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# Modulus of Rupture in twin samples (wet and absolutely dry) coming from wood of wind- broken trees of Scots pine (*Pinus sylvestris* L.)

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**Abstract:** *Modulus of Rupture in twin samples (wet and absolutely dry) coming from wood of wind- broken trees of Scots pine (Pinus sylvestris L.).* Analyses were conducted on two experimental stands damaged by strong wind I north part of Poland. The aim of this study was to determine whether static bending strength of broken and undamaged trees differ from one another. There were total of 354 samples coming from 22 trees. Twin samples were analysed, of which one was tested at a wood moisture content above fiber saturation point, while the other was tested at a moisture content close to 0%. All trees taken into consideration were between 50 and 60 year old. No differences were found in terms of static bending strength between the populations from Kolbudy and Świdwin. On the basis of these investigations it may be stated that static bending strength in trees, which are broken by strong wind, does not differ from strength of trees, which withstood the pressure of wind and were not broken.

*Keywords:* MOR, Modulus of Rupture, wind-broken trees, static bending strength

## INTRODUCTION

Dramatic disasters caused by wind, occurring in Europe every several years, result in windbreaks on a massive scale and supply in this way large amounts of timber. Such timber is characterised by highly variable quality. Frequently it may not be used as construction lumber due to the incurred macro and micro-damage of wood (Pazdrowski and Spława Neyman 2000, Jakubowski and Pazdrowski 2005, 2006). This pertains first of all to broken trees. An action which may be taken by forest management should thus be to prevent such damage. In order to fulfill this task it is necessary to gain insight into the mechanisms of stem damage under the influence of strong winds. Many research studies have been devoted to this problem (Peltola et al. 1999, Peltola et al. 2000, England et al. 2000, Müller et al. 2006). Considerable numbers of these studies focus mainly on the development of models forecasting the behaviour of the stand (Valinger and Fridman 1997, Jalkanen and Mattila 2000, Miller et al. 2000). In these models stand characteristics and biometric traits of trees are typically considered, while wood quality is frequently neglected. The wood tissue of trees exhibits relatively high variation in terms of its properties depending on the environment and biometric traits of trees. This also results from the variation in the chemical composition and ultrastructure of wood. Insight into the behavior of the wood tissue at considerable stresses generated as a result of strong winds may be a good supplementation of prediction models on the macro-scale. Several research papers concerning this problem do not exhaust this topic, but rather indicate the need to conduct in-depth studies in this field (Dill-Langer et al. 2002, Müller et al. 2003).

This study investigated static bending strength of pine wood collected from the stands, which incurred massive damage caused by wind. Strength was tested at a moisture content above fiber saturation point (characteristic of living trees) and at a moisture content close to 0%. This study is a part of a research project covering comprehensive studies on wind-damaged trees, taking into consideration their biometric traits and stand characteristics. The aim of this study was to determine whether static bending strength of broken and undamaged trees differ from one another.

METHODS

Experimental areas were located in the Świdwin and Kolbudy Forest Divisions. The areas were selected so that wind damage accounted for at least 20% stand damage (broken trees). All trees taken into consideration had between 50 and 60 year old. On each of the plots all broken trees and neighbouring standing trees were numbered. Next breast height diameters were measured on all marked trees and height was measured on standing trees. Then the height, at which individual trees broke, was measured. On the basis of collected data model trees were selected. Model trees were divided into three classes in terms of their diameters and four classes in terms of the height of the breakage. All model trees were felled and their biometric traits were measured. From each model tree a 0.5m block, located at a height of 1.3 m - 1.8 m, was collected for further laboratory analyses. Wood properties were analysed on samples cut from the heart plane, which was oriented in the direction in which the stem broke. Bending strength was tested on standard samples of 20 mm x 20 mm x 300 mm. Tests were performed on a TIRA TEST 2300 testing machine. Twin samples were analysed, of which one was tested at a wood moisture content above fiber saturation point, while the other was tested at a moisture content close to 0%.

RESULTS

Analyses were conducted on a total of 354 samples coming from 22 trees. A total of 12 trees (9 broken and 3 standing) came from the plot located in Świdwin. A total of 176 samples were cut from those trees. In turn, 10 trees (6 broken and 4 standing) came from the plot in Kolbudy and a total of 178 samples were cut from these trees. The average strength of dry samples was similar at both locations and it was approx. 38 MPa. Strength of dry samples was over two times greater and amounted to almost 84 MPa, while slightly higher values were recorded for samples coming from Świdwin (Tab. 1). However, no statistical differences in strength were found between the analysed locations. In contrast, the scatter of values within individual trees was considerable.

