Annals of Warsaw University of Life Sciences – SGGW
Forestry and Wood Technology No 115, 2021: 45-54
(Ann. WULS–SGGW, For. and Wood Technol. 115, 2021: 45-54)

Testing of the fatigue strength along wood fibres at different moisture contents

EWA DOBROWOLSKA[1], MATEUSZ NIEDBAŁA[2], DANIEL TABACZYŃSKI[3]

[1)] Department of Wood Sciences and Wood Preservation, Institute of Wood Sciences and Furniture, Warsaw University of Life Sciences – SGGW
[2)] Department of Technology and Entrepreneurship in Wood Industry, Institute of Wood Sciences and Furniture, Warsaw University of Life Sciences – SGGW
[3)] Faculty of Wood Technology, Warsaw University of Life Sciences - SGGW

Abstract: *Testing of the fatigue strength along wood fibres at different moisture contents.* The paper determines the effect of wood moisture content on the fatigue strength in compression along fibres. The method of determining the maximum stress at the proportional limit was used for the measurements. Fatigue strength was investigated for three wood species: pedunculate oak (*Quercus robur* L.), bearded birch (*Betula pendula* Roth.) and Norway spruce (*Picea abies* L.), with two moisture contents: close to the absolutely dry state and above the fibre saturation point. The ratio of fatigue strength to short term strength depends on moisture content and is similar for birch (70.3% in the dry state and 72.1% in the wet state), for oak (67.4% and 69.5% in both states) and for spruce (66.6% in the dry state and 68.1% in the wet state). The moisture content of the wood clearly influences the fatigue strength of the wood. On average, the fatigue strength of wood with moisture contents above the fibre saturation point constitutes about 0.20 of the fatigue strength of wood with moisture contents close to 0%. This tendency was found regardless of the tested species. The simplified method for testing fatigue strength at the limit of proportionality has shown its limited usefulness, requiring further analysis and comparison with other methods in order to be thoroughly tested and possibly improved.

Keywords: fatigue strength, moisture contents, simplified method for testing, oak, birch, Norway spruce

INTRODUCTION

Depending on the duration and magnitude of the applied force, stresses develop in wood structures, leading to deformation. The investigation of the strength properties of wood is based primarily on the determination of the short term strength. In practice, structures are usually subjected to long-term constant or alternating loads. Verification of their suitability requires the determination of rheological properties such as creep, stress relaxation and fatigue strength

Fatigue strength is the highest stress that a wood structure can withstand over a long period of time.

The fatigue strength of wood has been studied by relatively many researchers. Numerous theoretical works on models of wood exhibiting linear and non-linear viscoelastic characteristics have also been published (Zobel 2006, Dubois et al. 2005, Gołacki and Stropek 2001, Clorius et al. 2000, Kontankiewicz et al. 1996, Gonet 1991, Mukudai and Yata 1986, Siegel 1985, Gressel 1972, 1984, Krzysik 1957, Stüssi 1953). Based on this, coefficients were determined comparing the acceptable stresses for all types of loads relating to their instantaneous strength. The relationship between static and dynamic loads for defect-free wood corresponds to between 50% and 60% of the instantaneous strength (Niemz and Sonderegger 2017, Ylinen 1957, 1959, Wood 1947). The relatively wide range characterising this relationship is due to the synthetic treatment of wood material, often without taking into account interspecific structural differences, density, and the influence of moisture content.

The strength properties of wood are significantly affected by many factors (Gressel 1984), the most important of which is moisture content. It has been found that wood reaches its maximum strength when absolutely dry and its minimum strength when the fibre saturation point has been reached. The moisture content of wood above the fibre saturation point does not change the strength (Dobrowolska et. al. 2020, Niemz, Sonderegger 2017, Hering et al. 2012, Kozakiewicz 2010, Nielsen 2007, Mohr 2001, Matejak, Starecka 1971, Kollmann et al. 1968, Gillwald et al. 1966, Gillwald 1966, Rose 1965, Perkitny et al. 1963, Kollmann 1951).

When the fatigue strength of e.g. Douglas fir wood was examined with increasing moisture content, a faster failure was found with the same amount of load (Fidley et al. 1991). Work on this issue was also undertaken by A. Hanhijarvi et al. (1998), confirming the decrease of fatigue strength under the influence of moisture despite an increase in the cross-sectional area of the samples.

