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Growth and Wood Properties of Five Sugi (*Cryptomeria japonica* D. Don) Cultivars Grown in the Tokyo University Forest in Chiba

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1. Introduction

Japanese cedar, Sugi (*Cryptomeria japonica* D. Don), a prominent reforestation species in Japan, has been planted in all areas besides northrn part of the country for a long time. At present, Japan has about 10 million hectares of artifical forests, of which about fifty percent of the planting area and about sixty percent of the volume are sugi. There are numerous cultivars of sugi in Japan, and it is reported that their wood properties vary with cultivars, environmental factors, silvicultural treatments and so on[1-3]. Many studies, recently, carried out on anatomical and mechanical properties of sugi cultivars show that there are significant differences in intrinsic wood properties among the cultivars[4-8]. In Japan, great quantities of sugi will be supplied in ten to fifteen years. At that time, more efficient utilisation and wider development of a new usage of these sugi will be sought. Consequently it is very important to have good knowledge about the intrinsic wood properties of each cultivar for better selection of cultivars and efficient forest management. Timber grading and efficient processing technique will help us overcome the inherent weakness of cultivars of sugi. In this study, the growth and wood properties of 5 sugi cultivars grown in the same stand, and managed in the same way were examined.

2. Experimental Materials and Methods

2.1 Sample trees

The sample trees were 5 sugi cultivars, Hidarimaki-sugi, Tosaaka-sugi, Haara-sugi, Boka-sugi and Ji-sugi. They were 31 years old and had been planted in the Tokyo University Forest in Chiba. The Ji-sugi were in the nursery for 3 years after the seedlings and the others were in the nursery for 3 years after the cuttings, and then, each of them were planted. Ji-sugi is an indigenous sugi in the Chiba district and is not a well-defined cultivar. Five sample trees, which were growing normally in the plantation, were felled from each cultivar. Table 1 shows the tree height and the diameter at breast height of the sample trees. The diameters at breast height of the sample trees do not show remarkable difference, but the tree height of Ji-sugi was more than 50% higher than Hidarimaki-sugi. The color of heartwood was red in all sample trees.

2.2 Sampling

For stem analysis, discs about 10 cm thick were taken from each sample tree at 0.3 m, 1.3 m and every 2 m thereafter (5.3 m, 7.3 m, . . .) at ground level higher than 1.3 m, and the final disc was taken at a 1 m interval so that the length from the position of the disc to the

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Table 1. Data of sample trees

Cultivar	No.	Tree height (m)	Diameter at breast height (cm)
Boka-sugi	B-1	6.95	10
	B-2	7.30	9
	B-3	7.83	10
	B-4	7.30	10
	B-5	8.35	10
	Mean	7.54	10
Haara-sugi	Ha-1	9.18	11
	Ha-2	8.7	12
	Ha-3	8.48	13
	Ha-4	8.52	13
	Ha-5	8.67	11
	Mean	8.71	12
Hidarimaki-sugi	Hi-1	7.6	11
	Hi-2	6.72	10
	Hi-3	6.48	11
	Hi-4	7.12	11
	Hi-5	5.71	10
	Mean	6.72	10.6
Tosaaka-sugi	T-1	9.68	12
	T-2	9.3	11
	T-3	10.23	13
	T-4	10.21	11
	T-5	9.88	11
	Mean	9.86	11.6
Ji-sugi	J-1	12.01	12
	J-2	10.0	11
	J-3	9.6	10
	J-4	10.58	16
	J-5	9.63	10
	Mean	10.36	11.8

top was less than 2 m.

The specimens for measurements of green moisture content and basic density, compression test parallel to the grain, and bending test were taken from the log at about 1.3 m above ground level. The specimens for the compression test parallel to the grain and bending test were taken from both juvenile wood (inside of the tenth annual ring from the pith) and mature wood (outside of the 15th annual ring).

2.3 Stem analysis

As for the discs taken from each sample tree, marks were put on the annual rings at 5 ring intervals (5, 10, 15, 20, 25, 30 and 31) from the pith in the direction of north, south, east and west. Distance from the pith to every fifth ring position was measured using a caliper with an accuracy of 1/20 mm. Every fifth annual ring width was the average of the four directions. The basic stem-growth diagrams were figured from the stem analysis data, and then total growth curves in volume, height and diameter, annual growth curves and average growth curves were evaluated.

2.4 Measurements of green moisture content and basic density

A diametral strip about 10 mm wide, including the pith, and about 10 mm along the grain was taken from each 100 mm long disc. This diametral strip was split with a cleaver along the annual ring into blocks with 1 to 4 rings corresponding to the ring width in every heartwood, white zone and sapwood, and immediately the green weight was measured. Then the blocks were placed in a vacuum flask with distilled water until the blocks abosorbed water to the maximum moisture content weight. Then the weight of the

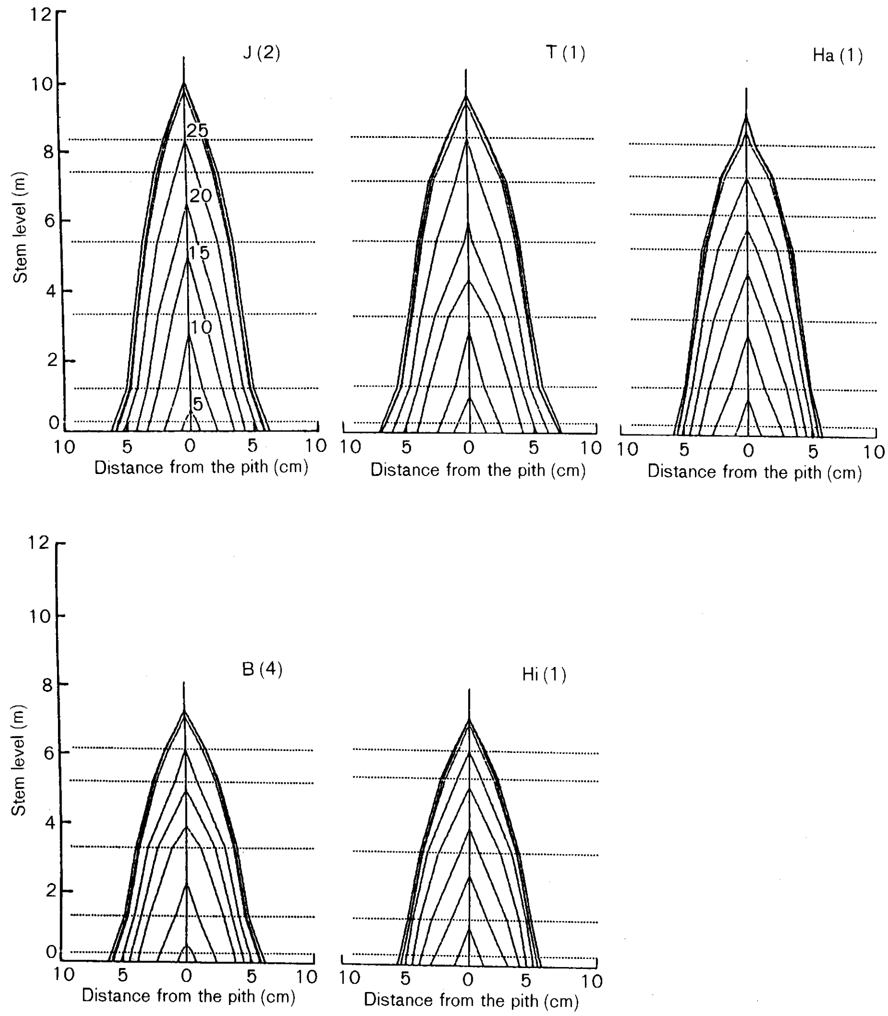

Fig. 1. Basic stem-growth diagrams.
J(2): Ji-sugi, T(1): Tosaaka-sugi, Ha(1): Haara-sugi, B(4): Boka-sugi, Hi(1): Hidarimaki-sugi
The figures in parenthesis indicate the tree number in each sugi-cultivar.

