

## EXPERIMENTAL RESEARCH CONCERNING THE OPTIMAL DIMENSIONS OF AN ELASTIC STRUCTURE OF BEECH WOOD PARQUET

**Olimpia-Minerva ȚURCAȘ (DIACONU)**

Transilvania University of Brașov, Faculty of Wood Engineering

Str. Universității nr. 1, 500036 Brașov, Romania

E-mail: [minerva2013diaconu@gmail.com](mailto:minerva2013diaconu@gmail.com)

### Abstract

*This paper presents the results of the experimental research concerning the modulus of elasticity and the average value of the bending strength in case of beech (*Fagus sylvatica* L.) wood. The investigations were performed according to **SR EN 408-2004**. The results of the research have been analysed in order to establish the variable parameters to be considered for the final experimental research focused on beech wood floor structures that meet the necessary requirements for the sports halls applications. The research presented in the paper is a part of the study theme of the Ph. D. thesis, which investigates the flooring structures able to support the requirements of sports halls activities, different from one sport to another.*

**Key words:** *bending strength; modulus of elasticity; beech wood; wooden floor.*

### INTRODUCTION

The actual research on wooden floors is continuously improved, due to the concerns of the specialists in this field, who want to improve the specific properties of the wood, using various research methods. Due to the fact that wood is an elastic material providing thermal and phonic insulation, it is an appropriate material for flooring. (Cismaru 2006, Cismaru et al. 2015).

Experimental research proved that the elasticity rate of wood is directly influenced by: species of wood, grain direction, density, temperature and defects of wood. (Curtu and Ghelmeziu 1984). It was proved that the value of the modulus of elasticity increases with the wood density and decreases with the increase of the humidity and temperature.

The strength of wood is directly influenced by its density (Kollmann and Côté 1968), and this theory has been also proved by other researchers who studied the behaviour of compressed veneer under the influence of steam, pressure, and temperature (Navi and Heger 2004, Kamke 2006, Fang et al. 2012).

The thermal treatment of flooring wood (Comșa and Comșa 2006) was proved to result in a uniform colour of wood, obtaining thus floorings with special appearance.

Other researchers (Duma 1973, Cismaru 2006, Cismaru and Salcă 2009, Cismaru and Fotin 2014) were concerned to find methods and solutions to mount the industrial wooden floor, in order to increase the assembling efficiency and use of small size wood, or to promote the less valuable local species (Comșa 2011).

As a conclusion, the research on wooden flooring is an on-going concern, based on economic, aesthetic and wood strength reasons.

### OBJECTIVE

The main objective of this research is to find the optimal parameters of beech wooden flooring structures that meet the requirements of a sports hall activities. For this purpose, an experimental research was established, so to determine the range of the elastic deformations of the tested material.

### MATERIAL, METHOD, EQUIPMENT

In order to reach the aim of the research, an experimental research was established, using the following variable parameters: *specimen thickness* ( $h_1=15\text{mm}$ ;  $h_2=20\text{mm}$ ;  $h_3=25\text{mm}$ ;  $h_4=30\text{mm}$ ); *specimen width* ( $b_1=30\text{mm}$ ;  $b_2=40\text{mm}$ ;  $b_3=50\text{mm}$ ;  $b_4=60\text{mm}$ ); *specimen length* ( $L_1=300\text{mm}$ ,  $L_2=350\text{mm}$ ;  $L_3=400\text{mm}$  și  $L_4=450\text{mm}$ ), and different distances between the specimens supports according to SR EN 408-2004 standard, namely:  $l_1=250\text{mm}$ ;  $l_2=300\text{mm}$ ;  $l_3=350\text{mm}$ ;  $l_4=400\text{mm}$ .

For the experiment, class A dry beech timber with widths ranging from 25mm to 50mm was acquired from **S.C. FOREX S.R.L.**, Ghimbav.

