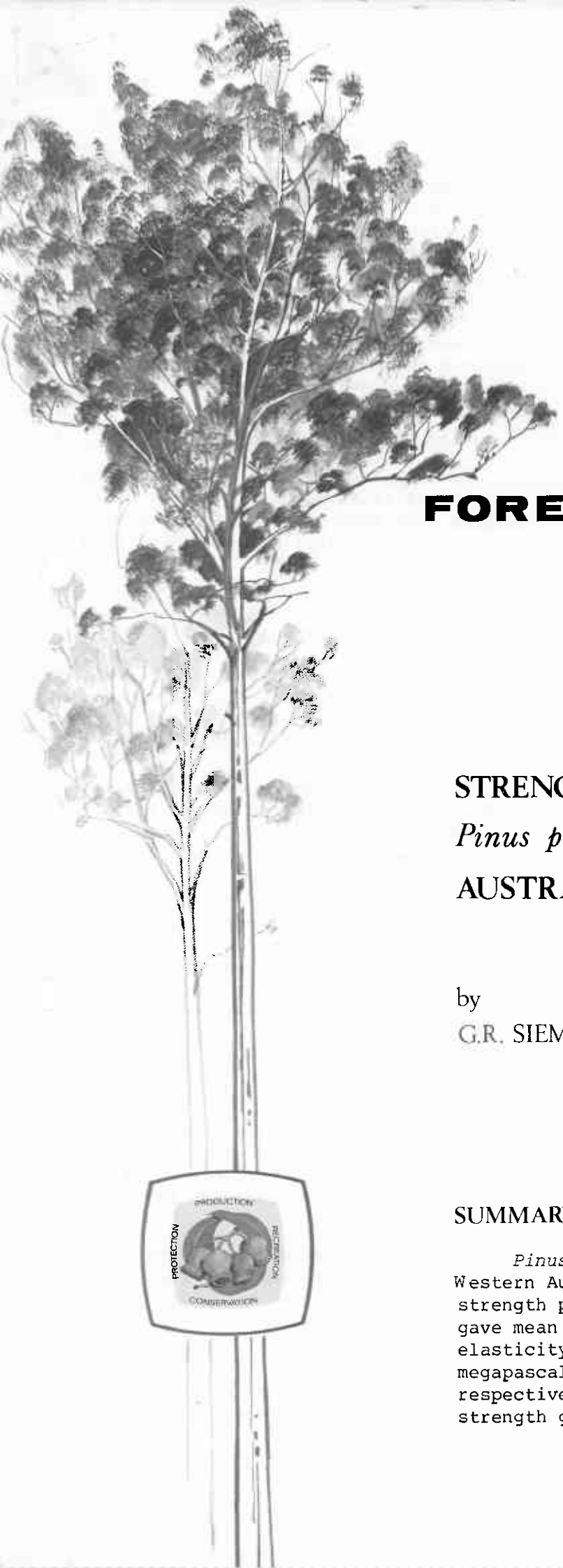

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STRENGTH PROPERTIES OF *Pinus pinaster* Ait. IN WESTERN AUSTRALIA

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SUMMARY

Pinus pinaster Ait. is a major exotic species in Western Australian pine plantations. A study of the strength properties of the species' seasoned timber gave mean values for modulus of rupture, modulus of elasticity and maximum crushing strength of 82.6 megapascals (MPa), 11 681 MPa, and 45.1 MPa respectively. These values indicate that the strength group of seasoned *P. pinaster* is SD6.

INTRODUCTION

The two major exotic *Pinus* species grown in Western Australia are *P. radiata* D. Don and *P. pinaster* Ait. In early 1980, more than 24 000 ha of each species was recorded (Forests Department of Western Australia, 1980 Annual Report). While there are four major geographic provenances of *P. pinaster* (Leirian, Landes, Esterel and Corsican (Hopkins, 1960)), the Western Australian resource is based on the Leirian provenance.

