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Effect of relative humidity on flexural properties of MFP

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Abstract: *Effect of relative humidity on flexural properties of MFP*. The effect of relative humidity on the mechanical properties of MFP was presented in the paper. Panel specimens were conditioned at 55, 65, 75, 85 and 95% RH. Moisture content, modulus of elasticity in bending and bending strength of MFP were determined on these specimens. The relationships between MOE and MOR and the moisture content and relative humidity of MFP were defined.

Keywords: MFP, particleboard, relative humidity, moisture content, MOE, MOR

INTRODUCTION

For years waterproof wood-based panels have been widely used in the construction industry, especially in building wooden houses. The most popular is OSB being used as sheathing in walls, flooring and roof decking. However, new materials that can be an alternative for it are still sought after. One of them is wood-based Multi-Function Panel (MFP) that is in contrast to OSB made of thin, long, non-oriented chips glued with phenol-melamine resin. As the building panel it is exposed to different moisture conditions.

The studies hitherto made on wood-based panels show that relative humidity to which they are exposed considerably affects their physical and mechanical properties. Schneider (1973) presented the sorption curves of particleboards depending on the adhesive resin. He found out that beginning from 40 % relative humidity (RH) the sorption curve of particleboards with phenol-formaldehyde resin runs higher than that of particleboards with urea-formaldehyde resin. Similar studies on effects of RH on the moisture content of typical wood-based panels of various thicknesses were conducted by Niemz and Sonderegger (2009). When examining equilibrium moisture contents of particleboards, they changed RH from 35 to 50, 65, 80, and 93 %. Moya *et al*. (2009) dealt with the effect of cyclical changes in humidity on the moisture content (MC) and thickness swelling (TS) of OSB. They subjected particleboard specimens to three alternating cycles of humidity in the range from 30 to 90 %. They found out that the greatest change in MC and TS occurred during the first week when specimens were conditioned. The effect of RH on the flexural properties of commercial OSB was investigated by Wu and Suchsland (1996). They examined MC of specimens, their TS, MOE and MOR. Measurements were conducted at 35, 55, 75, 85 and 96 % RH. They found out that the panel MC increases along with the growth of RH, which in turn results in a decrease in MOE and MOR values. Similar studies concerning particleboard, MDF and OSB were made by Pritchard *et. al* who examined the effect of RH on functional properties of wood-based panels, including their bending strength. Han *et al.* (2006) studied the effect of RH on the physical and mechanical properties of OSB, plywood, particleboard, and solid wood. They took several levels of relative humidity, i.e. 55, 75, 85, and 94% RH. They found out that that the MC and TS of the examined materials increases along with the growth of RH, whereas their stiffness and bending strength decrease. The effect of the panel MC on their flexural properties was also analyzed by Kask *et al*. (2011), changes in the MC being caused by soaking specimens in water. Tests were made on OSB and Durélis/Populair panels.

There are no similar research results with regard to MFP in the literature. Therefore, the tests were made to determine the effect of RH on the MC of MFP and its flexural properties.

MATERIALS AND METHODS

The tests were made on the MFP with a thickness of 18 mm and the following physical and mechanical properties:

- density – 760 kg/m3,
- moisture content – 8.5%
- water absorption after 24h – 26%
- thickness swelling after 24h – 9%,
- MOE – 4700 MPa,
- MOR – 22.5 MPa,
- internal bond – 0.82 MPa.

Thirty-six specimens with the dimensions of 410 x 50 mm were cut out from the panel sheet, and seasoned for a month in the laboratory at a temperature of 25°C and RH of about 32 %. Afterwards the specimens were measured and weighed, then divided into 5 groups of 6 pieces and placed in a climatic test chamber at a temperature of 20°C and 55% RH. Three specimens were every day weighed until the difference in their mass was less than 0.05% between successive weighings. At that time the first group of specimens was taken out from the chamber, then they were measured and weighed as well as their flexural modulus (MOE) and flexural strength (MOR) were determined according to PN-EN 310 (Fig. 1). A similar procedure was performed four more times, setting humidity in the chamber sequentially to 65, 75, 85, and 95%. After completion of testing all specimens were dried at 105°C for 48 hours, then weighed to determine their dry mass. Basing on the data obtained mean MC, MOE and MOR were calculated for each group of specimens. The significance of differences between respective mean values was tested by means of the one-way analysis of variance (ANOVA) and Tukey's test. To do that, the STATISTICA v. 10 software was used.