The specimens were cut in the frame of the Multifunctional Wood Processing Workshop (H I 5), from Wood Engineering Faculty of Transilvania University of Brasov. The following processing phases were performed:

a) cross-cutting – using the circular saw; b) edge-face straightening – using the straightening machine; c) ripping – using the circular saw; d) planing to the final thickness – using the planing machine; e) calibrating – using the wide tape sanding machine; f) cutting to the final length – using the circular saw (Fig. 1)



a) cross-cutting – using the circular saw



b) edge-face straightening – using the straightening machine



c) ripping – using the circular saw



d) planing to final thickness – using the planing machine



e) calibrating – using the wide tape sanding machine



f) cutting to length – using the circular saw

Fig. 1.

**Phases of specimens manufacturing**

The code numbers assigned to „type I” specimens are presented in Table 1 and Fig. 2.

**Table 1**

**„Type I” specimen code numbers**

Thickness [mm]		Width [mm]		Length between specimen supports [mm]	
15	R A	30	30	250	250
20	R B	40	40	300	300
25	R C	50	50	350	350
30	R D	60	60	400	400

Different thicknesses were investigated, so another 10 specimens were added to the test (according to SR EN 408:2004). The minimum length of the specimens was 19 times higher than the height of the sectioned area. For the four investigated thicknesses (15, 20, 25, and 30mm), the „type II” specimens presented in Table 2 and Fig. 3 have resulted.

**Table 2**

**„Type II” specimen code numbers**

Specimen Thickness (h) [mm]	Minimum Length (hx19) [mm]	Specimen Length [mm]	Specimen Dimensions [mm]	Length of the Support Span [mm]
15	285	303	15 x 15 x 303	126,5
20	380	404	20 x 20 x 404	177
25	475	505	25 x 25 x 505	227,5
30	570	606	30 x 30 x 606	278



**Fig. 2.**  
**„Type I” specimen code numbers**



**Fig. 3.**  
**„Type II” specimen code numbers**

The mean value of the wood moisture content measured before cutting the specimens was 11.4% and the moisture content was determined by **FMW moisture detector** (capacitive) (Fig. 4).

The specimens were conditioned at a temperature of (20±2)°C and a relative humidity of air of (65±5)%. The density of the specimens was calculated as the rate between the mass and the volume of the samples. The sizes were measured using a measuring tape and an electronic caliper (Fig. 5) and the mass was weighed using a Kern electronic balance (Fig. 6). The average calculated density was 674,917kg/m<sup>3</sup>.



**Fig. 4.**  
**FMW moisture detector**



**Fig. 5.**  
**Measuring with an electronic caliper**



**Fig. 6.**  
**Electronic weighing**

The specimens prepared according to the methodology presented herein above were tested to static bending strains. The tests were performed on the **WE 10A** universal testing machine belonging to the Composite Materials Laboratory (**HI2**) of the Wood Engineering Faculty of the Transilvania University of Brasov. The specimens were supported on the bending device and the force was applied at a constant speed in the middle point between supports. The deflections were measured in the centre point of the distance between supports.

The forces were registered for the following deflections:  $w_1=2\text{mm}$ ;  $w_2=4\text{mm}$ ;  $w_3=6\text{mm}$ ;  $w_4=8\text{mm}$ . Finally, the maximum fracture force ( $F_{\text{max}}$ ) was also recorded.

The appeared modulus of elasticity  $E_{m,app}$  was calculated using the formula:

$$E_{m,app} = \frac{l_1^3 (F_2 - F_1)}{48 I (w_2 - w_1)}$$

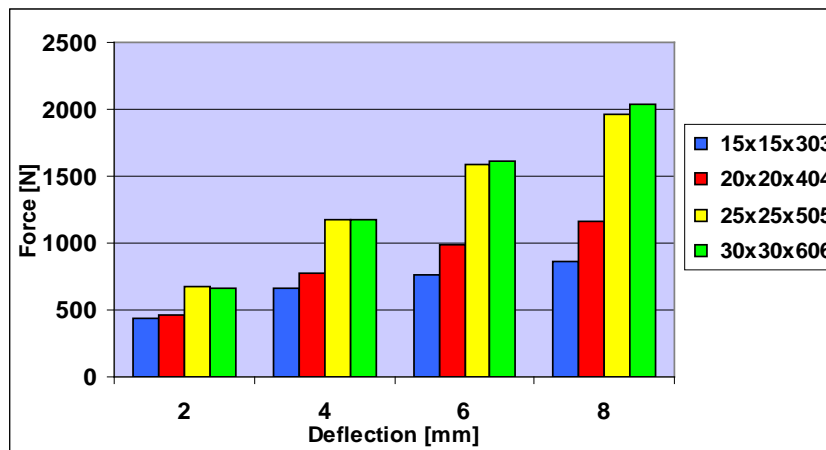
where:

