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Original

Mechanical characterization of timber from Spanish provenances of laricio pine according to European standards

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Abstract The Spanish grown laricio pine (*pinus nigra* subsp. *saltzmannii*) covers an area of 353,000 hectares and produces an annual figure of 310,000 m^3 of roundwood. It ranks as the fourth most important Spanish conifer and its timber is frequently used in construction. The results of the mechanical characterization of laricio pine timber coming from three different Spanish regions of provenance (R. 6 "Alto Maestrazgo", R. 7 "Sistema Ibérico Meridional" y, R.8 "Cordilleras Béticas"), carried out in accordance with the methodologies and requirements of EN 408, EN 384 and EN 338, are considered in the present study. 3612 boards, from 15 different samples ranging in size from 100×40×2500 mm to 200×70×4500 mm have been tested in accordance with EN 408. The samples represent the variety of cutting patterns, log sources, sizes and quality of the material present in the market.

The testing material was classified in accordance with the Spanish standard of visual strength grading UNE 56544, which sets two different grades, namely, ME1 and ME2. One part of the sample (681 boards) was classified by applying the German standard DIN 4074. In accordance with the results, Spanish grade ME1 can be assigned to strength class C35, and while grade ME2 is assigned to C18. The influence of the rate of growth on the mechanical properties of timber was also assessed concluding that the size of the growth ring, considered at species level, is not an adequate predictor of the mechanical quality of the material. When considering the use of this timber in structures, the high level of deformations during drying (an 11.1% average value) suggests the convenience of making use of dried timber.

Different relations between the strength and local modulus of elasticity in bending of timber and the major properties studied (E_{cen},$E_{m,g}$, ρ, RW) are also considered.

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Introduction

In general, five subspecies of black pine are distinguished (*nigra*, *dalmatica*, *pallasiana*, *laricio* and *salzmannii*), although it is sometimes difficult to make a precise distinction among the intraspecific differences. The only original subspecies from Spain is *salzmannii*, which is found in extensive areas (353,000 hectares in total) from the Pyrenees in the North to the Sierra de Baza (Granada) in the South. Some relictic populations are found in the Central System. Outside the Iberian peninsular area, this subspecies extends to limited zones of the French eastern Pyrenees and southern Cevennes (Regato 1993).

Taking into account the natural forest area of this species in Spain, the laricio pine can be ranked as the fourth Spanish conifer, representing 14.4% of the total surface area covered by conifer species (4,830,000 hectares). The 1999 estimated harvest (roundwood with bark) was 310,000 m^3.

In Spain there are ten different regions of provenance for *pinus nigra* subsp. *salzmannii* (Catalan et al. 1991), of which only four, in terms of productivity, stand out (R.3 Prepirineo Catalán, R.6 Alto Maestrazgo, R.7 Sistema Ibérico Meridional and R.8 Cordilleras Béticas). The other regions are protection forests in places that are strongly conditioned by environmental criteria.

The laricio pine is a slow-growing species, which is managed with variable (within regions) rotation periods, normally between 120 and 150 years, and have an average diameter (including the bark) of 45–50 cm. This rule is not applicable for the forests in region 3 (Prepirineo Catalán), as the average rotation period stands at 70 years and the DBH tends to be under 25 cm.

This timber has been traditionally renowned for its mechanical strength which, in the past, resulted in its use for naval construction and buildings, as well as for railway sleepers. It is currently used extensively in Spain in the structural refurbishing of old buildings and in construction in general, although its high resin content (up to 18%) restricts its usage in carpentry.

The Spanish standardization process for timber products is advancing in line with the work carried out by the European Committee for Standardization (CEN). From the structural point of view, EN 408 (2000), EN 338 (2000), EN 384 (2000) and EN 1912 (1997) standards have already been adopted as Spanish national standards (UNE-EN).

The Spanish UNE 56544 (2000) standard for "visual strength grading of structural timber", mainly oriented to pine timber (radiata, pinaster, nigra and sylvestris) grading, was approved in the year 2000 by the Spanish Technical Committee AENOR/TC 56.