Fig. 1 Stand for testing MFP specimens in bending

RESULTS AND DISCUSSION

Figure 2 shows a graph illustrating the relationship between the MC of the panel tested and the RH in which the panels were kept. Each point in the graph is the mean MC of 6 panel specimens at a given humidity. Error bars assigned to the point represent the value of standard deviation. MC of the panel substantially depends on RH (F=6197.2; p=0) and increases nonlinearly with the increase of this humidity. Within the tested range of RH the MC of the panel increases the more, the higher RH, reaching the value of 18 %. For the 65 % and the 85% RH, being the most important from the functional point of view, the moisture contents of the panel are 8,4 and 12,5 % respectively.

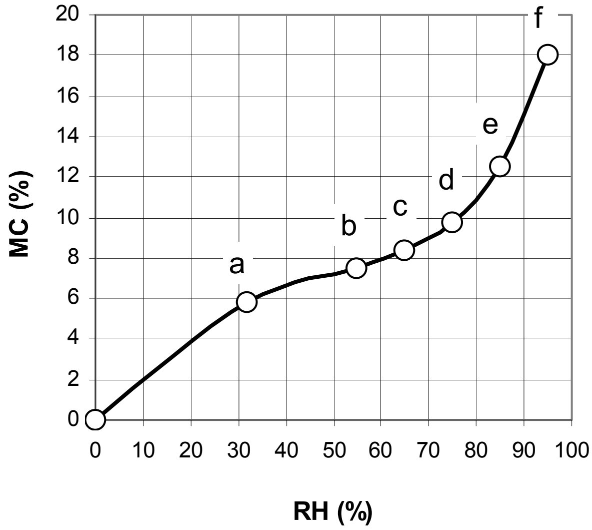

Fig. 2. Relationship between MC of the panel and RH.
Mean values with the same letter are not statistically different at the 5% significance level

Figure 3 shows the relationship between MOE and MOR and RH. Both properties decrease with increasing RH. This decrease is non-linear, is the greater, the greater RH. The analysis of variance confirmed the significance of the relationship between flexural properties and RH, both for MOE (F=235.0; p=0) and MOR (F=92.8; p=0). Tukey's tests showed that the differences between the values of tested properties are statistically significant for the RH of over 65 %.

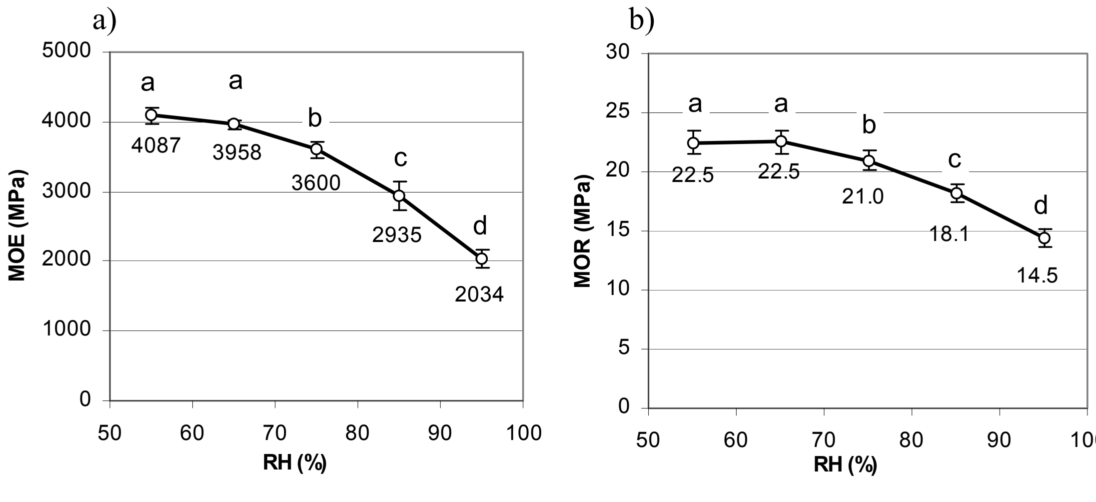

Fig. 3. Relationship between *MOE* (a) and *MOR* (b) of the panel and RH
Mean values with the same letter are not statistically different at the 5% significance level