Testing of the fatigue strength of wood as well as wood composites involves time-consuming, months-long application of force to samples of different shapes and dimensions (Wang et al. 2012, Bengtsson 2001, Gressel 1972, 1984, Gerhards 1977, Bryan 1960). The developed standardised tests (e. g. ASTM D 6815-02a/2004, DIN EN 1156, EN 1156:2013-07), are conducted under laboratory conditions, using relatively small and defect-free samples. They also include long-term measurements under normal climate conditions (20°C/65% relative humidity) with the load reduced to 75% of the breaking load.

The knowledge on fatigue strength for more wood species is limited despite so many studies. This is mainly due to the need for comparative analyses of numerous groups of identical samples held under appropriate load for very long periods of time under defined, constant conditions.

For the determination of the fatigue strength, methods have also been used which allow for shorter testing times, based, for example, on the relationship between the rate of deformation occurring and the associated stress. In this way, the determined fatigue strength differs approximately 5% from the generally accepted values (Beljankin 1957, Staudacher 1936). Another method developed on the basis of numerous observations was the determination of the fatigue strength at the proportional limit (Ivanov 1938, 1941, Staudacher 1936). The stresses arising up to the proportional limit when the material is loaded at a constant speed cause linearly dependent increments of deformation, determining the value of the fatigue strength (Čížek 1961, Beljankin et al. 1957, Krzysik 1957, Staudacher 1936). Tests according to this method were carried out for the longitudinal compressive, bending and tensile strengths of the wood. It has been found that the fatigue strength of the wood ranges from 50% to 75% of the instantaneous strength.

The aim of this study was to determine the effect of wood moisture content on the fatigue strength in compression along fibres. The method of determining the maximum stress at the proportional limit was used for the measurements. Fatigue strength was investigated for three wood species: pedunculate oak (*Quercus robur* L.), bearded birch (*Betula pendula* Roth.) and Norway spruce (*Picea abies* L.), with two moisture contents: close to the absolutely dry state and above the fibre saturation point.

STUDY MATERIAL AND METHODOLOGY

Investigations of fatigue strength were carried out on selected wood species characterised by different structure and density. These were: from the group of deciduous species, pin oak (Quercus robur L.), from the group of deciduous species, downy birch (Betula pendula Roth.), and from the group of coniferous species, Norway spruce (*Picea abies* L.).

Samples of dimensions compliant with PN-79/D-04102 "Wood - Determination of compression strength along fibres" were used for fatigue strength of wood in compression. The samples were cut from one element of a given wood species. Then, 40 defect-free samples of similar density were selected.

The samples were divided into two groups. In group A the absolute moisture content of the wood corresponded to the dry state and in group B it was significantly above the fibre saturation point.

The density of wood was determined with the stereometric method pursuant to PN-77/D-04101 "Wood. Determination of density". The wood moisture content was determined on the basis of the requirements of PN-77/D-4100 "Wood. Determination of moisture content".

An INSTRON 3382 testing machine was used to test the fatigue strength using a 10 kN load cell. The machine beam speed was set at 0.1 kN/s (5.88 kN/min) until the sample failed. During the test, the displacement of the machine beam was read with an accuracy of 0.001 mm at an increment of 1.0 kN for dry wood and 0.5 kN for wet wood.

From the relationship between the force and the difference in the resulting deformations, the ordinate of the end point on the section of the straight line was determined.

The fatigue strength at the proportional limit was calculated according to the formula (Ivanov 1938, 1941, Staudacher 1936):

$$\sigma_L = \frac{F_L}{A}$$

where:
F_L – Force corresponding to the load on the proportional limit (*kN*),
σ_L – Compressive strength along the fibres at the proportional limit at a given moisture content of the sample ($kN \cdot m^{-2}$),
A – Reference cross-sectional area in (m^2).

The instantaneous strength Rc was also determined for the tested wood in accordance with the requirements of PN-77/D-04101 standard, at the sample loading rate the same as for the fatigue strength test. On this basis, the ratio of the fatigue strength to the instantaneous strength was determined for the tested wood species and moisture content.