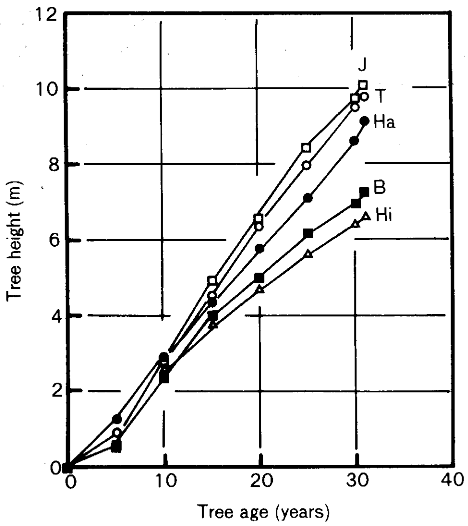

Fig. 2. Total height growth curves.
J: Ji-sugi, T: Tosaaka-sugi, Ha: Haara-sugi, B: Boka-sugi, Hi: Hidarimaki-sugi

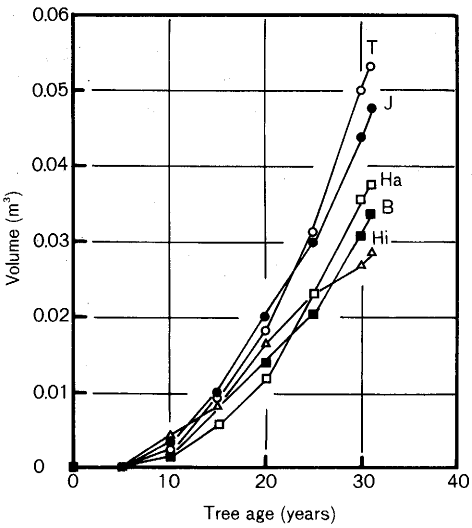

Fig. 3. Total volume growth curves.
J: Ji-sugi, T: Tosaaka-sugj, Ha: Haara-sugi, B: Boka-sugi, Hi: Hidarimaki-sugi

water-saturated blocks was measured in the air and in the water. After that the blocks were dried in an oven at 105℃, and the oven dried weight was measured. The green moisture content and basic density were calculated from the equations (1) and (2), respectively.

Green moisture content (%)=
$\{(W_g-W_o)/W_o\}\times 100$ (1)
Basic density$=\{Wo/(W_s-W_w)\}$ (2)
where, W_g:green weight (g)
W_o: oven dried weight (g)
W_s: weight in the air of the water-saturated block (g)
W_w: weight in the water of the water-saturated block (g)

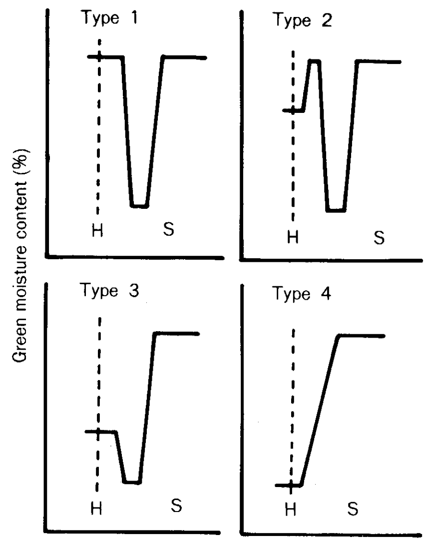

Fig. 4. Type of radial distribution of green moisture content at the breast height.
H: heartwood, S: sapwood

2.5 Compression test

Dimensions of specimens were 10 mm× 10 mm in cross section and 20 mm along the grain. Ten specimens were taken from the juvenile wood and mature wood of one sample tree, respectively.

The specimens were conditioned to about 12 percent moisture content in a room of 65% relative humidity and 20℃, and then compressive strength and Young's modulus parallel to the grain were measured. The Young's modulus was calculated from the ultrasonic velocity and the specific gravity in air dry of the specimen. The compressive strength was measured with a Universal Testing Machine (Autograph IS-5000, Shimazu Ltd.,). Compression test was done in a room of 65% relative humidity and 20℃.

2.6 Static bending test

Dimensions of specimens were 10 mm in the radial, 5 mm in the tangential and 110 mm in the longitudinal direction. Ten specimens were prepared from juvenile and mature wood, of one sample tree, respectively.

The specimens were conditioned to about 12 percent moisture content in a room of 65 % relative humidity and 20℃, and then the bending test was performed on a Universal Testing Machine (Autograph IS-5000, Shimazu Ltd.). The beam was supported over a 90 mm span, and a single, central load was applied on the radial surface. The load was measured by an electric load-cell, and the deflection was measured by the movement of the cross-head. The static bending test was done in a room of 65% relative humidity and 20℃.

2.7 Measurements of mean width of annual rings, latewood percentage, cell-wall thickness, diameter of lumen and microfibril angle

The mean width of annual rings and latewood percentage were measured in the usual way. The demarcation between earlywood and latewood was determined by the color change in a ring. The cell wall thickness (thickness of double tangential wall) and radial

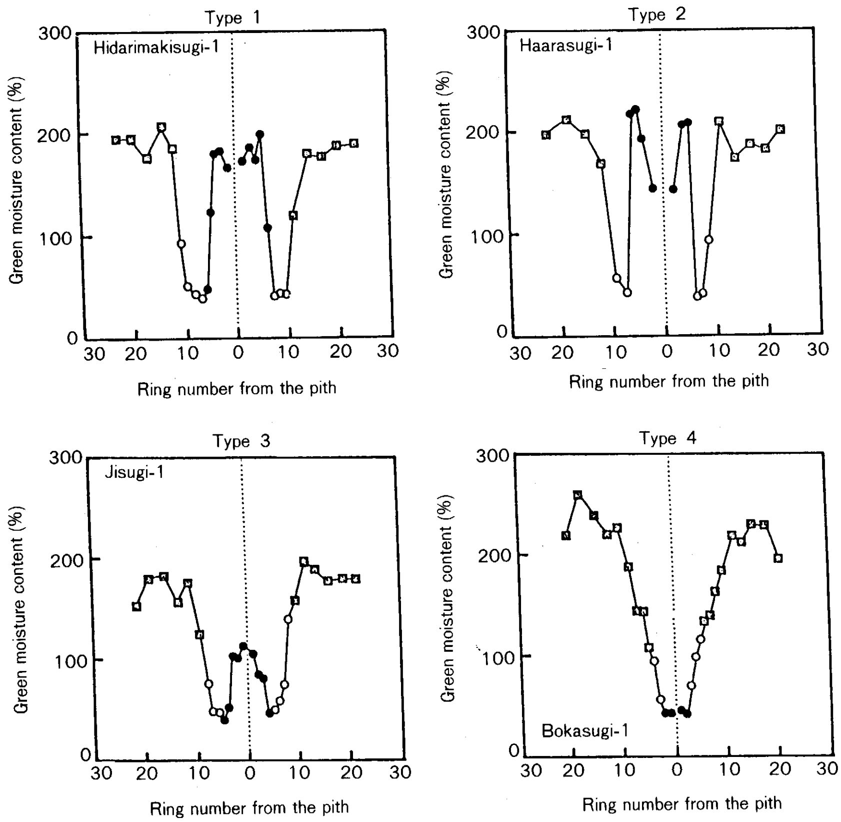

Fig. 5. Examples of radial distribution of green moisture content at the breast height.
●: heartwood, ○: white zone, ⊡: sapwood

diameter of lumen were measured on the microscopic photographs. The microfibril angle was measured by iodine crystal technique[9] and X-ray diffraction technique[10].