Table 1 Static bending strength of wet and dry samples coming from broken and standing trees. Descriptive statistics.

| | | | N | Mean | Median | Minimum | Maximum | Std dev. |
|---|---|---|---|---|---|---|---|---|
| **Broken** | **Świdwin** | **Wet** | 64 | 39,40 | 35.94 | 22.23 | 68.61 | 11.79 |
| | | **Dry** | 64 | 89.17 | 82.47 | 33.98 | 198.12 | 37.40 |
| | **Kolbudy** | **Wet** | 55 | 37.67 | 39.32 | 16.32 | 57.99 | 10.43 |
| | | **Dry** | 55 | 76.65 | 78.90 | 29.26 | 129.59 | 25.75 |
| **Standing** | **Świdwin** | **Wet** | 24 | 37.65 | 34.70 | 20.04 | 67.53 | 11.80 |
| | | **Dry** | 24 | 90.73 | 89.03 | 38.73 | 140.18 | 31.86 |
| | **Kolbudy** | **Wet** | 35 | 41.68 | 41.81 | 23.92 | 69.80 | 12.14 |
| | | **Dry** | 33 | 81.16 | 84.00 | 21.08 | 148.33 | 31.35 |

This is indicated by measures of position and dissipation practically in all analysed trees (Fig 1, 2). Such a great scatter results from the simultaneous testing of pith and circumference samples. Radial variation inside a tree is clearly visible in both populations, with strength increasing markedly in the direction from the pith to the circumference. In the described cases variation in strength was greater inside a single tree than between trees. Similar analyses were performed in relation to broken trees and control (standing) trees, undamaged by strong wind. Also in this case the differences between trees were slight and not confirmed statistically. Similar results were recorded for samples tested at a moisture content above fiber saturation point, as well as for dry samples. Thus it may be concluded that wind-broken trees and standing trees do not differ in terms of static bending strength. It needs to be stressed here that strength was tested at breast height, i.e. in case of most wind-broke trees at a considerable distance from the breakage position.

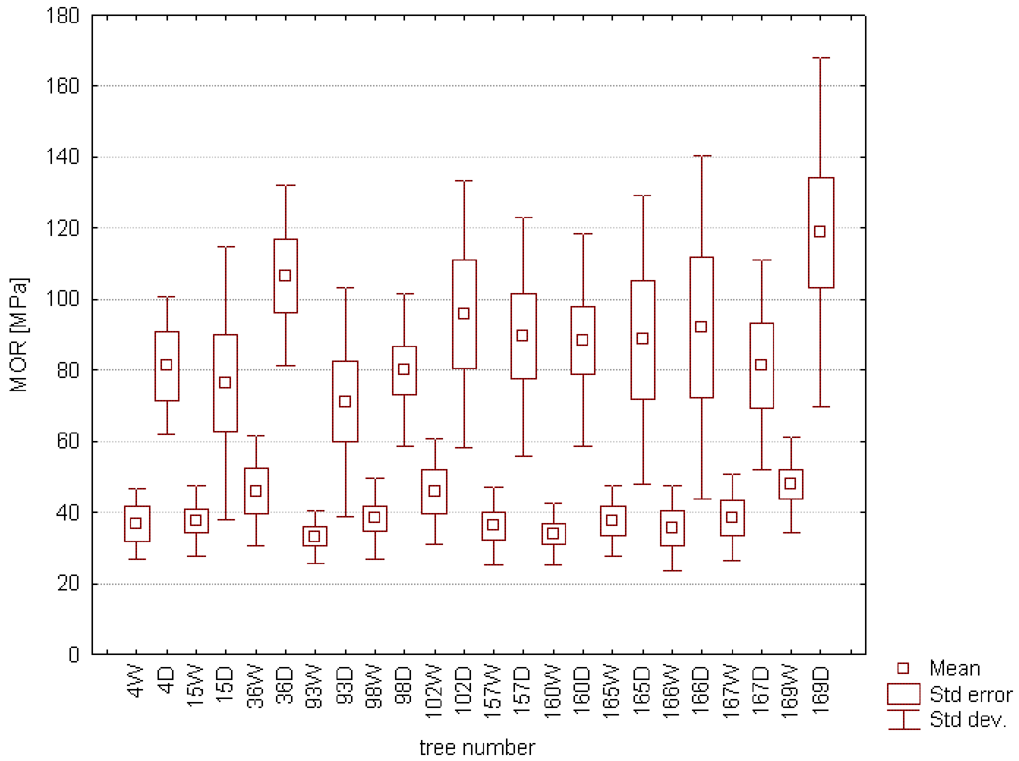


Fig. 1 A comparison of static bending strength of trees in samples tested at a moisture content above fiber saturation point (W) and absolutely dry samples (D), Świdwin.

