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BENDING CREEP BEHAVIOUR OF OSB LOADED IN THE PLANE OF THE PANEL

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ABSTRACT

The flexural creep behaviour of oriented strandboards OSB/3 10 mm thick was investigated for a period of 72 days. The samples divided into two series were loaded in the plane of the panel in 4-point bending under four stress levels: 30, 40, 50 and 60% of MOR (modulus of rupture). Values of rheological constants were calculated using the 3-element rheological model. Deflections increased about linearly with respect to stress level up to 50% of MOR. The creep process of samples tested at stress level of 60% of MOR was rather nonlinear. Many samples tested at this stress level failed before the experiment was completed.

Key words: oriented strandboard, creep, creep compliance, bending, rheological constants, isochronous lines, linearity.

INTRODUCTION

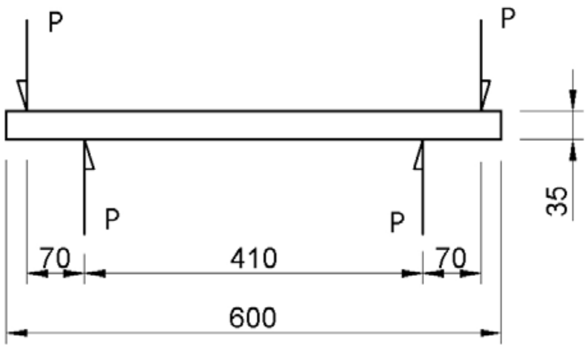
During the last few years, wood-based panel products have been more and more frequently used as structural components. Those wood composites are used not only as shield materials, but also as carrying elements of composite beams. The design of composite structural elements requires not only the knowledge of elastic and strength properties of used materials but also of their rheological behaviour. The creep behaviour of wood-based panels such as plywood, chipboard (particleboard) or OSB (oriented strand board) has been often investigated during the last two decades. Most creep data were obtained from bending test experiments carried out on samples of traditional chipboards loaded perpendicularly to the plane of the panel e.g. [5, 6]. Those experiments consisted in the recording of the creep process of samples tested under different stress levels, temperatures, moisture contents or climatic conditions. The investigations on creep behaviour of oriented strand boards were similar but not so numerous. Usually they were carried out on bending samples loaded perpendicularly to the plane of the panel [10]. Most composite panel products are recognised as non-homogenous and anisotropic materials. Some wood composites, i.e. certain types of particleboard and fibreboard can be classed as plane isotropic, that is, they have an infinite number of symmetry planes, all oriented in a direction perpendicular to the plate plane [2]. Oriented strand board, made of 3 layers, has characteristics similar rather to plywood. Those materials are commonly classed as orthotropic. Laminar structure of OSB plates causes different mechanical properties in two basic directions of the plate sheet: longitudinal and transverse. Properties of those plates loaded in the plane of the panel or perpendicularly to this plane are also different.

This paper describes investigations on creep behaviour of OSB plates during the bending test. The samples were loaded in the plane of the panel, i.e. just as in webs made of OSB in real composite beams.

MATERIALS AND METHODS

Polish Standards do not define method of creep tests for wood and wood-based composites. The EN 310 Standard describes method of short-time strength determination in three-point bend test. In presented studies a four-point bending scheme was chosen, because it ensures constant bending moment and absence of shear between middle bearings (Fig. 1). The deflection was measured in the mid-span of the samples in relation to inner supports (base), what corresponds to "pure" moment deflection. Constant loads of 30, 40, 50 and 60% of MOR (modulus of rupture) were applied to the test samples. There is a limited number of published works, e.g. [1, 3], containing elasticity constants of OSB loaded in the plane of the panel. Even fewer publications can be found on modulus of rupture of OSB loaded in this way [9]. For that reason it was desirable to recognise its value. The MOR value was determined (in four-point bend test on 12 specimens) as 19.8 MPa with standard deviation of 2.6 MPa. Two identical series of creep tests, each on 12 samples (3 for each stress level), were conducted due to limited workplaces. The samples were cut out from OSB/3 plates produced by Kronopol Zary. The most popular thickness of OSB webs of composite I-beams, i.e. 10 mm [8], was chosen for the experiment. The other dimensions of the samples: height 35 mm and length 600 mm were chosen to avoid their lateral buckling. The span of each specimen was parallel to the "grain" (strand orientation in the outer layers of the board). Before any test the specimens were seasoned for two weeks in temperature 15°C±1°C and relative humidity (RH) 45%±5%. Moisture content of the specimens was determined according to EN 322 as 6.42%. Average density of tested board was found as 640 kg/m^{-3}. The first series of creep tests was carried out at the following conditions: temperature 16.8°C±0.8°C and relative humidity 49.1%±4.5%. The second one was proceeded at different conditions: temperature 18.1°C±0.8°C and RH 55.0%±4.7%. Both the creep tests lasted about 72 days.

