WITHDRAWAL AND BENDING STRENGTHS OF DOWELS FROM THREE MALAYSIAN TIMBERS

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SAID AHMAD, ASHAARI HAJI AMIN, ROSLAN ALI & HILMI MD. TAHIR. 1993. Withdrawal and bending strengths of dowels from three Malaysian timbers. The factors influencing the performance of dowel joints using three Malaysian timbers, nyatoh (species of Sapotaceae), ramin (*Gonystylus* sp.) and rubberwood (*Hevea brasiliensis*) were assessed. The effects on withdrawal and bending strengths on dowel species, dowel patterns and depths of dowel insertion were determined on testing blocks made from nyatoh. Species differences were not detected. Spiral-grooved dowels provided higher withdrawal strength while straight-grooved dowels performed better in bending. Both withdrawal and bending strengths increased with an increase in depth of insertion. In terms of application, dowels made from rubberwood are recommended.

Key words : Dowel strengths - withdrawal - bending - nyatoh - ramin - rubberwood

SAID AHMAD, ASHAARI HAJI AMIN, ROSLAN ALI & HILMI MD. TAHIR. 1993. Kekuatan cabut dan lentur dowel dari tiga jenis kayu kayan Malaysia. Faktor-faktor yang mempengaruhi keupayaan dowel dari tiga jenis kayu kayan Malaysia, nyatoh, ramin dan kayu getah sebagai alat sambungan telah dinilai. Keberkesanan kekuatan lentur dan cabut, corak permukaan dowel dan kedalaman susup dari jenis-jenis tersebut telah dilaksanakan dengan menggunakan kayu nyatoh sebagai blok ujian. Perbezaan antara spesies tidak dapat dikesan. Dowel berpilin memberikan nilai kekuatan cabut yang lebih tinggi manakala dowel dengan corak menegak menghasilkan kekuatan lentur yang lebih baik. Nilai kekuatan cabut dan lentur meningkat apabila kedalaman bertambah susup. Dari segi kegunaan, dowel yang di buat dari kayu getah adalah disyorkan.

Introduction

Although doweled joints have been used successfully for joining wooden parts for a very long time (Groome 1985), information on the various factors that affect the performance of such joints from Malaysian timbers is almost non-existent.

The performance of such joints is seen to be influenced by, amongst other factors, the depth of insertion, glue types, pattern of dowels, grain orientation and species. This study attempts to assess some of these factors with regard to their withdrawal and bending strengths in three local timbers and to determine their suitability in the furniture industry.

Materials and methods

Three local light hardwood species were used: nyatoh (a species of Sapotaceae), ramin (*Gonystylus* sp.) and rubberwood (*Hevea brasiliensis*). Ramin was chosen because of its current popularity as a dowel material. Nyatoh is the mainstay of the furniture industry. Its off-cuts and other wastes generated could be utilised. Rubberwood, a plantation species, is seen to be in continuous supply, and popularly used in furniture.

The boards from the chosen species were first cut to 12 × 150 × 11 *mm* strips and conditioned to 10 - 12 % moisture content. They were then converted to dowels in the moulding machine. The outer surfaces of the dowels were profiled into either straight or spiral grooves by the doweling machine to a nominal diameter of 10 *mm*. The final length of the profiled dowels was cut to 60*mm* for the withdrawal test and 40*mm* for the bending test. A total of 216 dowels was needed to assemble the test samples.

The number of samples prepared for both the withdrawal and bending tests was as follows: For each pattern, two depths of insertion (15 *mm* and 20 *mm*) were used. Three species were selected for the study. Thus, the total number of assembled samples was 72 (2 patterns × 2 depths of insertion × 3 species × 6 assembled samples).

The sample test blocks were next prepared. The blocks were of nyatoh sp. dressed to 40 × 40 × 50 *mm* for the withdrawal tests and 30 × 50 × 175 *mm* and 30 × 50 × 125 *mm* for the bending tests. Two holes of 10 *mm* diameter were drilled into the sides of the bending test blocks to receive the dowels at dowel hole spacing of 32 *mm* from centre to centre to the depths of 15 *mm* and 20 *mm*. A single hole of similar diameter and depth was drilled into the withdrawal test blocks.

Polyvinyl acetate glue was then applied onto the dowel surfaces before the dowel pins were inserted into the respective receptive holes of the test components. The test samples were assembled as presented in Figure 1.