The European standard EN 1912 (1997) sets forth the assignment of visual grades and species to strength classes for the different timbers and European grading standards or those that may be of interest to the European market (NLGA, NGRDL). This standard is vital to ensure the free commerce of timber products within the European Union's market for building materials. In this way, and in order to introduce the most important Spanish timbers in the above cited EN 1912 (1997) standard, since 1992 the Spanish Forest Research Centre (CIFOR-INIA), belonging to the Ministry of Science and Technology, has been carrying out a systematic characterization of the most important building timbers grown in Spain: *radiata*, *pinaster*, *nigra* and *sylvestris* pines.

Of the four pines mentioned above, *radiata* and *pinaster* have been completely characterized (Fernández-Golfin and Díez Barra 1998) and in the year 2000 included in standard EN 1912 (1997). The research on the *nigra* (laricio) pine is

reviewed in this work and its inclusion in EN 1912 (1997) will shortly be requested; the research on the *sylvestris* (Redwood) will be finished by the beginning of 2002.

Material and methods

Study of the mechanical characterization of the timber of *pinus nigra* subsp. *salzmannii* initially focused on the commercial forests of the four most productive regions of provenance (R.3 Prepirineo Catalán, R.6 Alto Maestrazgo, R.7 Sistema Ibérico Meridional, R.8 Cordilleras Béticas), which cover 85.4% of the natural forest area of this species in Spain and 95% of the harvested volume.

Of the four regions of provenance originally pinpointed for study, one had to be eliminated (R.3. Prepirineo Catalan) due to the forest fires that devastated the area in the summer of 1997. An additional reason for elimination was because of the special managing system used in the area oriented towards the production of small-diameter timber which is primarily used by the pallet market, in particleboard production or in the manufacturing of power and telephone poles.

Therefore, the material tested belongs to three different regions of provenance (R.6 Alto Maestrazgo, R.7 Sistema Ibérico Meridional, R.8 Cordilleras Béticas) although the sampling of regions 6 and 7 took place at the same time because the timbers from these two provenances are usually mixed in the sawmills. All the samples together cover 75% of the area of distribution of the species and 85% of the harvested volume.

The sampling process took place both in forests and in sawmills. In the forest sampling, up to 45 different trees per region (selected by the managing plan of the year) were randomly selected from at least three different harvesting zones. All the standard qualities were represented in the sampling. In the sawmill samplings the timber was directly classified and selected in the timber yards of three different sawmills (regions 6 and 7) being taken at intervals of approximately six months. This sampling and selection system reasonably cover the variety of cutting patterns and log sources of the material present in the market. The characteristics and sizes of the samples are summarized in Tables 3 and 4.

Additionally, the forest sampling gave very useful information regarding the physic-mechanical properties of this wood and their evolution in the stem with the distance from the pith and from the ground (Fernández-Golfín et al. 2001).

In the joint forest sampling that took place in regions 6 and 7 (henceforth to be referred to as "Cuenca"), the material was sawn to a unique size of 160×60×3500 mm. This did not comply with the requirements of the last draft of the revised version of EN 384 (2000) regarding the minimum number of sections to be considered, and therefore was complemented by subsequent sawmill samplings (samples S2 to S8 in Tables 3 and 4) which took place over the period 1999–2000.

The forest sample of region 8 ("Cazorla") was sawn to 100×40×2500 mm, 100×50×2500 mm, 150×40×3500 mm and 150×50×3500 mm sizes, although the resulting mechanical data obtained were grouped by the two depths: 100 mm (samples M1, U1, R1, P1) and 150 mm (samples M2, U2, R2, P2). An additional sawmill sampling took place (S1) in order to include pieces of size 190×60×4500 mm.

The material was selected in green condition, air dried up to 30% and finally kiln dried up to a final moisture content (mc) of 12%. At the time of testing, the timber contained a moisture content of around 12%, according to prEN 13183-2 (1999) methodology.

All the tests took place in accordance with the methodology set forth in EN 408 (2000), and the calculations were made in accordance with EN 384 (2000). In order to achieve the assignment of strength classes, the criteria set forth in EN 338 (2000) were applied. The average rate of growth was measured in compliance with EN 1310 (1997).