The statistical significance of the coefficient of variation V was determined (Krysicki et al. 2000).

RESULTS AND THEIR ANALYSIS

Tests of fatigue strength were conducted for 3 selected wood species. Oak wood (*Quercus robur* L.) had an average density of 609 kg/m3, with a coefficient of variation of 5.8%. The wood density of the common birch (*Betula pendula* Roth.) was 589 kg/m3 (V=4.7%) and that of the Norway spruce (*Picea abies* L.) was 533 kg/m3 (V=4.7%) (Table 1)

Table 1. Density of oak, birch and spruce wood and moisture content of group A and B samples

Wood species	Density (kg/m^3)	Moisture (%)	
		A	B
Oak	609 V=5.8%	1.3 V=6.3%	94.0 V=5.2%
Birch	589 V=4.7%	1.7 V=18.0%	117.8 V=6.2%
Spruce	533 V=7.0%	1.7 V=11.5%	85.6 V=13.0%

V – Coefficient of variation (%)

The wood moisture content of group A samples was close to the absolutely dry state and equalled for oak wood 1.3% (V=6.3%) and for birch and spruce wood 1.7%, with coefficients of variation of 18.0% and 11.5%, respectively. The moisture content of wet samples in group B was 94.0% (V=5.2%) for oak wood, 117.8% (V=6.2%) for birch wood and 85.6% (V=13.0%) for spruce wood (Table 1). On the basis of statistical analysis of the results obtained for wood density and moisture content, their significance was found at the assumed confidence level equal to 0.95.

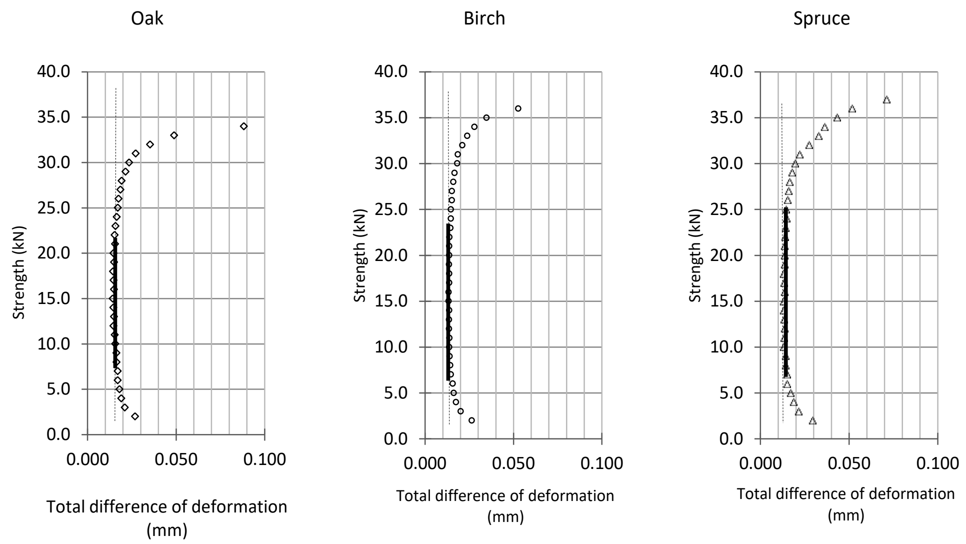

Fig. 1. Dependence of compressive force on the difference of total deformation of wood of group A samples: oak, birch and spruce

The deformations resulting from the applied force are shown in Figure 1 for group A samples and Figure 2 for group B. At low incremental loads in the initial stage of the test, deviations towards larger differences due to errors occurring in the initial stage of the test were neglected.

