Visual grading of large cross section structural timber of *Pinus sylvestris* L. according to UNE 56544:2007 standard

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Abstract Large cross section structural timber have been used in many structures over long periods of time and still make up an important part of the market due to its mechanical properties. Furthermore, it is frequent its employment in new construction site. It involves the need for a visual grading standard for timber used in construction according to the quality assessment. The material has to satisfy the requirements according to the currently regulations. UNE 56544 is the Spanish visual grading standard for coniferous structural timber. The 2007 version defined a new visual grade in the standard for large section termed Structural Large Timber (MEG). This research checks the new visual grading and consists of 116 structural size specimens of sawn coniferous timber of Scotch pine (*Pinus sylvestris* L.) from Segovia, Spain. The pieces had a cross section of 150 by 200 mm. They were visually graded according to UNE 56544:2007. Also, mechanical properties have been obtained according to standard EN 408. The results show very low output with an excessive percentage of rejected pieces (33%). The main reasons for the rejection of pieces are fissures and twist.

Keywords visual grading, *Pinus sylvestris* L., structural timber, large cross section

1. INTRODUCTION

Non-destructive evaluation is the science of identifying physical and mechanical properties of a material without altering its final application capabilities (Ross et al. 1998). It is an important tool and it can be used in the industry.

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It is completely accepted that structural sawn timber should be strength graded before use. For this purpose a major range of standards has been developed, and much research on the grading and sources has been carried out to evaluate timber quality.

The visual grading technique for wood quality assessment is based on measurement of the singularities and characteristics present in timber pieces, such as: knot size, slope of grain, presence of pith, bark and resin pockets, fissures, distortions, etc. Their limits define the different visual grades.

UNE 56544:2007 is the in force Spanish visual grading standard for coniferous structural sawn timber. It covers, among others, Scotch pine (*Pinus Sylvestris* L.) It defines a new visual grade in the standard for large section termed Structural Large Timber (MEG).

This standard is the result of several research projects (Martinez 1992, Hermoso 2001, Conde 2003, Íñiguez 2007). Samplings tests were carried out according to European standards EN 408:2003 and EN 384:2004, and they have been validated by the CEN TC 124 Committee to be added to the European standard EN 1912 (2010).

The main goal of this paper is to evaluate this standard and propose other non-destructive methods for grading the structural timber.

2. MATERIAL TESTED

The sample studied consisted of 116 structural size specimens of sawn coniferous timber of Scotch pine (*Pinus sylvestris* L.) from Segovia, Spain. The pieces had a cross section of 150 by 200 mm. They were selected and graded when its moisture content was > 20%, and its visual grading was Structural Large Timber (MEG).

The test material was selected to evaluate the drying effect on the visual grading of structural large timber (MEG). The sample represents the timber source and sizes that will be graded in production.

3. METHODOLOGY

3.1. Moisture content

The moisture content (MC) of all the pieces was evaluated using electrical resistance equipment following the procedure defined in EN 13183-2:2002. The MC of pieces in sawmill was upper to 20 % in all of them. Sawn timber pieces were air dried for twelve months. The average MC of pieces was 9,86 %, going from 7,1 % to 13,5 % after drying process.

3.2. Visual Grading

Specimens were visually graded according to UNE 56544:2007. This standard defines one visual grade for structural coniferous timber with > 70 mm thickness (MEG). The grade was assigned before the bending test was performed, considering the most unfavourable section in the whole length of the beam. The Strength Class assigned to the MEG visual grade of Scots pine according to the EN 1912:2010 standard is C22. According to the EN 338:2003 standard, the C22 Strength Class corresponds to a characteristic value of bending strength (f_m) of 22 N/mm^2, a medium value of modulus of elasticity (E_m) of 10 N/mm^2 and a medium value of density (ρ_m) of 340 kg/m^3.

The requirements of this grade are summarized in Table 1.