3. Results and Discussion

3.1 Growth

Annual growth in height of the cultivars was classified into two types; one was most Haara-sugi, Ji-sugi and Tosaaka-sugi, which showed a peak at 10 or 15 years, followed by levelling off with tree age. The other was most of Hidarimaki-sugi and Boka-sugi, which, after the peak, decreased rapidly with tree age. Annual growth in diameter showed a peak at 15 years and decreased rapidly with tree age for almost all sample trees. Annual growth

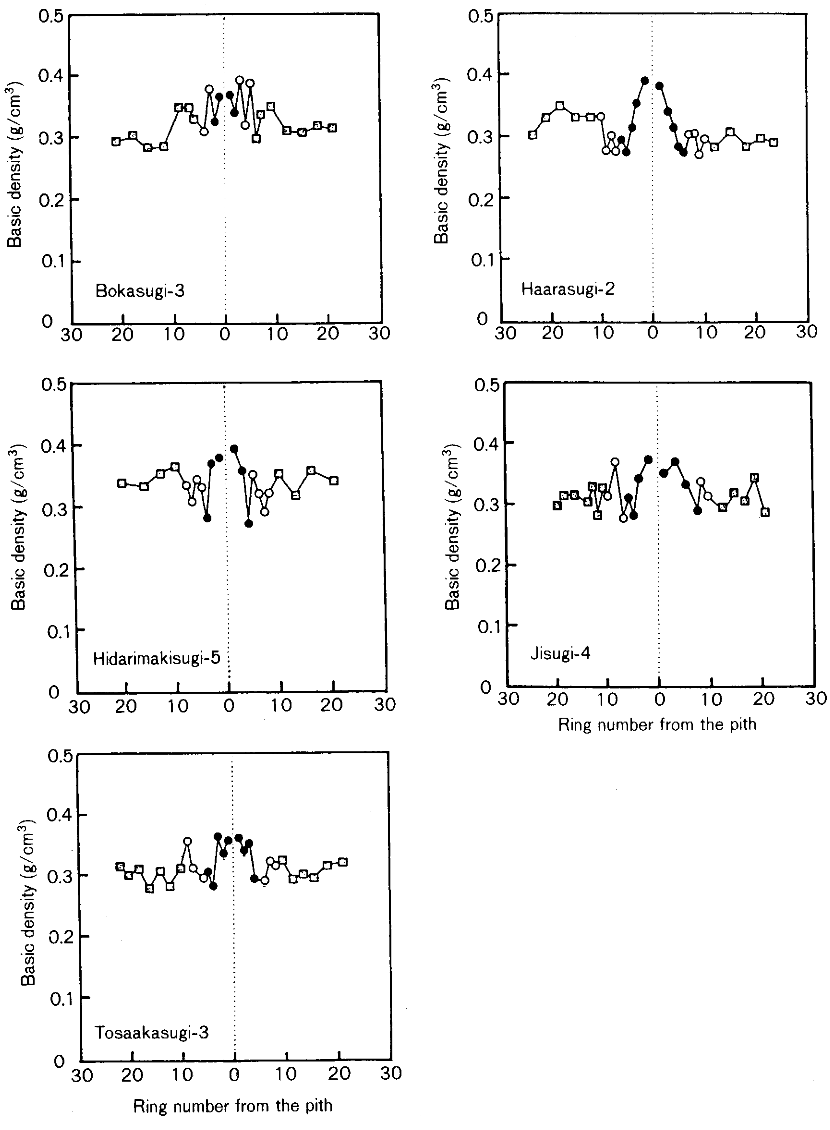

Fig. 6. Examples of radial distribution of basic density at breast height.
●: heartwood, ○: white zone, ⊡: sapwood

in cross-sectional area showed a peak at 15 years for almost all sample trees, and then it remained the same value with tree age for Tosaaka-sugi, Ji-sugi and Boka-sugi, while rapidly decreased outwards for Hidarimaki-sugi and Haara-sugi.

The basic stem-analysis diagrams for each cultivar are shown in Fig. 1 and total growth curves of the height and volume are shown in Figs. 2 and 3, respectively. The total height growth was the maximum in Ji-sugi, and Tosaaka-sugi, Haara-sugi, Boka-sugi, Hidarimaki-sugi in that order. The total volume growth was the maximum in Tosaaka-sugi, and Ji-sugi, Haara-sugi, Boka-sugi, Hidarimaki-sugi in that order. The greatest variation of the volume was found in Ji-sugi.

3.2 Green moisture content

The radial distribution of green moisture content was roughly classified into four types (Fig. 4). Type 1, the moisture content of heartwood shows almost the same value as that of sapwood, while that of white zone is lower than that of heartwood and sapwood. Type 2 is similar to Type 1, but the moisture content near the pith is somewhat low. Type 3, the moisture content in heartwood is somewhat lower than that in sapwood, and higher than that in white zone. Type 4 is that the moisture content in heartwood is lower than that in sapwood and slightly lower than that in white zone.

In Figure 5, typical examples are shown. All sample trees of Hidarimaki-sugi were the Type 1 and all sample trees of Haara-sugi were Type 2, but for Tosaaka-sugi, three of five sample trees were Type 3 and the rest was Type 1. For Boka-sugi, three of five sample trees were Type 4 and the rest was Type 3. For Ji-sugi, three of five sample trees were Type 3 and the rest was Type 1. Irrespective of the type, the green moisture content in sapwood was 200 to 250%, about 40% in the lowest parts of white zone. The value in heartwood was about 100% for Type 3 and about 45 % for Type 4.

Although the sample trees were collected from the limited forest area, the type of radial distribution of green moisture content was different even within cultivars in some cases. Though the green moisture content in heartwood of Type 1 and Type 2 was rather high, the color of their heartwood was not dark, but red.

3.3 Basic density

Typical examples of the radial distribution of basic density are shown in Fig. 6. Table 2 showed the average basic density of heartwood and sapwood. The figure and table indicate that the basic density near the pith was somewhat higher than that in sapwood of every cultivar.

Table 2. Basic density of heartwood and sapwood of 5 sugi cultivars

Cultivars	Heartwood	Sapwood
Ji-sugi	0.369	0.339
Boka-sugi	0.371	0.316
Haara-sugi	0.340	0.314
Tosaaka-sugi	0.338	0.312
Hidarimaki-sugi	0.355	0.345

unit: g/cm^3

3.4 Strength properties

(1) Relationships between Young's modulus in bending (E_b), bending strength (σ_b) and specific gravity in air dry

The relationship between Young's modulus in bending and specific gravity in air dry is shown in Fig. 7. The relationship between bending strength and specific gravity in air dry is shown in Fig. 8. Regression line and its coefficent appear when the correlation coefficient of regression line is more than 0.5. As shown in the figures, a good correlation was not always found in the juvenile

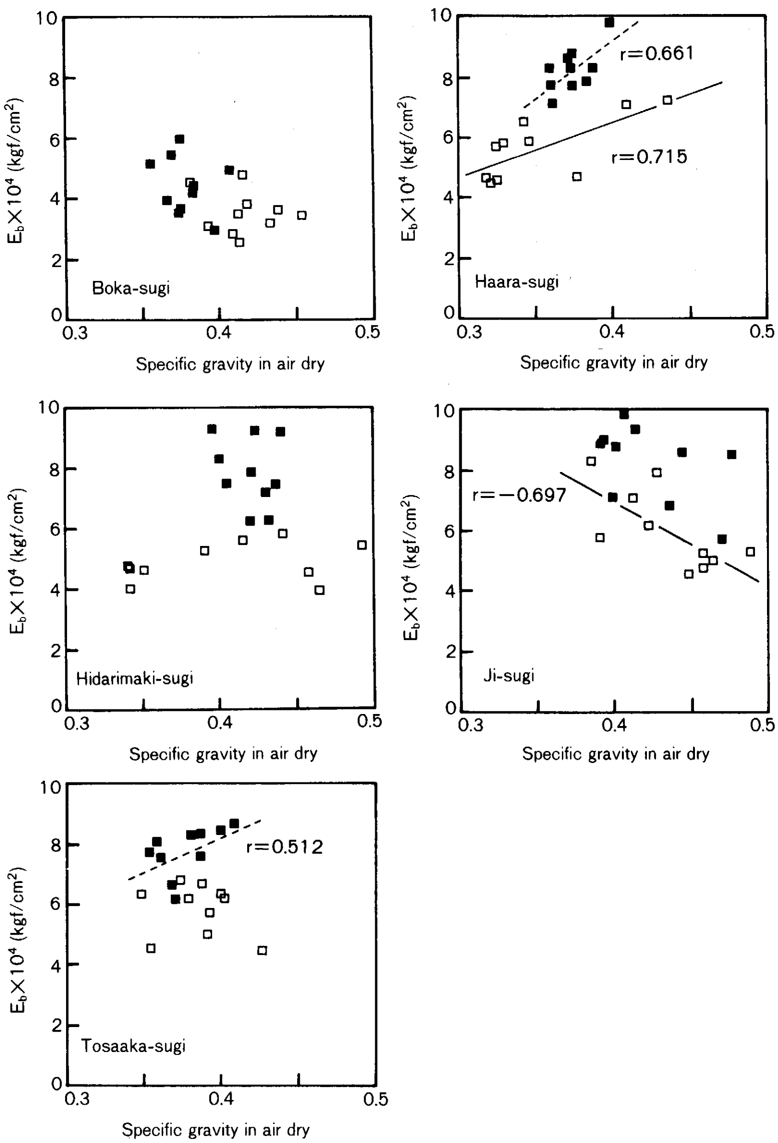

Fig. 7. Relationship between Young's modulus in bending (E_b) and specific gravity in air dry.
□: juvenile wood, ■: mature wood

woods or mature woods. As expected, mature woods exceeded juvenile woods either in Young's modulus in bending or in bending strength, except for Boka-sugi. Haara-sugi showed a good correlation between Young's modulus in bending and specific gravity in air dry, and bending strength and specific gravity in air dry. Boka-sugi did not show significant correlation between them, even in the juvenile woods or in the mature woods.

