

COMPARISON OF TWO CLASSIFICATION SYSTEMS (VISUAL AND VIBRATION) FOR STRUCTURAL TIMBER OF FIRWOOD (*ABIES CEPHALONICA* LOUD.)

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Abstract

Sawn timber has to be classified by means of its mechanical properties before using it for structural purposes. The two most common methods used are visual classification and classification using vibrations. In present paper these two methods were used for classifying fir wood from Peloponnese, Greece and possible similarities are discussed. For visual classification the proInsta 142:2008 (Scandinavian) Standard was used and for vibration method the MTG system (according to EN 14081-1:2005 standard) was used respectively. Although there is only indirect correlation between these two methods, some first results show that there is a not so strong relation between them, depending very much from the wood moisture content of timber.

Keys words: visual classification, vibration, MTG system

INTRODUCTION

In order to classify timber, wood industries for many years classified sawn wood according to visual defects like knots, checks, etc. and most of the countries develop standards for compliance. The grading is done at present by relying on the skill of the inspector and this is a problem for correct quality control. A combination of these factors gives a variable result. When a board presented between two grades, the inspector tends to downgrade it, and this leads to an undervalued product. Usually about 10% of the wood is out of expected grade and it can rise up to 20% (Sobey and Semple, 1989). In Greece, one of the most common wood species is fir wood (*Abies cephalonica* Loud.) mainly from South Greece. Till now all sawn timber from fir and other conifer species are being classified according to the local way and this is a great inconvenience for the saw mills, as it doesn't comply to international standards and so there is not a straight comparison to lumber that should be used according to Eurocode 5 for wooden structural timber. This paper presents two non destructive methods tests which are both used on Greek fir wood in order to examine the correlation between them. First method was visual classification (according to proInsta 142:2008, Scandinavian), while the second was classification with the usage of MTG system (according to EN 14081-1:2005 standard).

MATERIALS AND METHODS

267 boards fir wood (*Abies cephalonica* Loud.) from Peloponnese were used with the following dimension groups:

1. 55 boards : 55 x 100 x 2000 mm
2. 46 boards 115 x 115 x 2500 mm
3. 60 boards 75 x 145 x 3000 mm
4. 56 boards 60 x 120 x 2500 mm
5. 50 boards 75 x 175 x 3500 mm

These boards had been air dried for 1 year before starting measurements with the two methods. Finally the moisture content was 8-10%. According proInsta 142:2008 measurements carried out for single knots on face and edge side, slope of grain, width of annual rings, bow, spring, twist, cup, compression wood etc. After the measurements taken the pieces were graded according to criteria of proInsta 142:2008 to T3, T2, T1, T0 or REJECT (T3 is the best quality). Parallel to the first method all pieces were tested according to the second one with the MTG system, using parameters suitable for Central European fir.

RESULTS AND DISCUSSION

At the end of the experiment the results were placed in different tables (Table 1 to 5) on the left of the classification according to proInsta 142 are given and on the right classification according to MTG system. According to proInsta 142:2008 the tolerance in dimensions was separated in two classes and refers to a range of values of thickness and width. First class refers to thickness and width of the boards, when the values are lower or equal to 100 mm and the range of values was +3 up to -1 to the nominated values. When they are more than 100 mm the range of accepted values was +4, up to -2. In class II the same parameters (thickness and width), when the values are lower or equal to 100 mm, the range of values can be -1 up to +1 from the nominated values. When the values are more than 100 mm the range of values can be +1,5mm up to - 1,5mm. In both cases the length of the board is not permitted to be lower from the rated. All of these have to be measured in moisture content of 20%, but this was not happened during our measurements (the moisture content was under 20%, actually 8-10%) and this can explain some of the differences in the measured values. In Table 1 the results of the 33 criteria from proInsta 142:2008 and the classification according MTG results were presented.

