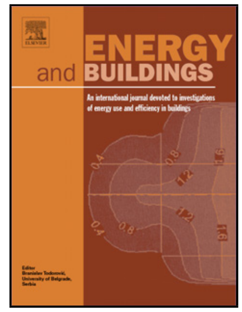
Accepted Manuscript



Title: A Hygrothermal Green Roof Model to Simulate Moisture and Energy Performance of Building Components

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PII: S0378-7788(17)31159-3
DOI: http://dx.doi.org/doi:10.1016/j.enbuild.2017.04.001
Reference: ENB 7497

To appear in: *ENB*

Received date: 3-1-2017
Revised date: 6-3-2017
Accepted date: 1-4-2017

Special Issue on The effect of indoor and outdoor vegetation on the building performance

A Hygrothermal Green Roof Model to Simulate Moisture and Energy Performance of Building Components

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Abstract

Green roofs enjoy a good reputation concerning comfort in summertime, energy savings, rain water retention and durability. However, applied on moisture sensitive substrates like timber constructions, their high thermal inertia and limited drying potential may lead to failure, especially in case of insufficient design or workmanship. As the conditions below the greenery cannot be evaluated by dew point calculations, only a more detailed simulation allows for a realistic prediction of the hygrothermal performance of the components. This contribution introduces a new hygrothermal green roof model based on field and laboratory tests. In difference to previous models it focuses on the moisture and temperature conditions beneath the greenery using more simple approaches for the plant cover but more detailed approaches for the moisture balance in the drainage and growth media. Therefore material data for moisture storage, vapor diffusion and liquid transport were determined in the laboratory and adapted to the built in situation by the help of additional field tests. The model is validated by the help of measured temperature conditions beneath the green roof test fields, as well as concerning the moisture conditions in the critical layers of sensitive timber roofs! The validation shows that the performance of the green roof can be well reproduced throughout the whole year and under all climate conditions including rain water absorption and storage, evaporation and freezing influences. Thus it can be used for both, moisture and energy performance simulations of roofs with greenery under different climatic conditions.

Keywords: green roof model, hygrothermal simulation, vegetation layer, moisture damage,

1. Introduction

Green roofs are considered to be particularly attractive as roof surface and to provide many benefits like better comfort conditions in warm summer periods, both for the indoor space and the ambience [1][2][3][4], reduced heating and cooling energy demand [5][6][7][8], rain water retention and reduction of sewerage loads [9][10][11], improved air quality [12][13][14] as well as a high durability of the sealing membrane, protected from climatic and mechanical impacts. Some of these advantages are well proven – others are less evident and difficult to verify. However, applying a green roof on a moisture sensitive construction can also cause problems, as the drying potential is rather low due to the limited heating up of the roof surface in summer time [15]. This is caused by the high thermal inertia of the greenery as well as by evaporation cooling and shading effects of the plant canopy. Nevertheless Green roofs become more and more popular in many countries. In Germany lastly around 8 million square meters of roofs were vegetated every year [16] and reached a share of above 14 % of all flat roofs [17]. In some cities a green roof is even obligatory when building a new flat roof. Also in the United States green roofs are a strongly growing construction type, with 25 % annual increase, however still on a clearly lower total level than in Germany [18]. Thus it becomes also more important to reliably simulate and predict the hygrothermal and energy performance of such roofs - an evaluation by the help of dew point calculation methods is not possible, as the conditions beneath the greenery clearly differ from the normal outdoor climate. Also many damages on wooden flat roofs with greenery [15] underlined the need of an appropriate green roof model to predict the moisture conditions in the constructions.

2. Existing green roof models

The effects in the soil layer and the plant cover are complex and difficult to handle [19][20]. However, with the growing importance of green roofs in the past decade also many calculation models were developed, especially to simulate the thermal performance of the roofs. Most of these existing models focus on the energetic behavior and assume a strong influence of shading and evaporation cooling in the plant canopy. Therefore these effects are modeled in great detail, mostly based on the models of Perrier [21] and Frankenstein and Koenig [22]. These are using for example the Leaf Area Index (LAI) to describe the shading quality as number of leaf levels