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The influence of changing moisture content in three- layer chipboard for static bending strength

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Abstract: *The influence of changing moisture content in three- layer chipboard for static bending strength*. The aim of the study was the analyse of the humidity change influence on static bending strength of three-layer chipboards. Samples were studied after seasoning three different climate conditions. First step was the analyse done after seasoning in normal conditions. The second after seasoning in the conditions of increased humidity (the samples were stored in water bath with water temperature of 20^{O}C). The last step was the study of the samples stores in dryer with temperature 97^{O}C. Studies showed the impact of humidity change to density and static bending strength of the analysed three- layer chipboard samples.

Keywords: chipboard, static bending, moisture, density

INTRODUCTION

Chipboards belong to the group of materials produced in the form of rigid boards (structural, insulation, cladding) derived from solid wood (derivative wood). They are obtained by processing the solid wood in a specific way. As the result, the board is characterized by very similar parameters to the parameters that solid wood have, such as humidity, density and static bending strength (Borowski et all. 1965).

Chipboards are made by pressing wood shavings bonded with synthetic resins under pressure at an elevated temperature. This group of products is divided into seven types and signed with names from P1 to P7 depending of the resistance to moisture (Boruszewski et all, 2013). The chipboards most often used in the furniture industry belong to the P2 group. This group is referred to as interior furnishing boards (including furniture) for use in dry conditions.

However, there are also different methods of chipboards classification. One of the most popular is classification depending on chipboard structure. In this case, there are five main groups of boards (Drouet, 1994):

1. Single-layer boards made of one chip fraction. They are characterized by a similar thickness and length of the chips of the entire layer.
2. Three-layer boards, composed of two outer layers and one middle layer, where the outer layers are formed with fine chips and the middle layer is formed with thicker chips.
3. Five-layer boards with the middle layer made of the longest and thickest chips. The intermediate layers are made of thin flat chips, while the outer layers are made of the finest particle fractions.
4. Fractionated boards, made of chips that continuously increase in size in the middle direction.
5. Layer fractionated boards in which only outer layers are most often fractionated.

Due to the market demand, the production plants focus mainly on the production of three-layer chipboards. However, the target properties of the chipboard largely depend on the intended use of the finished product. Often the target parameters are defined in the customer's specifications. However, there is an optimal set of chipboard properties proposed as standard. These data are provided in the technical characteristics of chipboards. It contains information on the optimal requirements and their ranges regarding density, humidity, tensile strength perpendicular to the plane, static bending and upset after soaking in water. This requirements has the main meaning for further use of the furniture by the customer (Starecki et all., 1980).

In fact, wood based materials used in furniture production (so chipboards too) are subject to different requirements based on the purpose of use (Gaborik and Langova, 2018). Anyway, no matter what type of furniture will be analysed, one of the most important parameter of chipboard will be its bending strength.

The aim of the research was to investigate the effect of changes in humidity on the static bending strength of three-layer chipboards of normal humidity, increased humidity and for air-dry samples.

MATERIALS AND METHOD

For the tests, 10 samples were taken from a three-layer chipboard with a moisture content compliant with the requirements of PN-EN 312: 2005. The samples were cut according to the EN 326-1 standard from standard 18mm thick boards produced for furniture use. Assumed dimensions of collected samples were 50x410mm. The sample cutting scheme is shown in Figure 1.