Figures 9 and 10 show the relationships between Young's modulus in bending, bending strength and specific gravity in air dry of 5 sugi cultivars, respectively. As is obvious from the figures, a good linear correlation was found between bending strength and specific gravity in air dry, but not a good correlation was found between Young's modulus in

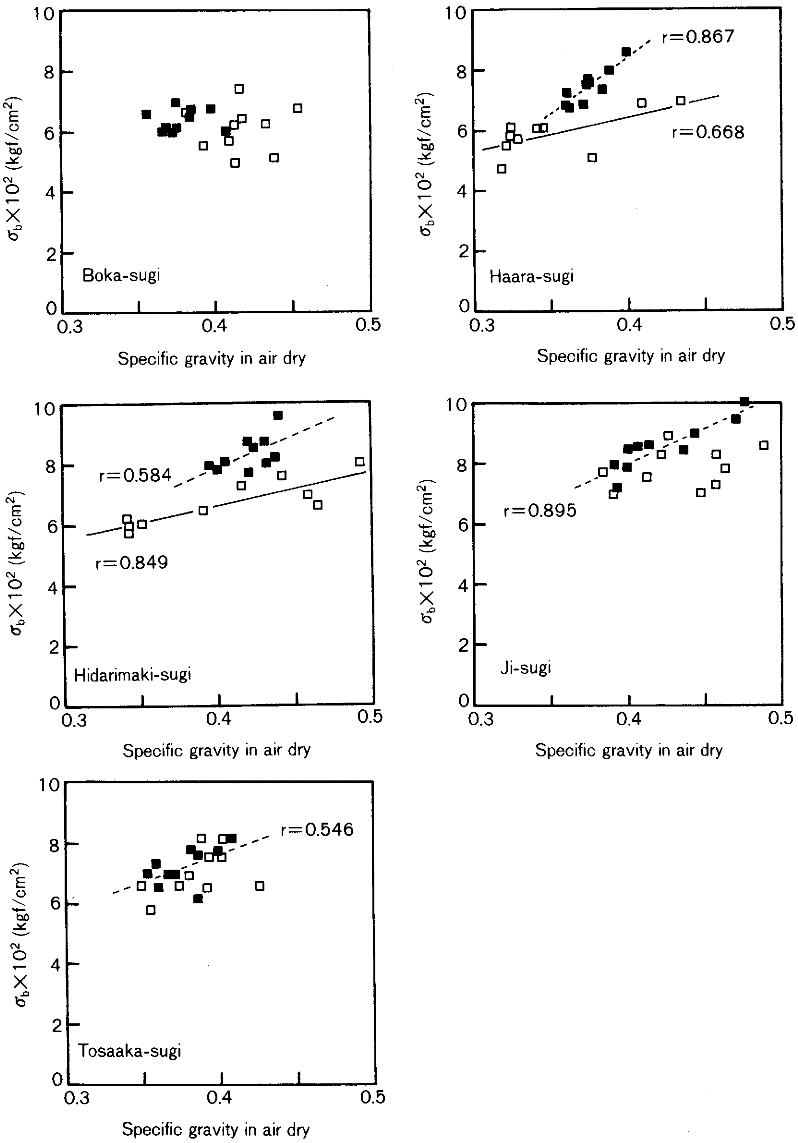

Fig. 8. Relationship between bending strength (σ_b) and specific gravity in air dry.
□: juvenile wood, ■: mature wood

bending and specific gravity in air dry. Young's modulus in bending and bending strength of Boka-sugi were lower than those of others, and it was remarkable in Young's modulus in bending of mature wood.

(2) Relationships between Young's modulus in compression parallel to the grain (E_L), compressive strength (σ_c) and specific gravity in air dry

Figures 11 and 12 show the relationships between Young's modulus in compression parallel to the grain, compressive strength and specific gravity in air dry, respectively. As is ovious from the figures, there was found a good correlation between Young's modulus and specific gravity in air dry in the juvenile wood and in the mature wood of almost all

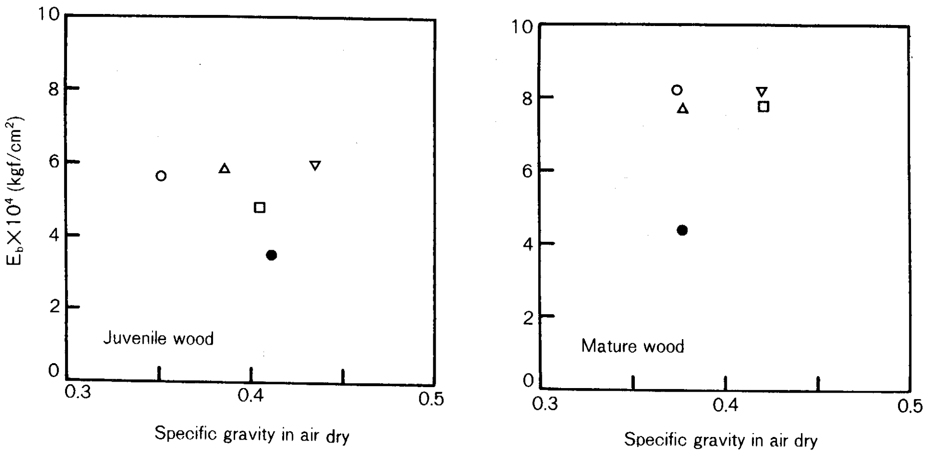

Fig. 9. Relationship between Young's modulus in bending (E_b) and specific gravity in air dry of 5 sugi-cultivars.
●: Boka-sugi

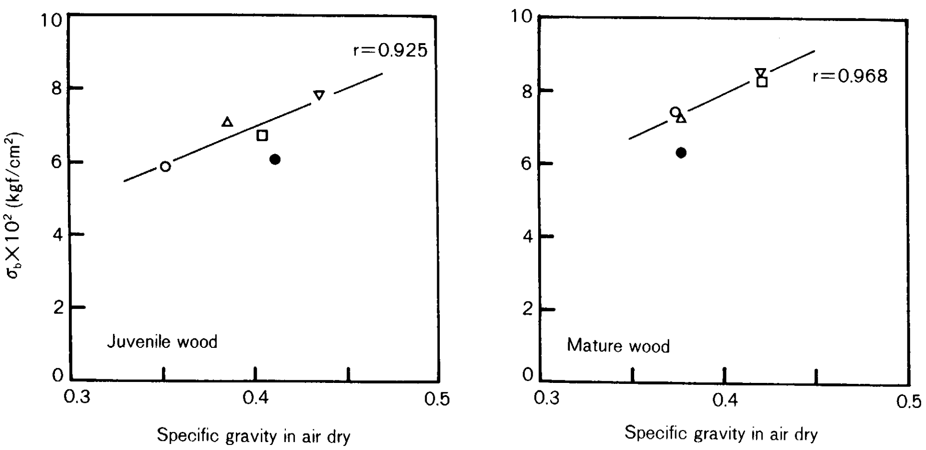

Fig. 10. Relationship between bending strength (σ_b) and specific gravity in air dry of 5 sugi-cultivars. Boka-sugi is not included in the calculation of regression line.
●: Boka-sugi

cultivars. A good correlation was found between compressive strength and specific gravity in air dry in the juvenile wood and in the mature wood of all cultivars. In comparison with bending, Young's modulus in compression and compressive strength showed small difference between the juvenile wood and the mature wood. Except for Tosaaka-sugi, it is not necessary to classify the juvenile wood and the mature wood to evaluate the compression strength properties parallel to the grain.