Fig. 1. Loading scheme and dimensions (in mm) of the bending samples



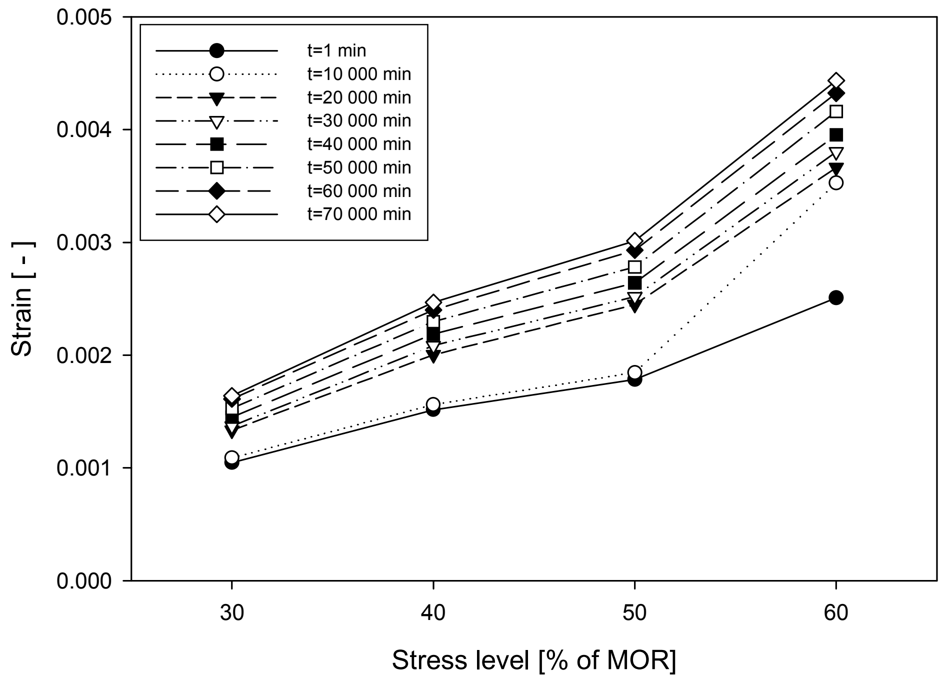
RESULTS

Bending deflections of all the creep tests were converted into the relative deflection (epsilon) of extreme fibres of the specimens. Then the linearity of viscoelastic creep process of the OSB was verified, because only below the limit of that linearity results are simply comparable [2]. Isochronous lines based on creep curves were obtained for eight time values chosen from the interval <1–70,000> minutes and for four stress levels. As it is shown in Figure 2, all the isochronous lines above the stress level of 50% of MOR distinctly diverge from the straight line. It means, that the stress level of 50% of MOR might be recognised as the limit of linearity of viscoelastic creep process for the OSB/3. The existence of such the limit is also confirmed by the frequent failures of specimens loaded at the level of 60% of MOR, which is typical for nonlinear viscoelasticity. The limit of linear viscoelastic behaviour of wood exists, by different tests, within the range of 36-84%, but commonly about 50% of MOR [11]. For particleboard this limit exists within the range of 30-50% of MOR [5]. The exact value of this limit for OSB should be determined from creep tests conducted at more stress levels. The results of creep tests – strain (ε) – conducted at different stress levels (σ_i) were converted into the values of the creep compliance ($J = \varepsilon/\sigma_i$) to make them comparable with each other. Fittings of obtained results (J) was made with use of the creep function of the three-element standard body:

$$J(t) = J_0 + J_d(1 - \exp(-t/\tau)) \quad (1)$$

where
J_0 = instantaneous compliance,
J_d = delayed compliance,
τ = retardation time.

Fig. 2. Isochronous lines based on results of creep tests of OSB/3



This approximation was carried out only for results of creep tests conducted at stress levels of 30, 40 and 50% of MOR, i.e. below the limit of viscoelastic creep linearity.