<i>T3</i>	<i>T2</i>	<i>T1</i>	<i>T0</i>	<i>REJECT</i>		<i>C30</i>	<i>C24</i>	<i>C18</i>	<i>REJECT</i>
0	0	0	0	55		2	23	22	8

Table 1. The clasification of 55 samples according proInsta and MTG (Dimension of the boards was 55 x 100 x 2000 mm)

As it can be seen, there is a complete disagreement between two methods. In order to find out which of the criteria was responsible for the big difference between the proInsta and MTG results on the Greek wood species, we removed the criteria of dimension, distortion and twist deviation which were serious and intense. The requirements for the twist according the proInsta Norm was 1mm per 25 mm of piece width and we changed it to 3 mm per 25 mm of piece width. The results after the changes of the criteria mention above presented in the following Table (2)

<i>T3</i>	<i>T2</i>	<i>T1</i>	<i>T0</i>	<i>REJECT</i>		<i>C30</i>	<i>C24</i>	<i>C18</i>	<i>REJECT</i>
3	3	6	9	34		2	23	22	8

Table 2. The classification of 55 samples according proInsta and MTG after the changes of the criteria in dimension, distortion and twist (Dimension of the boards was 55 x 100 x 2000 mm)

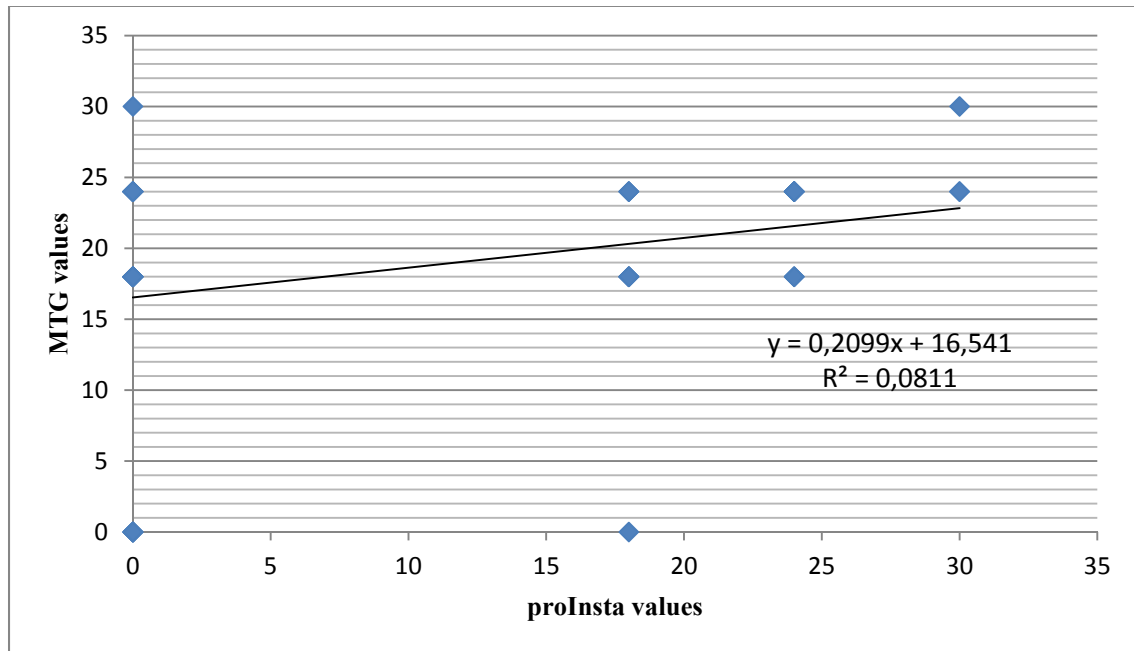


Figure 1. Correlation between the proInsta and MTG classification the group of samples with dimensions 55 x 100 x 2000 mm

In order to find the correlation between the two methods an equation was derived and Figure 1 shows that MTG system categorizes boards in higher values than the visual classification. It also shows that there are higher percentages of rejected boards with visual grading than with MTG. Although it was expected, the correlation is still very low $R^2 = 0,0811$.

We had the same measurements in different dimension board groups (115 x 115 x 2500 mm) and the results of the grading of group 2 according the two methods are shown in Table 3.

