

**DETERMINING THE BEHAVIOUR OF THE BASKETBALL, ON VERTICAL DIRECTION,
ON SURFACES OF FLOORINGS CONCEIVED FOR GYMNASIUMS
PART II**

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Abstract:

*The paper presents the results of the investigation of the elastic properties of two types of beech wood (*Fagus sylvatica* L.) floors designed for sports halls and the comparison between them. The aim of this research work is to test the new flooring structures for sports halls, and to investigate if they meet the requirement regarding the basketball bounce height. The tests were carried out using an original set-up (S-TPS-3), which was designed and built for this purpose at the Transilvania University in Brasov.*

Key words: wood floorings; sports halls; bounce height; basketball; testing set-up.

INTRODUCTION

The wood flooring market is a competitive one, so the Swedish researchers (Nordvik *et al.* 2009) have undertaken a study of 8 species of wood (spruce, birch, merbau, jarra, beech, maple, oak and cherry) for this purpose. Using the *Kansei* technique (Nagamachi 1997, Harada 1998), a prospecting of the wood flooring market was conducted, examining the relationship between wood flooring visualization and the impression left on potential customers. This technique helps to create both new wooden products and design solutions to achieve the desired properties of wooden floors.

Due to its properties, wood has all the chances of remaining a top material, given the dynamic of wood flooring market and the continued concern of specialists in the field for optimal valorization and improvement of wood-specific properties (Cismaru 2006, Cismaru *et al.* 2015).

In South Korea, there is a real concern for analyzing the thermal performance of the wood flooring structures for energy conservation purpose. The study (Seo *et al.* 2011) carried out on four different types of wood floorings and 21 wood species generally used in Korea for wood floorings, showed the influence of the floor structure upon its thermal performance. The heated plate method was used for this experiment and the performance of the heat transfer was proved to depend on the floor thickness and the mounting method (using adhesive or not). Better performance was reached by the glued floors than the floating floors.

A study by Nebel *et al.* (2006) aimed at assessing the life cycle of wood flooring (solid wood parquet, multilayer flooring, wooden block floorings) according to ISO 14040 – ISO 14043. The cycle includes forest management, woodworking, production, assembly and finishing of surfaces, refurbishment and end of life. The end-life scenario is related to the thermal performance of wooden floors. The objective was not to compare floorings to each other, but to provide a database of all wood floorings for comparing them with other types of floorings. The production and use of wood floorings have to main advantages: primarily, the supply of energy from post-consumer wood (it can replace fossil fuels), and secondly, wood floorings have the function of CO₂ storage during their lifetime use.

Due to the environmental reasons, wood floorings production recorded significant growth in France. According to the project launched at the end of 2002 (Guigou-Carter *et al.* 2005), the most used floorings were the floating wood and glued wood floorings, due to their convenient price and ease of implementation. The project investigated the sound impact performance for both floating and glued wood floors, in walking conditions when the noise was emitted by a walker in a room.

Wood flooring for dance, ballet, aerobic gymnastics or any other form of sport is considered to be special flooring due to its behaviour in response to the activity that takes place on its surface (Cismaru *et al.* 2015).

One of the concerns of the sports flooring specialists is to find the optimum balance between stiffness and flexibility in order to protect the user from suffering injuries or for making an extra effort. Another concern is to reduce the unevenness of the substrate and to achieve flat surfaces (<http://www.pardoselimagazin.ro/images/docs/pardoseli17.pdf>).

Thus, sports floorings have undergone a considerable development with a variety of variants, particularly with regard to the wood panel supporting type, ranging from the traditional one to the most innovative ones (depending on the performance level required by the sport and by the financial possibilities).

Despite the emergence of new materials, wooden floor systems currently have the supremacy in application for sports such as basketball, squash and dancing. As elasticity does not have to be punctual but on extended surfaces, wood is preferred to rubber (<https://kineticsport.ro>).

In the world of sports and recreational games, Kolitzus (2012) says that testing as a scientific process requires a highly specialized expertise. In the last decade, from the multitude of research centers developed in this field, the Dutch manufacturer of special (mobile) testing equipment for sports flooring - Del Tec (<http://deltecequipment.com>) have been remarked.

Following a study of 51 different flooring materials (Demker 2009), the researcher concluded that a global standard for measuring mechanical comfort for all types of floorings, both in-situ and in the laboratory is required and recommended the Swedish Standards Institute (SIS) to develop such technical specification based on testing methods required by EN 14808 and EN 14809.

