SUMMARY REPORT

Title

Determination of material properties and effective transfer coefficients of green roofs for a reliable simulation of the hygrothermal conditions of green roofs by using different indoor and outdoor climates.

Occasion / initial situation

Due to the fact that a significant part of inner city sites is soil sealed, green roofs are more and more used as climatic compensation areas. For planning and execution of green roofs – especially on wooden constructions – special care is required because of the low drying potential also in the summer months. The research project should establish the basis to calculate and plan green roofs reliably by the help of hygrothermal simulations.

Subject of the research project

Within the research project generic and product-specific models were developed in order to allow the green roof design by the help of hygrothermal simulations. Thus the models provide to planners and manufacturers of building materials and constructions a reliable basis for the planning of the moisture safety of extensive green roofs.

New field tests in Holzkirchen with different substrate types and thicknesses.

The generic green roof model was developed on the basis of field studies in Holzkirchen, Leipzig, Vienna and Kassel. The climate data available for the test period don't contain any data for the atmospheric counter radiation, so it was necessary to consider this influence in a simplified way by the other climate data and appropriate surface transfer coefficients. This is acceptable if the radiation conditions are comparable to the ones at the examined locations. Other radiation conditions (especially due to clearly different clouding) should be considered by a detailed calculation of the long-wave radiation losses. The generic green roof model can be used if no measured data for the atmospheric counter radiation or no detailed information

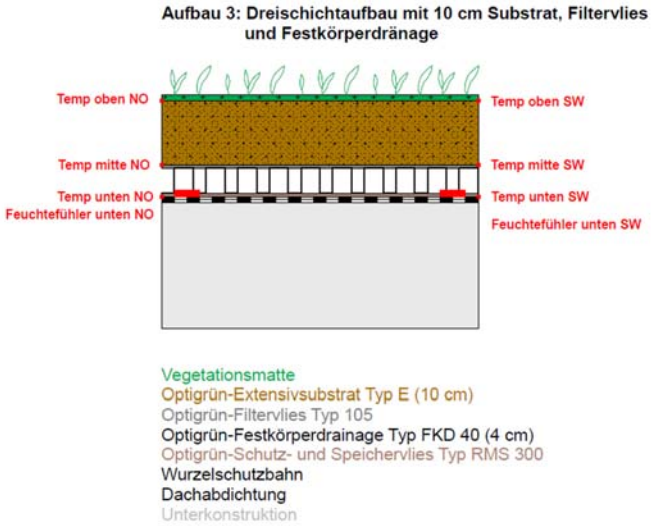
about the applied substrate type are available – generally it should be suitable for locations in Central Europe or locations with similar climate conditions.

Basket for manual weighing and registration of the substrate moisture content.

To develop the product-specific green roof models, new field tests with different substrate types and thicknesses were established in Holzkirchen. Parallel to the temperature and moisture measurements, the material properties of the applied substrate were examined in the laboratory. The specific models consist of a separate planting layer, a substrate layer and if necessary an additional drainage board. Due to the fact that these models also consider the long-wave counter radiation and thus all relevant climate elements in detail, they should be also suitable for other climate regions. Prerequisite is the availability of data for the atmospheric counter radiation. Validations have already successfully been performed for Holzkirchen and Milan.

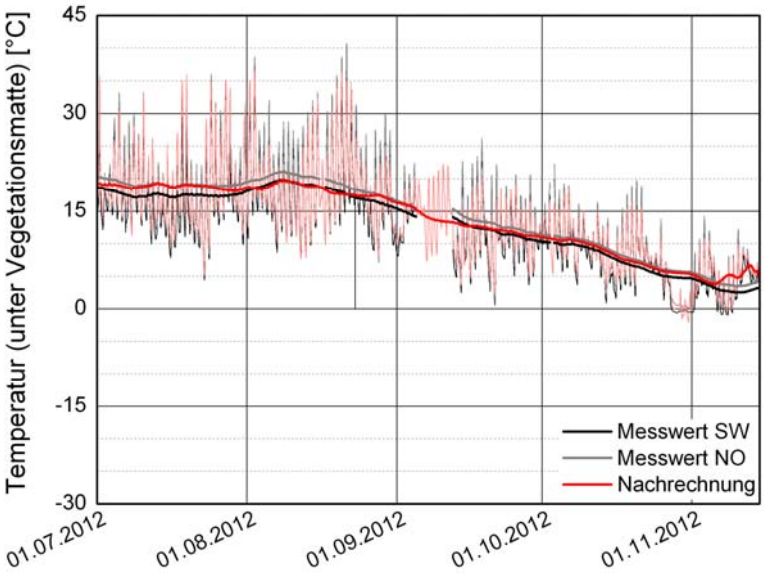
Determination of the material properties of the different substrates in the laboratory (here: diffusion resistance)

For the application of the green roof models a "Guideline for the calculation of extensive green roofs" is provided and can be downloaded from our homepage www.wufi.com together with the material data sets of the different green roof layers.