Figures 13 and 14 show the relationships between Young's modulus in compression parallel to the grain, compressive strength and specific gravity in air dry of 5 sugi cultivars, respectively. It is clearly shown in the figures that Young's modulus and compressive strength of Boka-sugi were lowest, and it was more obvious in Young's modulus than in compressive strength. A good linear correlation was found between them, except for Boka-sugi.

(3) Relationships between Young's modulus in bending (E_b) and bending strength (σ_b), and

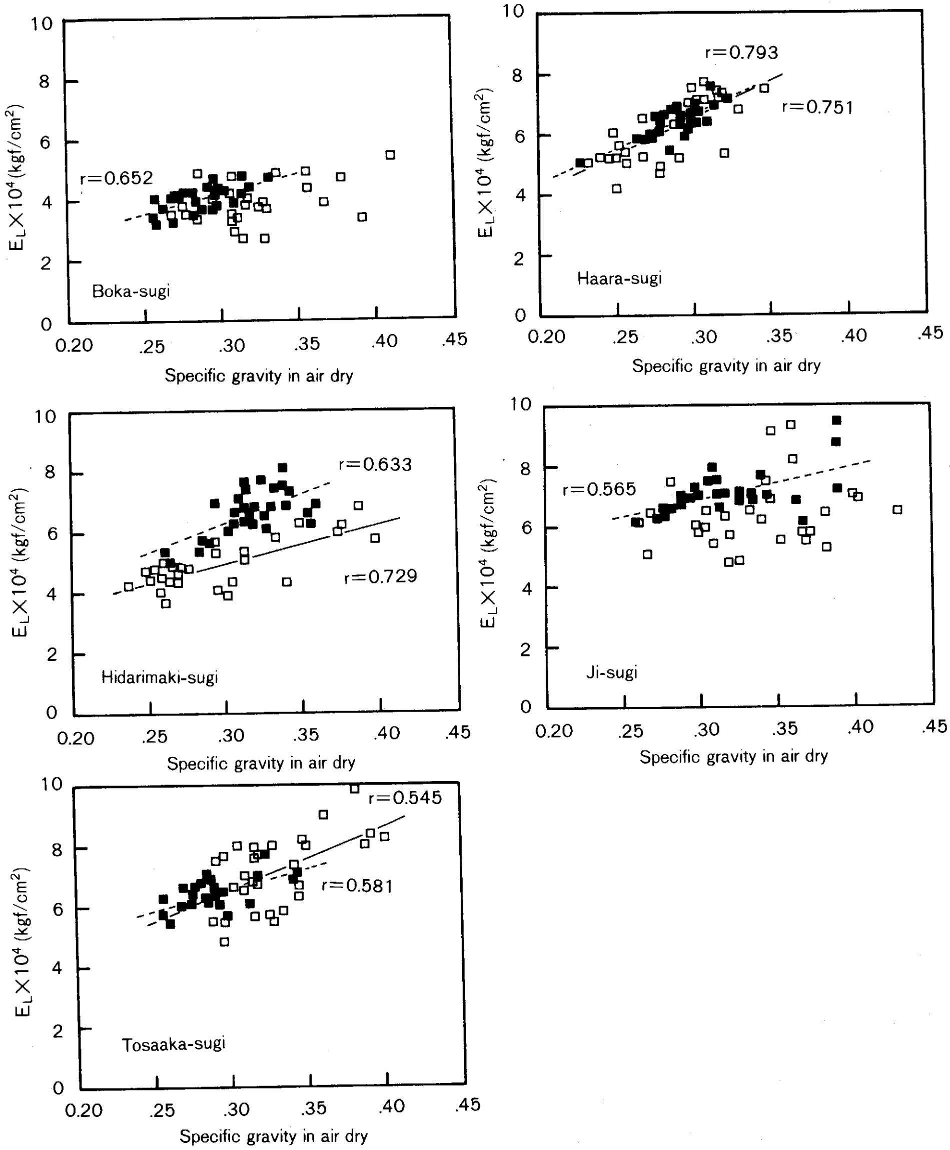

Fig. 11. Relationship between Young's modulus in compression parallel to the grain (E_L) and specific gravity in air dry.
□: juvenile wood, ■: mature wood

Young's modulus in compression parallel to the grain (E_L) and compressive strength (σ_c)

Figures 15 and 16 show the relationships between Young's modulus in bending and bending strength, and Young's modulus parallel to the grain and compressive strength, respectively. There was a relatively good linear correlation between Young's modulus in bending and bending strength, with exceptions of Ji-sugi and mature wood of some cultivars (Boka-sugi and Hidarimaki-sugi). A highly significant correlation between compressive strength and Young's modulus was also confirmed, with an exception of juvenile

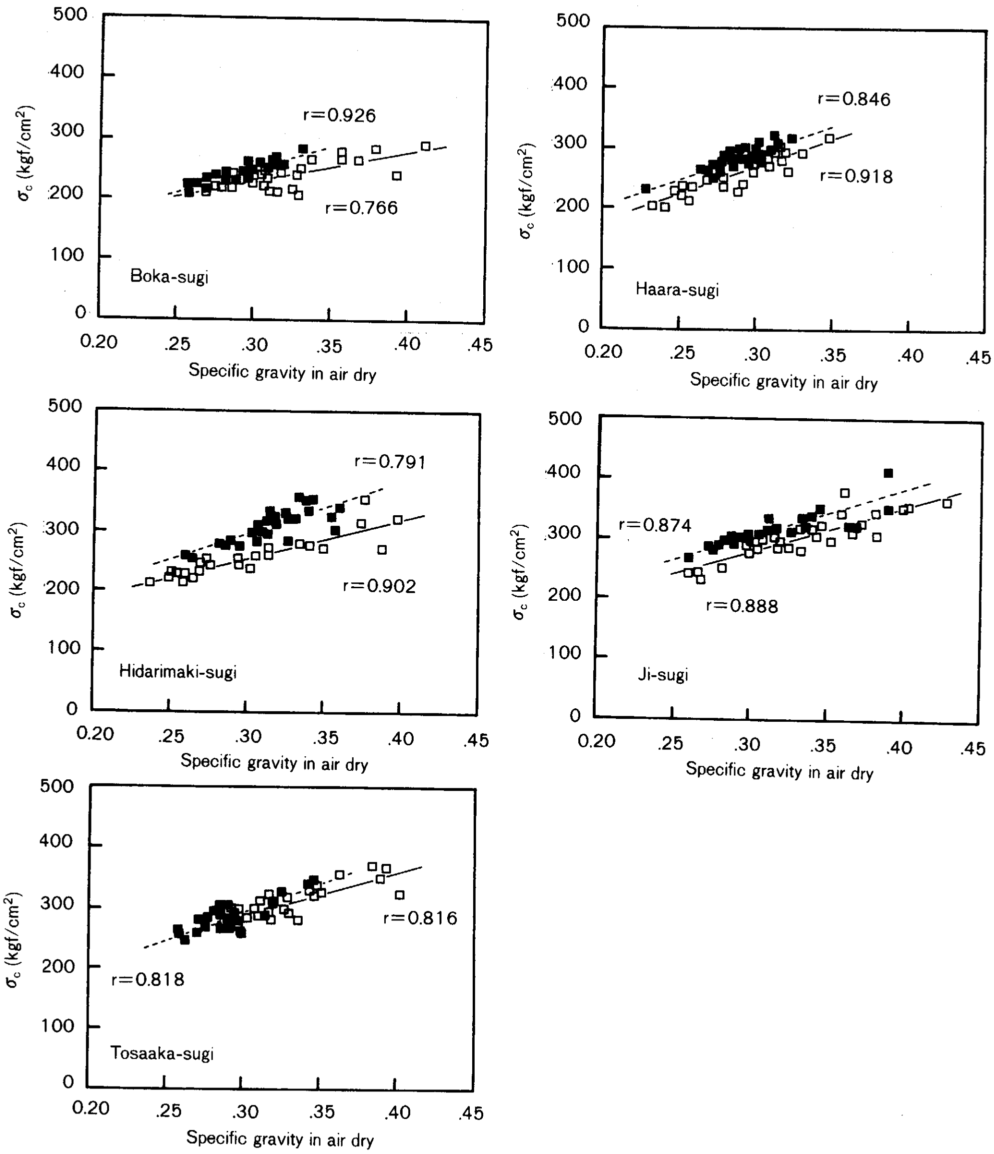

Fig. 12. Relationship between compressive strength parallel to the grain (σ_c) and specific gravity in air dry.
□: juvenile wood, ■: mature wood

wood of Ji-sugi.

