Holz Roh Werkst (2007) 65: 163–165
DOI 10.1007/s00107-006-0134-8

KURZORIGINALIA · BRIEF ORIGINALS

Bending strength and modulus of elasticity of particleboards at various temperatures

P. Bekhta · R. Marutzky

Published online: 10 August 2006
© Springer-Verlag 2006

Abstract Bending strength and modulus of elasticity of phenol-formaldehyde (PF)-bonded particleboards were studied at temperatures between −40 °C and +40 °C. These conditions may occur, for example, during exterior use of boards. Bending strength and modulus of elasticity are significantly affected by the temperature. Moreover, positive temperatures cause higher reduction of strength properties than negative temperatures. The bending strength of boards in the temperature range from −40 °C to 0 °C, for example, is reduced by 15% and in the temperature range from 0 °C to 40 °C by 28%.

1 Introduction

In service particleboards can be exposed to a range of environmental conditions, sometimes at high or low temperatures. As a result particleboards can change their strength properties with the change of the surrounding temperature. Therefore, the relationship between temperature and strength properties is very important if particleboards are to be used as structural members subjected to temperature changes. However, there is not enough information available in the literature (Bekhta et al. 2003, Suzuki and Saito 1987, Yu DeXin and Östman 1983) about the effects of temperature on the strength properties of particleboards. Therefore, such knowledge is very important from the practical point of view.

The objective of this study is the determination of the effect of various temperatures on the strength properties of particleboards.

2 Material and method

Phenol-formaldehyde (PF)-bonded particleboards were used in this study. All test samples were cut from commercial boards and in the same direction of the boards. The moisture content of the boards was 9.6%. Ten samples (with dimensions $450 \times 50 \times 19$ mm) for each temperature series were prepared. Investigated temperatures were: −40, −20, 0, +20 and +40 °C. All samples were conditioned for two weeks at 20 °C and 65% relative humidity. After conditioning each sample was air-tightly packed in a polyethylene package and placed into a chamber at a fixed temperature for three days. Samples were taken out from the chamber and from the package just before testing. Board thickness and weight were measured before testing. Then samples were quickly tested. Bending strength and the modulus of elasticity were determined according to EN 310.

3 Results and discussion

A very good correlation was found between bending strength, modulus of elasticity and temperature (Figs. 1 and 2). As can be seen from Figs. 1 and 2 both the bending strength and modulus of elasticity are reduced with rising temperature. Besides, the effect of temperature on the modulus of elasticity is more significant than

P. Bekhta (✉)
Department of Wood-Based Composites, National University of Forestry and Wood Technology of Ukraine,
Lviv, 79057, Ukraine
e-mail: p_bekhta@forest.lviv.ua

R. Marutzky
Fraunhofer Wilhelm-Klauditz-Institut für Holzforschung,
38108 Braunschweig, Germany

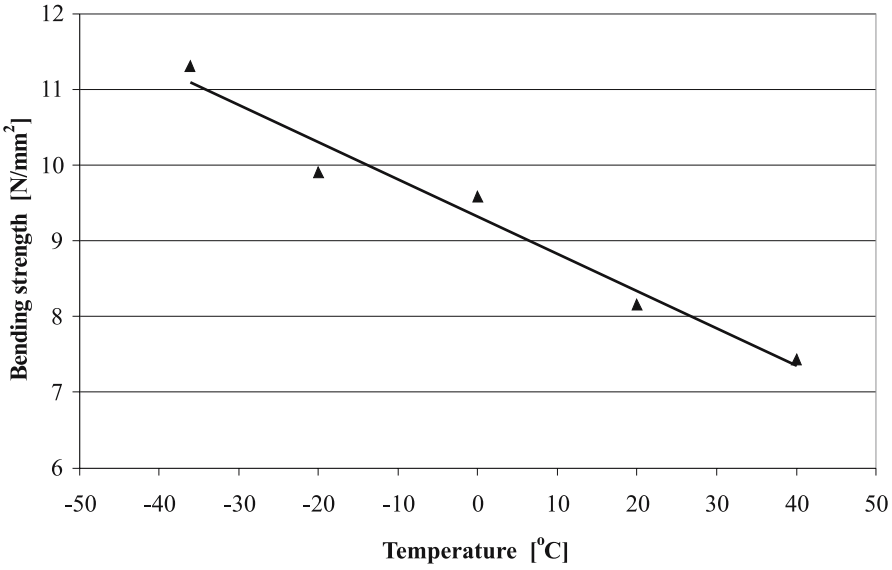

Fig. 1 Influence of temperature on the bending strength of particleboards
Abb. 1 Einfluss der Temperatur auf die Biegefestigkeit von Spanplatten