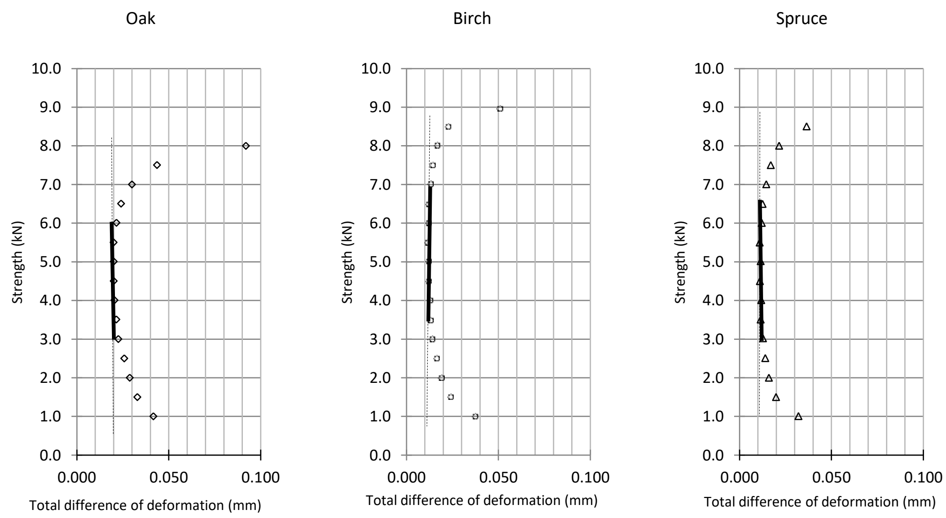

Fig. 2. Dependence of compressive force on the difference of total deformation of wood of group B samples: oak, birch and spruce

Analysing the deformations caused by the continuously increasing force, their course was similar for each of the tested wood species (Fig. 1, 2). After the load exceeded the proportional limit, a visible increase in the size of the measured deformations occurred. In the dry wood group A, this limit was reached by a force of 23.0 kN for oak wood and 25.0 kN for birch and spruce wood.

The average total deformations up to the proportional limit for the oak samples were equal to about 0.0151 mm and about 0.0136 mm for the birch and spruce samples.

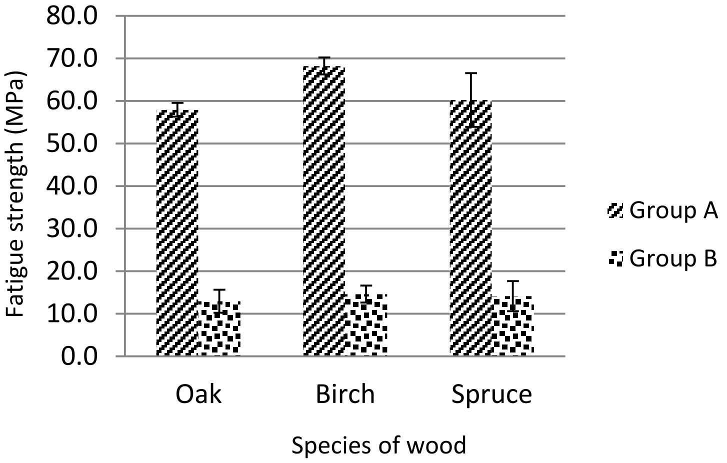

Fig. 3 Fatigue strength of oak, birch and spruce wood in compression from groups A and B

A similar character of the course of the difference in total deformation caused by the increasing force was observed for group B wood with moisture content above the fibre saturation point (Fig. 2). The limit load for wet oak samples was about 6.0 kN, and 6.5 kN for birch and spruce samples.

The average total deformation in the linear range of dimensional changes for the oak samples was 0.0143 mm and for the birch samples 0.0120 mm, reaching a value of 0.0129 mm for the spruce samples.

Among the examined wood species in the group A samples, the highest average strength determined at the proportional limit amounting to 68.2 MPa with the coefficient of variation equal to 3.3%, was achieved by birch wood (Fig. 3), and the lowest by oak wood amounting to 57.9 MPa with the coefficient of variation equal to 4.0%. The obtained value of the fatigue strength of spruce wood did not differ significantly from that of oak wood and amounted to 60.2 MPa with a coefficient of variation of 12.6%. Despite the relatively high coefficient of variation for spruce wood, the results obtained are statistically significant.

In group B of wet samples, birch and spruce wood had the highest strength at the proportional limit, with an average value of 14.6 MPa and 14.1 MPa, respectively (Fig. 3). The lowest strength of 12.9 MPa was found for oak wood. The coefficients of variation were 5.4% for oak wood, 4.0% for birch wood and 7.0% for spruce wood.

The strength determined at the proportional limit of the wood in the wet state was between 21.4% and 23.4% of the percentage points of the dry strength. The least susceptible to strength reduction was spruce, followed by oak and birch.