The Landes provenance provided the initial source of seed for Western Australian plantations. Subsequent trials showed that the Leirian provenance was superior, and consequently seed from this provenance has been used for general planting since 1942. A breeding programme commenced in 1957, and in the early 1960s a Western Australian forester collected material from superior phenotypes in the native forests of Leiria, Portugal (Perry and Hopkins, 1967). By 1971 commercial quantities of pedigreed (genetically improved) seed were produced, and by 1974 all plantings used pedigreed seed.

Pinus pinaster has been grown to a limited extent in South Australia and Victoria, but Western Australia has by far the largest resource.

Although the growth patterns of *P. pinaster* were basically known by 1980, more research into the utilization of pinaster timber was required, in particular on the assessment of this species' strength properties.

When designing timber structures according to the recommendations of the Timber Engineering Code (Standards Association of Australia, 1975) the strength grouping, the stress grade and the joint group of the species concerned must be known. The strength group is based on the results of standard tests on small defect-free specimens of the species (Mack, 1979), the specific properties tested being modulus of rupture, modulus of elasticity, and maximum crushing strength.[1] Strength groups are allocated, for both green and seasoned material, according to the requirements of the Standards Association of Australia (S. A. A. MP 45 - 1979).

Pinus radiata has been extensively tested for its strength properties (Ditchburne *et al.*, 1975), and has been subsequently allocated with strength groupings of S6 and SD6 (Standards Association of Australia, 1979). However, strength tests of Australian grown *P. pinaster* have not been made, and its provisional strength groupings of (S7) and (SD7)[2] were predicted from density measurements. The present study was designed to produce strength data for *P. pinaster* and to determine the strength group for seasoned timber.

MATERIALS AND METHODS

The sampling pattern was based on a total of 50 trees, with the number of trees sampled from each area varying according to provenance, age class and the total area planted.

The approximate breakdown of the *P. pinaster* resource is:

Landes provenance	(to 1940)	6 per cent
Leirian provenance	(1940-1966)	34 per cent
Leirian provenance	(1967-1973)	39 per cent
Pedigreed stock	(1974-1980)	21 per cent.

Although the Landes material is low priority, as it comprises only a small area of the total *P. pinaster* resource, it was considered advisable to sample a minimum of five trees from this provenance (Standards Association of Australia, 1979). The Leirian (1967-1973) areas and the general pedigreed stock are too young to provide representative strength data.

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[1]Modulus of rupture - a measure of the maximum fibre stress of timber, being bent, at the point of rupture.

Modulus of elasticity - a measure of timber's resistance to bending under a load and its capacity to return to its original shape and size when the load is removed.

Maximum crushing strength - a measure of the resistance of timber to compression along the grain, i.e. the strength of timber as a column.

[2]brackets around the figures indicate provisional strength groupings.

However, pedigreed material from research trials was included. Details of sampling are given in Appendix 1.

Trees were randomly selected in the compartments[3], and 2.1 m log lengths randomly taken, with the requirement that the minimum small end diameter of each log was 20 cm.

Specimen preparation

The sample logs were sawn into lengths of 70 x 70 mm cross-sections at the Forests Department sawmill at Harvey. The sections were high temperature dried to the requirements of the Radiata Pine Association of Australia Industry Standard No. 100 (1979).

Each piece was dressed to a 50 x 50 mm cross-section, according to the requirements of the American Society for Testing and Materials (A.S.T.M. D143-52 (1972)) and the British Standards Institution (B. S. 373:1957 (1957)), as summarized by Mack (1979). The required dimensions of timber specimens for static bending tests are 760 x 50 x 50 mm, and for compression parallel to the grain tests are 200 x 50 x 50 mm. One specimen was randomly tested from each group. The compression specimen was cut from the same length as the static bending specimen.

Testing

The tests were carried out at the Western Australian Institute of Technology (W.A.I.T.) by Department of Civil Engineering staff, using the methods summarized by Mack (1979). After testing, a 50 mm length was taken from each specimen to determine moisture content and air-dry density.