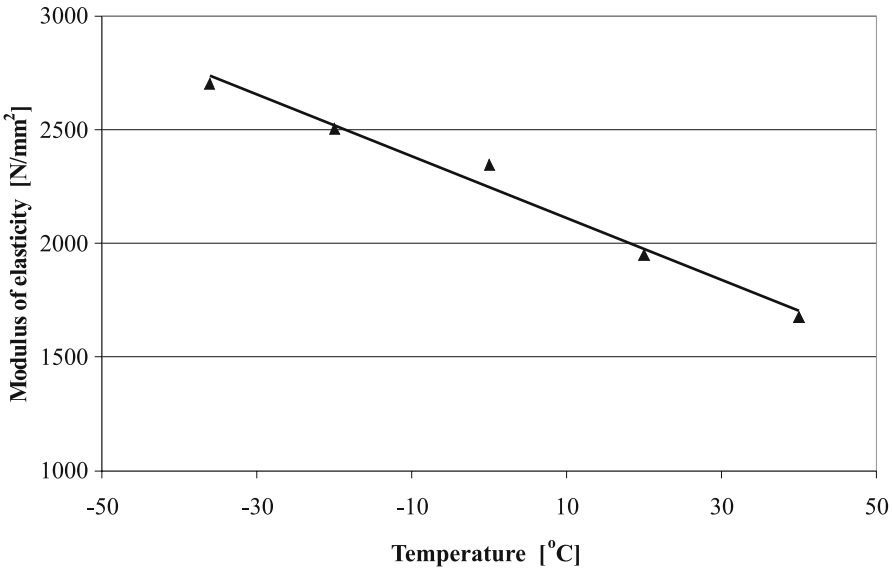

Fig. 2 Influence of temperature on the modulus of elasticity of particleboards
Abb. 2 Einfluss der Temperatur auf den E-Modul von Spanplatten

the same on the bending strength. With increasing temperature from $-40\,^{\circ}\mathrm{C}$ to $+40\,^{\circ}\mathrm{C}$ the bending strength and modulus of elasticity are decreased by 34% and 38% accordingly. The strength properties of the board change more at positive temperatures than at negative temperatures.

The relationships between bending strength (MOR), modulus of elasticity (MOE) and temperature (T) were established using a liner model with the following form:

$$MOR = 9.3184 - 0.0493 \cdot T \qquad (R^2 = 0.97)$$

$$MOE = 2246 - 13.599 \cdot T \qquad (R^2 = 0.98)$$

It can be noted that there are two temperature ranges, which are the reason for the qualitatively different changes of the boards' strength properties, namely: 1. from $+40$ up to $0\,^{\circ}\mathrm{C}$. In this range the increase of boards' strength takes place because of variability of the properties of polymeric substances, which are involved in their constitution. The constitution of the wood substance is very complex, but cellulose and lignin constitute the basic part. As it is known, the strength of such polymers depends on the temperature, namely: with temperature reduction their strength is increased, as molecules approach each other and the connection between them becomes stronger. It explains the fact that even air-dry wood noticeably changes its strength at the temperature variation. 2. from 0 up to $-40\,^{\circ}\mathrm{C}$. This area is the most intensive phase of the transition of moisture (which is involved in the board) from one state to an-

other. Certainly, the polymer substances prolong to have an effect, but water freezing is the main reason for strength change.

Acknowledgement This paper was written while P.A. Bekhta was visiting Professor at the Wilhelm-Klauditz-Institut für Holzforschung (WKI). His work has been supported by the WKI and Deutsche Akademischer Austausch Dienst (DAAD). This support is gratefully acknowledged. Thanks to Dr. C. Boehme and Dipl.-Ing. S. Thiele for technical assistance in this study.

References

Bekhta P, Lecka J, Morze Z (2003) Short-term effect of the temperature on the bending strength of wood-based panels. Holz Roh-Werkst 61(6):423–424

Suzuki S, Saito F (1987) Effects of environmental factors on the properties of particleboard. I. Effect of temperature on bending properties. Mokuzai Gakkaishi 33(4):298–303

Yu DeXin, Östman BAL (1983) Tensile strength properties of particle boards at different temperatures and moisture contents. Holz Roh- Werkst 41(7):281–286