# Watertightness of window frames: relating testing methodologies to actual weathering conditions

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## EXTENDED ABSTRACT:

The watertightness of window frames can be measured according to different existing standards and codes in Europe, North-America and Asian coutries. These testing methodologies find there raison d'être in the fact that they can separate the sheep from the goats in a way that reflects actual weathering conditions that might occur throughout a certain period in time. Test procedures should define criteria to determine whether a window fails or not, based on typical failure modes of windows. The two basic failure phenomena of windows are inadequate pressure equalization and drainage design on the one hand, excessive air flow rates with inappropriate frame geometry on the other. While the building industry typically uses standards and codes to benchmark their products and as basis for their vision for the future concerning research and development, it is important that testing methodologies correlate well with actual weathering conditions and typical failure modes.

A lot of the standards and codes used today have a long history and in most cases their roots are conceived a few decades ago. Throughout the last few decades a great deal of research efforts have been made to quantify wind pressure loads, wind driven rain and wetting intensities on buildings and facade constructions: perhaps these studies might add information to adjust or optimize the existing methods. Furthermore, next to the testing methodology, different types of performance criteria have been established in different countries. Depending on the specific standard and country, these criteria take into account different parameters, e.g. building height, location, shielding, location on the building, building geometry, return period, building typology etc. Hardly any information is available concerning the scientific basis of the testing methodologies, nor on the background of performance criteria for window frames. The different damage initiation phenomena need to be closely examined to develop the test conditions for static or dynamic testing. On one hand there is a difficult balance between the conditions and performance of a window during its total service time, and the conditions and performance in the test facility. On the other hand there is also a balance between creating a test method that comes close to reality and a test method that is economically realistic and viable in laboratory conditions.

Most publications focus on the fundamental physics of wind driven rain based on measurements and computer simulations. In some cases the research results are demonstrated by specific case-studies or a general methodology is developed to calculate the wind driven rain on a specific building. However, the relation between the calculated wind loads, wind driven rain and a testing methodology is in most cases not made explicit. Sahal and Lacasse (Building and environment 43, 2008, 1250-1260) developed a very usefull methodology for calculating water penetration test parameters of wall assemblies, based on research by Choi, Straube and Mayo. However, although this methodology is usefull and consistent, it does not allow to integrate additional information generated by simulations or on-site testing, and it can only be used if a certain set of climatic data is available. This paper elaborates on the suggested methodology and offers additional ways of utilization.

A First step towards a usefull testing methodology is the characterization of the local climate: this concerns wind data and driving rain intensities, preferably for different averaging periods. Within the European context there is a big variety in available meteorological data, rendering it practical impossible to develop a uniform methodology to convert climatic data into a test method. A practical solution would be to use the operative standards in the field of structural engineering in Europe (Eurocodes) wich are widely accepted and already implemented and into practice. These standards have a solid scientific basis and offer a methodology to calculate wind pressure loads based on hourly averaged climate data. Furthermore, these standards are currently used to calculate the mechanical performance of window frames and glazing, and are consequently familiar to the industry.

The next stept constitutes the translation of climatic data of a specific location towards coinciding wind loads and rainfall intensities for a specific part of a building. Even though this may seem obvious for specific projects, the majority of product testing is done within the scope of product development and should hence be done for a number of generic buildings with varying geometric characteristics. There are a number of methods which can be used to generate proper coefficients and data to calculate local wind driven rain intensities on buildings: next to standard procedures found in literature it is possible to use computational fluid dynamics (CFD), wind tunnel experiments, on-site experiments and the procedure in the eurocode.

Thirdly, a testing methodology should be derived from the calculated boundary conditions, taking into account the damage intitiation phenomena of the component which needs testing. By way of illustration: since most standard window frames are not made out of porous materials, consecutive wetting over a longer period of time will probably not affect their performance. The dominant constraint for the test method is the feasibility and practical implementation in a test setup. Even though any conceivable pressure fluctuation can be generated using the appropriate laboratory equipment , practice points out this would not be economically viable. This necessitates testing methods with simplified static of cyclical static pressure loads and static rainfall intensities. The pressure loads generated during existing dynamic test methodes (aircraft engine and European dynamic watertightness test) are inadequatly documented and the relation to actual wheatering conditions is unclear and not explicit.

For a specific building the performance criteria can be determined by taking into account the function of the building, the appropriate return period and the risk assessment in case of failure. This is in shear contrast with the existing standards which seem to be mutually divergent, both in testing methodology as in performance criteria. By integrating information from different branches of knowledge it is possible to generate a uniform step by step methodology that can be applied in any project, independent of the available type of data.