Table 1 –Specifications proposed in UNE 56544:2007 for *Pinus sylvestris* L. timber with thickness > 70 mm

Specifications	***MEG***[e]
Face (h) knot diameter	d ≤ 2/3 of h
Edge (b) knot diameter	d ≤ 2/3 of b
Maximum width of annual ring [a]	Unlimited
Fissures	

Seasoning checks [b,c]	f ≤ 2/3 of b Those fissures are considered only if they are longer than 1 m or 1/4 of L
Other types	Not accepted
Ring shakes	Not accepted
Resin and bark pockets	It is accepted if its length is ≤ 1/5 of h
Compression wood	Accepted 2/5 of the cross section.
Slope of grain	1:6 (16,7%)
Wane	
Length	≤ 1/3 of L
Relative dimension	g ≤ 1/3
Pith [a]	Accepted
Biological damage	
Mistletoe	Not accepted
Blue stain	Accepted
Fungi decay	Not accepted
Insect's galleries	Not accepted
Distortions [b,c,d]	
Bow	≤ 20 mm over a length of 2 m
Spring	≤ 12 mm over a length of 2 m
Twist	≤ 2 mm per 25 mm width over a length of 2m
Cup	1/25 of h

[a] Those specifications are considered if it is wet timber commercialized.
[b] Those specifications are not considered in case of wet grading.
[c] Referred to 20 % of MC.
[d] Higher distortions can be accepted if it is not a problem for the construction stability (because it can be corrected during the assembly) and if there is an agreement between supplier and customers.
[e] Indicates one of the following: b: thickness, h: with, L: length of the piece, d: knot diameter measured for individual knots and groups of knots, f: sum of the fissure depths of both faces divided by width of the piece.

3.3. Physical and mechanical properties

The density (ρ) was determined following the methodology of the standard EN 408:2003, using a cross section slice (150 mm x 150 mm x 200 mm) free of defects from a zone close to the rupture section and referred to 12% MC.

The global elasticity modulus (E) and bending strength (f_m) were obtained according to the EN 408 standard (2003). The test consists on a simply supported beam with 18·h span and symmetrically loaded in bending at 6·h. According to the standard EN 384:2010, E values were adjusted to 12 % MC by the appropriate correction. There were no modifications of f_m because of MC.

4. RESULTS AND DISCUSION

The output of grading of wet (all the pieces) and dry (according to the different criteria of grading) timber obtained using the standard are shown in Table 2.

Table 2 –Visual strength grading according to UNE 56544:2007. Percentage of pieces complying with specifications. Wet and dry timber.

Specifications	*MEG (%)*	*R(%)*
Wet timber (all the pieces)	100	0
Dry timber (according criteria)		
Face knot	99	1
Edge knot	98	2
Fissures	87	13
Resin pockets	100	0
Bark pockets	97	3

Slope grain		98	2
Wane		98	2
Biological damage		100	0
Distortions	Bow	100	0
	Spring	98	2
	Twist	88	12
	Cup	100	0
Dry timber (all the pieces)		67	33

In the sawmill all of the pieces were selected and graded when wet as MEG according to the current standard (UNE 56544:2007). After drying, only 67 % of the pieces could be graded as MEG, so a 33 % of the pieces were rejected. The main reasons for the pieces rejection were fissures (13 %) and twist (12 %). It means that the 73 % of the rejected pieces were rejected due to fissures and distortions, which are effects of this drying process.

Lower rejection percentages were owing to subjective aspects in visual grading and loss of section because of the drying process.

After the visual grading, mechanical and physical properties of all the pieces were obtained. The density (ρ), modulus of elasticity (E) and bending strength (f_m) values obtained are included in Table 3, and the statistical comparison between MEG or rejected pieces are shown in the Figures 1 to 3. As can be seen, no significant differences between the mechanical and physical properties of MEG and rejected pieces can be found.

Table 3 –Mechanical properties for each visual grade. Dried timber.

Mechanical properties	*TOTAL 116 pieces. 100%*		*MEG 78 pieces. 67%*		*Rejected 38 pieces. 33%*	
	Average	*5th percentile*	*Average*	*5th percentile*	*Average*	*5th percentile*
ρ (kg/m^3)	485	419	481	417	495	428
E (N/mm^2)	9391	7286	9320	7317	9537	6896
f (N/mm^2)	41,26	24,11	40,24	23,85	43,36	23,60

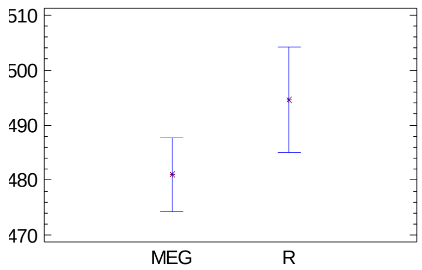

Figure 1 – Means plot of one-way analysis of variance: ρ Reb (kg/m^3) vs. Visual grade.