The study showed a significant difference between the fatigue strength obtained in dry wood and in wood with moisture content above the fibre saturation point, confirming the state of the art regarding the influence of moisture content on the mechanical properties of wood (Niemz, Sonderegger 2017, Hering et al. 2012, Kozakiewicz 2010, Nielsen 2007, Mohr 2001).

Irrespective of the tested wood species, the ratio of the fatigue strength of wet wood with a moisture content above the fibre saturation point to the strength of the wood in the absolutely dry state is about 0.20. The resulting small discrepancies may be due to significant differences in moisture content of the wood tested in the wet state.

When the fatigue strengths of birch, spruce and oak wood were tested, the instantaneous strengths were also determined and are summarised in Table 2. The resulting failure stresses differed significantly between sample groups A and B.

Table 2. Average fatigue strength and instantaneous strength of the tested wood species of group A with low moisture content

Strength	Oak	Birch	Spruce
Fatigue (MPa)	57.9 (V=4.0%)	68.2 (V=3.3%)	60.2 (V=12.6%)
Instantaneous (MPa)	86.0 (V=5.8%)	97.1 (V=3.7%)	90.3 (V=10.8%)

V – Coefficient of variation (%)

Table 3. Average fatigue strength and instantaneous strength of the tested wood species in group B with moisture above the fibre saturation point

Strength	Oak	Birch	Spruce
Fatigue (MPa)	12.9 (V=5.4%)	14.6 (V=4.0%)	14.1 (V=7.0%)
Instantaneous (MPa)	18.6 (V=8.1%)	20.2 (V=3.7%)	20.7 (V=5.8%)

V – Coefficient of variation (%)

The highest mean instantaneous strength in group A of absolutely dry samples (97.1 MPa with a coefficient of variation of 3.7%) was found in birch wood, while the lowest (86.0 MPa with a coefficient of variation of 5.7%) was found in oak wood. In group B of the wet sample, the highest value of 20.7 MPa with a coefficient of variation of 5.8% was obtained for spruce wood, followed by birch wood at 20.2 MPa with a coefficient of variation of 3.67%. The lowest strength value was again recorded for oak wood, equal to 18.60 MPa with a coefficient of variation of 5.74%.

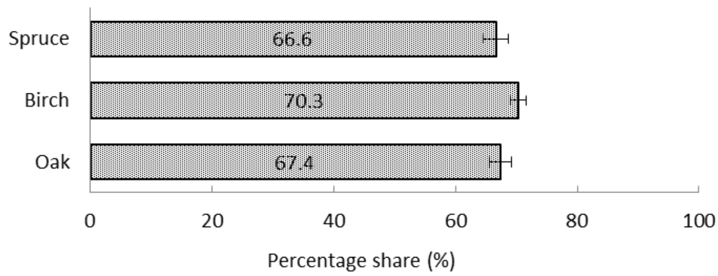

Fig. 4 Ratio of fatigue strength to instantaneous strength expressed as a percentage for the tested group A for oak, birch and spruce wood

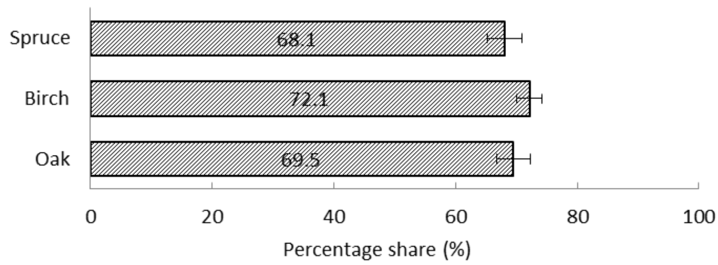

Fig. 5 Ratio of fatigue strength to instantaneous strength expressed as a percentage for the tested group B for oak, birch and spruce wood

In group A of dry samples, as well as in group B of wet samples, birch wood had the highest ratio of fatigue strength to instantaneous strength (Fig. 4 and 5). Both values were 70.3% and 72.1%, respectively, with coefficients of variation equal to 2.5% and 4.2%. The lowest ratio of the two values was obtained for spruce wood, which for group A was 66.6% with a coefficient of variation of 4.2%, and for group B was 68.1% with a coefficient of variation of 5.7%. In the case of oak wood, it was 67.4% in group A and 69.5% in group B with coefficients of variation of 3.5% and 5.6%, respectively. Analysis of the results obtained allows for their recognition as statistically significant for a confidence level of 95%.