Prior to testing, all the material was classified in accordance with the Spanish visual strength grading standard UNE 56544 (2000), which sets forth two different quality grades, ME1 and ME2. The forest samples from region 8 "Cazorla" were also classified using the German standard DIN 4074-89 (Díez et al. 2000). All boards with excessive deformations, measured in accordance with EN 1310 (1997) and evaluated according to prEN 14081-1 (2000), were removed from the test sample but were included in calculation of the grading yields (% deformation).

Part of the material classified as "rejects" under the Spanish standard UNE 56544 (2000), but nevertheless apt for testing from the viewpoint of their deformations (571 boards), was also tested in accordance with EN 408 (2000) in order to determine the relationships among the testing variables (f_m, $E_{m,g}$, E_{cen}, ρ, RW). The description of the relationships among variables was completed by fitting linear models between the variables under study.

The most updated version of standard EN 408 (2000) sets forth two different testing methodologies to determine the modulus of elasticity in bending, both local (E_{cen}) and global ($E_{m,g}$). Both testing methods were carried out although the assignment of grades to strength classes was completed in conformance with EN 338 (2000) and according to the calculated values of local modulus of elasticity ($E_{m,l}$) by means of the expression given in EN 384 (2000).

In determining the global modulus of elasticity ($E_{m,g}$), the deformation was measured at the center of the span and at the neutral axis, thus the final value became the mean of measurements made on both sides of the test piece. The deformation was also measured at the center of the tension edge but this value was not considered in calculation of the final value for global modulus of elasticity ($E_{m,g}$).

Results and discussion

Table 1 gives a brief summary of the average grading results, according to visual grading standards UNE 56544 (2000) and DIN 4074 (1989) (only applied to the Cazorla sampling).

According to the results of Table 1, it can be concluded that the level (%) of rejects and first quality (ME1 and S13) are very similar with both standards. As far as the grading yields are concerned with the second quality material (ME2 and S10+S7), it is also possible to conclude that the results are very close according to Spanish and German standards.

Table 1. Grading summary (%)

Sampling/region	**Grades**(UNE 56544 2000)				**Rejects***
	ME1	**ME2**		**Reject**	
Forest/"Cuenca"	22.9	53.1		24.0	9.6
Forest/"Cazorla"	22.6	51.9		25.5	11.1
Sawmill/"Cuenca"	6.6	57.8		35.6	–
	Grades(DIN 4074 1989)				
	S13	**S10**	**S7**	**Reject**	
Forest/"Cazorla"	20.7	33.6	20.9	24.8	11.1

*Due to excessive deformations after drying

Table 2. Relationships among testing variables

Model	R^2 (%)	Significance	
		Intercept	Slope
$f_{m,c}$=0.828183+0.00400995*E_{cen}	51.7	N.S.	***
$E_{cen,c}$=1.14027*$E_{m,g,c}$−792.455	82.4	***	***
$f_{m,c}$=−16.3596+0.0069402*$E_{m,g,c}$	55.7	***	***
$f_{m,c}$=−33.8903+0.149717*ρ	28.1	***	***
$f_{m,c}$=63.9978–9.56858*RW	9.5	***	***
$f_{m,c}$=79.65–23.2519*RW(sample S2)	25.9	***	***
$f_{m,c}$=72.21–19.6529*RW(sample S3)	20.4	***	***

***Significant at the 99% confidence level
**Significant at the 95% level
*Significant at the 90% level
N.S.: Not significative

Table 2 gives the relationships between the studied properties (E_{cen}, $E_{m,g}$, ρ, RW), taking into account not only the testing results of boards graded as ME1 and ME2 but also those graded as rejects.

Tables 3 and 4 give the results of the mechanical characterization per sampling zone and region and also the assignment of ME1 and ME2 visual grades to strength classes.

Figure 1 includes the distributions of relative knot size (face and thickness), rate of growth and density.

