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The impact of climatic conditions on the dimensional changes of the stairs layered facings

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Abstract: *The impact of climatic conditions on the dimensional changes of the stairs layered facings.* In this work, the influence of air parameters on selected properties of the stairs layered facings was examined. The external layer of stairs facing consisted of oak wood (*Quercus robur* L.) and merbau (*Intsia* spp.). Moisture resistant hardwood plywood was used as the base. In addition, selected variants of the tested facings had a backpressure layer made of hardwood plywood. The facings were conditioned at a constant temperature of 22°C and in a relative humidity of 25, 45, 60 and 75%. Shrinkage and swelling of the facings in tangential direction were investigated after 8 weeks of conditioning. It was found that the most optimal humidity for the use of stairs layered facings is a relative humidity of 45 - 60%. The facings with a backpressure layer showed the largest dimensional stability.

Keywords: climatic conditions, stairs facing, plywood, *Quercus robur* L., *Intsia* spp.

INTRODUCTION

Wood is a versatile material which finds application in many sectors of industry. However, because of wood shortage on the European markets, including Polish (Mroziński 2009), there has been a trend for several years to optimize the use of raw wood material. The importance of wood as a raw material is reinforced by the fact that of the fifteen branches of industry selected by the Minister of the Economy to promote the Polish economy four are connected with the use of wood e.g.: cabinet making, window and door woodwork, production of yachts, boats and construction (Strykowski 2012). One of the possibilities to optimize the use of wood is the production of stairs layered facings as a substitute for solid wooden stairs.

Being a hygroscopic and anisotropic material, wood shows significant changes of properties depending on climatic conditions. The phenomena of swelling and shrinkage of wood due to humidity changes cause dimensional changes in finished products. During winter flats are often overheated and humidity drops from the optimum value of about 55% even below 20%. In order to meet the air quality standards inside modern commercial buildings, it is necessary to supply fresh air and keep the humidity on the right level. For example, a kilogram of air at a temperature of 0^{o}C and a relative humidity of 80% contains about 3g of water vapour. After heating the air to a temperature of 20^{o}C, the relative humidity drops to 20%, and if the air is heated to 25^{o}C, the humidity is only 15%. Spring and autumn are transitional periods during which it is easiest to maintain optimal humidity indoors, creating the appropriate conditions for the use of wooden products (Odyjas 2009). According to PN-78-B-03421, the optimal relative humidity of the air in residential buildings should be in the range of 40 - 60%.

Wood moisture content indoors shows considerable annual fluctuations. A factor which has significant impact on the formation of the indoors climate, and thus the moisture content of wooden elements, is the method of heating the indoors. In typical flats, the moisture of wooden products varies from about 5% during the heating period to about 13% during summer (Krzysik and Sobczak 1960). Limitation of the results of significant fluctuations in the relative humidity of air is possible through the use of proper species of wood, both domestic and exotic. For example, the total volumetric contraction of merbau wood (*Intsia* spp.), which is one of the most dimensionally stable species of wood, is 9.9% (Jankowska et al. 2012). In case of oak wood (*Quercus robur* L.), the total volumetric contraction stands at 12.6%, and in the case of beech wood (*Fagus silvatica* L.) it reaches 21.0% (Krzysik 1978). The total linear swelling of plywood is usually analyzed only in terms of its thickness. It is comparable with the swelling of solid wood, despite a certain densification of veneers during the pressing process. A cross-shaped layout of veneers reduces the swelling of the plywood along the length and width of a sheet to less than 1%. Therefore, it is generally not taken into account (Mahút et al. 2007). According to EN 318:2002 acceptable changes in the dimensions of plywood, depending on the changes of air humidity, should not exceed 0.5%. Thus, it is reasonable to replace the solid wood with the more dimensionally stable plywood.

The purpose of the research was to determine the dimensional changes of four types of stairs facings depending on the changes of relative humidity of air.

MATERIALS

Samples were obtained from full size stairs facings and selected so that they do not have any visible defects. The external layer of the facings was made of solid oak wood (*Quercus robur* L.) and merbau wood (*Intsia* spp.). The base was moisture resistant hardwood plywood with a cross-shaped layout of veneers. In some variants of the facings, moisture resistant plywood was used as a backpressure layer. PVAc adhesive class D3 (classification according to EN 204:2001) was used for bonding the external layer (wood) with the base (plywood). The variants of the stairs facings and their characteristics are shown in Table 1.