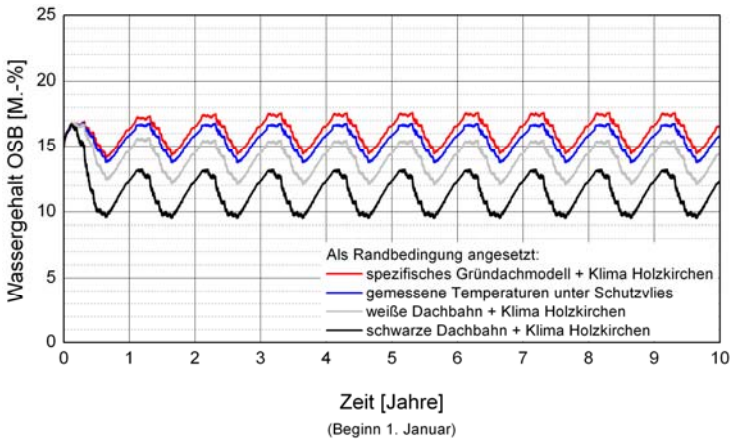
Schematic construction assembly of one of the four green roof field tests in Holzkirchen with positions for temperature and relative humidity measurements.

The energetic effects of greeneries were evaluated in a simplified way based on the heat flow through the cross-section of the roof. Green roofs thereby especially show advantages for the summer situation in comparison to flat roofs without a cover layer – however the differences in the winter months are rather low. For a detailed evaluation of the green roof influence on the indoor climate whole building simulations are required. However the new models also provide the prerequisite for these simulations.

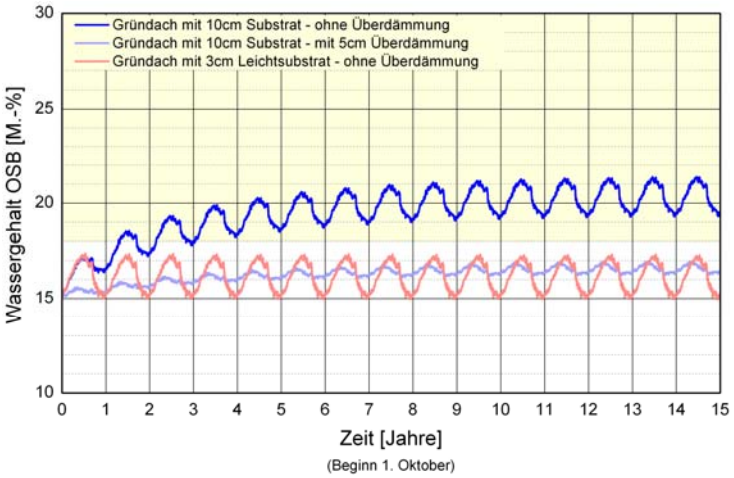


Calculated temperature below the vegetation mat of one of the four new field tests (red) in comparison to both measurement positions (grey / black). The bright curves show the hourly values, the dark curves the floating monthly average.

For a common light-weight flat roof the resulting hygrothermal conditions were determined considering different green roof assemblies, insulation materials, insulation thicknesses and interior diffusion resistances. Based on these results general practice recommendations for light-weight green roofs were worked out. However it seems to be necessary to distinguish between the design of new buildings and the evaluation of existing constructions. For planning the limit value of 18 M.-% according to DIN 68800 shouldn't be exceeded, so an additional insulation above the exterior sheathing is necessary in almost all constructions. Due to the fact that the approaches have certain security margins, not all existing constructions have to keep the limit value according to DIN 68800. If the existing constructions are damage free, it can be acceptable to exceed the limit value for short periods – in case of doubt measurements of the actual moisture conditions in the wooden sheathing should be done during winter time.



Calculated water content in the OSB-sheathing of a light-weight roof (insulation thickness 15 cm) over the calculation period of 10 years using both the measured and the modelled temperature below the greenery in comparison to a white resp. black roofing membrane.



Calculated water content in the OSB-sheathing of a light-weight roof with 20 cm insulation and variable vapour retarder. While the water content remains below the critical limit of 18 % by mass acc. to DIN 68800 in case of a thin light weight substrate, the limit value is exceeded with a normal substrate thickness and standard construction (dark blue curve) and can only be kept with an additional insulation above the exterior sheathing (bright blue curve).

Conclusion

The aim of the research project was to establish the basis for a reliable calculation and planning of green roofs – especially on wooden constructions – by the help of hygrothermal simulations. Based on existing and new measurements the specific surface transfer coefficients and the material properties of different specific substrates were determined, so that the calculated and measured conditions below the greenery match as good as possible. In the future, the specific quantification of the energy performance in winter and summer as well as a safe moisture design of the construction should be possible with these approaches.

Basic information

Short title: Reliable evaluation of hygrothermal and energetic effects on green roofs.

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