Due to few publications in this field, the present research is based mainly on the regulations and actual standards imposed by the Sports Forums (European & International Standards 2014).

OBJECTIVE

The objective of the present research is to create flooring systems that meet the basket ball bounce height requirement according to SR EN 12235 (2014). The test method used for present investigation is based on the measurement of the height reached by the ball after falling down on the surface of the wooden floor. The response of the ball is compared afterwards with the result of the same test on the concrete / mosaic floor, considered as standard one. This method verified whether the designed structure corresponds to the requirements imposed for sports halls by the Sports Forums.

MATERIAL, METHOD, EQUIPMENT

Preliminary testing has been carried out to properly design the wood floorings for sport application. Specimens made of steamed beech wood of different lengths (300, 350, 400 and 450mm), widths (30, 40, 50 and 60mm) and thicknesses (15, 20, 25 and 30mm) were subjected to bending strains in order to dimension the component strips of the flooring panels. The results led to the selection of parquet strips with the dimensions (L x W x T): 500mmx50mmx20mm. The strips were arranged according to the English model.

Panels of 1.00mx1.00m (L X W) were produced from these strips according to the requirements of SR EN 12235 (2014), which is the minimum test area recommended by the standard. The strips were glued with Jowacoll® 103.05 glue and supported on three softwood beams. Two variants of structures were made, namely type A (Fig. 1a) and type B (Fig. 1b).

The panel performance of the A-type panel was presented by Turcas *et al.* 2017.

The present paper refers to the B-type panel performance and its comparison to the A-type panel. As compared to the A-type panel structure, the B-type panel has different size and arrangement of the strips. Its dimensional characteristics are given in Table 1.

Beech strips with dimensions of 500mmx50mmx20mm were arranged according to the English model and glued with adhesive Jowacoll® 103.05. They are supported on 1000mmx40mmx20mm resinous beams arranged at 500mm distance between them and measured from their central axis. The strips were fixed with wooden screws of 3,5mm diameter and length of 30mm (Fig.1b). The panel is fixed to the support layer with screws of 6mm diameter and length of 65mm.

The support layer consists of the reinforced concrete layer over which a quick primer for non-absorbent substrates (Super Grund from BAUMIT) was applied and a 2-3mm self-leveling screed (BAUMIT's Levello Duo) was poured to ensure flatness.

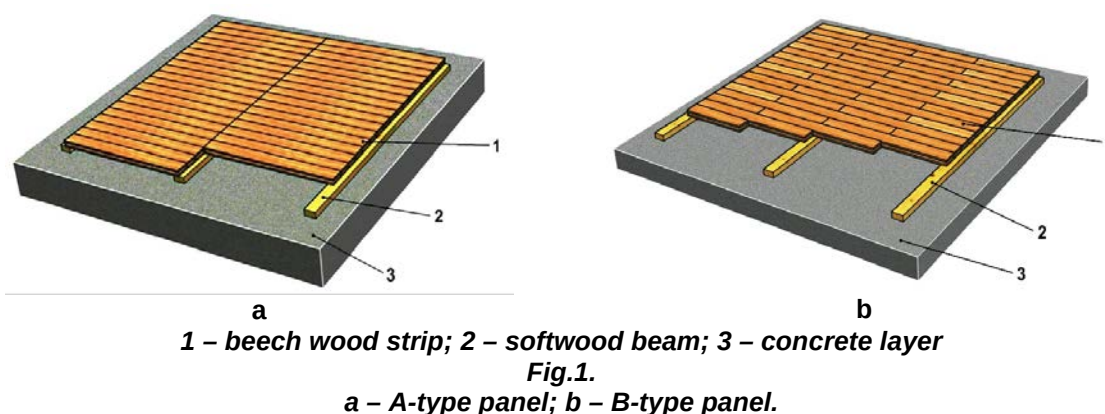


Table 1

Characteristics of B-type panel							
Structure of B-type panel (1,00 m x 1,00 m)							
Strips				Beams			
Length (mm)	Width (mm)	Thickness (mm)	Total (pcs)	Length (mm)	Width (mm)	Thickness (mm)	Total (pcs)
500	50	20	30	1000	40	20	3
250	50	20	20				

The working method used in the experiment is in accordance with SR EN 12235 (2014) which provides an equation for calculating the ball bounce height on the sports floor surface:

$$R\% = \frac{R_s}{R_c} \times 100 \quad (1)$$

where:

- R% - represents the relative height of the ball rebound, as a percentage;
- R_s - the height of ball rebound from a wooden flooring surface, in meters;
- R_c - the height of ball rebound from a concrete flooring surface (used as reference), in meters.