Test data required correction to the standard 12 per cent moisture content (M.C.), using the following standard corrections (Mack, 1979):

(1) modulus of rupture - 4 per cent for every 1 per cent M.C. variation;

(2) modulus of elasticity - 1.5 per cent;

(3) maximum crushing strength - 5 per cent.

RESULTS

The mean values and standard deviations for modulus of rupture, modulus of elasticity, maximum crushing strength and air-dry density are given in Table 1.

[3]a compartment is a discrete forest management area.

TABLE 1

Combined strength data and air-dry density

Material	Modulus of rupture (MPa)		Modulus of elasticity (MPa)		Maximum crushing strength (MPa)		Air dry density kg.m^3	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
1963 Landes	96.2	13	14 952	2 524	57.4	5	625	44
1936 Leirian	103.2	3.1	16 943	461	55.3	9.4	649	35
1946 Leirian	94.2	28.0	14 103	2 102	55	10.1	647	49
1956 Leirian	88.3	18	13 201	2 303	48.1	10.5	582	46
1966 Leirian	74.4	16.5	9 941	1 817	39.1	5.9	527	53
1966 Pedigreed (genetically improved)	71.6	6	8 653	699	37.2	2.6	474	25
Overall mean	82.6	18.9	11 681	3 079	45.1	10.3	558	74

The overall mean data gave the preliminary classification values for seasoned timber (S.A.A. MP45-1979). The groups indicated were:

(1) modulus of rupture - SD5;

(2) modulus of elasticity - SD6;

(3) maximum crushing strength - SD6.

Combining these groups indicated that the overall strength group of *P. pinaster* is SD6.

DISCUSSION

As *P. radiata* and *P. pinaster* are the major exotic species in Western Australia, their individual strength properties can be compared (Table 2).

These data indicate that strength properties of Western Australian-grown *P. pinaster* are similar to those of *P. radiata* sampled Australia wide.

The combined test data for *P. pinaster* indicate that the seasoned strength group should be SD6. If only 25-year-old and older trees were taken (ignoring one specimen with internal defects) the mean strength values would be:

(1) modulus of rupture - 97.2 MPa;

(2) modulus of elasticity - 14 334 MPa

These figures would give an overall result of SD4 (Standards Association of Australia, 1979). However, as the younger trees were capable of providing mill logs, they were included in the sample, which produced the lower average values recorded.

The air-dry density measurement of 558 kg.m^3, in the absence of strength data, would confirm the existing provisional strength grouping of (S7) for unseasoned material.

Further testing of pedigreed *P. pinaster* is desirable when stands become older, and the proposed SD6 strengt group could then be reassessed.

ACKNOWLEDGEMENTS

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TABLE 2

Comparison between strength properties of *P. pinaster* and *P. radiata pine*

Property	P. pinaster[1]	P. radiata[2]
Modulus of rupture (MPa)	82.6	87.2
Modulus of elasticity (MPa)	11 681	11 480
Maximum crushing strength (MPa)	45.1	48.3
Air-dry density (kg.m^3)	558	530

[1] Present study

[2] Pith-included material (Ditchburne *et al.*, 1975)

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APPENDIX I

Sampling details for study of strength properties of *P. pinaster*

Material	Plantation	Planting Year	Compartment No.	No. trees per Compartment
Landes	Gnangara	1936	12	2
	Myalup	1933	33	2
	Ludlow	1936	27A	1
Leirian	Gnangara	1936	12	2
		1946	70, 71	2
		1946	69	3
		1955	6, 90	1
		1956	102, 103, 105	1
		1965	11, 125	1
		1966	20, 25, 36	1
	Pinjar	1956	12, 13	1
		1964	95	1
	Yanchep	1966	6, 10, 18	1
		1966	45A	5
	Gleneagle	1956	9A	1
		1966	25C	1
	Myalup	1955	3, 9	2
		1965	96	1
	McLarty	1956	4, 11	2
		1966	43	1
Pedigreed	Mundaring	1966	16	10