Timber grading within the European Union - Irish and Polish example

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Abstract: Timber grading in European Union on the example of Ireland and Poland. The paper presents the principles of timber strength grading by visual and machine methods in the European Union with particular emphasis on Poland and Ireland. The study highlights the similarities and differences in the methodology of visual strength grading methods in accordance with: PN-A-94012: 2013 and IS 127:2002, standards followed in Poland and Ireland, respectively. In addition, the usage trends of strength graded timber in both countries are discussed.

Keywords: Stress grading, structural timber, mechanical properties of structural timber

INTRODUCTION

Since health and safety are of a prime importance, timber with guaranteed mechanical properties should only be used in construction industry, namely strength graded. There are two methods of strength grading: visual and machine. In accordance with the visual method each piece of sawn timber is classified to the grading class on the basis of visible defects in the wood structure and shape, and defects resulting from the processing. Twisted fibres, knots, checks, inbarks, resin pockets, and reaction wood are considered as the wood structure defects. Furthermore, defects due to the process of converting timber to a commercial form include wane, diagonal grains, while defects in shape include wraps and twists. Decay due to fungi and insects’ actions is unacceptable in structural timber.

Valid national standards exist in every EU member state that regulate the issue of the strength visual grading of structural timber. In Poland this is currently PN-D- 94021 Tarcica iglasta konstrukcyjna sortowana metodami wytrzymałościowymi, in Germany DIN 4074 Sortierung von Nadelholz nach Tragfähigkeit. Teil 1: Nadelschnittholz, in Ireland IS 127:2002 Structural timber - Visual strength grading - Sawn softwoods with rectangular cross-section. In the UK: BS 4978 Specification for visual strength grading of softwood, in Slovakia STN 491531: Drevo na stavebné konštrukcie. Grading in accordance with these standards results in different grading strength classes; in Poland - KW , KS, KG; in Germany and Austria - S13 , S10 , S7; in Ireland – GS, SS, RS; France - ST- I, ST- II, ST- III; in the Nordic countries - T3 , T2, T0 (Krzosek 2009). Various standards for visual grading specify differently, one of the most important parameters that is taken into account in this type of grading, namely knot area ratio (KAR). For example, the PN- D - 94021 and BS 4978 specify KAR as the ratio of the line knot (whorl) from cross-section recognised to be the worst to the area of this cross-section. While the standard DIN 4074 and DIN 4974 ÖN determine KAR as the ratio of the diameter of the largest knot to the length of one of dimensions - the thickness or width, depending on the position of the knot in the graded specimen. Slovak standard STN 491531 allows both ways of establishing the KAR.

In turn, in accordance with Irish standard IS 127:2002 knots shall be assessed by their total knot area ratio (TKAR), defined as ratio of the sum of the total projected cross-sectional areas of all knots intersected at any cross-section to the total cross-sectional area of the piece, and their margin knot area ratio (MKAR), defined as ratio of the sum of the projected cross-
sectional areas of all knots or portions of knots in a margin intersected at any cross-section to the cross-sectional area of the margin. Knots should be considered as part of the same cross-section if any part of the knots, or the grain disturbances for which they are responsible, overlap along the length of the piece. Fig. 1 presents the method of deriving a projection of knots on a cross-sectional plane.

Fig. 1. Knot projection – Axonometric view (IS 127:2002)

Three visual strength grades called General Structural (GS), Special Structural (SS) and Regular Structural Grade (RS) are specified. When grading a batch of timber to RS Grade, it is not permitted to also grade to GS and/or SS Grade.

In order to speed up grading process and improve its effectiveness, a machine grading has been implemented to common use in a number of countries. The two basic systems can be distinguished, referred to as output controlled and machine controlled. Both systems require a visual override inspection to cater for strength-reducing characteristics that are not automatically sensed by the machine.

It should be noted that the purpose of grading machines usage is to be able to sort timber according with a set of requirements. These requirements include, but are not only limited to, strength. There is currently no technology that allows directly establishing strength and therefore, it must be predicted from at least one another indicating parameter, which can be recorded. For example bending stiffness and density can be directly measured and indeed serve as indicating parameters for bending strength (Ridley-Ellis et al. 2008).

The output-controlled system, predominantly used in USA and Australia, is suitable for use where the grading machines are situated in sawmills with grading limited sizes and species, and grading runs in repeated production of around one working shift or more. This enables the system to be controlled by testing timber specimens from the daily output. These tests together with statistical procedures are used to monitor and adjust the machine settings to maintain the required strength properties for each strength class. This system allows less demanding machine approval requirements and having different settings for machines of the same type.

