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Metamodel Development for Predicting Hygrothermal Performance of Wood-Frame Wall under Rain Leakage

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1 Introduction

Recent years, stochastic modelling approach has been increasingly applied to investigate the uncertainties of input parameters in hygrothermal simulation and the moisture damage risks of building envelopes. However, the high computational cost inhibited the wide application of stochastic modelling. To improve the computational efficiency, the data-driven metamodels can be developed as substitutes of traditional hygrothermal model, to predict hygrothermal performance of building envelopes. ANNEX 55 performed a comparative study to investigate the performance of different metamodeling methods (Janssen *et al*., 2015). It was suggested that the metamodel can only be used within the range of the training data values. However, there is still a lack of studies investigating the reliability of the metamodels at different data ranges.

This paper develops metamodels for a conventional 2x6 wood-frame wall under different rain leakage levels using polynomial regression and neural network methods. The performance indicators- Root Mean Square Error (RMSE) and Maximum Absolute Error (MAE) are used to evaluate the reliability of the developed metamodels at different rain leakage levels.

2 Methods

Figure 1 shows the configuration of the investigated wall. Material properties and their ranges are determined from the material databased developed by NRC. The Canadian Weather Year for Energy Calculation (CWEC) data of Vancouver is used as weather data except for the rain data, which is extracted from WUFI weather database. The wind-driven rain is calculated based on the semi-empirical model in ASHRAE 160. Hygrothermal models are created for three rain

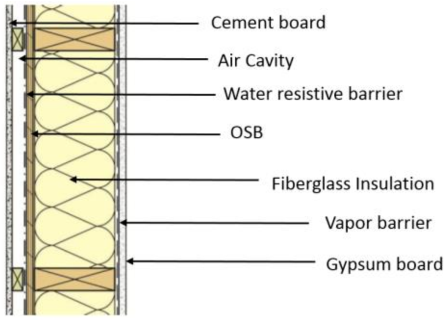

Figure 1. Configuration of 2x6 wood-frame wall.

leakage levels: 0.1%, 0.5% and 1 % of wind-driven rain. The penetrated rain water is assumed to be deposited on the exterior surface of OSB.

The data used for training the metamodels are obtained from the stochastic simulations, which are performed for 5 years (Wang and Ge, 2019). The input data includes stochastic hygric material properties of OSB and fiberglass, and the rain deposition factor. The outputs are maximum moisture content and mold growth index of the interior surface of OSB for the 5-years' simulation.

The polynomial regression and neural network methods are applied to develop the metamodels. For each rain leakage level, the metamodels are developed based on 100 sample size. Additionally, a metamodel representing the whole range of rain leakage level from 0.1% to 1% is also developed with 300 sample size.

3 Results and Conclusions

In overall, the developed metamodels are performing well to substitute the original hygrothermal models for predicting maximum moisture content and mold growth index (maximum RMSE is 3.29% for moisture content, and 0.39 for mold growth index) of OSB sheathing in the 2x6 wood-frame wall under different rain leakage levels. The metamodels for lower rain leakage level perform better that those for higher rain leakage level. For 0.1% and 0.5% rain leakage levels, the RMSE and MAE of neural network metamodels are slightly higher than those of polynomial metamodels. While, for 1% rain leakage level and the metamodels representing all the rain leakage levels (from 0.1% to 1%), the neural network method has a lower RMSE and MAE than polynomial regression method.

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