In order to comply both with the provisions of standard SR EN 12235 (2014) and those of the General Regulations for Organizing Basketball Competitions 2016-2017 (RGOCB) (www.frbaschet.ro/documente), a special testing set-up was designed and built within the laboratories of the Faculty of Wood Engineering (Fig. 2a).

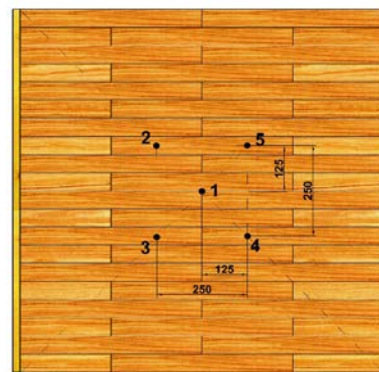
The operating principle of the set-up consists of fixing the RGOCB ball inside a 3-point ring (2 fixed points and one with mechanical retraction element) and releasing it from the height of 1.80 + 0.01m (according to SR EN 12235). Using an Einstein™ Distance Sensor - (Distance Sensor DT020-1), the height to which the ball rises after falling on the floor surface is measured. Calculation of the ball bounce height is done with MiLAB software, which is installed on a digital tablet. This software allows data collection, data display and analysis, and graphical representations.



a.



b.



c.

Fig. 2.

Testing set-up S-TPS-3, ball used for the test and the points of measurements.

The Molten 7 ball shown in Fig. 2b was used for testing. This is the official ball used for competitions organized under the aegis of FRB, according to the RGOCB. The ball pressure was constant at 0.7bar for all tests. The height from which the ball was released was $1.80 \pm 0.01\text{m}$. Five measurements of the ball bounce height were done in the experiment. Fig. 2c shows the points where the five measurements were made.

The reference concrete standard rebound ball height (R_c) is 1,204m, and all results were reported to this value.

RESULTS AND DISCUSSION

Fig. 3 shows the results obtained from the five-point measurements of the ball bounce height when falls on the surface B-type floors.

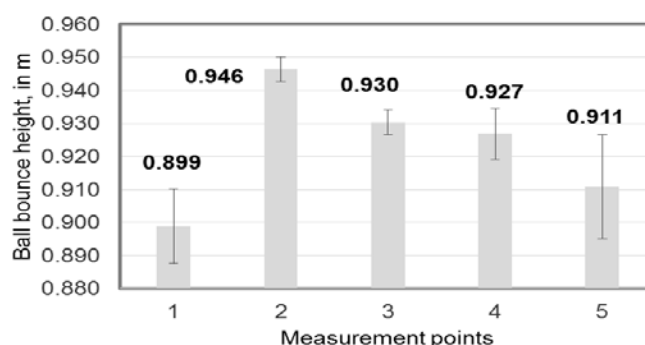


Fig. 3.

Basket ball bounce height on the surface of B-type floor structure.

The data processing involves a lot of "hidden" work (which is not visible) and some results obtained in the intermediary phases are to be visualized, so the Chart Analysis of candle stick (Anghelache 2014) was adapted and used in processing the data obtained in the experiments on the S-TPS-3 stand for sports wood flooring investigation. The method responds to the necessity of representing in a relevant graphical form the experimental data, which are readable, easy to analyse and explained in this form.

Table 2 shows the basic parameters of a „candle” and its adaptation/conversion to the test conditions of the present research.

Table 2

Conversion of parameters			
Technical classical analysis		Adapted technical analysis	
a candle = represents the behaviour/ characteristics of a market in a specific period of time		a candle = behaviour of the basketball ball in 5 sec	
- basic parameters	minimum maximum close open	= first bounce height, SR EN 12235 = distance between sensor and floor = releasing height, SR EN 12235 = first bounce height, FIBA	- basic parameters

When adapting the diagram from Fig. 3 to the „candle stick” analysis, the diagram in Fig. 4 was obtained.