The terminology used in Tables 2, 3 and 4 is as follows:

Grade: grade according to the Spanish visual grading standard UNE 56544 (2000)
RW: average ring width
t: thickness of cross section (mm)
h: depth of cross section (mm)
n: sample size (number of tested boards)
mc: moisture content (%)
f_{mean}= sample mean value of bending strength (N/mm^2)
s= standard deviation
f_{05}= sample 5-percentile value of bending strength (N/mm^2)
k_h= depth factor=$(150/h)^{0.2}$
$f_{05\ h}$= h-adjusted sample f_{05}value=(f_{05}/k_h)
$\bar{f}_{05}$ = mean value of $f_{05\ h}$ of several samples (N/mm^2)
$\bar{f}_{05} = \frac{\sum f_{05hj} * n_j}{\sum n_j}$
k_s= factor for adjusting $\bar{f}_{05}$ according to the number and size of samples (EN 384 2000)
f_k= characteristic value of bending strength (N/mm^2)=($\bar{f}_{05} \times k_s$), being the minimum value of $\bar{f}_{05}$ and 1.2*Min(f_{05h})
$E_{g,12}$= sample mean global modulus of elasticity adjusted to 12% mc (if needed)
$E_{cen,12}$= sample mean of tested local modulus of elasticity adjusted to 12% mc (if needed)

Table 3. Characteristic values according to EN 384 (2000) (ME1 quality)

Sample	Sampling	Grade	*RW*	*t*	*h*	*n*	mc	f_{mean}	S	f_{05}	k_h	$f_{05\,h}$	f_{05}	f_k	$E_{g,12}$	S	$E_{0,g,mean}$	$E_{cen,12}$	$E_{l,12}$	$E_{l,mean}$	$\bar{\rho}$	S	ρ_{05}	ρ_k
Regions 6&7 "Cuenca"																								
PL	Forest	ME1	1.0	60	160	89	12	62.9	16.1	35.8	0.987	36.3			13210	2642		14271	14483		617.7	74.3	495.1	
FC	Forest	ME1	1.0	60	160	45	12	65.6	19.2	31.8	0.987	32.2			12668	2660		13652	13778		590.0	69.6	475.2	
CG	Forest	ME1	1.2	60	160	108	12	71.2	18.4	40.2	0.987	40.7			15467	2939		16844	17417		648.6	82.4	512.6	
S2	Sawmill	ME1	0.8	40	100	90	12	86.6	21.9	55.4	1.084	51.1			14170	3050		14815	15731		597.0	79.5	465.8	
S3	Sawmill	ME1	0.9	50	100	62	12	74.3	17.7	38.4	1.084	35.5			13373	2570		13594	14695		576.4	64.8	469.5	
S4	Sawmill	ME1	1.0	40	150	70	12	69.4	16.8	48.0	1.000	48.0			14421	3037		14553	16057		608.2	99.1	444.7	
S5	Sawmill	ME1	1.3	50	150	40	12	63.5	16.5	36.0	1.000	36.0			11870	2523		12237	12741		578.0	68.3	465.3	
S6	Sawmill	ME1	1.2	70	150	48	12	68.3	16.7	38.7	1.000	38.7			12416	2205		12926	13451		553.0	53.5	464.7	
S7	Sawmill	ME1	1.0	50	200	40	12	64.6	15.0	35.8	0.944	37.9			13717	2545		14849	15142		643.2	80.8	509.9	
S8	Sawmill	ME1	1.3	70	200	83	12	72.1	13.4	46.3	0.944	49.0			13120	2476		13958	14366		629.3	85.9	487.6	
Total region		ME1											**41.6**	**36.6***			**13686.7**	**14461**		**15102.6**				**481.1**
Region 8 "Cazorla"																								
M1	Forest	ME1	1.0	40	100	143	12	79.7	22.6	42.3	1.084	39.0			14185	2924		15623	15751		605.6	69.1	491.6	
U1	Forest	ME1	1.1	40	100	99	12	86.6	19.7	54.4	1.084	50.2			15157	2968		17350	17014		611.4	75.8	486.3	
R1	Forest	ME1	1.1	40	100	83	12	81.4	20.6	45.0	1.084	41.5			13790	2482		15130	15237		598.3	46.0	522.4	
P1	Forest	ME1	1.1	40	100	120	12	85.5	16.5	58.9	1.084	54.3			15727	3146		17484	17755		648.2	76.2	522.5	
M2	Forest	ME1	1.2	50	150	52	12	61.1	18.3	29.3	1.000	29.2			13000	2642		13950	14210		592.0	72.8	471.9	
U2	Forest	ME1	1.2	50	150	42	12	72.1	17.3	41.1	1.000	41.1			13671	2399		15189	15082		602.4	64.9	495.3	
R2	Forest	ME1	1.2	50	150	56	12	65.9	15.5	36.6	1.000	36.6			12462	1998		13440	13511		576.4	49.4	494.9	
P2	Forest	ME1	1.3	50	150	41	12	64.0	17.4	38.2	1.000	38.2			13477	2768		14059	14830		606.2	89.5	458.5	
S1	Sawmill	ME1	1.2	60	190	40	12	63.5	17.1	42.4	0.954	44.4			12264	2013		13045	13253		602.3	70.7	485.6	
Total region		ME1											**43.1**	**35.1***			**14130.1**	**15562**		**15679.2**				**496.7**
Total																								
Total**														**35.1**						**15103**				**481**

