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Strength Grading of the Structural Timber

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Strength and stiffness properties of Lithuanian pine and spruce specimens of structural sizes have been tested using bending loading method. Derived modulus of elasticity enabled classification and grading of tested timber pieces into strength classes accordingly to LST EN 338:2000. The investigation of quality distribution of structural timber visually graded according to BS 4978:1988 into strength grades SS – special structural and GS – general structural confirmed high strength properties and performance and good export abilities of Lithuanian structural sawn timber.
Keywords: wood, structural timber, physical properties, mechanical strength, modulus of elasticity.

1. INTRODUCTION

Strength grading provides a possibility to assess the strength of a piece of sawn timber [1]. This process can be carried out by visual or machine based method. Visual grading rules and standards [2, 3] define growth characteristics, such as knots, wane, slope of grain, fissures, distortions, reaction wood, fungal and insect damage, etc. [4, 5] Standards provide restrictions on the size, type and number of defects allowed in each grade. A certified grader visually assesses each piece of timber.

Machine strength grading is based on the relationship between the stiffness and strength properties of a timber specimen [6]. The requirements for the machine strength grading systems in the standards are based on the experience of the bending type machines and also radiation type machines. Bending type machines are most common and they work in one of the two ways:

- a defined test load is applied to each piece of timber as it passes through the machine and the maximum deflection or deformation indicates the grade or strength class;
- the defined deflection is reached applying the test load and the minimum needed load indicates the grade.

Most strength grading systems are species-related and many different combinations of species and strength grades exist with different strength properties. To simplify the design, species-grade combinations of similar strength are grouped together into strength classes, thus making them interchangeable [7]. This means that the engineer can base all calculations on the strength class and any of the species/grade combinations in that strength class can be used for the construction. Timber can be allocated into strength classes either visually by its species and strength grade, or by machine grading directly according to the strength class limit. In this case visual override is also needed to meet the requirements of the growth characteristics of each piece, such as fissures, distortion, wane, resin and bark pockets, slope of grain and knot diameter (only for partially machine graded portions of piece) [8, 9].

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There are many different strength grading systems and rules in different countries as well as standards to back-up and maintain them. In Lithuania there are many sawmills producing and exporting strength graded structural timber. Some other companies are involved in the export of local and imported (mostly from the CIS countries) structural timber.

In spite of the fact that large volumes of graded and non-graded structural timber are used locally or exported, no data and statistics exist about species and quality distribution. The main objective of the research was to evaluate strength properties of produced in Lithuania structural timber by means of visual grading as well as testing of mechanical properties in order to determine distribution of specimens according to strength classes.

2. MATERIALS AND METHODS

Specimens of European redwood and whitewood (Scotch Pine *Pinus sylvestris* and Norway Spruce *Picea abies*) species have been tested [11]. All samples possessed structural sizes that are used in real timber construction. The following structural timber strength related standards were translated by the authors of this paper and provided methodical basis for the testing (subsequently they were approved as national Lithuanian standards) [2, 6, 7, 12 – 14].

The first part of the research was focused on bending testing of the structural size sawn timber according to LST EN 338, LST EN 384, LST EN 408 and LST EN 519. The objectives of the experiments were to test timber on a specially designed test bench what allowed simulating to some extent machine stress grading process. (Fig. 1) [14].

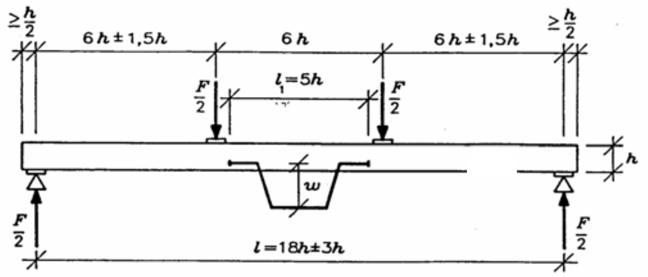

Fig. 1. Testing bench for bending loading of timber pieces

The device enabled to carry out flatwise and edgewise bending testing of specimens. Changeable testing span allowed adaptation it according to the testing depth h. The following dimensions of spruce and pine timber pieces were used: length 1500 mm, thickness 25 and 32 mm, width – 50 mm. Moisture content 20 %. Measurement accuracy was ± 0.1 mm. Sample increment when testing certain parts of pieces consisted of 85 – 100 mm each.

Testing procedures complied to the requirements of LST EN 384 and LST EN 408. Applied load values F_p were determined by the formula:

$$F_p = \frac{t \cdot h \cdot f_p}{18}; \qquad (1)$$

where h is the depth of cross section, t is the thickness, f_p is the proof stress $f_p = 0.96\, k_h f_{m,k;}$, k_h is the size factor for h as given in LST EN 384; $f_{m,k}$ is the characteristic bending strength for 150 mm testing depth.

Characteristic values of the modulus of elasticity were calculated using such a formula:

$$E_a = \frac{1242 \cdot F}{t \cdot \omega}; \qquad (2)$$

where F is the applied force; ω is the deflection at the span center.

