Pressure equalization as design strategy for watertightness

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I. INTRODUCTION

In order to shield the indoor environment from the exterior most building components are assembled out of several layers of materials to meet different performance requirements (watertightness, airtightness, thermal resistance, structural stability etc). Although a lot of research has been done in that area, experience points out the weakest link in water management is the interface between those different components. Most cases of water infiltration occur at corners, reveals or other junctions of building components. It is currently unclear whether this is caused by external parameters (higher pressure gradients, higher wind driven rain intensity) or construction parameters (discontinuities in water schedding surface, water buffering capacity, drainage, airtightness…).

This research focuses on the performance assessment of building envelope interfaces concerning watertightness, while taking into account boundary conditions relating to thermal performance, airtightness and structural stability. However, current building construction practice generally solves interface problems using techniques and materials to that may be subject to severe degradation over time like sealants, tapes and self adhering membranes. Therefore artificial aging is used to predict the long-term performance of the interfaces.

II. PRESSURE EQUALISATION

The most common design strategy for watertight building components is pressure equalisation, although pressure moderation might be a more appropriate name [1]. The performance of different types of cladding that use pressure equalisation has well been studied over the last 40 years: an extensive literature review can be found in [2].

Every pressure equalised building component consists of a water shedding surface (with of without buffering capacity), a cavity with drainage paths and an airtight plane on the inside. As the pressure difference induced by meteorological conditions will predominantly be absorbed by the airtight plane, the pressure in the cavity will approach the induced pressure on the outside surface. Hence, there is no driving force on the water to migrate into the cavity.

The Pressure Equalised Percentage (PEP, eq. 1) is a specific value between 0 and 100% which measures the rapidity and degree to which the internal air pressure within the cavity can equalise with the external air pressure [3]. A PEP value of 100% implies a perfect pressure equalisation of the cavity with the same amplitude and in phase with the external air pressure.

$$PEP = 100\left(1 - \frac{1}{2PT}\int_0^T \left|P_e(t) - P_c(t)\right|\right) \qquad (1)$$

III. WINDOWS

In order to simulate the performance of building components a numerical model will be developed to solve the mass continuity equations for air and water. As windows have no buffering capacity and the parameters are well known and verifiable they are an ideal case-study to develop a model. Furthermore, windows are an outstanding example of a building envelope interface: it is a transition from the building component to the insulated glass unit where all the different materials and functions are literally forced together. Currently no simulation models are available to predict the performance of windows during static and dynamic as well as during dry and rainy conditions.

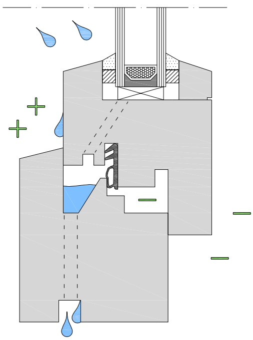

Figure 1. Mass balance in window frames

IV. INTERFACES

Once the model is fully developed and validated the performance of building envelope interfaces will be modeled. However, the influence of secondary effects like partial pressure differences, water buffering and geometric uncertainties come into play. The model will need adjustments and fine-tuning to correctly simulate pressure equalisation and water management.

In order to determine the long-term performance of interfaces more information is needed on the behaviour of sealants and adhesives. Experimental research has started [4] to develop an artificial aging methodology for self-adhering membranes and tapes. A parametric analysis on different foil types, adhesives, substrates, surface treatments and boundary conditions gives reference values for initial conditions. Artificial aging techniques will take into account temperature, relative humidity, cyclic effects, and both static as dynamic stresses.

These products are used for airtight as well as watertight connections, so benchmark values need to distinguish between the boundary conditions a certain product will be subjected to during it's lifetime. Initial results already suggest current construction guidelines are insufficient to prevent severe damage in time. Certain combinations of adhesives and substrates prove to be incompatible after artificial aging. During these experiments more data on airtightness of different types of interfaces will be generated, which is needed for the computer model.

V. CONCLUSIONS

The main goal of the research project is to develop a numerical model to predict the performance of building envelope interfaces. Window frames are used to develop the model, and other experimental research on air- and watertightness is ongoing to provide the necessary information to feed the model.

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