$F_2 - F_1$  - represents the increase of the force on the linear part of the graph resulted as force/deformation curve, in N,;

$w_2 - w_1$  - represents the increase of the deflection, corresponding to  $F_2 - F_1$ , in mm.

## RESULTS AND DISCUSSION

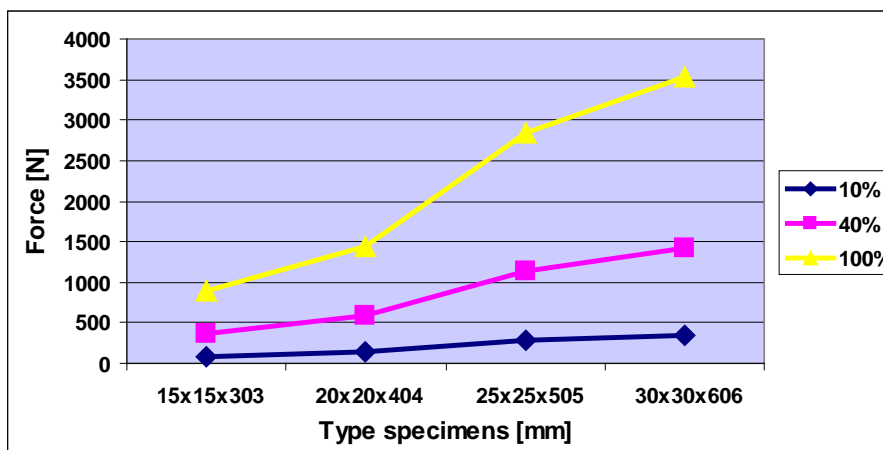
In the present research, the „type II” specimens were subjected to static bending strains, until fracture. The mean values of the fracture forces recorded during the tests, are shown in the diagram from Fig. 7.



**Fig. 7.**

**Variation of the fracture force for the „Type II” specimens, tested according to SR EN 408**

In order to determine the range of the elastic deformations of the beech wood tested in the present research, an analysis of the recorded data was done, calculating according to the standard the values of the forces ranging from  $0.1 F_{max}$  to  $0.4 F_{max}$ , where  $F_{max}$  is the maximum fracture force. (Fig. 8). Tables 3 to 6 present the values of the deflections recorded in the delimited range of the elastic deformations.



**Fig. 8.**

**Delimited range of elastic deformation - for „Type II” Specimens, tested according to SR EN 408**

**Table 3**

**Deflections recorded for specimens of 15 mm thickness, with different widths and distances between specimen supports, corresponding to the  $0.1 F_{max}$  -  $0.4 F_{max}$  force value range**

w	R A-30				R A-40				R A-50				R A-60			
	250	300	350	400	250	300	350	400	250	300	350	400	250	300	350	400
<2																
2																
3																
4																
5																
6																

**Table 4**  
*Deflections recorded for specimens of 20 mm thickness, with different widths and distances between specimen supports, corresponding to the  $0.1 F_{max} - 0.4 F_{max}$  force value range*

w	R B-30				R B-40				R B-50				R B-60			
	250	300	350	400	250	300	350	400	250	300	350	400	250	300	350	400
<2																
2																
3																
4																
5																
6																

**Table 5**  
*Deflections recorded for specimens of 25 mm thickness, with different widths and distances between specimen supports, corresponding to the  $0.1 F_{max} - 0.4 F_{max}$  force value range*

w	R C-30				R C-40				R C-50				R C-60			
	250	300	350	400	250	300	350	400	250	300	350	400	250	300	350	400
<2																
2																
3																
4																
5																
6																