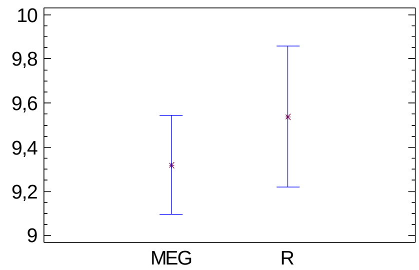

Figure 2 – Means plot of one-way analysis of variance: E (N/mm^2) vs. Visual grade.

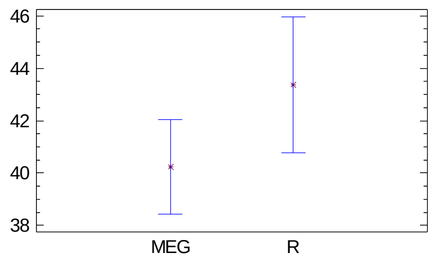

Figure 3 – Means plot of one-way analysis of variance: f (N/mm^2) vs. Visual grade.

On the other hand, if the effects of the drying process are not considered on the visual grading the results are showed in Table 4, and the comparison between visual grades are shown on the Figures 4 to 6. Similar conclusion can be obtained in comparison with the precedent results.

Table 4 –Mechanical properties for each visual grade. Dried timber. Without considering fissures and distortions

Mechanical properties	*TOTAL 116 pieces. 100%*		*MEG 110 pieces. 91%*		*Rejected * 6 pieces. 9%*	
	Average	*5th percentile*	*Average*	*5th percentile*	*Average*	*5th percentile*
ρ (kg/m^3)	485	419	485	418	485	430
E (N/mm^2)	9391	7286	9421	7290	9074	7290
f (N/mm^2)	41,26	24,11	41,68	20,48	36,89	24,17

* The sample is not representative. The number of pieces is insufficient.

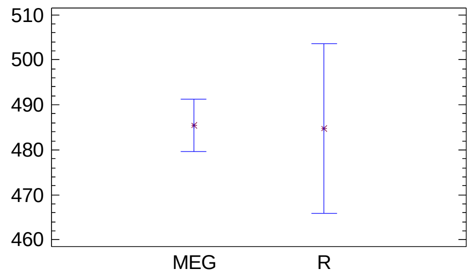

Figure 4 – Means plot of one-way analysis of variance: ρ Reb (kg/m^3) vs. Visual grade.

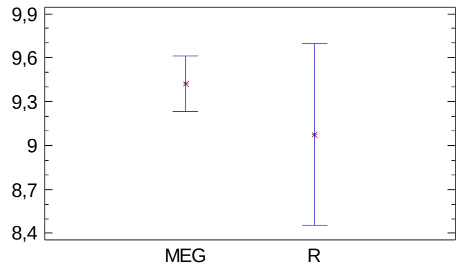

Figure 5 – Means plot of one-way analysis of variance: E (N/mm^2) vs. Visual grade.

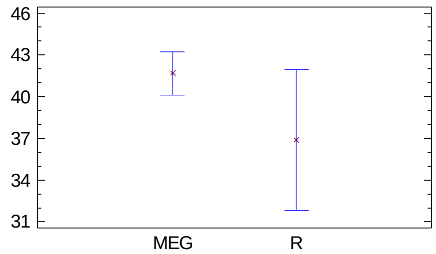

Figure 6 – Means plot of one-way analysis of variance: f (N/mm^2) vs. Visual grade.

5. CONCLUSIONS

Mechanical and physical properties values of the tested sample graded as MEG are congruent with the C22 Strength Class assigned on the current version of the EN 1912:2010 standard.

Drying effects are the reject reason of the 25 % of the pieces previously graded as MEG when green.

There are no significant differences between mechanical properties of the visual graded pieces attending to the criteria of fissures and deflections related to the drying process, among the rest of the visual criteria, or graded without attending to these criteria.

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