A withdrawal test sample assembly consisted of a test block component from which the dowel was to be withdrawn, and a load block, whose purpose was to provide a structure for securing the other end of the dowel. In the bending test sample assembly, a sheet of wax paper was placed between the component blocks to prevent them from sticking to each other as a result of any excess glue that might be transferred from the dowel surfaces.

The assembled samples for both tests were then conditioned in 65% RH at 24°C for 10 days.

The tests were carried out on the Shimadzu and Zwick universal testing machines. For the withdrawal test, the load block at the top was secured to a jig which was connected to the testing machine yoke through a universal ball joint. Tensile load was applied at a speed 2 *mm* min^{-1}. The load, in Newton (*N*), at which failure occurred was taken to be the maximum withdrawal strength.

For the bending test, each test sample assembly was loaded at 100 *mm* from the column (*i.e.*, the moment arm was 100 *mm*) at a constant rate of 2 *mm* min^{-1} . The bending force versus deflection curve which gave the maximum load in Newton (*N*) and the amount of deflection in *mm* were recorded.

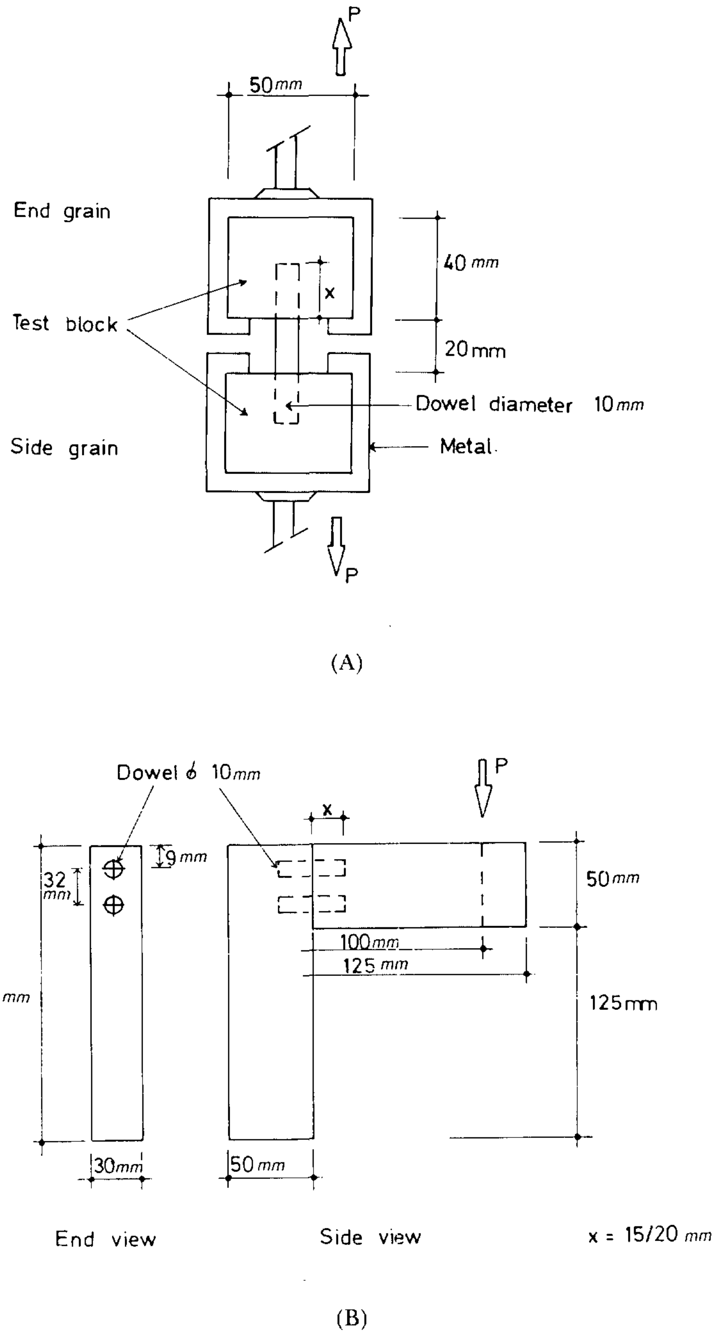


Figure 1. Assembled components for withdrawal (A) and bending (B) tests

A 3-way factorial design of 3 × 2 × 2 with six replications for analysis of variance (ANOVA) was used in order to analyse the effects of all factors and their interactions. To examine the significant difference of any one of the factors, a least significant difference (LSD) procedure was applied.

