XV International Conference on Durability of Building Materials and Components
DBMC 2020, Barcelona
C. Serrat, J.R. Casas and V. Gibert (Eds)

Durability of Internally Insulated Historical Solid Masonry under Future Climates: A Stochastic Approach

Sahar Sahyoun[1], Lin Wang[2], Hua Ge[3], Maurice Defo[4] and Michael Lacasse[5]

[1] Ph.D. Student, s_sahyo@concordia.live.ca; [2] Post-Doctoral Fellow, forestwang2013@gmail.com; [3] Associate Professor, Concordia University, Montreal, Canada; hua.ge@concordia.ca
[4] Associate Research Officer, Maurice.Defo@nrc-cnrc.gc.ca; [5] Senior Research Officer and Team lead, Façade Systems and Products, National Research Council Canada, Ottawa, Canada; Michael.Lacasse@nrc-cnrc.gc.ca

Keywords: *Historical Buildings, Solid Masonry, Stochastic Approach, Future Climates, Durability.*

1 Introduction

One typical way to reduce a building's heating energy consumption is insulating its envelope. The retrofit of historical buildings is usually done through adding interior insulation in order to preserve their cultural heritage value. However, after insulation is installed, the moisture content of the masonry wall increases, which may lead to a higher potential for hygrothermal problems, such as frost damage. Previous research has shown that under a changing climate, higher rainfall intensity, stronger winds, and more frequent storms are expected, which may increase wind-driven rain loads on the façade and subsequently, risks for rain penetration. It is therefore important to assess the effect of climate change on the potential risk to freeze-thaw (FT) damage. This paper investigates the impact of the interior insulation thickness on the FT damage risk of existing masonry wall assemblies under climate change.

2 Methods

The methodology includes a deterministic and a stochastic modelling approach to investigate the impact of insulation thickness on the FT risk of masonry walls.

Climate data and MRY selection – Weather data for Ottawa were provided by the National Research Council of Canada (NRC). A continuous time-series of hourly climate data was prepared for a baseline and future time-periods (Gaur *et al.,* 2019). A one-year period was chosen for the selection of reference years based on the Severity Index (Isev) (ASHRAE, 2010).

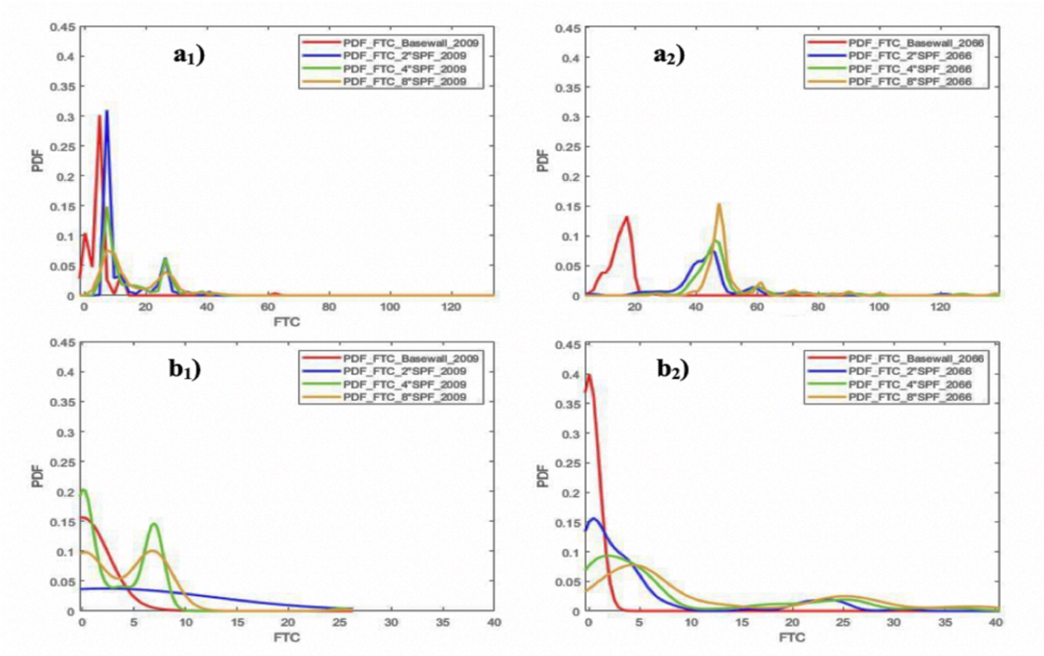
Wall assemblies and materials – Four wall assemblies are evaluated in this study: a solid masonry wall assembly and three internally retrofitted solid masonry wall assemblies. The base wall consists of historical brick and gypsum plaster. The retrofitted wall assemblies differ only by their insulation thickness; 2", 4" and 8" of polyurethane foam were considered.