On the other hand, since the large number of sizes, species and grades exist within Europe, it was often impossible to carry out quality control tests on timber specimens drawn from production. Therefore, machine controlled system relies on the machines being strictly assessed and controlled. The studies were conducted in order to determine the machines settings, which remain constant for all machines of the same type.

Because of the diversity in existing visual grading rules in different countries, it is currently impossible to lay down a single set of acceptable rules for all EU member states. The requirements given in IS EN 14081-1:2006 on visual strength grading rules therefore,
give basic principles, which should be followed when drawing up requirements for limits for some of the characteristics. The visual characteristics of each piece of machine graded timber shall meet the requirements of the grade, related to fissures, warp and slope of grain. In addition, where a machine does not fully grade to the ends of each piece of timber (as in bending type machines) these non-fully graded portions shall be visually examined.

Due to the large variety of grading classes acting in different countries there is a need to find mutual correlations between these national grading classes. In order to address this issue standard EN 338: Structural timber - Strength classes introduced strength class C. The following strength classes, which define characteristic values for each of the class, for structural timber from softwood have been established: C14, C16, C18, C20, C22, C24, C27, C30, C35, C40, C45, C50. The characteristic mechanical and elastic properties and density of the wood has been taken into account. EN 1912 Structural timber - Strength classes - Assignment of visual grades and species is the standard that establishes assignment of grading classes from different countries based on visual grading. For example, in accordance with this standard German grading class for pine and larch S7 corresponds to the strength grading class C16, grading class S10 to strength grading class C24 and S13 corresponds to the grading strength class C30. Irish grading class SS for Sitka spruce corresponds to the strength grading class C18, grading class GS corresponds to the strength grading class C14.

TIMBER GRADING IN IRELAND

According to Irish Forestry and Forest Products Association (IFFPA 2014) the Irish sawmilling sector has invested more than €200 million in recent years to create a modern, efficient and customer focused industry. This sector includes five large and three medium-size companies, representing more than 90% of the industry. It provides the primary outlet for the sawlog and stake wood, however structural timber is primary produced from large sawlogs of diameters exceeding 20 cm. The sawmilling sector also supplies significant volumes of sawmill residues to the panel products and energy sectors.

Picardo (2000) conducted comprehensive study involving the machine grading of about 5000 pieces of timber from Irish-grown Sitka spruce into different strength classes. Sitka spruce is the most widely grown specie in Ireland due to conditions providing its rapid growth and short rotation length. Therefore, Irish-grown Sitka spruce is characterised as a fast growing and low density. As a result, Irish Sitka spruce meets predominantly the requirements of strength class of C16 that was reported by investigations and grading results carried out by sawmills (Harte et al. 2014). In addition, Picardo (2000) found that the yields (mean of cubic metres of solid stem wood added to an area of woodland per hectare per year) for C14 and C16 were very high and the thickness has a significant impact on the yield. Unsurprisingly, the relatively lower yields were obtained for the 35 mm thickness section. Although he did not carried out destructive testing regime, several contributory factors were pointed. It was believed that the same size knots occupy resulted in a greater proportion of a smaller section than of larger section, and since the smaller sections are generally converted from smaller sized logs the proportion of juvenile wood (which has lower strength) is greater in these sections. Finally, the effect of thickness to span ratio in the machine may be too severe for the thinner sections.

Raftery and Harte (2014) undertook an extensive study to characterise timber from fast-growing Sitka spruce. They confirmed, previously reported in literature, greater correlations between knot area ratio and strength in comparison to the density for both compression and tension specimens. Furthermore, modulus of elasticity was the most highly correlated parameter to the tensile strength. On the other hand, density was a much more accurate predictor of the compressive strength than the tensile strength. Moreover, weak correlations also existed between the modulus of elasticity and KAR as well as the density.
Because of the similarities in climate between Ireland and Scotland mechanical and physical characteristics of UK-grown Sitka spruce are relevant from the Irish perspective. Ridley-Ellis et al. (2008) reviewed the technologies, techniques and approaches required to grade the UK’s timber resource. It was pointed out that UK-grown Sitka spruce has been graded to a C16/reject scheme because C24/reject scheme was regarded as uneconomic, as the reduced yield would be too high with respect to price difference. The study confirmed that UK timber has mechanical properties that meet C16 grading class requirements. However, the authors noted a large amount of variation in wood stiffness between stands.