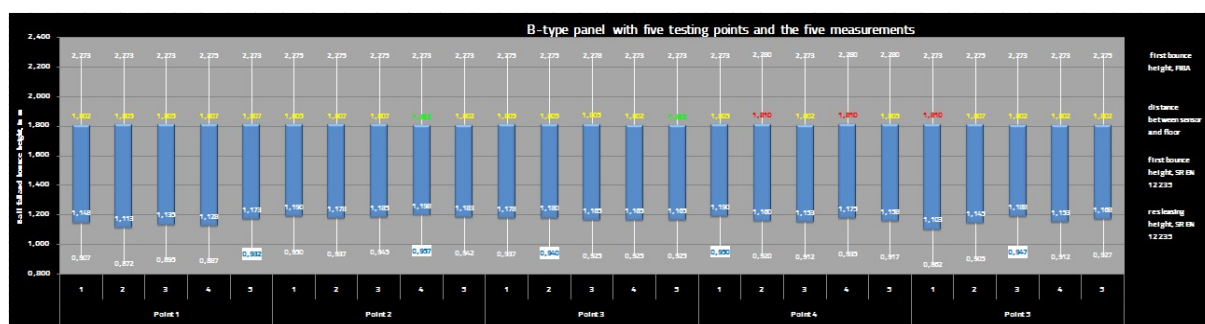


Fig. 4.

Representation of the variation of the height of the basket ball bounce height with the graph resulting from the adaptation of the Japanese candle chart for the B-type wooden floor panel.

Table 3

Comparison between ball bounce heights for A-type and B-type floorings					
Flooring type	Structure	Ball bounce height		Comparison	
A		0,891 m	74,05 %	B to A	
				0,031 m	2,59%
B		0,923 m	76,64 %		

The vertical movement of the basketball ball (after impact with the floor) according to SR EN 12235 must be of minimum 90% of the reference standard height. The B-type wood flooring managed to obtain only 76.64% at the performed test. The improvement of the ball bounce height in case of B-type flooring compared to A-type flooring is presented in Table 3.

This result demonstrates that this structure is not recommended for sport halls floorings. In the diagram shown in Fig. 5 the comparison between the heights of the ball rebounds on the sport surfaces (R%) of type A and type B are presented.

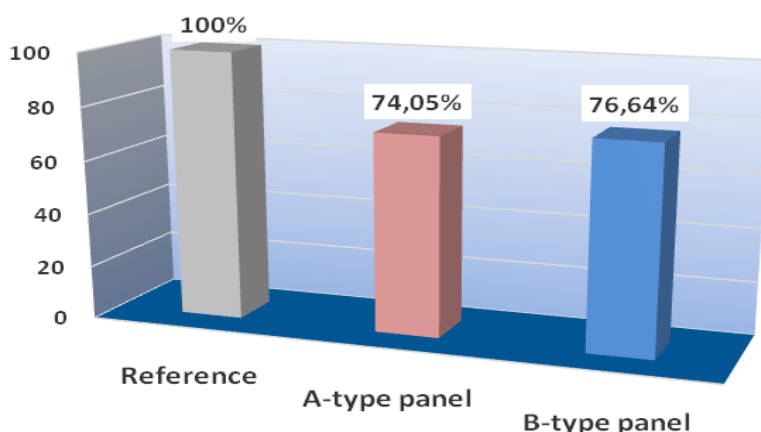


Fig. 5.
R% for A-type and B-type floorings compared to the reference.

CONCLUSIONS

Based on the results, it was found that the ball pressure with which the tests were carried out has a great influence. All tests were carried out with a single pressure in the ball, namely 0.7 bar. At this pressure, the concrete standard ball bounce height was of 1,204m (Turcas *et al.* 2017), and all results were reported to this value.

The R% result obtained for the B-type flooring structure is 76.64%. This structure is composed from parquet strips with dimensions of 500mmx50mmx20mm and arranged according to the English model.

Compared to the A-type flooring structure, the B-type flooring structure responds better to the test, the ball bounce height increasing with 2.59% in this case. A-type structure consists of floor strips of 500mmx50mmx20mm, arranged as floorboards on three beams.

However, the increase in the type B wood flooring response is insufficient compared to 90%, which is the minimum value admitted for sports floorings. Consequently, this type of flooring is not recommended for basketball sport halls.

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