<i>T3</i>	<i>T2</i>	<i>T1</i>	<i>T0</i>	<i>REJECT</i>		<i>C30</i>	<i>C24</i>	<i>C18</i>	<i>REJECT</i>
0	0	0	0	46		0	22	12	12

**Table 3. The classification of 46 samples according proInsta and MTG
(Dimensions of the boards were 115 x 115 x 2500 mm)**

In order to find which of the criteria was responsible for the big difference between the proInsta and MTG results on the Greek wood species we removed again the criteria of dimension, distortion and twist deviation which were serious and intense. The requirements for the twist according the proInsta Norm was 1mm per 25 mm of piece width and we changed it to 3 mm per 25 mm of piece width. The results after the changes of the criteria mention above presented in the following Table (4)

<i>T3</i>	<i>T2</i>	<i>T1</i>	<i>T0</i>	<i>REJECT</i>			<i>C30</i>	<i>C24</i>	<i>C18</i>	<i>REJECT</i>
5	4	5	10	22			0	22	12	12

Table 4 The classification of 46 samples according proInsta and MTG after the changes of the criteria in dimension, distortion and twist (Dimensions of the group of boards was 115 x 115 x 2500 mm)

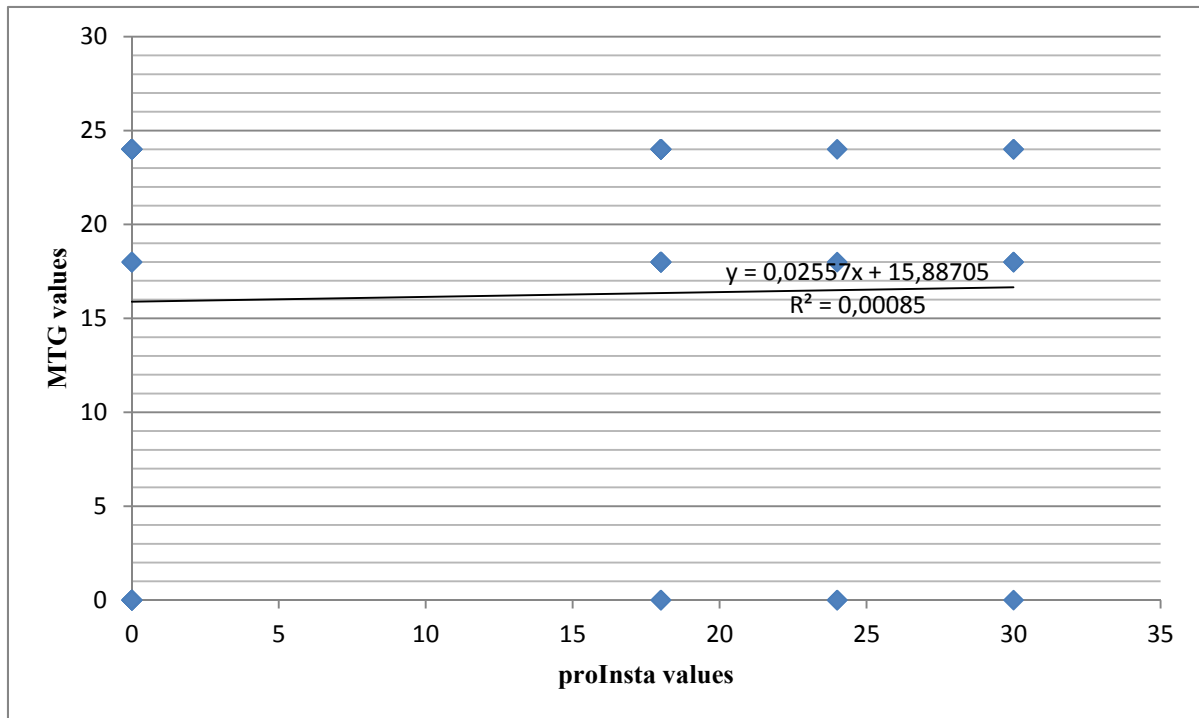


Figure 2. Correlation between the proInsta and MTG classification in the group of samples with dimensions 115 x 115 x 2500 mm

The equation that was derived after correlation is shown in Figure 2. and we can see that MTG system categorizes boards in higher values than the visual classification. It also shows that there are higher percentages of rejected boards with visual grading than with MTG. The correlation is still very low $R^2 = 0,00085$

The same measurements in group of boards no3 (75 x 145 x 3000) were carried out and the results of the grading according the two methods shown in Table 5.

