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Predominant Climate Exposure Strains - Thermal Degradation Testing Compared to Historical and Future Climate Scenarios

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1 Introduction

The service life of buildings and building products is presumed to be 60 years. Wall membrane and roofing products, including adhesive products, are widely used in modern building assemblies and the service life of these products that play an important role in ensuring the air and rain tightness of the buildings has to reach 60 years. Furthermore, the inspection of these products, that are often hidden from visual inspection by cladding material mounted on the outermost layer of a building, is difficult.

Wall membrane and roofing products are usually subjected to an accelerated ageing procedure (see Table 1), depending on the use of the product in question. The test standards are designed with regards to the product in question and the prevailing climate condition in the use area of the product.

The ageing procedures are often, but not always a combination of what is believed to be a realistic climatic condition: elevated temperatures, (UV) radiation, water spray, freeze-thaw cycles, to mention the most common ones. Studies on material degradation usually involve a very detailed study of the degradation mechanism. The common ground for building products is usually their application area and not the type of material. Hence, test procedures should preferably account for the climatic strains, and attempt to reproduce the climatic conditions in service (Riahinezhad *et al.,* 2019) as correctly as possible.

In this study, historic and future climate data from Calgary, Canada, are used to explore according laboratory test durations based on a number of assumptions made in order to be able to estimate acceleration factors.

2 Methods and Results

This study is only focusing on thermal degradation and the calculations for the acceleration factor are based on the Arrhenius equation.

The value of the acceleration factor AF solely on the activation energy E_a and the two temperatures T_1 and T_2, representing the laboratory test temperature and the outdoor temperature. With all assumptions considered, the acceleration factor varies between 23 and 1325 for a test temperature of 80ºC, 11 and 648 for a test temperature of 70°C and between 5 and 304 for a test temperature of 60°C.

Basing the calculation of the test duration on annual average values leads to an acceleration factor of 379 for historic (T_2 = 4,7ºC) and 225 (T_2 = 9,4ºC) for future climate scenarios (for

E_a=72 kJ/(mol K) and 70ºC test temperature), leading again to a laboratory test duration of 28 days and 48 days.

With a calculation of the outdoor temperature T_2 in the study, the duration of the accelerated test is based on shorter time intervals with their respective duration based on hourly mean values. This contributes to a more accurate calculation, compared to e.g. using and average monthly or annual values, where the calculated test duration is considerably.

3 Discussion

Due to the uncertainty in estimations of acceleration factors, test procedures for durability evaluation in product standards or for certification purposes normally specify longer test periods than those calculated from the Arrhenius equation. Thus, these tests have an inherent error margin to be on the safe side with regards to durability. This is known as stress testing, and the goal of the test is to assess whether it is probable that a product will have sufficient durability in the end use environment rather than specifying a particular service life. The error margin of durability testing may become smaller in the future due to climate change. For instance, in a common test method for roofing membranes (EN 1296:2000), the temperature during the laboratory test is set to 70°C and the test duration is 24 weeks (168 days). Assuming an activation energy of 72 kJ/(mol K) this test roughly corresponds to an outdoor exposure period of 102 years based on historical climate data. Based on the future climate scenario, however, the laboratory testing would only correspond to 53 years of outdoor exposure.

The results show a significant influence of the increasing temperature on the accumulated amount of time where certain temperature threshold values are exceeded. For the Calgary data, where the historic average temperature is 4.7°C and the future average temperature over a 30-year time period is 9.4°C, the increase in amount of days where the threshold value exceeds 30°C is from 30 to 352.

4 Conclusions

In a durability test, based on the calculated acceleration factors, given a number of assumptions, based on thermal degradation and on historic climate data for Calgary, 49 days account for an outdoor test period of 30 years. Based on future climate data, the test duration must be increased to 94 days.

Compared to a commonly used laboratory durability test for roofing membranes (EN 1295, 2000), the test duration of 24 weeks (168 days) accounts for an outdoor test period of 102 years for historical climate and 53 years for future climate.

This calculation shows that future climate scenarios should be considered when designing laboratory experiments.

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References

EN 1296 (2000). Flexible sheets for waterproofing - Bitumen, plastic and rubber sheets for roofing - Method of artificial ageing by long term exposure to elevated temperature. The European Standardization Organization.

Riahinezhad, M., Eve, A., Armstrong, M., Collins, P. and Masson, J.F. (2019). Field temperature and moisture loads from a building envelope as the basis for accelerated aging of barrier membranes. *Canadian Journal of Civil Engineering, 46,* 969-978. https://doi.org/10.1139/cjce-2018-0757