Figures 17 and 18 show the relationships between Young's modulus in bending and bending strength, and Young's modulus in compression parallel to the grain and compressive strength of 5 sugi cultivars, respectively. Highly significant linear correlations were found, and it is possible to estimate the strength from the Young's modulus.

(4) Relationships between Young's modulus in bending (E_b), bending strength strength (σ_b) and mean width of annual rings

As is shown in Figures 9, 10, 13 and 14, Young's modulus and strength of Boka-sugi

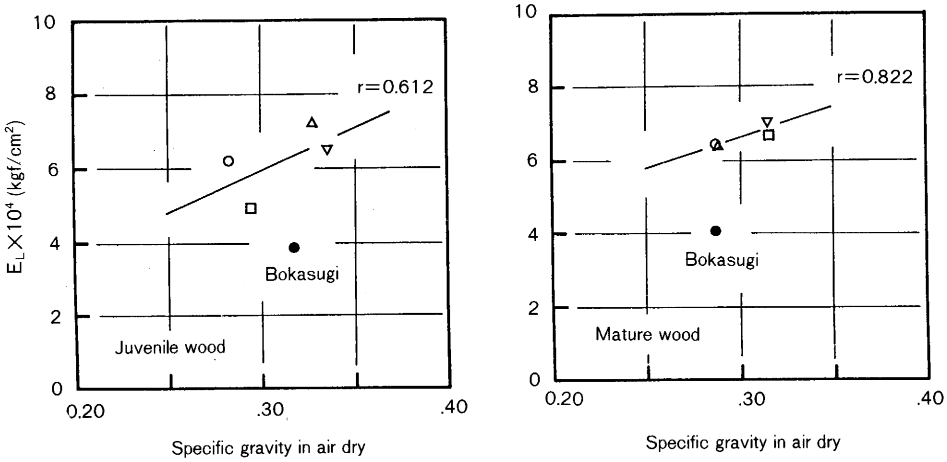

Fig. 13. Relatioship between Young's modulus in compression parallel to the grain (E_L) and specific gravity in air dry of 5 sugi-cultivars. Boka-sugi is not included in the calculation of regression line.
●: Boka-sugi

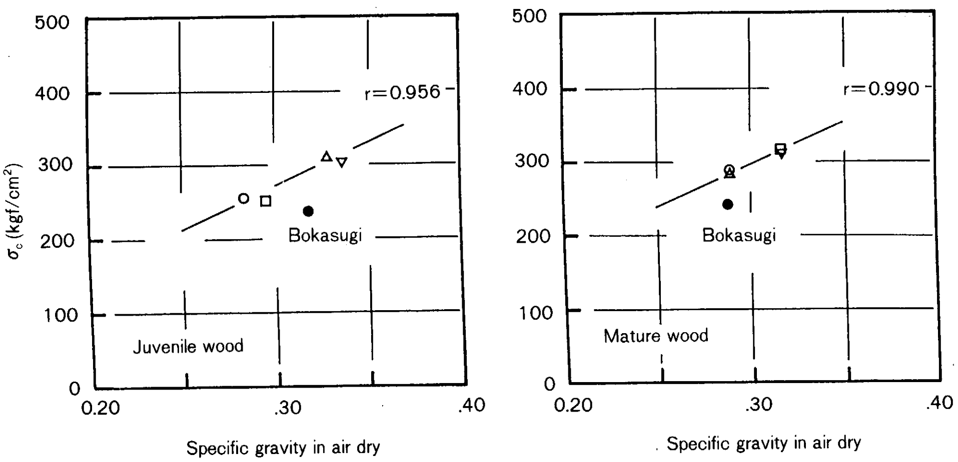

Fig. 14. Relationship between compressive strength parallel to the grain (σ_c) and specific gravity in air dry of 5 sugi cultivars.
Boka-sugi is not included in the calculation of regression line.
●: Boka-sugi

were lower than these of others. To determine this, the annual ring structures of Boka-sugi were compared with Hidarimaki-sugi which was selected as a typical sample of the 4 sugi cultivras. Figures 19 and 20 show the relationships between Young's modulus in bending, bending strength and mean width of annual rings, respectively. It is obvious that Young's modulus in bending and bending strength decreased with increasing mean width of annual rings. At the same mean width of annual rings, Boka-sugi showed lower values than Hidarimaki-sugi. This tendency was also found between Young's modulus in compression parallel to the grain and mean width of annual rings, and compressive strength and mean width of annual rings.

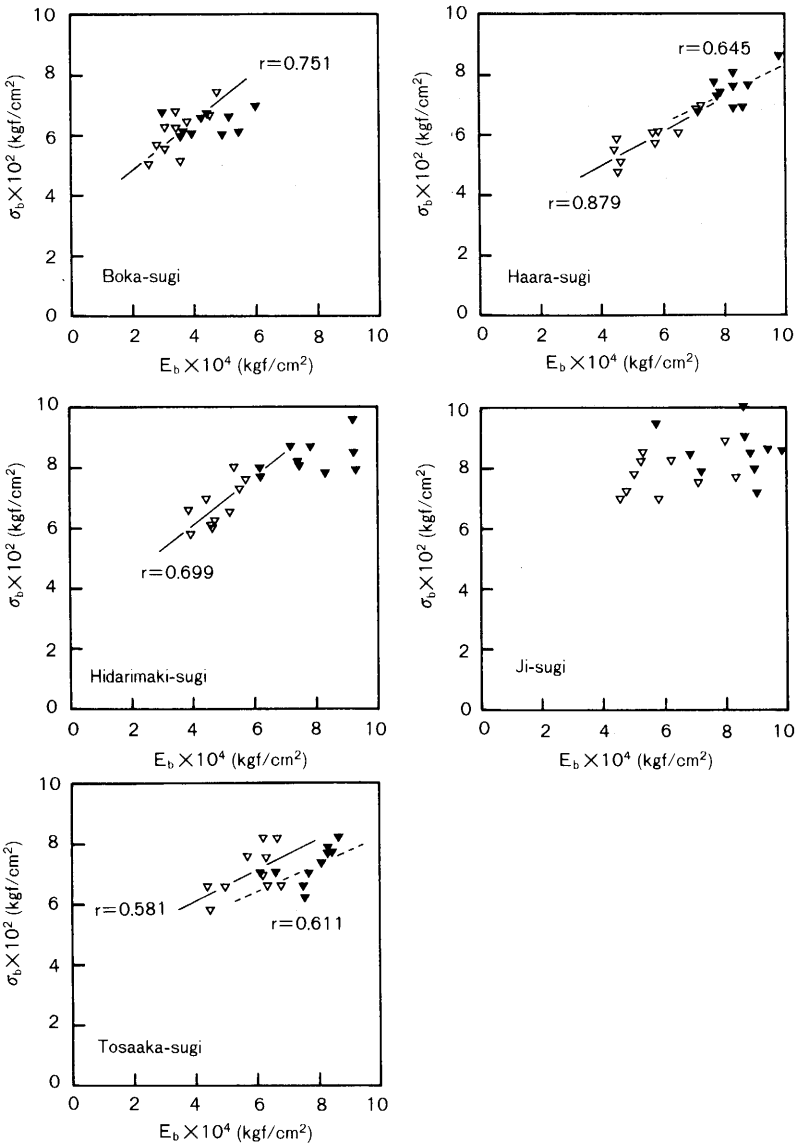

Fig. 15. Relationship between bending strength (σ_b) and Young's modulus in bending (E_b).
▽: juvenile wood, ▼: mature wood

(5) Relationships between Young's modulus in compression parallel to the grain (E_L), compressive strength (σ_c) and percentage of latewood

Figures 21 and 22 show the relationships between Young's modulus in compression parallel to the grain, compressive strength and percent of latewood, respectively. As can be seen from the figures, Young's modulus and compressive strength showed a tendency to increase with increasing percentage of latewood. At the same percent of latewood, Boka-sugi showed lower values than Hidarimaki-sugi. This tendency was found between Young's modulus in bending and percentage of latewood, and bending strength and percentage of latewood. From these results, it can be noted that the lower strength