Table 1. Investigated variants of the stairs layered facings

Variant	External layer		Base		Backpressure layer	
	Material	Thickness [mm]	Material	Thickness [mm]	Material	Thickness [mm]
I	European oak	9	13 layers plywood	18	-	-
II	merbau	9	13 layers plywood	18	-	-
III	European oak	6	9 layers plywood	15	5 layers plywood	6
IV	merbau	6	9 layers plywood	15	5 layers plywood	6

Samples of 265 x 70 x 27 mm (length x width x thickness) were conditioned in a climatic chamber. The conditioning temperature was 22^{o}C and the relative humidity was at the level of 25, 45, 60 and 75%. The measurements of changes in the test samples were carried out after 8 weeks. The scope of the tests included the determination of:

- moisture content of the external layer of facing (solid wood) using an electronic meter - capacitive method. Moisture content measurements were performed on 12 samples of each variant (3 measurements per sample),
- linear swelling of solid wood in the tangential and radial directions, linear swelling of facings in tangential direction according to PN-82/D-04111.

RESULTS

The linear swelling of oak and merbau wood is shown in Figure 1. The linear swelling of oak wood in the tangential and radial direction was respectively 10.5% and 6.1%. According to the literature for oak it is respectively 7.8% and 4.0% (Krzysik 1978). The study indicates that the total linear swelling of merbau wood in the tangential and radial direction was 6.4% and 2.9% respectively. However, according to the data found in the literature of the subject, the linear swelling of merbau wood in the tangential and radial direction is 5.2% and 3.1% respectively (Jankowska et al. 2012).

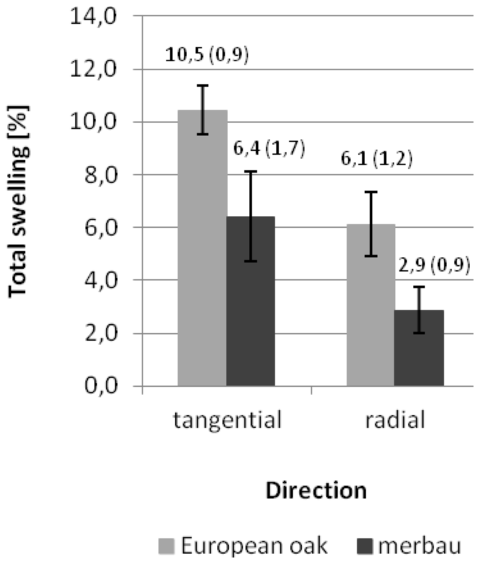

Figure 1. Linear swelling of oak and merbau (standard deviations in brackets)

The obtained values are significantly higher than the literature data. This may be due to differences in the annual growth of wood. Merbau shows greater dimensional stability than oak. The values of tangential and radial swelling for oak were respectively 42% and 55% higher than those for merbau. Anisotropic swelling ratio for oak and merbau was 1.55 and 2.21 respectively.