Creep at stress level of 30-50% of MOR

The graphs of the creep compliances (J) obtained from creep tests conducted under the same environmental conditions and stress level are not always similar one to another (Fig. 3). Different starting points of these curves and their vertical shift show that the instantaneous compliance J_0, which is simply related with modulus of elasticity (MOE), has a significant scatter of values through one plate sheet of the OSB. Additionally, different speed of the creep process occurs for samples cut out from one plate sheet, what points at considerable scatter of rheological properties of the OSB/3. The rheological constants (J_0, J_d, τ) from Eq. 1 were obtained using the least square method with the aid of Sigma Plot 2001 software. These constants are summarised in Table 1. Analysing these data it can be concluded, that there is no apparent relation between compliance J_0 and J_d for the OSB/3. The J_0/J_d ratio varies from 0.9 to 2.9 for different stress levels and environmental conditions. The retardation time seems to be affected by stress level and temperature. This time is shorter if the stress level or temperature is higher. It is visible that experimental curves are not smooth. It may be caused by insignificant fluctuations of air temperature and humidity during the experiment or, on the other hand, by a randomness of the creep process [7]. The averaging theoretical creep curves obtained by approximation of experimental curves for each series and stress level are illustrated in Figure 4. It is evident that, regardless of the load level (within the range of 30-50%

of MOR), the creep functions are rather similar. This, as well as isochronous lines, points at linearity of viscoelastic creep process of the OSB/3. It can be noticed however that higher air temperature and humidity (series II) intensify this process.

Fig. 3. Experimental creep curves for OSB/3 tested in I series at stress level of 50% of MOR