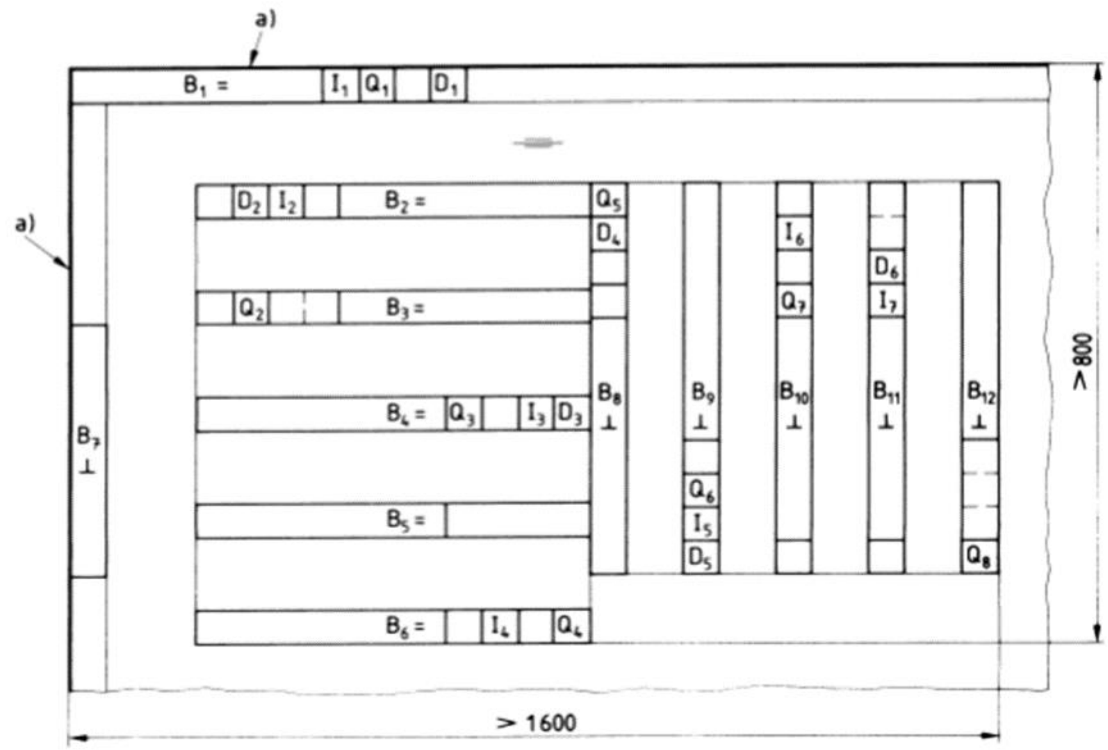

Figure 1. Diagram of sample cutting [EN 326-1]

In the first phase of the research, a standard measurement of the density of the tested samples was done. Density was determined due to the normative method, according to which it is determined by the ratio of the mass of the tested sample to its volume, assuming the measurement in the same humidity parameters. This test was performed in accordance with the PN-EN 323 standard.

The initial moisture content of the three-layer chipboard was determined in accordance with the PN-EN 322 standard, which defines the method of testing with the use of the dryer-weight method. The same studies were done for samples of increased humidity and air- dried samples.

The parameters of tested samples are shown in Table 1.

Table 1. Characteristic of samples

	Chipboards of normal humidity		**Chipboards of increased humidity**		**Air-dried chipboards**	
Sample number	**Density [kg/m3]**	**Humidity [%]**	**Density [kg/m3]**	**Humidity [%]**	**Density [kg/m3]**	**Humidity [%]**
1.	642.8	5,8	668,2	13,7	621,4	0
2.	643.2	5,8	675,3	13,1	611,9	0
3.	649,2	5,7	655,7	17,5	632,3	0
4.	655,3	5,8	671,4	13,7	622,3	0
5.	647,6	5,8	657,9	17,5	631,9	0
6.	648,3	5,8	665,7	14,1	617,0	0
7.	644,7	5,8	653,8	14,3	633,8	0
8.	662,9	5,3	658,8	13,5	604,8	0
9.	654,6	5,7	654,6	14,9	614,3	0
10.	658,1	5,7	648,7	12,8	609,5	0

The key part of the tests, carried out on the samples, was the measurement of their static bending strength. The test and analysis of the results were carried out in accordance with the PN-EN310 standard. According to it, the static bending strength is determined by calculating the quotient of the bending moment M, at the breaking load F_{max}, to the section strength index of the sample. So it is calculated according to the formula:

$$f_m = \frac{3F_{max}l}{2bt^2}$$

Designation:
f_m- bending strength [N/mm^2];
F_{max}- maximum load [N];
l- distance between the centers of the supports [mm];
b- sample width [mm];
t- sample thickness [mm].

The static bending strength test was performed using a 10-ton testing machine in accordance with EN 325. According to it, the testing device must be constructed of:

- cylindrical thrusts, the length of which is greater than the width of the specimen and the diameter (15 ± 0.5) mm
- cylindrical thrust of the same length and diameter (30 ± 0.5) mm as the support, placed parallel and equidistant to the supports.
- a suitable instrument for measuring the deflection arrow in the middle of the sample length with an accuracy of 0.1 mm
- a load measurement system capable of measuring the load exerted on the sample, with an accuracy of 1% of the measured value (Smardzewski, 2008).

The tests were carried out consecutively for samples with operational humidity, high humidity and air-dry condition. Thanks to the simultaneous testing of humidity and bending strength of individual samples, it was possible to determine the influence of one parameter on another.

RESULTS

The analysis of the results obtained during the static bending strength test of the samples is presented in Table 2. It shows the influence of humidity on the static bending strength depending on the seasoning conditions.

Table 2. The test results of the static bending strength

	Chipboards of normal humidity		**Chipboards of increased humidity**		**Air-dried chipboards**	
Sample number	**Humidity [%]**	**The static bending strength [N/mm^2]**	**Humidity [%]**	**The static bending strength [N/mm^2]**	**Humidity [%]**	**The static bending strength [N/mm^2]**
1	5,8	8,9	13,7	7	0	10,1
2	5,8	8,3	13,1	7,3	0	9,6
3	5,7	9,9	17,5	6,9	0	8,7
4	5,8	8,9	13,7	7,1	0	8,4
5	5,8	9,5	17,5	7,3	0	9,9
6	5,8	8,5	14,1	7,3	0	9,5
7	5,8	8,6	14,3	6,9	0	9
8	5,3	8,3	13,5	7	0	9
9	5,7	9,1	14,9	7,9	0	9,4
10	5,7	8,9	12,8	7,5	0	8,8

The influence of sample moisture on the static bending strength is also presented in Figure 2. The diagram shows the decisive influence of the plate seasoning parameters on their static bending strength and the course of changes.

