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Assessment of Glued Laminated Timber Beams

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Abstract: This article focuses on glued laminated timber beams and their properties. It is focused on part of more complex research of glued laminated timber beams. In this paper we focus on pulse method, which is used to measure the dynamic modulus of elasticity of GLULAM beams. In the article we describe basic information of how the pulse method works, describe the tested material and compare the results of testing. In the conclusion we discuss the results, make conclusions and describe the direction of our further research of glued laminated timber beams.

Keywords: Glued Laminated Timber; Beam; Pulse Method; Dynamic Modulus of Elasticity.

1 Introduction

In our complex research we focus on glued laminated timber (GLULAM) beams, because GLULAM is currently very popular in civil engineering, mainly due to excellent ratio of weight to capacity [5]. We are performing complex research of GLULAM beams beginning at nondestructive testing of available samples. We will reinforce the beams with carbon fiber fabric and then perform the destructive bending tests on it. We have two sets of samples available so we will be able to compare common beams to reinforced ones. When we finish with physical testing of samples we will create FEM models of beams. FEM models will be made for common and reinforced beams separately. FEM models then will be compared to real results from destructive testing of beams. Part of our research also focuses on micromechanical properties of wood that will be used to refine the FEM models [4]. This article will be mainly focused on nondestructive testing (namely on pulse method) and presenting its results.

2 Testing

2.1 Tested Material

Tested material was glued laminated timber (GLULAM) in the form of beams (Fig. 1) with strength class of GL24 made of spruce wood. Altogether we have tested eleven rectangular shaped beams of glued laminated timber with dimensions of length 4.5 mm, width 0.1 mm and height of 0.32 mm.

Fig. 1: Second set of Glued laminated timber beams.

The first five beams (referred to as the first set) numbered from I to V are from the first batch and six beams (referred to as the second set) numbered from 1 to 6 are from the second batch obtained one and a half year later, but both batches should have the same or very similar physical properties because It was made by the same production process.

2.2 Testing Method

The pulse method is suitable for determining the dynamic elastic properties of flexible materials which are preferably isotropic and homogeneous, but it can be used on any type of material, in our case the timber. The resonant frequency of the elements obtained from such materials, are dependent on the modulus of elasticity, weight and geometry of the test element. Dynamic-elastic properties of the material may be calculated based on the identified geometric dimensions (usually with wood in forms of rectangular or cylindrical shapes), weight, and resonance frequency of the test element [1].

In our research we have focused on dynamic modulus of elasticity obtained from flexural and longitudinal natural frequencies which are most accurate methods for our type of samples.

Natural flexural frequency is measured in the position, where the beam is laid at longer side, with support in the middle of length and width, but the difference is at sensor and excitation force position. The sensor is placed in the center, but on top of one side and the excitation force is introduced at the same place but on the other end of specimen (Fig. 2) [1].

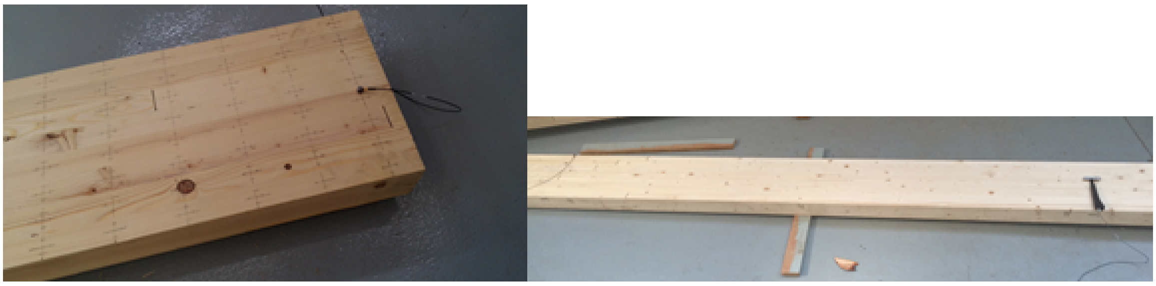

Fig. 2: Setting up the sensor and driver for flexural natural frequencies s measurement.

Natural longitudinal frequency is measured in the position, where the beam is laid at longer side, with support in the middle of length and width. The sensor is placed in the center of the forehead of one side and the excitation force is introduced at the same place but on the other end of specimen (Fig. 3) [1].