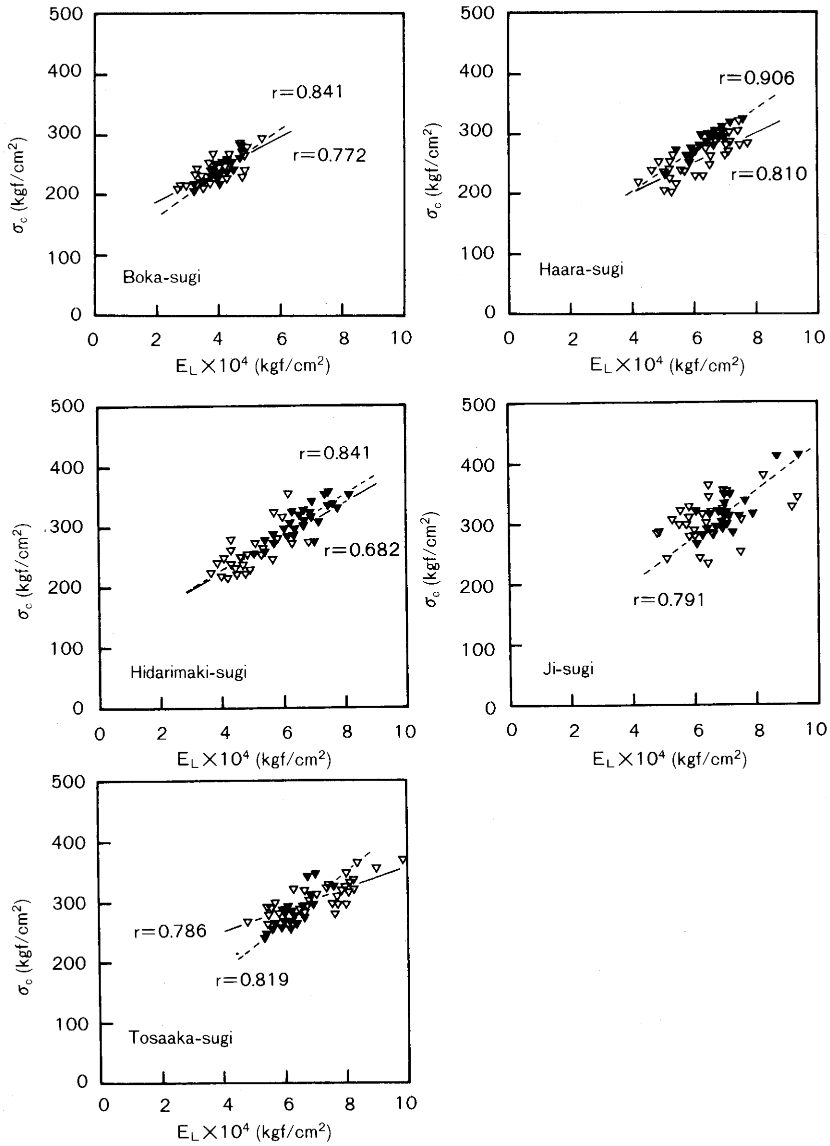

Fig. 16. Relationship between compressive strength paralell to the grain (σ_c) and Young's modulus in compression parallel to the grain (E_L).
▽: juvenile wood, ▼: mature wood

properties of Boka-sugi than those of other 4 sugi cultivars was not due to the mean width of annual rings/or percentage of latewood. To determine this further, the thickness of tangential wall and radial diameter of the lumen, and microfibril angle were measured. The results are shown in Tables 3 and 4. No significant difference in radial diameter of lumen was found between them. In spite of higher density of heartwood, thickness of tangential wall of Boka-sugi showed somewhat thinner than that of Hidarimaki-sugi (there was a significant difference between the earlywood and the latewood of the 30th ring, the earlywood of the 25th ring and the latewood of the 16th ring of two cultivars). The

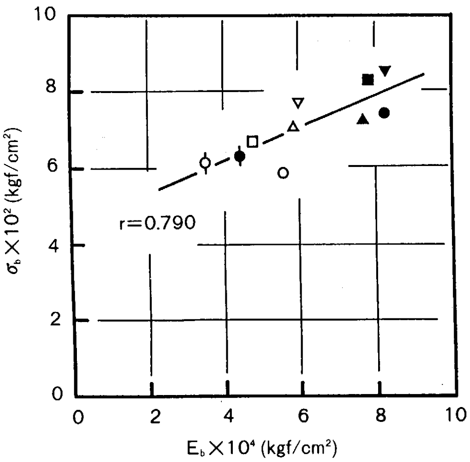

Fig. 17. Relationship between bending strength (σ_b) and Young's modulus in bending (E_b) of 5 sugi cultivars.
closed: juvenile wood, open: mature wood

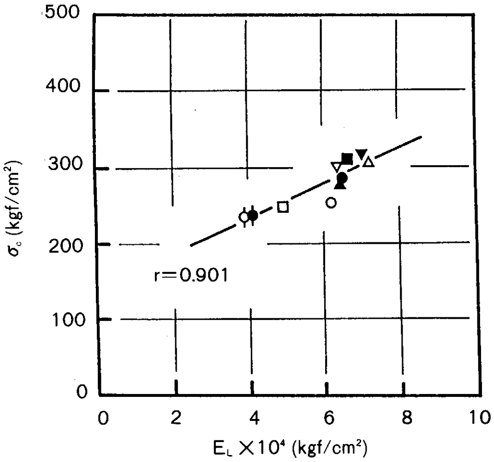

Fig. 18. Relationship between compressive strength parallel to the grain (σ_c) and Young's modulus in compression parallel to the grain (E_L) of 5 sugi-cultivars.
closed: juvenile wood, open: mature wood

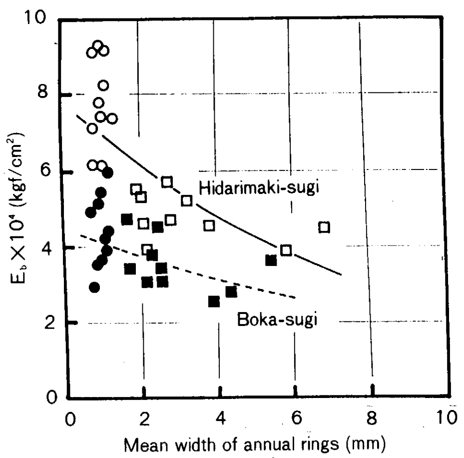

Fig. 19. Relationship between Young's modulus in bending (E_b) and mean width of annual rings.
squares: juvenile wood, circles: mature wood

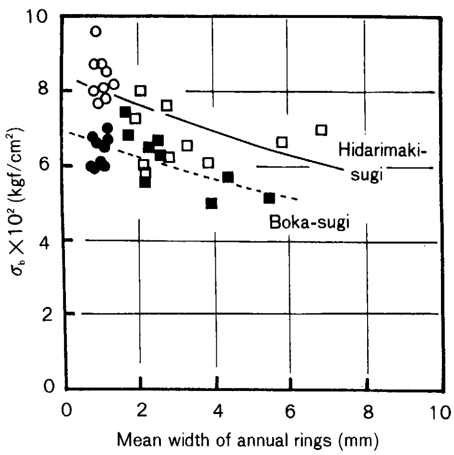

Fig. 20. Relationship between bending strength (σ_b) and mean width of annual rings.
squares: juvenile wood, circles: mature wood

microfibril angle in the cell wall of Boka-sugi was greater than that of Hidarimaki-sugi (a significant difference was found in both annual rings between them). From these results, the lower strength properties of Boka-sugi than those of the other 4 sugi cultivars was due to qualitative difference of the cell wall of tracheid.

