Calculating water runoff from a building surface as a function of the intensity of driving rain: Summary

As part of the project, it was tested if there is a simple relationship between driving rain, runoff and the size of the test object that allows the runoff volume to be estimated based on the driving rain, the size of the façade being rained on and, when appropriate, the material class. Data and results from the German Federal Institute for Materials Research and Testing (BAM) and the Fraunhofer Institute for Building Physics IBP were used as an information base for the calculation. A literature review supplemented the experimental data pool relating to materials and the volume. First, meteorological and building physics terminology – such as precipitation, rain and driving rain – were defined and referenced. Next, the differences between the experimental measurement of precipitation in terms of building physics and meteorology were explained. In meteorology, precipitation is recorded using rain gauges and a collection area of 200 cm². It is recommended to use the same collection area for gauges of driving rain, to ensure results are comparable. Driving rain and the associated collision rain significantly influence the hygrothermal characteristics of a building façade and thus its long-term durability. Damage caused by driving rain has been scientifically evaluated for several decades. B. Blocken, D. Derome und J. Carmeliet have provided a detailed overview of previous research from the last 80 years related to driving rain and rain runoff from building façades. The literature review carried out focused primarily on the following terminology: driving rain, rain runoff and leaching. In total, 73 publications were included; 57 of these discussing driving rain and rain runoff. Evaluation of the literature and the existing measurement data shows – in respect to collected precipitation R_N and collected driving rain R_S – that it is possible to estimate the amount of rain runoff R_A when the annual amount of precipitation and the average prevailing wind speed u are known. The simplified equations of Lacy and Choi can be used to calculate the amount of driving rain in an open area with a proportionality factor a = 0.2 s/m and to calculate the amount of driving rain on a building with a proportionality factor F_b = 0.1 s/m. A proportionality factor F_a = 0.035 s/m was experimentally measured for a building with a façade oriented toward the prevailing wind direction, a surface area of approximately 40 m² and a rain runoff R_A. The following general rule can be derived from the measured factors for calculating the amount of rain runoff from non-absorbent building surfaces:

$$R_A \sim (a \times 0.5 \ \times 0.3) \times u \times R_N \quad [mm]$$

whereby:

$$\frac{F_b}{a} \sim 0.5$$

$$\frac{F_a}{F_b} \sim 0.3$$

For absorbent substrates, the proportionality factor F_a was between 0.005 s/m and 0.020 s/m. As a result, an average proportionality factor F_a = 0,01 s/m can be given for absorbent substrates. For the amount of rain runoff R_A from absorbent substrates, the following is true:

$$R_A \sim (a \times 0.5 \ \times 0.1) \times u \times R_N \quad [mm]$$

whereby:

$$\frac{F_b}{a} \sim 0.5$$

$$\frac{F_a}{F_b} \sim 0.1$$

The proportionality factor F_a is dependent on time and not static. The proportionality factor changes over time due to aging of the rained-on surface.

The average annual precipitation of the evaluated monitoring stations maintained by the Deutscher Wetterdienst DWD (excluding mountain stations such as Brocken, Feldberg, Zugspitze, etc.) were between 456 mm (Berlin Tegel) and 1697 mm (Oberstdorf). The average annual precipitation value for the named DWD monitoring stations was 728 mm. Mean wind speeds were between 1.8 m/s (Bamberg) and 4.5 m/s (Helgoland). The average speed was calculated at 2.5 m/s.

As a result, the average yearly amount of rain runoff R_A for a single-family home with a non-absorbent surface (ca. 40 m²) is approximately 55 L/m²; for an absorbent surface, the amount of rain runoff is approximately 18 L/m².