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Change of moisture distribution in ribbed plate with different opposite surface temperatures

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Abstract

Nowadays to predict hygrothermal performance the methodology of ISO 13788:2012 is widely used. In calculations according to this methodology no material properties are taken into account that leads to overestimate of the risk of interstitial condensation. Therefore in order to provide insight how much results determined according to ISO 13788:2012 can differ from the actual hygrothermal performance the ribbed plywood plate with different opposite surface temperatures was tested. Temperature and relative humidity of the surfaces and internal layers were measured. After data comparison obtained experimentally and by calculation according to ISO 13788:2012 it can be seen that condensation in contrast to the predictions does not occur. Therefore on the basis of this methodology it can be wrongly concluded that analyzed envelope is unsuitable for exploitation. Hence new more accurate calculation methodology is necessary for prediction of hygrothermal performance.

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Keywords: higrothermal performance; ISO 13788:2012; ribbed plywood plate.

1. Introduction

To provide durability and designed properties of building envelope it is necessary to predict its hygrothermal performance. To consider structure as suitable for exploitation it shall be confirmed by calculations that the condensate accumulation balance within a year's time is not positive and does not harm the construction whereas the

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emergence of condensates in wooden construction elements is not permissible at all. [1] Otherwise rot may occur that can lead to degradation of wood-based material and subsequently also to the collapse of construction.

Nowadays for prediction of hygrothermal performance standard ISO 13788:2012 is widely used. This standard gives a method to establish the moisture balance and to calculate the maximum amount of accumulated moisture due to interstitial condensation. [2] Attention should be paid that accepted simplifications for calculation method such as disregarding of moisture absorption in material lead to overestimate of the risk of interstitial condensation. That can result in restrictions on use of wood-based materials which are natural, renewable and cost-effective resource.

To provide insight how much results determined according to ISO 13788:2012 can differ from the actual hygrothermal performance the envelope behavior was simulated. Since prediction of hygrothermal performance is particularly important for durability and deformation [3] of wood-based materials and at present also is ongoing research of the composite plywood plates with increased specific stiffness [4, 5] that could be also used as building envelope, ribbed plywood plate with expanded polystyrene (EPS) insulation was selected as the research object. The experiment was carried out for about one month. To observe the formation of condensation relative humidity in the inner layers of plate were continuously measured. Also data of temperature distribution was collected. In addition the moisture content of plywood was determined indirectly by the Hailwood-Horrobin equation to control that fiber saturation point is not exceeded and thereby no free water occurs that could cause rot. Usually this process does not occur if moisture content of wood is below 25 – 30%. [6]

The experimental results can serve not only for evaluation of analytical results according to ISO 13788:2012 but also for validation of new and more accurate calculation models.

Nomenclature

d_n	material layer thickness (m)
EMC	equilibrium moisture of wood (%)
G	specific gravity of wood (–)
g	moisture flux (kg/(m^2·s))
M	moisture content of wood (%)
M_c	accumulated moisture content per area at the condensation interface (kg/m^2)
p	partial water vapour pressure (Pa)
p_c, p_+, p_-	respectively partial water vapour pressure at condensation interface, on warm surface and on cold surface (Pa)
p_{sat}	water vapour saturation pressure (Pa)
R_n, ΣR_n, R_T	respectively resistance of the analyzed layer, total thermal resistance of layers from the external face to the analyzed layer and total thermal resistance of all layers ((m^2·K)/W)
$s_{d,c}$, $s_{d,n}$, $s_{d,T}$	respectively water vapour diffusion-equivalent air layer thickness of the layers from the cold surface to the condensation interface, water vapour diffusion-equivalent air layer thickness of layer "n" and total water vapour diffusion-equivalent air layer thickness of the whole construction (m)
T	temperature of air (°C)
T_n, T_+, T_-	respectively temperature at interface between layer "n" and "n+1", temperature of air on warm and cold surface (°C)
v_a	porosity of wood (–)
W, k, k_1, k_2	coefficients (–)
Δt = 10 min	time step of experimental measurements (s)
$\delta_0 = 2 \cdot 10^{-10}$ (kg/(m·s·Pa)	water vapour permeability of air with respect to partial vapour pressure
λ_n	thermal conductivity (W/(m·K))
μ_n	water vapour resistance factor (-)
φ	relative humidity (-)
indexes "j" and "n"	respectively the number of calculation step and the number of layer (–)