* More than 5 samples and minimum size of samples>40 boards, then k_s=1.0 and k_v=1
The selected value of f_k is the lower of f_{05} and 1.2*Min($f_{05\,h}$)
** Minimum values of both regions

Table 4. Characteristic values according to EN 384 (2000) (ME2 quality)

Sample	Sampling	Grade	RW	t	h	n	mc	f_{mean}	S	f_{05}	k_h	$f_{05\,h}$	f_{05}	f_k	$E_{g,12}$	S	$E_{0,g,mean}$	$E_{cen,12}$	$E_{l,12}$	$E_{l,mean}$	$\bar{\rho}$	S	ρ_{05}	ρ_k
Regions 6&7 "Cuenca"																								
PL	Forest	ME2	1.3	60	160	109	12	40.9	13.0	21.9	0.987	22.2			10923	2185		11663	11510		576.9	82.8	440.3	
FC	Forest	ME2	1.5	60	160	118	12	38.7	13.8	19.2	0.987	19.5			10241	2151		10885	10623		538.0	69.2	423.8	
CG	Forest	ME2	1.8	60	160	193	12	46.4	16.0	25.2	0.987	25.6			12349	2717		13289	13364		557.7	86.3	415.3	
S2	Sawmill	ME2	1.1	40	100	59	12	52.3	16.0	27.0	1.084	24.9			10897	2126		11475	11476		527.6	75.1	403.7	
S3	Sawmill	ME2	1.1	50	100	80	12	54.1	17.2	27.8	1.084	25.6			11542	2421		11825	12315		530.6	57.5	435.7	
S4	Sawmill	ME2	1.7	40	150	56	12	46.3	17.2	20.9	1.000	20.9			11634	2888		11574	12434		556.6	59.3	458.8	
S5	Sawmill	ME2	1.9	50	150	74	12	44.8	20.1	18.0	1.000	18.0			9971	2747		10317	10272		570.5	80.4	437.8	
S6	Sawmill	ME2	1.7	70	150	83	12	47.9	16.4	26.0	1.000	26.0			10839	2047		11045	11401		544.5	67.1	433.8	
S7	Sawmill	ME2	1.5	50	200	78	12	40.7	12.5	21.7	0.944	23.0			11421	2182		10803	12157		560.5	96.3	401.6	
S8	Sawmill	ME2	1.8	70	200	96	12	53.7	17.0	25.5	0.944	27.0			11301	2374		11848	12001		592.4	108.2	413.9	
Total region		ME2											**23.5**	**21.6***			**11219.3**	**11683**		**11895**				**424.9**
Region 8 "Cazorla"																								
M1	Forest	ME2	1.1	40	100	159	12	50.1	19.3	22.0	1.084	20.3			11743	2466		12463	12576		565.3	66.9	454.9	
U1	Forest	ME2	1.3	40	100	76	12	50.8	20.0	20.6	1.084	19.0			11314	2276		12191	12018		551.0	82.4	415.0	
R1	Forest	ME2	1.4	40	100	93	12	48.1	19.6	21.9	1.084	20.2			11021	2516		11817	11637		565.5	65.2	457.9	
P1	Forest	ME2	1.3	40	100	88	12	61.3	18.9	27.9	1.084	25.7			14184	3214		15390	15794		613.6	77.1	486.4	
M2	Forest	ME2	1.2	50	150	99	12	47.6	16.9	20.9	1.000	20.9			10896	1992		11815	11475		561.8	63.1	457.7	
U2	Forest	ME2	1.1	50	150	64	12	45.5	17.7	19.5	1.000	19.5			11164	2064		11909	11823		594.4	54.7	504.1	
R2	Forest	ME2	1.3	50	150	57	12	44.8	17.4	20.8	1.000	20.8			10882	2059		11839	11457		543.3	41.7	474.5	
P2	Forest	ME2	1.2	50	150	40	12	47.7	16.8	17.3	1.000	17.3			11851	2671		12593	12716		576.3	79.0	445.9	
S1	Sawmill	ME2	1.4	60	190	68	12	47.5	15.0	26.8	0.954	28.2			11821	2394		12701	12677		568.6	75.2	444.5	
Total region		ME2											**21.4**	**20.7***			**11704.4**	**12548**		**12559**				**459.6**
Total																								
Total**														**20.7**						**11895**				**425**