Stochastic model's setup – The stochastic models are generated according to the stochastic hygric material properties of brick; and the Latin Hypercube Sampling method is applied to produce the stochastic models (Wang and Ge, 2018). For each level of insulation thickness, 100 stochastic models are generated.

Performance indicator for assessing wall performance – The risk of FT damage is computed using the number of freeze-thaw cycles (FTC). One cycle is counted when temperature drops below its freezing point and moisture content exceeds its critical level. Values of (Scrit) equal to 0.25, 0.35, 0.5 and 0.8 were considered. The point of investigation was placed at 5mm of the brick surface.

3 Results and Discussion

Estimated FTCs indicated zero for all stochastic results when brick has higher Scrit of 0.5 and 0.8. Therefore, results for a brick with Scrit equals 0.25 and 0.35 are only assessed (Figure 1). In general, after interior insulation was added, the number of FTCs increased, indicating a higher potential of FT to occur. Moereover, the probability distribution of FTCs for the same type of brick under future climate denoted a larger difference between the base wall and the retrofitted options. Comparing results obtained by the deterministic and the stochastic methods, they seem in good agreement. Values of FTCs calculated using the deterministic approach corresponds in most of the cases to the FTC number having the highest probability density within the stochastic results range.



PDF = Probability density function; SPF = Spray polyurethane foam; [1]Historical year (2009); and [2]Future year (2066).

Figure 1. Stochastic results – the impact of insulation thickness on the estimated number of freeze-thaw cycles (FTC) for brick masonry having a critical degree of saturation of a) Scrit = 0.25; and b) Scrit = 0.35.

4 Conclusions

The durability performance of a masonary basewall and three retrofit alternatives of the same wall, having three different insulation thicknesses were evaluated using both deterministic and stochastic methods. This study took into account the uncertainties in brick masonry properties. The brick was tested for different Scrit. The insulation thickness did not have any influence on the durability of the masonry brick with better frost resistance. However, for a Scrit of 0.25 and 0.35, the number of FTCs increased. Results obtained by the deterministic and the stochastic methods were in good agreement. In addition, both methods showed an increase in FTCs' number and spread under future conditions; thus, a higher risk to frost damage. To provide a safe thickness range for the retrofit of masonry walls and to account for the uncertainty of future climate, a study will be carried out later.

ORCID

Sahar Sahyoun: https://orcid.org/0000-0001-5131-6134
Lin Wang: https://orcid.org/0000-0002-6529-1123
Hua Ge: http://orcid.org/0000-0003-1368-4301
Maurice Defo: http://orcid.org/0000-0001-9212-6599
Michael Lacasse: https://orcid.org/0000-0001-7640-3701

References

ASHRAE. (2010). Environmental weather loads for hygro- thermal analysis and design of buildings. RP-1325, ASHRAE, Inc., Atlanta.

Gaur, A., Lacasse, M. and Armstrong, M. (2019). Climate Data to Undertake Hygrothermal and Whole Building Simulations Under Projected Climate Change Influences for 11 Canadian Cities. *Data*, *4*(2), 72.

Wang, L. and Ge, H. (2018). Stochastic modelling of hygrothermal performance of highly insulated wood framed walls. *Building and Environment, 146,* 12–28.