Results and discussion

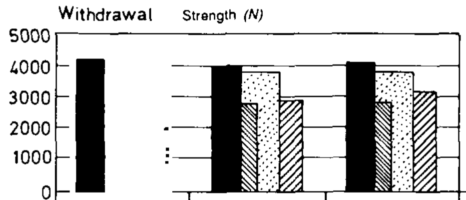
The data were subjected to ANOVA. Table 1 summarises the responses of the withdrawal strength due to the factors considered.

Table 1. Summary of ANOVA of some relevant factors for withdrawal strength

Source	df	SS	MS	F
Species (S)	2	267393.2	133696.6	2.70ns
Pattern (P)	1	715586.8	715586.8	14.43***
Depth (D)	1	20546293.6	20546293.6	414.21***
SP	2	426390.0	213195.0	4.30*
SD	2	385012.3	192506.2	3.88*
PD	1	756716.5	756716.5	15.26***
SPD	2	108809.4	54404.7	1.10ns
Error	60	2976202.4	49603.4	

ns = not significant; * = 5% significant; ** = 1% significant; ***= 0.1% significant.

Figure 2 provides a quantitative presentation of the effects of species and dowel characteristics.



	Nyatoh	Ramin	Rubberwood	Average	Average
Spiral – 20 mm	4313·7	3992.9	4129.2	4145·3	3503·6
Spiral – 15 mm	2903·7	2807·9	2874·0	2861·9	
Straight – 20 mm	3763·3	3673·1	3756·1	3730·8	3299.2
Straight 15 mm	2626·8	2847·2	3128·5	2867·5	

ALL SPECIES

Spiral - 20 mm
Straight - 20 mm
Average - 3938·05· N

Spiral - 15 mm
Straight - 15 mm
Average - 2877.52. N

■ Spiral 20 mm
⁝ Spiral 15 mm
▨ Straight 20 mm
▪ Straight 15 mm

Figure 2. Withdrawal strength: effect of species and dowel characteristics

Since mean withdrawal strength of rubberwood is significantly higher than that of ramin, it appears that rubberwood should be the better choice for dowel making.

The analysis generally reveals that spiral-patterned dowels provide a significantly higher withdrawal strength than straight-patterned ones, 3503.6 *N* versus 3299.2 *N* respectively. This difference seems logical owing to the better holding capability of the former and should always be considered in the making of dowels.

An increase of 5*mm* depth of insertion for all the species tested, as expected, increases the withdrawal strength from 2877.5 to 3938.0 *N*. In practice, this depth advantage is limited to the depth of the member component in which a dowel is to be fixed.

Table 2 summarises some of the pertinent factors which affect the bending strength and Figure 3 quantifies the effects of species and dowel characteristics on bending strength.

Table 2. Summary of ANOVA of some relevant factors for bending strength

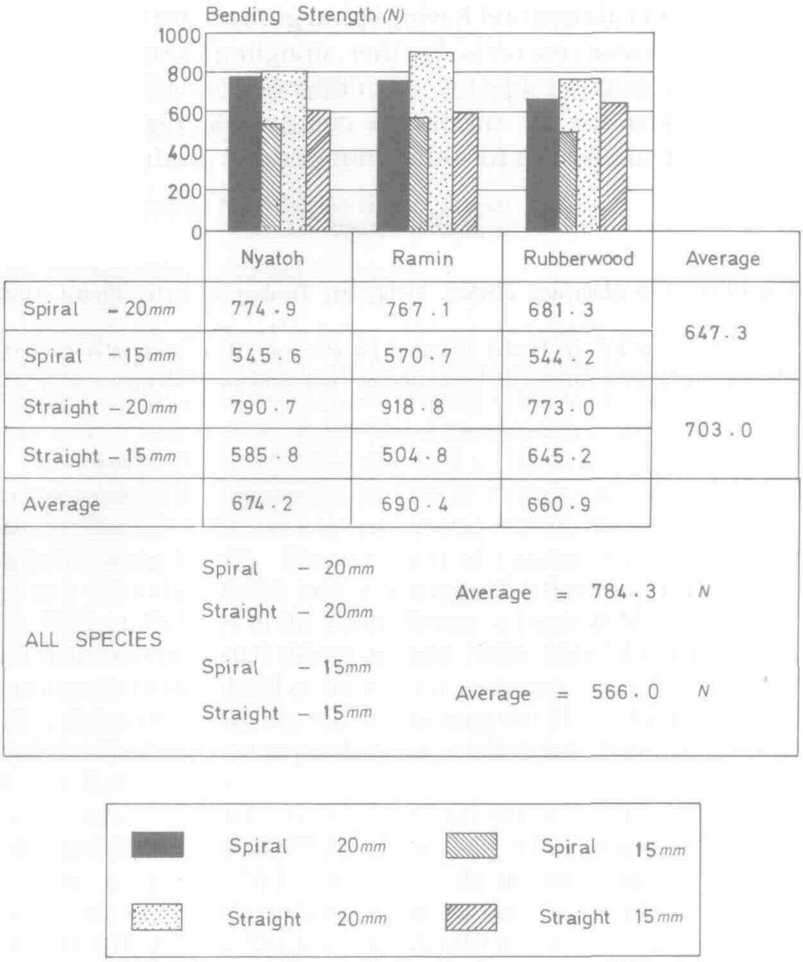
Source	df	SS	MS	F
Species (S)	2	38636.1	19318.1	2.57ns
Pattern (P)	1	94385.0	94385.0	12.55***
Depth (D)	1	731465.3	731465.3	97.28***
SP	2	17786.8	8893.4	1.18ns
SD	2	47362.4	23681.2	3.15*
PD	1	3515.4	3515.4	0.47ns
SPD	2	18242.6	9121.3	1.21ns
Error	60	451172.7	7519.5	