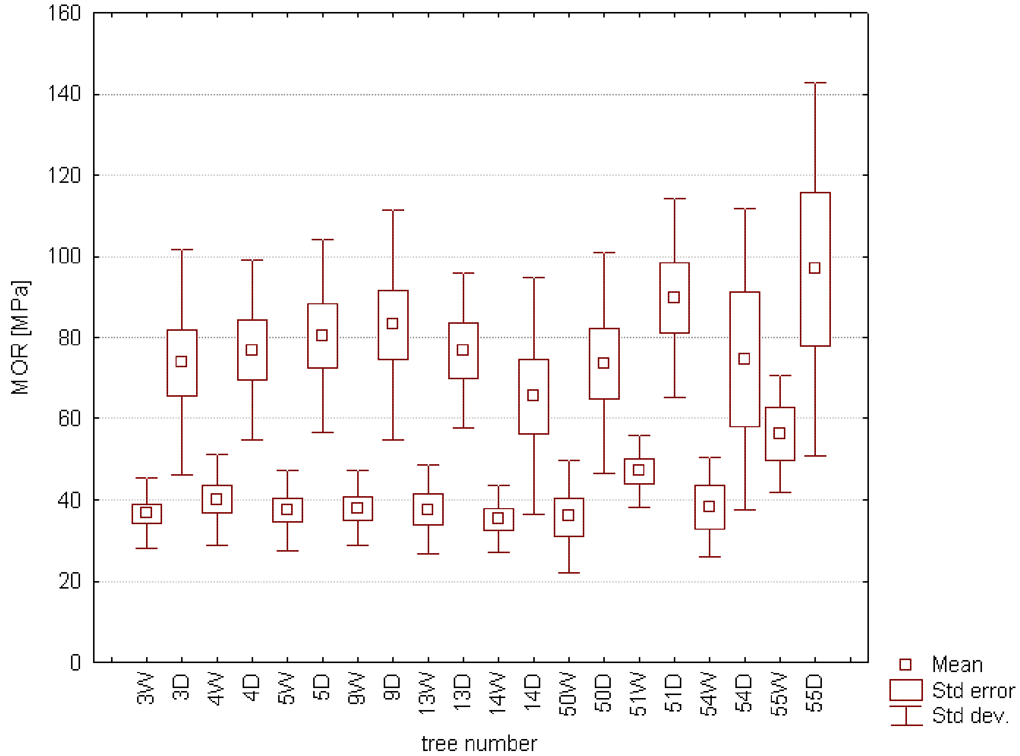


Fig. 2 A comparison of static bending strength of trees in samples tested at a moisture content above fiber saturation point (W) and absolutely dry samples (D), Kolbudy.

Immediate vicinity of breakage causes the occurrence of disturbances in strength of the wood tissue and it is frequently connected with wood defects, particularly in reaction wood (Cameron and Dunhan 1999, Jakubowski and Pazdrowski 2006). On the basis of these investigations it may be stated that static bending strength in trees, which are broken by strong wind, does not differ from strength of trees, which withstood the pressure of wind and were not broken.

CONCLUSIONS

1. No differences were found in terms of static bending strength between the populations from Kolbudy and Świdwin. Despite differences in their geographical location and site conditions wood strength in the analysed populations was similar.

2. No differences were recorded in static bending strength between broken and standing trees, which may indicate that susceptibility of the stem to breakage caused by wind does not depend on wood strength. They will probably influence biometric traits of trees and the related temporal distribution of dynamic stresses during the gust of strong wind.

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**Streszczenie:** *Wytrzymałość na zginanie statyczne prób bliźniaczych (mokrych i absolutnie suchych) pochodzących z drewna wiatrołomów sosny zwyczajnej (Pinus sylvestris L.).* Celem badań było stwierdzenie czy wytrzymałość na zginanie statyczne drzew złamanych i nieuszkodzonych różni się od siebie. Powierzchnie badawcze zlokalizowano na terenie Nadleśnictwa Świdwin i Kolbudy powierzchnie dobrano tak aby szkody od wiatru stanowiły co najmniej 20% uszkodzeń drzewostanu (połamanych drzew). Na każdej z powierzchni ponumerowano wszystkie drzewa połamane oraz sąsiadujące z nimi drzewa stojące. Badaniom poddano łącznie 354 próbki pochodzące z 22 drzew. Nie stwierdzono różnic wytrzymałości na zginanie statyczne między populacją z Kolbud i Świdwina. Pomimo różnic w położeniu geograficznym oraz w warunkach siedliskowych, wytrzymałość drewna badanych populacji jest zbliżona. Nie stwierdzono różnic wytrzymałości na zginanie statyczne między drzewami złamanymi i stojącymi, co wskazywać może na to, że podatność strzały na złamanie wskutek wiatru nie zależy od wytrzymałości drewna.

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