*More than 5 samples and minimum size of samples>40 boards, then k_s=1.0 and k_v=1
The selected value of f_k is the lower of f_{05} and 1.2*Min($f_{05\,h}$)
**Minimum values of both regions

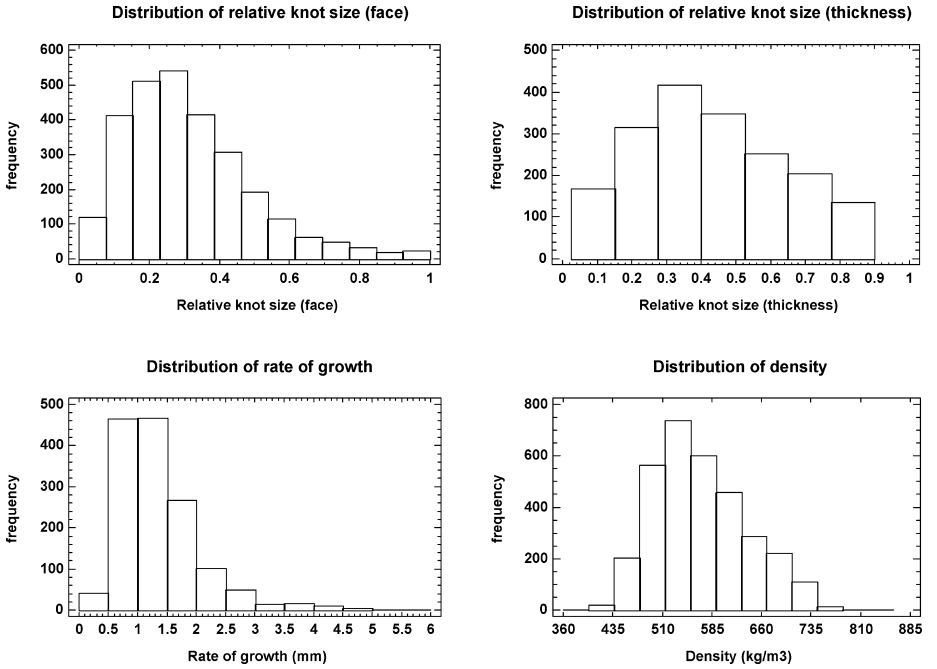

Fig. 1. Distributions of relative knot size (face and thickness), rate of growth and density

$E_{l,12}$= sample mean of calculated local modulus of elasticity adjusted to 12% *mc* (if needed). The expression used to calculate this value is (EN 384 2000): $E_{l,12}=1.3\times E_{g,12}-2690$

$E_{0,l/g,mean}$= mean characteristic value of local (calculated)/global modulus of elasticity parallel to grain of several samples (N/mm^2)

$$E_{0,mean}=\frac{\sum E_{12,j}*n_j}{\sum n_j}$$

$\bar{\rho}$= mean density value for one sample (kg/m^3).