It was also noted in the course of the study that the proportion of the average fatigue strength to the average instantaneous strength is similar in both groups A and B for each of the species. The differences are within a range of two percentage points.

CONCLUSIONS

The results of the study allow the following conclusions to be drawn:

1. Among the tested wood types, birch wood in the absolutely dry state and in the wet state of 68.2 MPa and 14.6 MPa respectively had the highest fatigue strength, determined at the proportional limit, followed by spruce wood with 60.2 MPa in the absolutely dry state and 14.1 MPa in the wet state. The lowest fatigue strength of 57.9 MPa in the absolutely dry state and 12.9 MPa in the wet state was recorded for oak wood.
2. The ratio of fatigue strength to instantaneous strength depends on moisture content and is similar for birch (70.3% in the dry state and 72.1% in the wet state), for oak (67.4% and 69.5% in both states) and for spruce (66.6% in the dry state and 68.1% in the wet state)
3. The moisture content of the wood clearly influences the fatigue strength of the wood. On average, the fatigue strength of wood with moisture contents above the fibre saturation point constitutes about 0.20 of the fatigue strength of wood with moisture contents close to 0%. This tendency was found regardless of the tested species. In the case of the analysed wood, this relation is as follows: for birch wood it is 21.4%, for oak wood 22.3% and for spruce wood 23.4%.
4. Verification of the simplified method for testing fatigue strength at the limit of proportionality has shown its limited usefulness, requiring further analysis and comparison with other methods in order to be thoroughly tested and possibly improved.

REFERENCES

1. BELJANKIN-JACENKO, F. P. (1957). Deformativnost i soprotivlaemost drevesiny: 200. Kiev 1957.
2. BENGTSSON, C. (2001). Mechano-sorptive bending creep of timber – influence of material parameters. Holz als Roh- und Werkstoff, 59. 229-236.
3. BRYAN, J. (1960). Particle Board under Long-Term Loading. Forest Products J. Bd.10 (1960) 4. 200-204.
4. ČÍŽEK, L. (1961). Dauerfestigkeit und rheologische Eigenschaften von Holz und Holzwerkstoffen. Holz als Roh- und Werkstoff 19. 83-85. https://doi.org/10.1007/BF02609519.
5. CLORIUS, C., PEDERSEN, M., HOFFMEYER, P. et al. (2000). Compressive fatigue in wood. Wood Science and Technology 34. 21-37.https://doi.org/10.1007/s002260050005.
6. DOBROWOLSKA E., LICHACZEWSKA B., PINCHEVSKA O. (2020). The impact of crosshead speed on the strength of spruce wood (Picea abies L.). Annals of Warsaw University of Life Sciences – SGGW Forestry and Wood Technology No 109. 126-136. https://10.5604/01.3001.0014.3430.
7. DUBOIS, F., RANDRIAMBOLOLONA, H., PETIT, C. (2005). Creep in Wood Under Variable Climate Conditions: Numerical Modelling and Experimental Validation. Mech Time-Depend Mater 9, 173–202. https://doi.org/10.1007/s11043-005-1083-z.