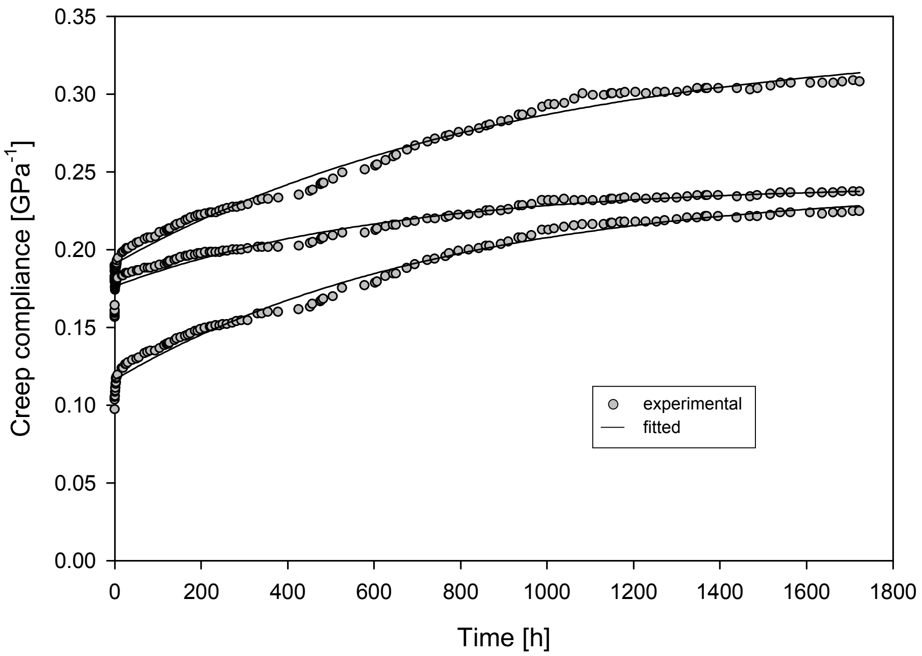


Fig. 4. Approximated creep curves of OSB/3 for stress levels of 30 - 50% of MOR

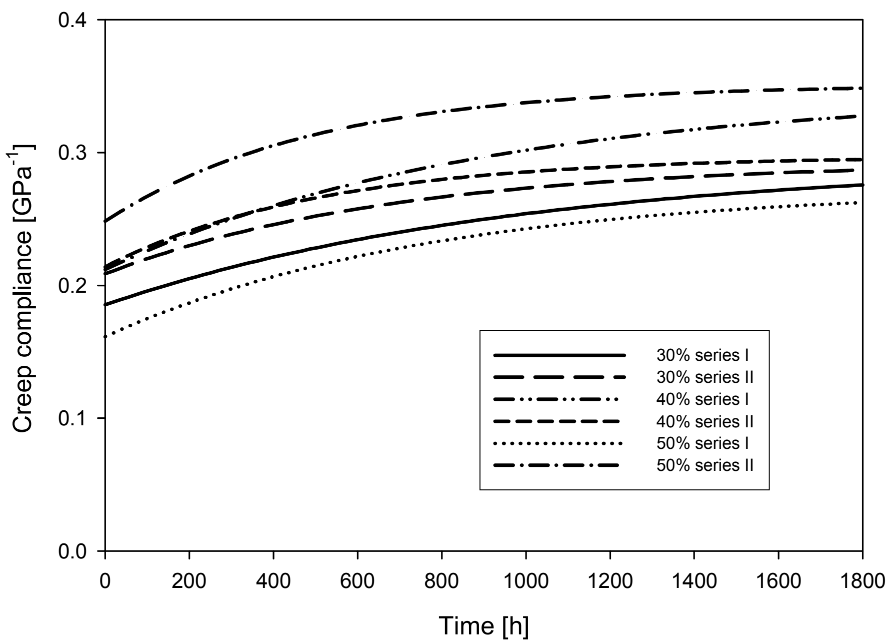


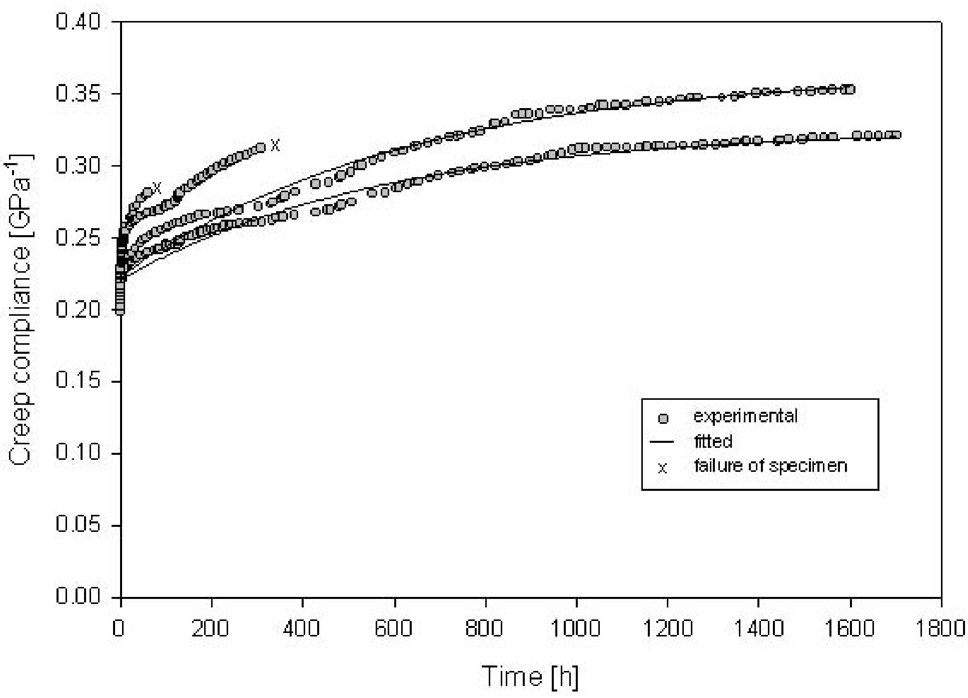
Table 1. Rheological constants of OSB/3 loaded in the plane of the panel for different stress levels

Stress level [% MOR]	Series	J_o [GPa^{-1}]	J_d [GPa^{-1}]	τ [h]
30	I	0.18529	0. 10747	982.88
	II	0. 20869	0. 08428	691.43
40	I	0. 21194	0. 13318	892.95
	II	0. 21394	0. 08327	513.65
50	I	0. 16134	0. 11184	772.76
	II	0. 24823	0. 10293	469.35

Creep at stress level of 60% of MOR

OSB/3 creep specimens tested for quite long time at stress level of 60% of MOR behave like nonlinear viscoelastic material. From Figure 5 it is evident that many of test pieces of the first and second series failed before the experiment was completed, when the other behave like those tested at lower stress levels. For some test pieces which failed, no tertiary creep period [4] was observed and the time to failure was situated in the interval (10–1,600 hours) i.e. within the whole experimental period. An analysis of pictures of the failed specimens showed that strands were pulled out rarely, they were rather simply broken. It speaks well for a quality of joints inside the OSB/3.

Fig. 5. Experimental creep curves for OSB/3 tested in I series at stress level of 60% of MOR



CONCLUSIONS

1. The creep behaviour of the OSB/3 plates during the bending test depends on stress level. For samples loaded in the plane of the panel deflections increased about linearly with respect to stress level up to 50% of MOR.
2. The creep behaviour of the OSB/3 plates tested at stress level of 60% of MOR was rather nonlinear. A tertiary creep stage was observed in some specimens. Many of them failed before the experiment was completed.

3. The creep compliance of the OSB/3 plates increased markedly when the relative humidity was raised from 49% to 55% and the temperature from 16.8°C to 18.1°C.
4. The rheological constants of the OSB/3 plates have a significant scatter of values through one plate sheet.

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