<i>T3</i>	<i>T2</i>	<i>T1</i>	<i>T0</i>	<i>REJECT</i>		<i>C30</i>	<i>C24</i>	<i>C18</i>	<i>REJECT</i>
0	0	0	0	60		1	21	12	26

Table 5 The classification of 46 samples according proInsta and MTG (Dimension of the boards was 75 x 145 x 3000mm)

As there was a total rejection using proInsta 142 standard we removed once more the criteria of tolerance in dimensions, distortion and twist deviation. The results after the changes of the criteria mention above are presented in the following Table (6)

<i>T3</i>	<i>T2</i>	<i>T1</i>	<i>T0</i>	<i>REJECT</i>		<i>C30</i>	<i>C24</i>	<i>C18</i>	<i>REJECT</i>
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						1	21	12	26
6	6	5	18	24					

Table6 The classification of 60 samples according proInsta and MTG after the changes of the criteria in dimension, distortion and twist (Dimension of the boards was 75 x 145 x 3000mm)

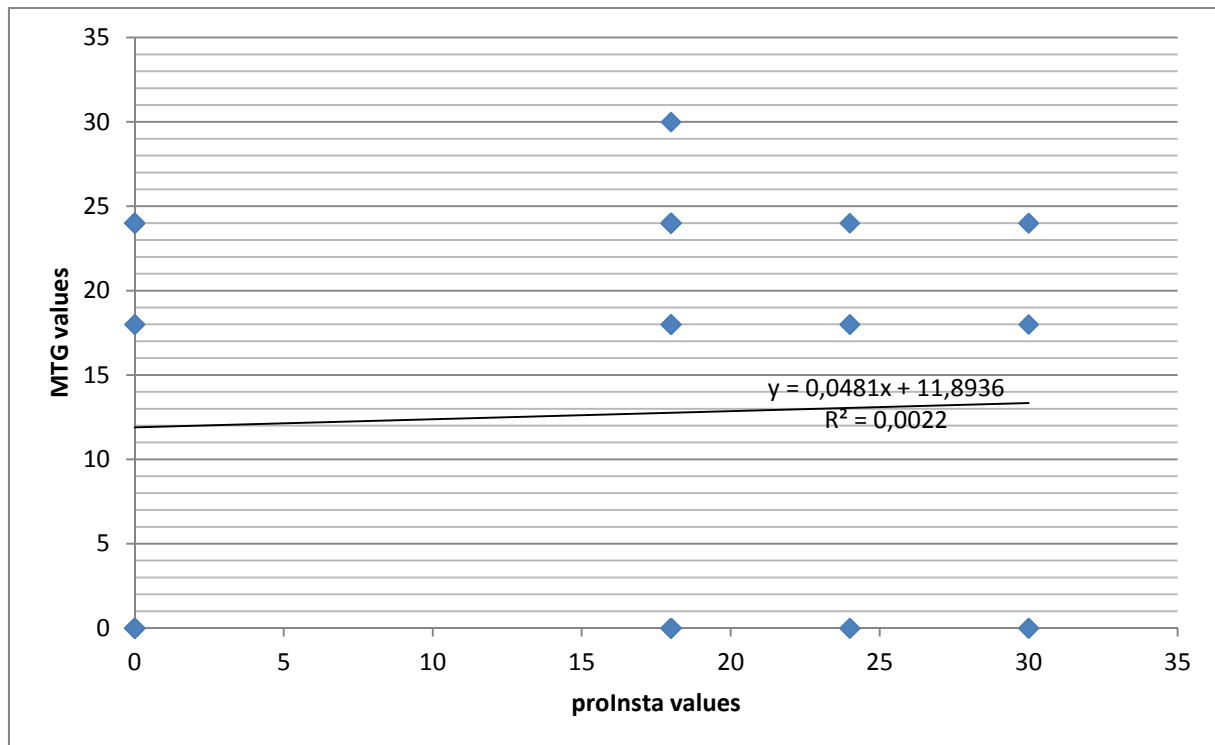


Figure 3. Correlation between the proInsta and MTG classification in the group of samples with dimensions 75 x 145 x 3000

The equation that was derived after correlation is shown in Figure 3. and we can see that MTG system categorizes boards in higher values than the visual classification. It also shows that there are higher percentages of rejected boards with visual grading than with MTG. The correlation is still very low $R^2 = 0,0022$.