8. FRIDLEY, K. J., TANG, R. C., SOLTIS, L. A. (1991). Moisture effect on load-duration behavior of lumber. Part I. Effect of constant relative humidity. Wood and Fiber Science, 23(1). 114-127.
9. GERHARDS, C. C. (1977). Effect of duration and rate of loading on strength of wood and wood-based materials. USDA, Forest Service Research Paper FPL 283. Forest Products Laboratory, Madison, WI.
10. GILLWALD, W. (1966). Untersuchungen über die Dauerfestigkeit von mehrschichtigen Spanplatten. Holz als Roh- und Werkstoff. 24 (10). 293-298.
11. GILLWALD, W., LUTHARDT H. (1966). Beitrag zur Dauerstandfestigkeit an Vollholz und Holzspanplatten. Holztechnologie 7 (1). 25-29.
12. GOŁACKI, K., STROPEK, Z. (2001). Przegląd modeli reologicznych materiałów roślinnych o dużej zawartości wody. Inżynieria Rolnicza 2. 63–68.
13. GONET, B. (1991). Reologiczne właściwości drewna. Przemysł Drzewny. 3. 3-5
14. GRESSEL, P. (1972). Zeitstandbiegeverhalten von Holzwerkstoffen in Abhängigkeit von Klima und Belastung. Holz als Roh- und Werkstoff 30. 479-488. https://doi.org/10.1007/BF02621491.
15. GRESSEL, P. (1984). Zur Vorhersage des langfristigen Formänderungsverhaltens aus Kurz-Kriechversuchen. Holz als Roh- und Werkstoff 42. 293-301. https://doi.org/10.1007/BF02608938.
16. HANHIJARVI, A., GALIMARD, P., HOFFMEYER, P. (1998). Duration of load behaviour of different sized straight timber beams subjected to bending in variable climate. Springer-Verlag, Holz als Roh- und Werkstoff, 56. 285-293.
17. HERING, S., KEUNECKE, D., NIEMZ, P., KALISKE, M. (2012). Moisture-dependent orthotropic elasticity of beech wood. Wood Science and Technology, 46 (5): 927-938.
18. IVANOV, J. M. (1938). Doklady Akademii Nauk SSSR: 551.
19. IVANOV, J. M. (1941). Predel platičeskogo tečenija drevesiny. Moskau 1941.
20. KOLLMANN, F. (1951). Technologie des Holzes und der Holzwerkstoffe (2. Ausg. Bd. 2). Berlin/Göttingen/Heidelberg. Springer-Verlag.
21. KOLLMANN, F., COTE, W. (1968). Principle of wood science and wood technology. Solid wood - Part I. Springer-Verlag, Berlin, Heidelberg, New York.
22. KONSTANKIEWICZ, K., PUKOS, A., ZDUNEK, A. (1996). Teorie odkształceń materiałów biologicznych w świetle relaksacji naprężeń. Zesz. Prob. PNR, 443. 353-363.
23. KOZAKIEWICZ, P. (2010): Wpływ temperatury i wilgotności na wytrzymałość na ściskanie wzdłuż włókien wybranych rodzajów drewna o zróżnicowanej gęstości i budowie anatomicznej. Wydawnictwo SGGW, Warszawa.
24. KRYSICKI, W., BARTOS, J., DYCZKA ,W., KRÓLIKOWSKA, K., WASILEWSKI, M. (2000). Rachunek prawdopodobieństwa i statystyka matematyczna w zadaniach. Cz. II Statystyka matematyczna. PWN, Warszawa.
25. KRZYSIK, F. (1957). Nauka o drewnie. PWN, Warszawa.
26. MATEJAK, M., STARECKA, D. (1971). Einfluβ des Gefrierens von Holz auf seine Druckfestigkeit. Holztechnologie 12 (3), 144-146.
27. MOHR, B. (2001). Zur Interaktion der Einflüsse aus Dauerstandbelastung und Ermüdungsbeanspruchung im Ingenieurholzbau. München. TU München, Berichte aus dem Konstruktiven Ingenieurbau.
28. MUKUDAI, J., YATA, S. (1986). Modelling and simulation of viscoelastic behaviour (tensile strain) of wood under moisture change. Wood Sci. Technol. 20. 335-348, https://doi.org/10.1007/BF00351586.