**Table 6**  
*Deflections recorded for specimens of 30 mm thickness, with different widths and distances between specimen supports, corresponding to the  $0.1 F_{max} - 0.4 F_{max}$  force value range*

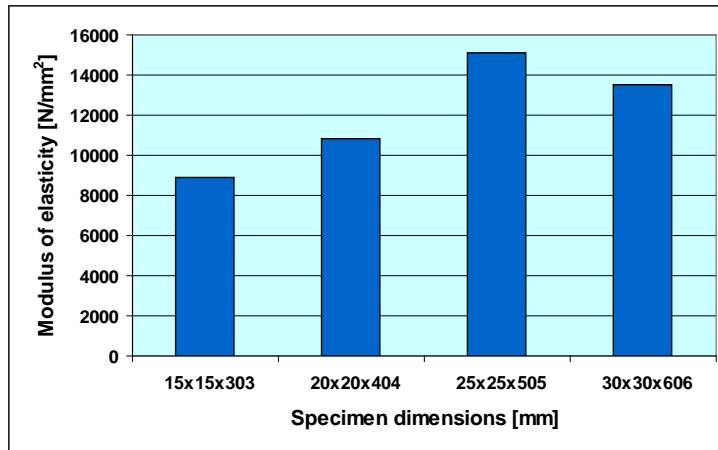
w	R D-30				R D-40				R D-50				R D-60			
	250	300	350	400	250	300	350	400	250	300	350	400	250	300	350	400
<2																
2																
3																
4																
5																
6																

Legend:

	Deflection is lower than 2 mm for forces in the range of $0.1 F_{max} - 0.4 F_{max}$ and was not recorded
	About 50% of the deflection value corresponds to the force values in the range of $0.1 F_{max} - 0.4 F_{max}$
	Deflection corresponds to force values in the range of $0.1 F_{max} - 0.4 F_{max}$

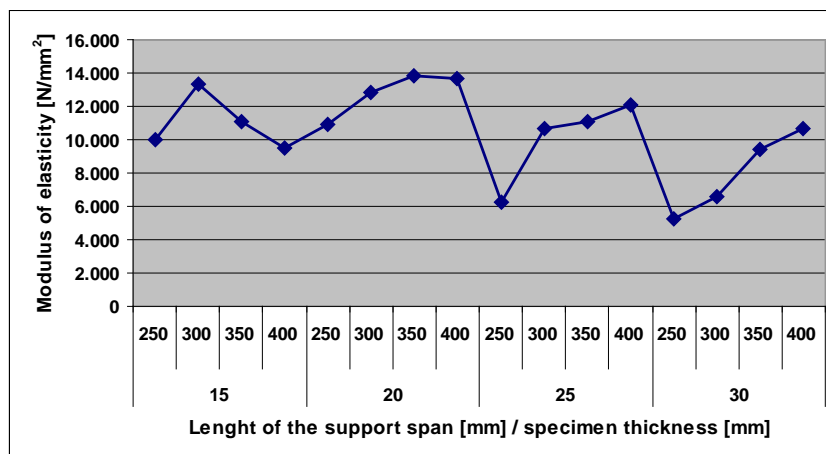
It was noticed that in many cases, the deflection had to be recorded for values lower than 2mm.

The modulus of elasticity values, determined at the static bending tests for the „type II” specimens, ranged between 8863 [N/mm<sup>2</sup>] and 13483 [N/mm<sup>2</sup>]. The variation of the modulus of elasticity is presented in the diagram from Fig. 9:

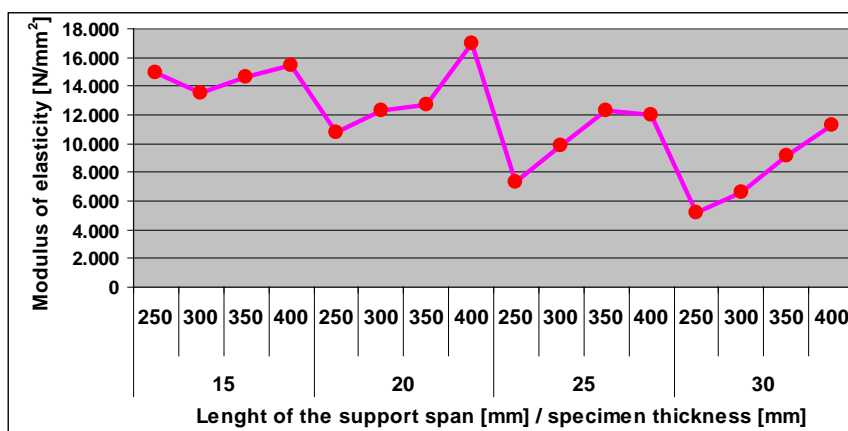


**Fig. 9.**  
**Values of the modulus of elasticity for the "Type II" Specimens**

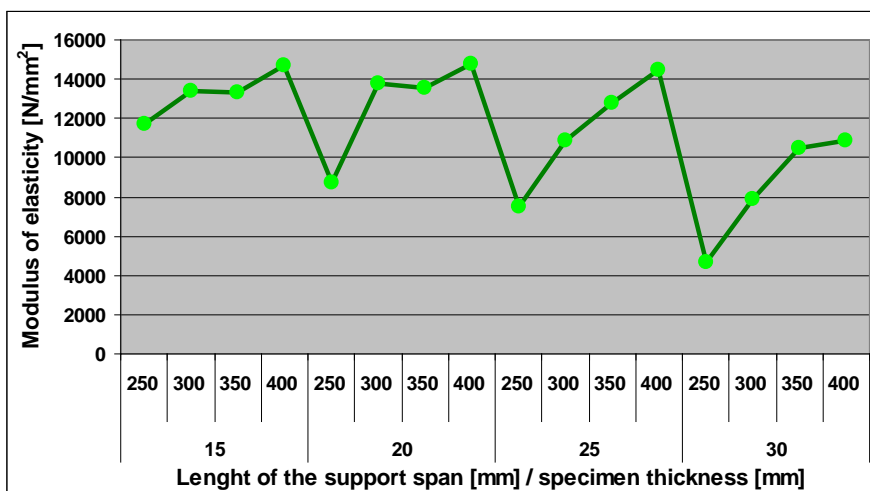
The modulus of elasticity was calculated also for the „type I” specimens. The variation of the values of the modulus of elasticity against the distance between the specimen supports is presented in the diagrams from fig. 10...13.



**Fig. 10.**  
**Modulus of elasticity for 30 mm width specimens against the distance between specimen supports during bending test and the specimen thickness**

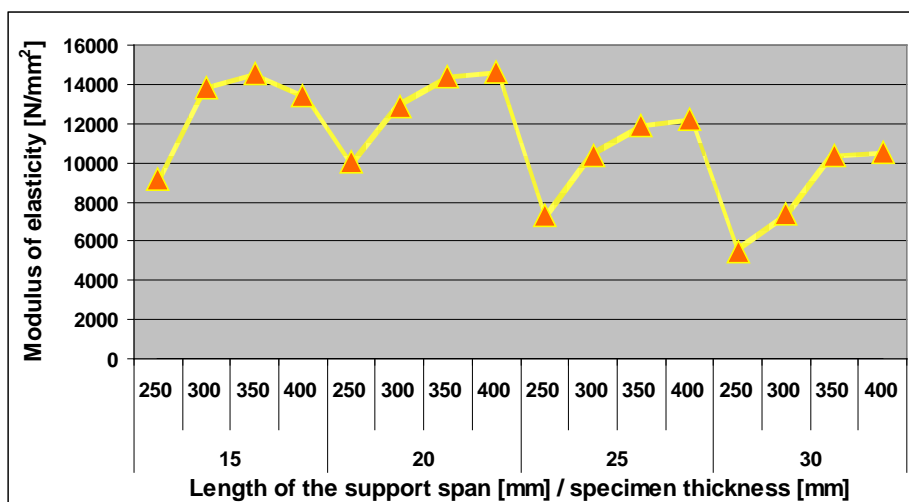


**Fig. 11.**  
**Modulus of elasticity for 40 mm width specimens against the distance between specimen supports during bending test and the specimen thickness**