Values derived by the formulae then were compared with the standard ones from LST EN 338 and a corresponding strength class was given to a certain timber piece [12]. As a reference, the limits of respective values of modules of elasticity for different strength classes and grades are presented in Table 1.

Table 1. Modulus of elasticity according to strength classes and grades

Strength class						
C14	C16	C18	C22	C24	C27	C30
Modulus of elasticity, N/mm^2						
<7000	7000-8000	8000-9000	9000-10000	10000-11000	11000-12000	>12000
Strength grade (General Structural GS or Special Structural SS)						
GS			SS			

The other part of the research was devoted to the investigation of quality distribution of structural timber visually graded accordingly to BS 4978:1996 [3]. Skilled certified graders in repeated production runs were grading pine and spruce timber pieces during two months in the Pajūrio Mediena Sawmill. The main part of the production at the sawmill was graded according to the National Grading Rules for Dimension Lumber - NLGA, Canada [15] – and the rest timber according to BS 4978:1996, so there was a possibility to compare grade distribution. Some 4000 m^3 of pine and spruce structural timber has been evaluated. An extra 60 m^3 have been graded in Girionys Sawmill and weighed statistical data from Ochoco Lumber Sawmill was added to expand the geography and, thus, to some extent estimate the influence of different growing conditions on sampled timber pieces.

3. RESULTS AND DISCUSSION

According to the obtained characteristic values of the modulus of elasticity parallel to grain and density timber pieces have been allocated to different strength classes and SS and GS grades. Fig. 2 shows the distribution and allocation of the tested timber pieces to different strength classes.

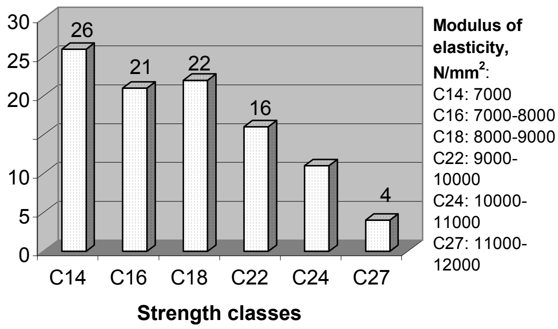

Fig. 2. Distribution of the tested timber pieces to strength classes

Strength class C14 received 26 %, C16– 21 %, C18 – 22 %, C22 – 16 %, C24 – 11 % and C27 only 4 % from the total structural timber yield. 69 % of the pieces could be allocated to the general structural GS and 31 % to the special structural SS strength grades according to BS 4978:1996.

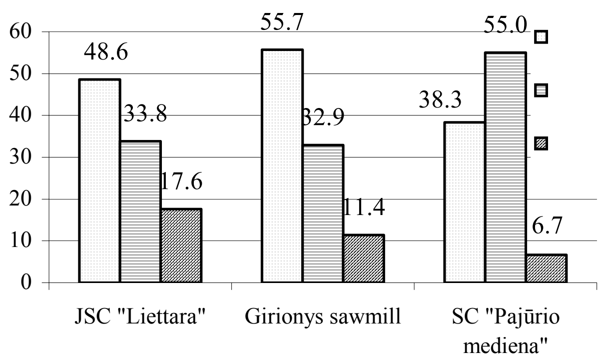

Fig. 3. The share of the grades GS, SS and rejects for different sawmills

According to the available data from the Ochoco Lumber sawmill, grade distribution for local timber is as follows: GS grade makes 60 – 70 %, SS grade - 30 – 40 %. Imported from Russia and processed in this sawmill timber possesses a definitely better quality: SS grade reaches 60 – 70 % and GS grade respectively 30 – 40 %. Considerable differences occur due to the strict import quality demands and the timber from Russia was shipped pre-graded.

Fig. 3 presents the share of GS, SS grades and rejects for the main sawmill "Pajūrio mediena" as well as results from two other testing plots - Girionys and Liettara sawmills - both situated in Kaunas.

The figures obtained coincide rather well with the ones mentioned above for "Ochoco Lumber" and thus can represent average quality distribution of visually graded sawn timber from the reference areas.

Fig. 4 and Fig. 5 display the impact of thickness and width of the timber pieces and it is seen it was minor for testing conditions.

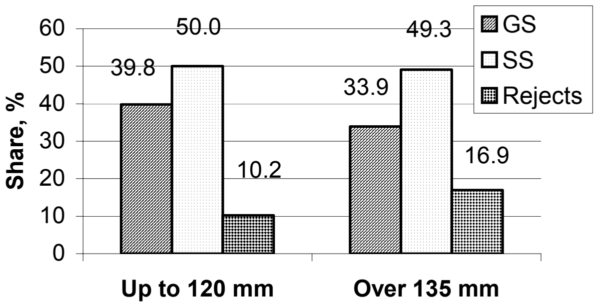

Fig. 4. The influence of width of the timber pieces to the grade distribution

Difference of width of the tested specimens was minor (15 mm) therefore also the differences of distribution into SS and GS strength grades could be estimated also as a minor.