Same measurements was carried out for dimension group 4 (60 x 120 x 2500mm) and the results of the grading according the two methods shown in Table 7.

<i>T3</i>	<i>T2</i>	<i>T1</i>	<i>T0</i>	<i>REJECT</i>		<i>C30</i>	<i>C24</i>	<i>C18</i>	<i>REJECT</i>
0	0	0	0	56		0	8	20	28

Table7 . The classification of 46 samples according proInsta and MTG (Dimension of the boards was 60 x 120 x 2500mm)

As there was a total rejection using proInsta 142 standard we removed once again the criteria of tolerance in dimensions, distortion and twist deviation. The results after the changes of the criteria mention above are presented in the following Table (8)

<i>T3</i>	<i>T2</i>	<i>T1</i>	<i>T0</i>		<i>REJECT</i>		<i>C30</i>	<i>C24</i>	<i>C18</i>	<i>REJECT</i>
2	6	4	12		31		0	8	20	28

Table8 The classification of 60 samples according proInsta and MTG after the changes of the criteria in dimension, distortion and twist (Dimension of the boards was 60 x 120 x 2500mm)

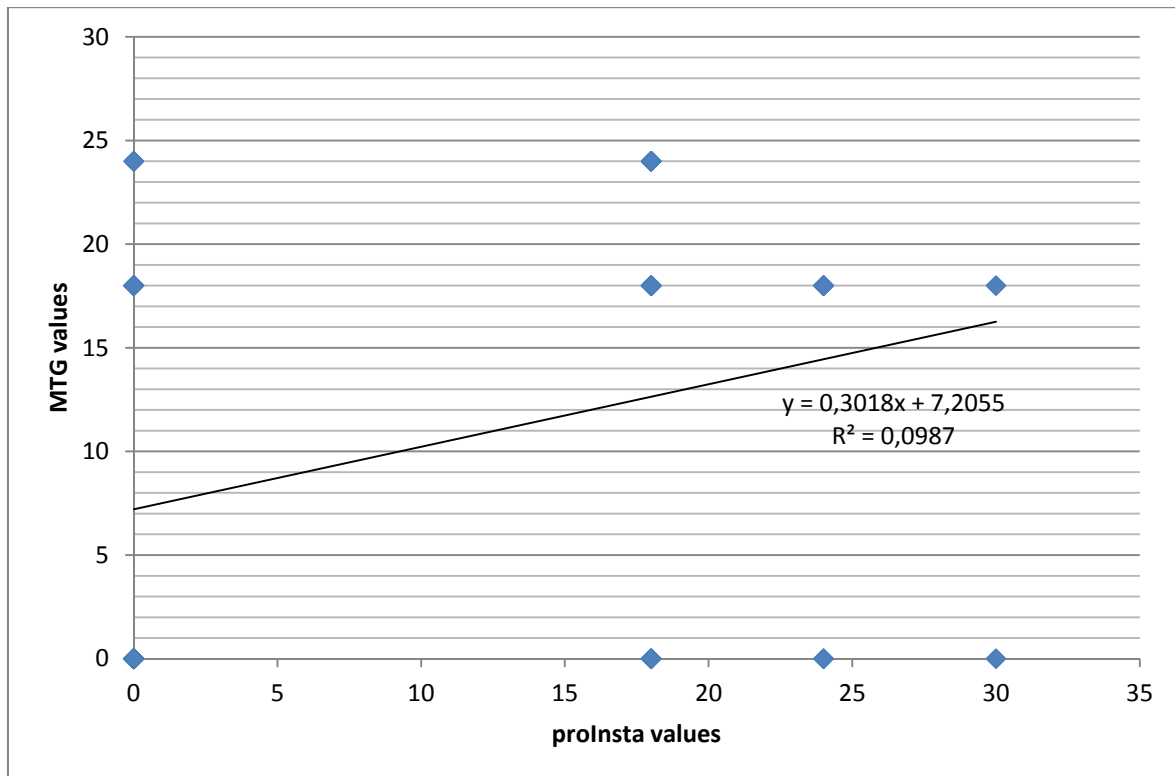


Figure 4. Correlation between the proInsta and MTG classification in the group of samples with dimensions 60 x 120 x 2500mm