**Fig. 12.**

**Modulus of elasticity for 50 mm width specimens against the distance between specimen supports during bending test and the specimen thickness**



**Fig. 13.**

**Modulus of elasticity for 60 mm width specimens against the distance between specimen supports during bending test and the specimen thickness**

**CONCLUSIONS**

The tests performed in the present aimed to the determination of the range of the elastic deformations, in order to find the optimal parameters for a wooden flooring structure that meets the requirements of a sports hall activities. The following conclusions of the research have resulted:

- the best static bending behavior of the specimens are to be considered for further research, according to the obtained results;
- only the specimens having the value of the modulus of elasticity smaller than that found in the literature (Curtu și Ghelmeziu 1984), namely 14200 [N/mm<sup>2</sup>] or [MPa] will be selected for further research;
- the smaller values of the modulus of elasticity reported to widths, thicknesses, and distances between specimen supports will be considered for further research, in order to achieve the more elastic and economic structures.

This paper is a part of the research theme of the Ph. D. thesis entitled *The Influence of the Structure on Mechanic, Thermal, and Acoustic Properties of the parquet-type wooden floorings.*

#### ACKNOWLEDGEMENT

This paper is supported by the Sectoral Operational Programme Human Resources Development (SOP HRD), financed from the European Social Fund and by the Romanian Government under the contract number POSDRU/159/1.5/S/134378.

#### REFERENCES

- Cismaru I (2006) Pardoseli din lemn (Wooden Floorings), Editura Universității Transilvania Brașov.
- Cismaru I, Salcă EA (2009) Pardoseli industriale cu design modular repetitiv (Industrial floorings with repeated modular design), *Revista PRO LIGNO* 5(4):25-32.
- Cismaru I, Fotin A (2014) Proiectarea și fabricarea în sistem industrial a parchetului modular (Design and Manufacturing of Modular Parquet Flooring in Industrial System), *Revista PRO LIGNO* 10(3):34-45.
- Cismaru I, Filipașcu M, Țurcaș OM, Fotin A (2015) Pardoseli din lemn – între prezent și viitor. (Wooden Flooring – Between Present and Future), *Revista PRO LIGNO* 11(2):39-50
- Comșa D, Comșa GN (2006) *Technological and architectural study on parquet floors*, Proceedings “Forest and Sustainable Development”, Universitatea Transilvania din Brașov, pp. 551-556.
- Comșa GN (2011) Promovarea pardoselilor parchetate cu panouri originale de parchet stratificat din specii lemnoase autohtone (Promoting floors inlaid with original parquet panels of indigenous tree species), *Urbanism. Arhitectură. Construcții*, Vol. 2(4).
- Curtu I, Ghelmeziu N (1984) *Mecanica lemnului și materialelor pe bază de lemn*, Editura Tehnică, București.
- Duma V (1973) Producerea panourilor de parchet, *Revista Industria lemnului* nr. 3.
- Fang CH, Mariotti N, Cloutier A, Koubaa A, Blanchet P (2012) Densification of wood veneers by compression combined with heat and steam, *Eur. J. Wood Prod.* 70(1-3):155-163. DOI: 10.1007/s00107-011-0524-4.
- Kamke FA (2006) Densified radiata pine for structural composites, *Maderas. Ciencia y Tecnología* 8(2):83-92.
- Kollmann F, Côté W (1968) *Principles of Wood Science and Technology, Vol. I: Solid Wood*, Springer Verlag, Berlin.
- Navi P, Heger F (2004) Combined densification and thermo-hydro-mechanical processing of wood, *Mrs. Bull.* 29(5):332-336
- SR EN 408 (2004) Structuri de lemn. Lemn masiv și lemn lamelat încleiat. Determinarea anumitor proprietăți fizice și mecanice.