Figure 4 shows graphs of relationships between MOE and MOR of the panel and its MC. Each point in the graph is the mean value of the examined property of 6 specimens at a given mean MC of the panel. For the points in the graph, regression lines were drawn, and their equations and coefficients of determination were calculated. As expected both MOE and MOR decrease with increasing the MC of the panel and this relationship is close to linear.

The change in the MC of the panel by 1 % results in a change in MOE and MOR by 200 and 0,67 MPa, which with regard to the initial value gives a decrease by 4,9 and 3,0 % respectively for 1 % of the MC of the panel.

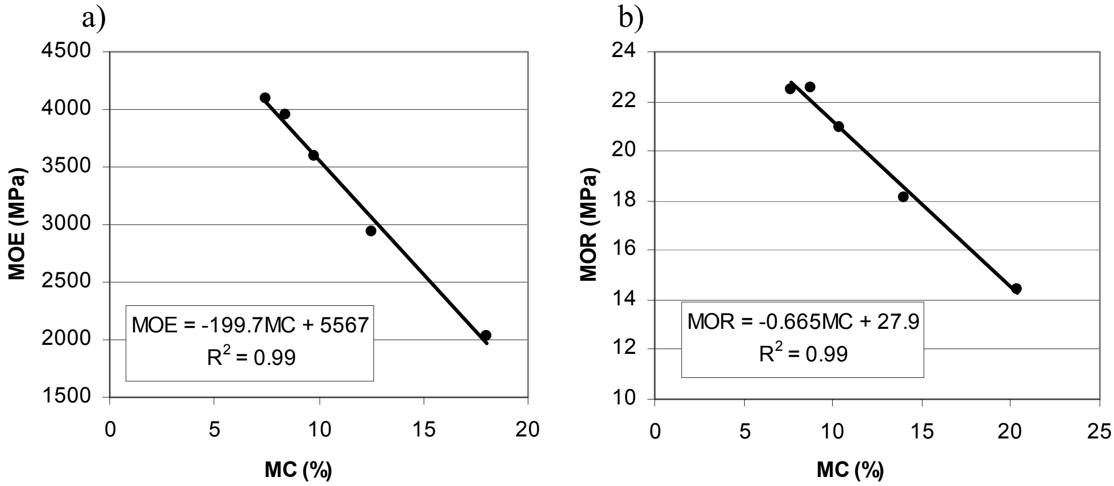

Fig. 4 Relationship between MOE (a) and MOR (b) of the panel and its MC

CONCLUSIONS

1. The properties of MFP substantially depend on relative humidity in which they are used, especially at higher values of humidity.
2. The moisture content of MFP increases with increasing relative humidity, reaching 18 % at 95 % RH.
3. Relative humidity up to 65 % of its value does not significantly affects the values of MOE and MOR. An increase in RH to over 65 % causes a considerable reduction of these properties.
4. An increase in relative humidity to 95 % causes a reduction of MOE by about half and of MOR by more than a third.
5. The flexural properties of MFP decrease proportionally with increasing the moisture content of the panel. The change in the moisture content of the panel by 1 % results in the change of MOE by about 5 % and of MOR by about 3 %.

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Streszczenie: *Wpływ wilgotności otoczenia na właściwości mechaniczne płyty MFP przy zginaniu.* W pracy zaprezentowano wpływ zmiennej wilgotności otoczenia na wilgotność płyty oraz jej właściwości mechaniczne przy zginaniu. Próbki płyty były klimatyzowane w warunkach 55, 65, 75, 85 and 95% wilgotności powietrza. Dla próbek przetrzymywanych w tych warunkach oznaczono wilgotność płyty, moduł sprężystości przy zginaniu (MOE) i wytrzymałość na zginanie (MOR). Wyznaczono zależności MOE i MOR od wilgotności otoczenia oraz od wilgotności płyty MFP.

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