29. NIELSEN, L. F. (2007). Strength of wood versus rate of testing – A theoretical approach. Holz als Roh- und Werkstoff, 65(3), 223-229.
30. NIEMZ, P., SONDEREGGER, W. (2017). Holzphysik. Physik des Holzes und Holzwerkstoffe. Fachbuchverlag Leipzig im Carl Hanser Verlag, Carl Hanser Verlag München.
31. PERKITNY, T., SZYMANKIEWICZ, H. (1963). Verlauf und Geschwindigkeit von Feuchtigkeitsänderungen in Holz und Holzspanplatten in Abhängigkeit von der Differenz zwischen Anfangs- und Ausgleichsfeuchte. Holztechnol.4 (1). 17-22.
32. ROSE, O. (1965). Das mechanische Verhalten des Kiefernholzes bei dynamischer Dauerbeanspruchung in Abhängigkeit von Belastungsart, Belastungsgröβe, Feuchtigkeit und Temperatur. Holz als Roh- und Werkstoff, 23 (7). 271-284.
33. SIEGEL, J. (1985). Urcenie materiałowych charakteristik z Burgersovho modelu pro lepene drevo. Drev. Vysk., 107. 66-78.
34. STAUDACHER, E. (1936). Der Baustoff Holz. Zürich-Leipzig.
35. STÜSSI, F. (1953). Dauerfestigkeit von Aluminium-Legierungen. IABSE publications – Mémoires AIPC – IVBH Abhandlungen, 13 (1953). 357-366. http://doi.org/10.5169/seals-13210.
36. WANG, J. B., LAM, F., FOSCHI, R. O. (2012). Duration-of-load and creep effects in strand-based wood composite: experimental research. Wood Sci. Technol. 46. 361-373.
37. YLINEN, A. (1957). Zur Theorie der Dauerstandfestigkeit des Holzes. Holz als Roh- und Werkstoff 15. 213-215.
38. YLINEN, A. (1959). Über den Einfluß der Verformungsgeschwindigkeit auf die Bruchfestigkeit des Holzes. Holz als Roh- und Werkstoff Bd.17 (1959)6. 231–234.
39. ZOBEL H., ALKHAFAJI T. (2006). Mosty drewniane Konstrukcje przełomu XX i XXI wieku. Wydawnictwo Komunikacji i Łączności, Warszawa.
40. ASTM D 6815-02a, 2004. Evaluation of duration of load and creep effects of wood and wood-based products. West Conshohocken, USA.
41. DIN EN 1156. Wood-based panels. Determination of duration of load and creep factors.
42. PN-77/D-04100 Drewno. Oznaczenie wilgotności.
43. PN-77/D-04101 Drewno. Oznaczenie gęstości.
44. PN-79/D-04102 Drewno. Oznaczenie wytrzymałości na ściskanie wzdłuż włókien.
45. PN-EN 1156:2013-07. Płyty drewnopochodne – Określanie czasu trwania obciążenia i współczynników pełzania.

Streszczenie: *Badanie wytrzymałości zmęczeniowej wzdłuż włókien drewna przy różnej wilgotności.* W pracy określono wpływ wilgotności drewna na wytrzymałość zmęczeniową przy ściskaniu wzdłuż włókien. Do pomiarów wykorzystano metodę wyznaczania maksymalnego naprężenia na granicy proporcjonalności. Wytrzymałość zmęczeniową zbadano dla trzech gatunków drewna: dębu szypułkowego (*Quercus robur* L.), brzozy brodawkowatej (*Betula pendula* Roth.) i świerka pospolitego (*Picea abies* L.), o dwóch wilgotnościach: zbliżonej do stanu absolutnie suchego i powyżej punkt nasycenia włókien. Stosunek wytrzymałości zmęczeniowej do wytrzymałości chwilowej zależy od zawartości wilgoci i jest podobny dla brzozy (70,3% w stanie suchym i 72,1% w stanie mokrym), dębu (67,4% i 69,5% w obu stanach) oraz świerka (66,6 % w stanie suchym i 68,1% w stanie mokrym). Zawartość wilgoci w drewnie wyraźnie wpływa na wielkość wytrzymałości zmęczeniowej drewna. Średnio wytrzymałość zmęczeniowa drewna o wilgotności powyżej punktu nasycenia włókien stanowi 0,20 wytrzymałości drewna o wilgotności bliskiej 0%. Tendencję tę stwierdzono niezależnie od badanego gatunku. Uproszczona metoda badania wytrzymałości zmęczeniowej na granicy proporcjonalności wykazała swoją ograniczoną przydatność, wymagającą dalszej

analizy i porównania z innymi metodami w celu dokładnego przetestowania i ewentualnego udoskonalenia.

Corresponding autor:
Ewa Dobrowolska
Department of Wood Sciences and Wood Preservation
Institute of Wood Sciences and Furniture
Warsaw University of Life Sciences – SGGW
166 Nowoursynowska St.
02-787 Warszawa, Poland
Email: ewa_dobrowolska@sggw.edu.pl