Moisture supplement for the thermal conductivity of insulation slabs in inverted roofs

The evaluation of both literature as well as field test results shows a clear influence of moisture on the thermal performance of inverted roof assemblies. Therefore this influence must be considered by appropriate supplements for technical approvals.

Two different effects can arise: if the rain water is running of below the insulation slabs the water is heating up on its flow path and releases the heat from the roof to the environment. The additional heat losses correspond approximately to an increase of the U value of the assembly by 0.05 W/m²K. If an appropriate membrane ensures a run off above the insulation slabs this additional heat loss can be avoided and no supplement is required. However there remains normally most of the time a thin water film below the insulation slabs which results in a high water vapor pressure and a vapor flux into the insulation material. Depending on the drying situation on the top of the slabs this vapor flux can lead to moisture accumulation in the slabs and consequently also to an increase of the thermal conductivity.

During this project a new model was developed to simulate the whole moisture balance of inverted roof insulations including also the conditions below the slabs and in the cover layers like soil or gravel. Beneath the insulation slabs a thin storage layer is implemented which absorbs a small part of the precipitation water during rain spells and afterwards passes this moisture to the insulation slabs by vapor diffusion transport. On top of the slabs, layers with gravel or soil are considered which also absorb, store and evaporate rain water. All models are evaluated by field and laboratory tests and provide realistic results concerning both energy and moisture behavior. In case of doubt the models are adapted to stay slightly on the safe side which means colder or more humid than the measured values.

With the new model typical inverted roof assemblies were examined to determine the average long term moisture contents over a normal life cycle of 25 years depending on operation and outdoor climate conditions the roofs are exposed to in Central Europe. The results show that green roofs hardly allow any dry out to the top as the soil is normally humid and close to free saturation all year round. The moisture accumulation leads for thinner insulation slabs (140 mm) to an increase of the thermal conductivity by 5 mW/mK. For thicker slabs (180 mm) the value is lower with only 3,5 mW/mK as more or less the same total amount of moisture disperses to a bigger volume. Gravel roofs experience significantly longer dry periods than green roofs – consequently also the water content in the insulation slabs remain lower and the supplement on the thermal conductivity accounts for 1.5 mW/mK.

In future the new model allows to predict the long term hygrothermal performance of inverted roof insulation depending on the specific and transient influencing factors: material properties, operation of the building, cover layer types and local outdoor climate.