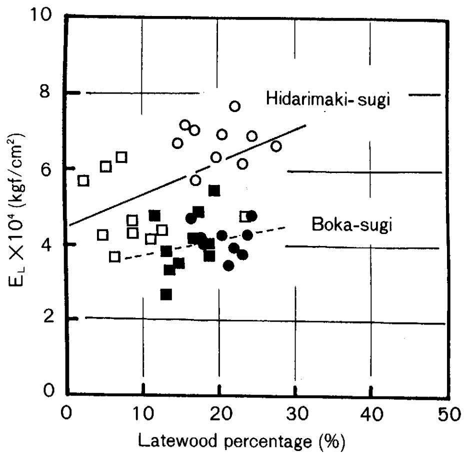

Fig. 21. Relationship between Young's modulus in compression parallel to the grain (E_L) and latewood percentage.
squares: juvenile wood, circles: mature wood

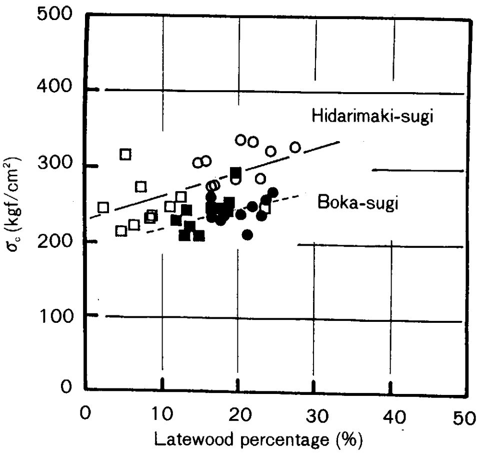

Fig. 22. Relationship between compressive strength parallel to the grain (σ_c) and latewood percentage.
squares: juvenile wood, circles: mature wood

4. Conclusion

Five Japanese cedars, Sugi(*Cryptomeria japonica* D. Don) cultivars grown in the same stand and managed in the same way, were examined in the radial distribution of green moisture content, basic density and strength properties. The results are summarised as follows:

(1) Total volume growth was the greatest in Tosaaka-sugi, followed by Ji-sugi, Haara-sugi, Boka-sugi and the least in Hidarimaki-sugi.

(2) The radial distribution of green moisture content was classified into four types.

(3) The basic density was somewhat higher near the pith than in sapwood.

(4) A good linear correlation was found between the compressive strength and the specific gravity in air dry of juvenile wood and mature wood of all cultivars, but not a good correlation was found between Young's modulus in compression parallel to the grain, Young's modulus in bending, bending strength and specific gravity in air dry, either of juvenile wood or mature wood of cultivars.

(5) A highly significant correlation was confirmed between Young's modulus and strength.

(6) The strength properties in Boka-sugi showed lower values than those of the other 4 sugi cultivars and it was remarkable in Young's modulus. This was due to qualitative difference in the cell wall of tracheids.

(7) Both the growth and the strength properties in Boka-sugi were not good.

(8) For Hidarmaki-sugi the strength properties were good, but growth was not good.

(9) Both the growth and the strength properties were good for Tosaaka-sugi, Ji-sugi and Haara-sugi.

Table 3. Cell-wall thickess (M) and dimension of lumen (L) of Boka-sugi and Hidarimaki-sugi

Ring number		Boka-sugi		Hidarimaki-sugi		Level of significant	
		M	L	M	L	M	L
30	Late wood	6.0 (1.3)	6.0 (4.2)	9.0 (1.6)	4.1 (4.9)	**	NS
	Early wood	3.5 (0.7)	26.8 (7.0)	4.1 (0.8)	25.5 (6.7)	*	NS
25	Late wood	7.9 (0.9)	5.1 (3.8)	7.3 (1.1)	4.6 (4.7)	NS	NS
	Early wood	3.5 (0.5)	27.7 (6.1)	3.9 (0.4)	28.9 (5.5)	**	NS
20	Late wood	7.6 (1.9)	5.5 (4.7)	8.9 (1.8)	4.7 (4.4)	*	NS
	Early wood	3.3 (0.4)	29.3 (6.5)	4.3 (0.9)	24.9 (4.9)	**	NS
16	Late wood	6.9 (0.9)	4.9 (3.2)	7.8 (1.6)	4.4 (3.9)	**	NS
	Early wood	4.2 (0.7)	24.1 (8.0)	4.4 (0.9)	24.7 (7.0)	NS	NS

M: thickness of double tangential wall (μm).
L: radial diamater of the lumen (μm).
*: Significant at 5% level.
**: Significant at 1% level.
NS: Not significant.
( ): standard deviation.

Table 4. Microfibril angle of the latewood in Boka-sugi and Hidarimaki-sugi

	Ring number	ϕ (degrees)[1]	ϕ (degrees)[2]
Boka-sugi	13	40.6 (3.9)	41.6
	25	32.3 (1.9)	30.4
Hidarimaki-sugi	13	30.1 (1.8)	26.0
	25	21.9 (3.5)	22.8

Notes: [1] measured by Iodine crystal technique.
Values are mean of 11 to 14 measurements and associated standard deviation.
[2] measured by X-ray diffraction technique.

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Summary

The growth and wood properties of 5 sugi cultivars grown in the same stand and managed in the same way were examined. The sample cultivars were Hidarimaki-sugi, Tosaaka-sugi, Haara-sugi, Boka-sugi and Ji-sugi, and they were 31 years old and had been planted in the Tokyo University Forest in Chiba. The discs were taken from sample trees at fixed heights for stem analysis, and the specimens for green moisture content, basic density, compression test parallel to the grain and bending test were taken from the log at about 1.3 m above ground level. The specimens for compression test parallel to the grain and bending test were taken from both juvenile wood and mature wood. The test was done in a room of 65% relative humidity and 20℃. The results are summarised as follows; 1) Total volume growth was the greatest in Tosaaka-sugi, followed by Ji-sugi, Haara-sugi and the least in Hidarimaki-sugi. 2) The radial distribution of green moisture content was classified into four types. 3) The basic density was somewhat higher near the pith than in sapwood. 4) A good linear correlation was found between the specific gravity in air dry and compressive strength of both juvenile wood and mature wood for all cultivars, but a good correlation was not found betwenn Young's modulus in compression paralell to the grain, Young's modulus in bending, bending strength and specific gravity in air dry, either of juvenile wood or mature wood of cultivars. 5) A highly significant correlation was confirmed between Young's modulus and strength. 6) The strength properties in Boka-sugi showed lower values than those of the other 4 sugi cultivars and it was remarkable in Young's modulus. This was due to qualitative difference in the cell wall of tracheids. 7) Both the growth and the strength properties in Boka-sugi were not good. 8) For Hidarimaki-sugi the strength properties were good, but growth was not good. 9) Both the growth and the strength properties were good for Tosaaka-sugi, Ji-sugi and Haara-sugi.

Key words: Sugi, Cultivar, Strength properties, Juvenile wood, Mature wood

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東京大学千葉演習林に生育したスギ5品種の生長と材質特性

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要　旨

スギの品種による材の基本的な性質の違いを調べるために，同じ環境で，同じ施業を受けたスギ5品種についてその成長と材質について検討した。試料は東京大学農学部付属千葉演習林の品種試験地に植栽されていた31年生のスギ5品種（ヒダリマキスギ，トサアカスギ，ハアラスギ，ボカスギ，ジスギ）である。心材の色は5品種とも赤色であった。各供試木から樹高別に樹幹解析用の円盤を採取した。また，胸高部位より生材含水率（容積密度），曲げ試験片及び縦圧縮試験片を採取した。曲げ試験片及び縦圧縮試験片は未成熟材部と成熟材部に分けて採取し，気乾状態で試験を行なった。得られた結果は次の通りである。1) 材積成長量はトサアカスギが最大で，次にジスギ，ハアラスギ，ボカスギ，ヒダリマキスギの順であった。2) 生材含水率の半径方向分布は大きく4つのタイプに分けられた。3) 容積密度はいずれの品種においても，樹心部分が辺材部分よりも若干高い傾向を示した。4) 縦圧縮強さと気乾密度との間には各品種とも成熟材，未成熟材で良い相関が見られたが，繊維方向のヤング率，曲げヤング率及び曲げ強さと気乾密度との間には各品種について，成熟材，未成熟材に分けても必ずしも良い相関は見られなかった。5) ヤング率と強さとの間には良い相関が見られた。6) ボカスギの強度，ヤング率は他の4品種のそれより小さい値を示した。特にヤング率の場合に顕著であった。これは，ボカスギの細胞壁の質的要因が関与しているものと思われた。7) ボカスギは強度的性質も成長も良くなかった。8) ヒダリマキスギは強度的性質は良好であったが，成長が良くなかった。9) トサアカスギ，ジスギ，ハアラスギは成長も強度的性質も優れていた。

キーワード： スギ，品種，強度的性質，未成熟材，成熟材