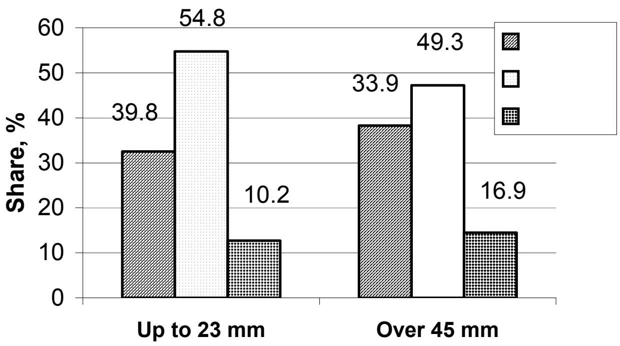

Fig. 5. The influence of thickness of the timber pieces to the grade distribution

Fig. 5 demonstrates considerably higher influence of thickness to the grade distribution for the specimens tested. Double growth of specimens thickness results in considerable changes of distribution to the strength grades. Share of SS strength grade decreases for thicker boards due to the increased number of strength reducing characteristics. It could be explained as an influence of the scale factor.

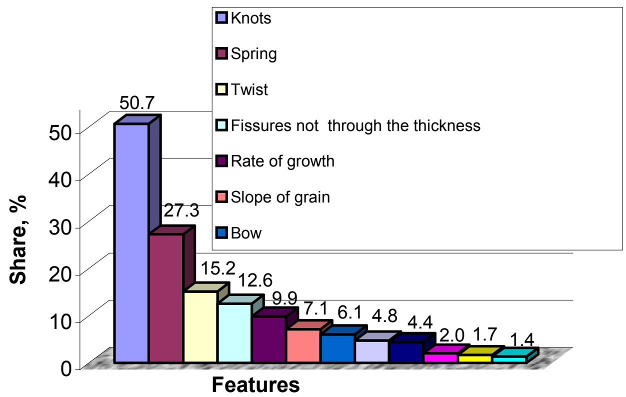

Fig. 6. Ranking of the main strength reducing characteristics in judging the grade

Ranked influence of the main strength reducing characteristics, like knots, distortions, fissures, wane, growth rate, resin and bark pockets and insect damage, as decisive factors to judge lower grade, is shown in Fig. 6. Knots, distortions and fissures together overweigh and predetermine the grade in 62.4 % of cases. Other growth characteristics, depending mostly on the quality of sawlogs, have minor influence as separate features. For mentioned above sawmills interpreting of the graphs emphasize the demand to improve sawing accuracy and quality of drying. The two latter factors together predetermine lower grade in 24.1 % of cases. In some cases better production follow-up and quality control could be more important and profitable regarding final strength graded timber yield than the aspirations to purchase better quality sawlogs.

Notwithstanding that spruce structural timber share main part of the global application in wood constructions, some of them are built also of pine structural timber. Therefore it was important to test specimens of both species. Comparison of distribution of strength grades for pine and spruce is given in Fig. 7.

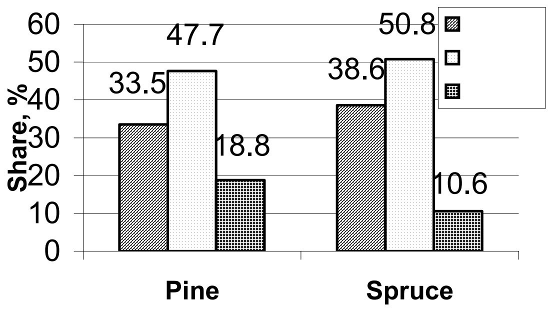

Fig. 7. Strength grades accordingly to the species

Fig. 7 demonstrates a slightly better total SS quality grade yield for spruce timber in comparison to pine, mostly due to smaller knots. Considerably lower are also volumes of rejects when grading. Share of GS grade is practically the same for both species.

3. CONCLUSIONS

1. We believe that this kind of research based on the methods described in standards could be useful to settle down the interrelations and feedback between the requirements of the standards and the production, thus enabling to define necessary corrections as well as better production follow-up and quality management.
2. Mechanical properties and allocating to the strength classes and strength grades of the timber specimens by bending testing as well as visual grading confirmed high strength properties and performance and good export abilities of Lithuanian structural sawn timber. There were not noticed any considerable changes when comparing with the similar experiments in the neighbouring countries with the same forest growth conditions.
3. An extremely important in all respects problem and the nearest task is to elaborate the national visual strength grading standard and rules for softwood and hardwood species to be used for the load bearing structural purposes. The requirements and recommended layout for such a standard are given in LST EN 518. There is also given an approved ECE list of standards for the stress grading and finger jointing of structural coniferous sawn timber. From this list the

most acceptable as a model seems to be BS 4978:1996 [3] Positive experience of applying this standard in the conducted research supports this recommendation. Reportedly, this standard was used as a basis during preparation of the national structural timber visual grading standard in Latvia.

4. In addition to the above-mentioned package of Lithuanian standards, it is reasonable to complement it by EN 386 [16].

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