ρ_{05}= 5-percentile adjusted (to 12% *mc*) density for a sample (kg/m^3)

ρ_k= characteristic density (kg/m^3)

f_m= bending strength (N/mm^2). $f_{m,c}$ is the value corrected by depth factor

$E_{m,g}$= global modulus of elasticity in bending (N/mm^2). $E_{m,g,c}$ is the value corrected by moisture content

$E_{l,m}$= local modulus of elasticity in bending (N/mm^2). $E_{l,m,c}$ is the value corrected by moisture content

ρ: density value (kg/m^3). ρ_c is the value corrected by moisture content

All the calculations and coefficients used to obtain the characteristic values included in Tables 3 and 4 have been applied in accordance with EN 384 (2000). According to this standard, the selected characteristic values for each region (f_k) have been the minimum value among the average values for the samples ($f_{o5\ h,i}$) included in the region and 1.2 times the extreme minimum sample value (f_{o5hi}).

Based on the results of Tables 3 and 4, it can be concluded that grade ME1 can be assigned to class C35 and grade ME2 to C18 or possibly C20. In order to simplify the process, only the assignment of C18 has been considered, therefore all second graded timber (ME2) from Spanish grown pines (*nigra*, *sylvestris*, *radiata* and *pinaster*) would be C18.

The relationships among variables reflected in Table 2 demonstrate the low degree of influence in which, in terms of species, the rate of growth has on bending strength of the timber. These results partially confirm the conclusions reached in previous studies on other species (Fernández-Golfín and Díez Barra 1996).

In Table 2, the bending strength versus density relationship exhibits a coefficient of determination value which is somewhat lower than that normally registered by other pine species in Spain (Fernández-Golfín and Díez Barra 1996). This can be explained by the fact that this timber usually has a high resin content (up to 18%) which therefore means that this variable must be treated with extreme care when used as an indicator of the mechanical quality of this timber.

Finally, it should be stressed that the global modulus of elasticity ($E_{m,g}$) is a better indicator of the bending strength than the local modulus of elasticity (E_{cen}), and is also considerably less complex to test and more accurate.

It is important to point out that because the variability in the bending strength of pine timber is extremely high (coefficient of variation of up to 40%), the non-parametric method considered by EN 384 (2000) to calculate the characteristic values of this variable is sometimes complicated due to interpolation between extremely distant values; this is especially true when sample sizes are close to 40–60 pieces.

Conclusions

The following conclusions may be drawn from the results set forth in Tables 1, 2, 3 and 4:

1. For Spanish grown laricio pine the first grade timber (ME1), according to UNE 56544 (2000) visual strength grading standard, can be assigned to class C35 and the second grade (ME2) to C18.
2. The laricio pine is the most resistant and stiff timber among the pines growing in Spain and studied to date (*radiata*,*pinaster*, *sylvestris* and *nigra*).
3. The global modulus of elasticity seems to be a better predictor of bending strength of the timber than the local modulus of elasticity which has been used to date. The global modulus' testing is also considerably easier to apply. The coefficient of variation of global modulus of elasticity is about 16–22% and for the local modulus of elasticity it is about 26–31%; this is yet another reason to support global testing instead of local testing.
4. The application of the non-parametric method considered in EN 384 (2000) for determination of the characteristic value of bending strength of a batch of timber is highly complex as it is not precise when applied to timber whose variability coefficients are high (up to 40%). For this reason, the need arises to increase the sample size considerably more than the minimum of 40 stipulated in standard EN 384 (2000).
5. At species level, and considering the huge variations in climate, age, soils and genetics usually present in Southern countries like Spain, the growth rate does not seem to be a useful indicator of the mechanical quality of a timber. Nevertheless, this indicator may be useful when applied to provenances that are highly homogeneous, i.e., samples S2 and S3 in Table 2.
6. The comparative results of the grading process of the Cazorla sample by means of the Spanish UNE 56544 (2000) and the German DIN 4074 (1989) visual grading standards permit the conclusion that both standards are very close insofar as the grading yields are concerned.

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