It is evident that in the case of air-dry panels and panels stored in operational humidity, the change in bending strength is insignificant and amounts to an average of 2%.

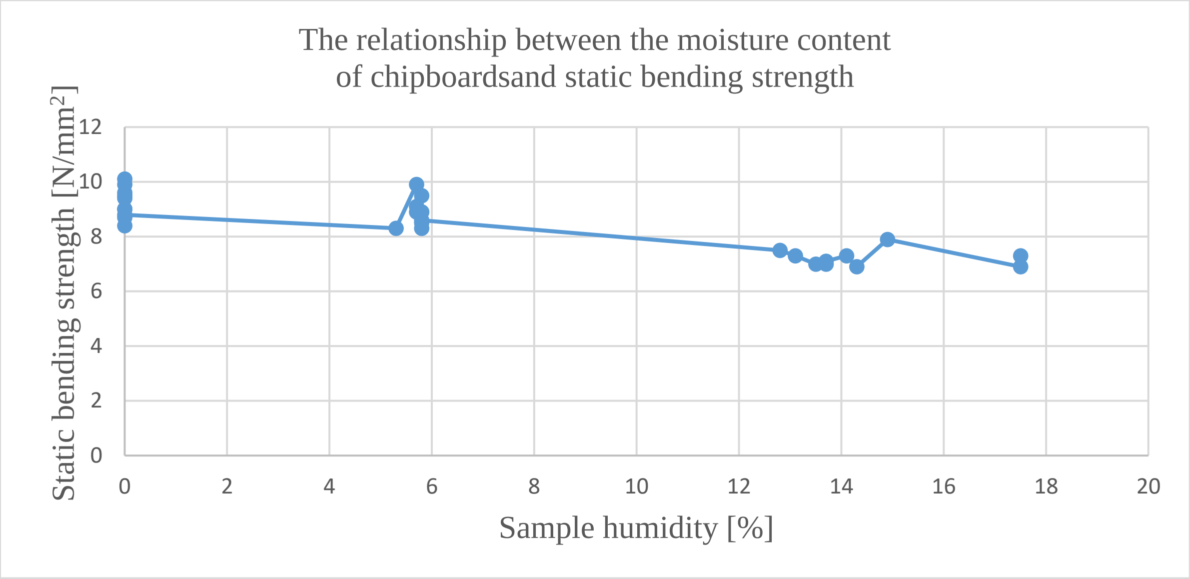

Figure 2. Diagram of the results of the static bending strength

It is evident that in the case of air-dry panels and panels stored in operational humidity, the change in bending strength is insignificant and amounts to an average of 2%.

On the other hand, for samples with condensed moisture, the change in bending strength was already 9%. This is a definite change in the strength parameters of the boards, which may indicate that standard three-layer chipboards used in furniture may not meet the requirements of the customer who uses them in conditions with increased humidity, e.g. in a bathroom or kitchen.

CONCLUSIONS

The analysis of the research material showed that a 10% increase in humidity caused a 3% increase in density. However, the maximum decrease in humidity also caused a 3% decrease in density. Hence, it was found that the changes in the density of the three-layer chipboard did not have a significant impact on their static bending strength.

However, a decisive influence of the moisture of particle boards on their static bending strength was found. In general, there is a tendency to decrease the static bending strength with a simultaneous increase in their moisture content. However, the greatest impact has the increase in humidity above the usable humidity, where the decrease in static bending strength amounted to an average of 9%.

Therefore, it should be stated that the standard three-layer chipboard may not fulfil its role in the furniture industry, if it is used in conditions of increased humidity. Any damage to the veneered surface may reduce the strength of the furniture to static bending, which may ultimately lead to a complaint about the product or, in a worse case, a threat to the user's life.

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Streszczenie: *Wpływ zmian wilgotności na wytrzymałość płyt wiórowych trójwarstwowych na zginanie statyczne*. Celem pracy była analiza wpływu zmian wilgotności na wytrzymałość na zginanie statyczne płyt wiórowych trójwarstwowych. Próbki badano po sezonowaniu w trzech różnych warunkach klimatycznych. Pierwszym krokiem była analiza wykonana po sezonowaniu w warunkach normalnych. W drugim kroku przeprowadzono badania po sezonowaniu w warunkach podwyższonej wilgotności (próbki przechowywano w łaźni wodnej o temperaturze wody 20^{O}C). Ostatnim krokiem było badanie parametrów próbek po sezonowaniu w suszarce nastawionej na temperaturę 97^{O}C. Badania wykazały wpływ zmiany wilgotności na gęstość i wytrzymałość na zginanie statyczne analizowanych próbek płyt wiórowych trójwarstwowych.

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