TIMBER GRADING IN POLAND

Comparative studies of pine timber graded visually were carried out in Poland in accordance with Polish standard PN- 82/D-94021 and German DIN 4074. The results showed that as a result of the modulus of elasticity and flexural strength class KW corresponds to class S13, KS class to class S10 and class KG to class S7 (Krzosek 2010). However, Polish grading classes KW, KS, KG are not yet introduced to the standard EN 1912. Therefore, as a temporary solution, the assignment was given in the National Annex PN-EN 1995-1-1 Eurocode 5: Design of timber structures - Part 1-1: General - Common rules and rules for buildings (Tab. 1).

Tab. 1. Table NA2. The relationship between grading classes of domestic structural timber in accordance with PN-D-94021 and grading strength classes C in accordance with PN -EN 338 (PN-EN1995 -1-1:2010)

<table>
<thead>
<tr>
<th>Wood species</th>
<th>Thickens of boards</th>
<th>KW</th>
<th>KS</th>
<th>KG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scots pine</td>
<td>≥ 22 mm</td>
<td>C35</td>
<td>C24</td>
<td>C20</td>
</tr>
<tr>
<td>Norway spruce</td>
<td></td>
<td>C30</td>
<td>C24</td>
<td>C18</td>
</tr>
<tr>
<td>European silver fir</td>
<td></td>
<td>C22</td>
<td>C18</td>
<td>C14</td>
</tr>
<tr>
<td>European larch</td>
<td></td>
<td>C35</td>
<td>C30</td>
<td>C24</td>
</tr>
</tbody>
</table>

In accordance with the current European Union regulations it is required to harmonise national standards with the European standard EN 14081 Part 1: Timber structures - Strength graded Structural timber with rectangular cross section - part 1: General requirements. The standard PN- 82/D-94021, existing until last year in Poland, obviously, did not meet this requirement. In 2013, this standard has been updated and now has the status of a harmonised standard with EN 14081. Following the introduction of mandatory marking requirement with CE safety mark for structural timber, in accordance with EN 14081 Part 1 procedures, many Polish producers of structural timber obtained certificates entitling them to label products with the CE mark. However, currently in Polish plants producing structural timber only visual method of strength grading is in use. The second grading method: machine method is currently not in use in Poland, although the first machines for strength grading were used in Poland as early as in the 80s of the last century. There were two Finnish machine Timgrader used by sawmills in Murów and Sławno (Dzbeński 1990).

The requirements for timber strength grading machines are described in EN 14081, Parts 2, 3 and 4. Part 4 of this standard includes a detailed list of machines approved for the use in different countries, and a detailed information on the species, dimensions, and strength classes of timber. From the latest generation of machines devices produced by the Italian company Microtec and the Dutch company Brookhuis Microelectronics BV obtained recently approval for grading structural timber from Polish Scots pine (Krzosek, Bacher 2011). The only grading machine Microtec GoldenEye 706 located in Poland is in STEICO SA in Czarnków, and the only Brookhuis MTG device was purchased by the Department of Wood
Technology at the Warsaw University of Life Science, and it is used for the research purposes (Krzosek 2009).

In Poland, strength graded structural timber is predominantly used for the production of precast roof trusses connected to the plate fasteners in the system MITEK. If a deficiency in visually graded timber occurs in plants, producers of timber trusses, more often, import machine graded timber from Sweden or the Czech Republic. Strength graded timber is also used by manufacturers of timber frames, traditionally on construction sites, and by manufacturers of prefabricated wooden houses. However, these types of constructions have not been popular in Poland yet and Polish producers of prefabricated wooden houses export them mainly to customers in Germany and Scandinavia (Kosycarz 2013). Strength graded timber is also used for traditional roof trusses, manufactured by mean of specialized machines, types: Hundegger or Schmidler. For the purposes of the traditional production of roof truss by joiners, glued laminated timber is being more and more often used in Poland.

CONCLUDING REMARKS

Timber can be defined as inhomogeneous, anisotropic and orthotropic mate-

rial. Therefore, its mechanical properties significantly vary depending on specie, region of origin, silviculture practice, ect. Because of these variations and diversity in existing visual grading rules in different countries, it is currently impossible to lay down a single set of acceptable rules for all European Union member states, as indicated on the example of Ireland and Poland. However, for the decades the attempts have been made to harmonise the grading process and classes within EU member states as much as possible. Such uniform grading system could be beneficial for the end users in better understanding what is defined by actual grade and might better address the needs of end users. Consequently, further standardisation of grading procedures and classes may be beneficial for sawmillers. Since prosperities of their products would be more recognised this could increase popularity of timer and trade on the European Union internal market. Due to the above, the need still exists to find better mutual correlations between national grading classes, and progress even further into the development of common grading system.

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