Fig. 3: Setting up the sensor and driver for longitudinal natural frequencies measurement.

Tab. 1: Dynamic modulus of elasticity for flexural and longitudinal natural frequencies of tested GLULAM beams.

	Flexural natural frequencies	Longitudinal natural frequencies
Sample Number	E_{d1} [GPa]	E_{d2} [GPa]
I	14.92	15.08
II	14.30	14.38
III	13.04	13.07
IV	14.67	14.87
V	15.59	15.18
Average	14.50	14.52
1	14.44	12.86
2	14.13	12.29
3	14.30	12.85
4	13.82	12.25
5	16.09	14.39
6	13.86	12.37
Average	14.44	12.83

To evaluate the measured properties and the subsequent establishment of values required modulus of elasticity was necessary, for the purposes of calculation, measurement of all beams and determine their exact length, width, thickness, weight and volume weight. The measured values of natural frequencies and characteristics of the element can go to recalculating the individual modules.

3 Results

To obtain the most accurate results of our measuring, all beams from the both sets of samples were tested in the same laboratory conditions, even the same equipment were used (sensors, impact hammer and computer).

Natural frequencies of flexural and longitudinal vibration obtained from our measurement were used to calculate dynamic modulus of elasticity using equations from Standard Test Method for Dynamic Young‘s Modulus [1]. All results, presented in Tab. 1 in form of dynamic modulus of elasticity, were calculated from first natural frequency of each tested specimen.

There is an obvious difference between flexural and longitudinal modulus of elasticity, although the difference is in just few percent, it is still difference which must be taken into account. Main difference is at second set of beams, where the difference between flexural and longitudinal modulus of elasticity is up to 15 %. It is mainly because the timber is not homogenous material and has variable properties along the entire length and directions, also, even that the both sets of samples are made of spruce wood this great difference in material properties can be caused just by using the timber from different forest, even though the manufacturing process of GLULAM beams was exactly the same.

4 Conclusion

We have tested in total eleven GLULAM beams by use of nondestructive pulse method. From results of that method, in form of natural frequencies for longitudinal and flexural vibrations, we were able to calculate dynamic modulus of elasticity for the first natural frequencies of each beam of both sets of samples and compare them. Even that there are differences between dynamic modulus of elasticity obtained from flexural and longitudinal vibrations, the difference of every beam is very similar to others, but only within each set. The difference in the measured values is therefore in line with expectations and it is possible to say that the measurement was performed correctly. Resonance method proved to be a suitable method for non-destructive testing of wooden elements made of glued laminated timber. It allows relatively accurately and quickly determines the dynamic modulus of elasticity, when kept under proper procedures for measurement using resonance method. However, it is necessary to anticipate a significant difference between the value of dynamic and static modulus of elasticity. From the results and character of its difference, it is obvious that this nondestructive method is rather suitable for obtaining approximate values of dynamic modulus of elasticity and appears to be ideal for comparison of the same set of samples where it can easily and fastly detect defective or materially different samples.

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References

[1] ASTM E1876 - 09,. Standard Test Method for Dynamic Young‘s Modulus, Shear Modulus, and Poisson‘s Ratio by Impulse Excitation of Vibration. ASTM International, West Conshohocken, PA, 2006. Available from: http://www.astm.org/Standards/E1876.htm

[2] Ewins, D.: Modal Testing – Theory, Practice and Application. Research Studies Press 2000, 400 p. ISBN 0-86380-218-4.

[3] Klapálek, P., Melzerová, L., Methods of Non-Destructive Assessment of Timber. Applied Mechanics and Materials [online]. 2015, vol. 732, s. 369-372 [cit. 2015-04-22]. doi: 10.4028/www.scientific.net/amm.732.369.

[4] Prošek, Zdeněk, Vlastimil Králík, Jaroslav Topič, Václav Nežerka, Kateřina Indrová a Pavel Tesárek. Microstructure description and micromechanical properties of spruce wood. Acta Polytechnica [online]. 2015, vol. 55, issue 1, s. 39-49 [cit. 2015-05-14]. doi: 10.14311/ap.2015.55.0039.

[5] Angst, V. et al.: Handbook 1: Timber structures. 2008, 242 p.