The equation that was derived after correlation is shown in Figure 4. and we can see that MTG system categorizes boards in higher values than the visual classification. It also shows that there are higher percentages of rejected boards with visual grading than with MTG. The correlation is still very low $R^2 = 0,0987$

The fifth group of samples included 50 boards (75 x 175 x 3500 mm) and the sum of visual grading and the sum from MTG system measurements are shown in Table 9.

<i>T3</i>	<i>T2</i>	<i>T1</i>	<i>T0</i>	<i>REJECT</i>		<i>C30</i>	<i>C24</i>	<i>C18</i>	<i>REJECT</i>
0	0	0	0	50		0	16	27	7

Table 9. Classification of 50 samples according proInsta and MTG (Dimension of the boards was 75 x 175 x 3500).

As there was a total rejection using proInsta 142 standard we removed once again the criteria of tolerance in dimensions, distortion and twist deviation. The results after the changes of the criteria mention above are presented in the following Table (10)

<i>T3</i>	<i>T2</i>	<i>T1</i>	<i>T0</i>	<i>REJECT</i>		<i>C30</i>	<i>C24</i>	<i>C18</i>	<i>REJECT</i>
3	3	5	20	19		0	16	27	7

Table10. The classification of 50 samples according proInsta and MTG after the changes of the criteria in dimension, distortion and twist (Dimension of the boards was 75 x 175 x 3500)