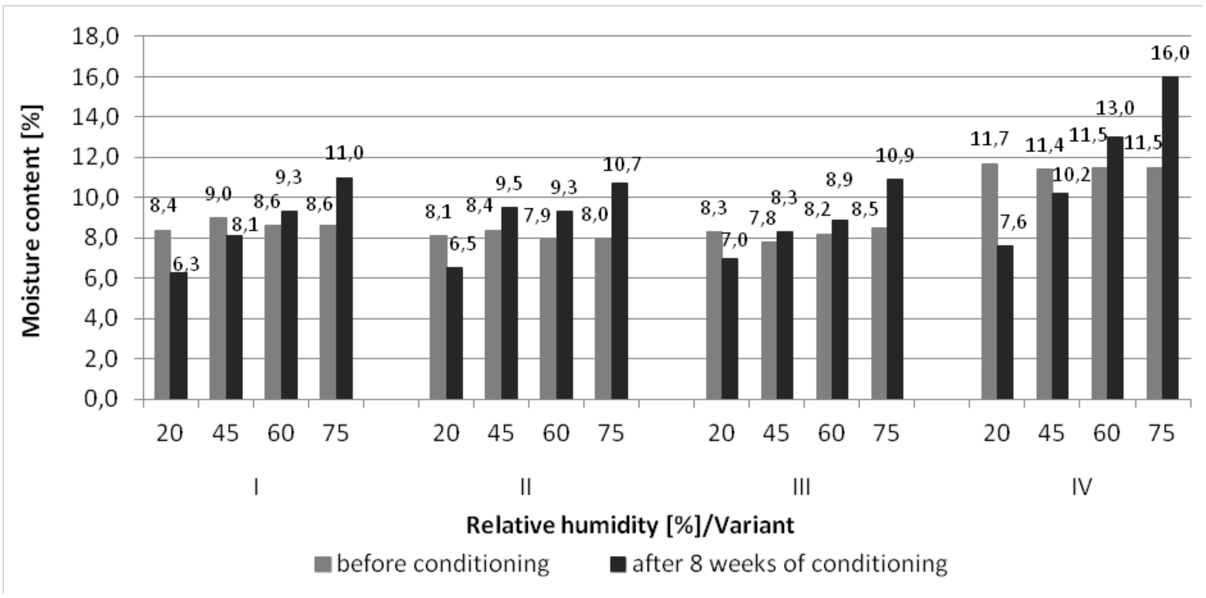

Figure 2. Moisture content of the external layer

Moisture content of the external layer of the facings before and after conditioning is shown in Figure 2. The study indicates that the moisture content of the external layer of facings showed significant differences depending on the air parameters. The moisture content of oak before conditioning was within the range of 8.3 - 11.0% (variants I and III), and the moisture content of merbau in the range of 7.9 - 11.7% (variants II and IV). After 8 weeks of conditioning, the moisture content of oak and merbau was respectively 6.3 - 11.0% and 6.5 - 16%. The higher differences of wood moisture content before and after the conditioning were observed for merbau, which formed the surface layer of the facings with a backpressure layer. Depending on the relative humidity, the differences ranged from 1.2 to 4.5%. It resulted from the high initial moisture content of merbau. The moisture content differences before and after the conditioning for other external layers did not exceed 2.7%.

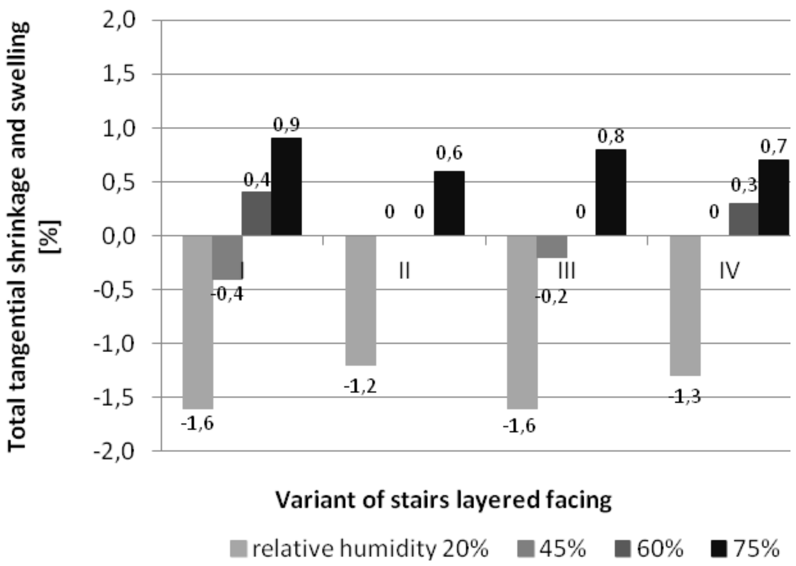

Figure 3. Shrinkage and tangential swelling of the facings after 8 weeks of conditioning

The values of the tangential shrinkage and swelling of the facings after 8 weeks of conditioning is shown in Figure 3. Positive values represent the swelling, negative - the shrinkage of wood. The study shows that all the air-conditioned facings at a relative humidity of 20% showed contraction in the range of 1.2 - 1.6%. The conditioning of facings for 8 weeks in a relative humidity of 75% causes tangential swelling within the range of 0.6 - 0.9%. As in the case of the samples with the surface layer of merbau, no changes were observed in the case of the samples with the surface layer of oak in the range of relative humidity of 45 - 60%. The samples conditioned at a relative humidity level of 20% have been significantly damaged. Greater contraction of the external layer than the backpressure layer caused the wood and the glue joint between the outer layer and the base layer to crack. The samples conditioned in a relative humidity of 75% underwent greater distortion due to more swelling caused by the external layer, compared to the plywood backing. As for the facings without the backpressure layer, regardless of the wood species used in the testing, the glue joints cracked on the edges.

CONCLUSIONS

The study showed that of the analyzed conditions, the optimal conditions for the use of layered stairs facings are those of the relative humidity within the range of 45 - 60% and a temperature of 22^{o}C. No changes deforming the elements were observed, neither were any damages in any of the tested variants of the facings. The elements having a thinner layer of solid wood and a backpressure layer (variants III and IV) show greater dimensional stability (decreased shrinkage and swelling) compared to the facings without the backpressure layer (variants I and II).

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Streszczenie: *Wpływ warunków klimatycznych na zmiany wymiarowe warstwowych okładzin schodów.* W pracy badano wpływ parametrów powietrza na wybrane właściwości warstwowych okładzin schodów. Warstwę wierzchnią okładziny stanowiło drewno dębu (*Quercus robur* L.) i merbau (*Intsia* spp.), jako podkładu użyto sklejki liściastej suchotrwałej. Dodatkowo, warstwę przeciwprężną w wybranych wariantach okładzin stanowiła sklejka liściasta. Okładziny klimatyzowano przy stałej temperaturze 22^{o}C i wilgotności względnej powietrza 25, 45, 60 i 75%. Oznaczono skurcz i spęcznienie okładzin w kierunku stycznym po 8 tygodniach klimatyzowania. Stwierdzono, że najbardziej optymalnymi warunkami eksploatacji warstwowych okładzin schodów jest przedział wilgotności względnej powietrza 45 - 60%. Największą stabilność wymiarową wykazały okładziny posiadające warstwę przeciwprężną.

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