ns = not significant; * = 5% significant; ** = 1% significant; ***= 0.1% significant.

The mean bending strength was 690.4 *N* for ramin, 674.2 *N* for nyatoh and 660.9 *N* for rubberwood. This strength order is in line with the established modulas of rupture of these species: (88 - 134 $N\,mm^{-2}$) for ramin, followed by that of nyatoh (79 - 129 $N\,mm^{-2}$) and that of rubberwood (66 $N\,mm^{-2}$) (Anonymous 1986). However, the ANOVA reveals that these strengths are not significantly different. It follows that although ramin and nyatoh have higher bending strengths than rubberwood, this difference (about 4.4% maximum) in strength has proven not too critical to discredit the use of rubberwood for dowel material.

The analysis also reveals that straight-patterned dowels provide a significantly higher bending strength as compared to spiral-patterned ones: 703.0 *N* versus 647.3 *N* respectively. The difference obtained is most probably due to the weak spots of torn fibers running at an angle to the axis in the spiral-grooved dowel during surface profiling.

An increase of 5*mm* depth of dowel insertion for all the species tested increases the bending strength by 21% from 566.0 to 784.3 *N*. In practice, however, this depth is limited to the depth of the member component where a dowel is to be effected.



	Nyatoh	Ramin	Rubberwood	Average
Spiral - 20mm	774·9	767.1	681·3	647·3
Spiral - 15mm	545·6	570·7	544·2	
Straight - 20mm	790·7	918·8	773·0	703.0
Straight - 15mm	585·8	504·8	645·2	
Average	674·2	690·4	660·9	

ALL SPECIES		
	Spiral - 20mm Straight - 20mm	Average = 784.3 N
	Spiral - 15mm Straight - 15mm	Average = 566·0 N

Figure 3. Bending strength: effect of species and dowel characteristics

Before rubberwood made its debut in the early 1980's, ramin had been the more popular species for dowel making. Further, ramin is a more expensive timber and would be of greater beneficial use other than for dowels.

With the current replanting rate encouraged by the government, the availability of rubberwood is expected to be sustained, if not increased, whereas ramin's availability is questionable. As for nyatoh, it is the mainstay of the furniture industry and their wastes could be converted to dowels. The above tests proved that in dowel making, the selection of the three species is trivial.

Conclusion and recommendation

The withdrawal and bending strengths of dowels made from rubberwood were found to be comparable to those of ramin or nyatoh. As for pattern, spiral-grooved dowels had higher withdrawal strengths than straight-grooved dowels. Their bending strengths, however, were reversed. Joint strength increased with an increase in depth of insertion in all species and patterns tested.

Dowels made from rubberwood having spiral grooves are recomended for use in joints having withdrawal reactions. Further, straight-grooved pattern dowels are more suitable for joints most subjected to bending reactions. Since the withdrawal and bending strengths for all species are comparable, the use of rubberwood would relieve ramin and nyatoh for other more valued products.

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