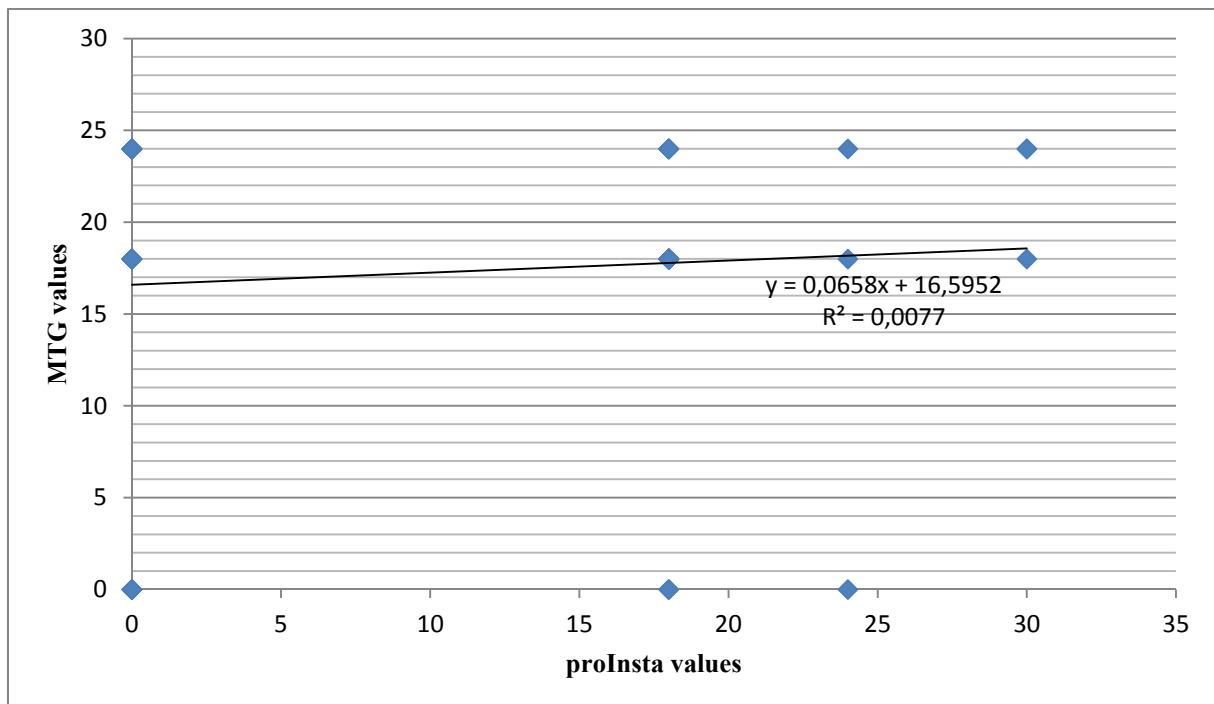


Figure 5 Correlation between the proInsta and MTG classification in the group of samples with dimensions 75 x 175 x 3500

The equation that was derived after correlation is shown in Figure 5. and we can see that MTG system categorizes boards in higher values than the visual classification. It also shows that there are higher percentages of rejected boards with visual grading than with MTG. The correlation is still very low $R^2 = 0,0077$

In general, it seems that statistically doesn't exist any correlation between the above used methods, although "clear" boards should belong in premium class, boards with minor defects to second class etc. It is believed that a more suitable software, developed especially for Greek fir wood, would help in a more reliable wood classification. Final evaluation of such a method and the correlation between the specific method and visual classification, should be safely judged only after destructive tests.

CONCLUSIONS

There is a need for grading wooden boards after they finalize their dimension in saw mills either in warehouses. Visual grading of course may be easier for experienced personnel, but there is always the problem of subjectivity of the evaluator and also the problem that visual grading systems from other countries -which maybe are developed for different wood species - are totally useless or not comparable to other species. ProInsta for example, after all the changes that we committed to criteria in order to find a correlation between the visual method and the MTG

method, was done without significant results as we can find out in Figures 1-5, where the R^2 was always less than 0,08.

It is obvious that for Greek wood species and especially for fir wood we need to develop a totally new visual grading system or to use only other nondestructive tests like MTG or Wood Eye etc.

We have also to consider that we use MTG system with software which was proper for fir wood coming from Central Europe. In our case, a proper software has to be developed taking into account the peculiarities of the above measurements. Of course, verification of such methods should be confirmed using destructive tests.

REFERENCES

- Baltrušaitis, A., Mišeikytė, S. (2011). Strength and stiffness properties of the Lithuanian grown scots pine (*pinus sylvestris*): non-destructive testing methods vs. Static bending. Kaunas University of Technology, Department of Mechanical Wood Technology Kaunas, Lithuania, 56 (2): 2011 pp. 157-168.
- EN 14081-1:2005. Timber structures. Strength graded structural timber with rectangular cross section General requirements.
- Haralick R. M., Shanmugam, K. (1973). Computer classification of reservoirs and stones, IEEE Trans. Geosci. Electron. G F-11, 171-177.
- proInsta 142:2008. Visual strength grading of Nordic T and LT timber.
- Rajeshwar, B., Bender, D. A., Bray, D. E., McDonald, K. A., (1997). An ultrasonic technique for predicting tensile strength of southern pine lumber. Transactions of the American Society of Agricultural Engineers, 40(4): 1153-1159.
- Rozema, P., (2007). Timber Grader MTG.- Brookhuis Micro-Eletronics BV. The Netherlands
- Schafer, M.E., (2000). Ultrasound for defect detection and grading in wood and lumber. Perceptron, Inc. Ultrasound Technology Group, 5. 185 Campus Drive, Plymouth Meeting, PA 19462. IEEE Ultrasonics symposium.
- Sobey P. J., Semple C. (1989). Detection and sizing visual features in wood using tonal measures and a classification algorithm. Pattern recognition, Vol. 22, no. 4, p. 367-380.
- Song-Yung, W., Jin-hau Chen, M., Tsai Cheng-Jung, Te-Hsin L. Y. (2008). Transportation planning in grading of softwood lumber using non-destructive techniques (ed.), Journal of materials processing technology 208, pp. 149–158.