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A probabilistic-based approach for predicting mould growth in timber building envelopes: Comparison of three mould models

Klodian Gradeci[a,*], Nathalie Labonnote[b], Berit Time[b], Jochen Köhler[a]

[a]*Norwegian University of Science and Technology, Høgskoleringen 1, 7491 Trondheim, Norway*
[b]*SINTEF Building and Infrastructure, Høgskoleringen 7b, 7465 Trondheim, Norway*

Abstract

This paper applies a probabilistic-based approach as a methodology to analyze and compare the mould growth computations' results from three different mould models. This approach, instead of the conventional deterministic ones, offers the advantage of accounting for uncertainties concerning prediction of mould growth. The results are able to demonstrate more realistic and conclusive outcomes that can be applicable to real-life situations.

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Keywords: mould, mould model, probabilistic approach, uncertainty, building envelope, timber, wood

1. Introduction

Mould is one of the problems in wooden constructions, which can result in financial loss and unfavourable social problems such as discomfort and health risks [1-3]. Mould growth is a very complex phenomenon [4] influenced by variables of stochastic nature such as weather conditions and indoor climate that are characterized by uncertainties in the models representing the phenomena. Uncertainties in predicting mould occurrence are twofold; a) those related to the representation of the biological activity, and b) those related to the representations of climate exposure.

During the last two decades, different mould models have been developed to predict mould growth on the surface of wood-based materials [4]. Many authors have compared the calculated mould growth from different mould models,

* Corresponding author. Tel.: 0047-938-82468.
E-mail address: klodian.gradeci@ntnu.no

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where both agreements and disagreements have been found [4-10]. However, these comparative studies are based on a deterministic approach, and therefore they do not account for the uncertainties involved. By applying the latter methodology, it may lead to inconclusive results for applications in building engineering, where mould models are expected to assess the likelihood of mould germination (onset of mould) on the material surface exposed to natural weather conditions. Plausible comparison between mould models are required in order to deliver directions and guidelines of their applicability. In light of this, this paper proposes to analyse and compare mould models by using the results of mould occurrence in a timber envelope calculated by a probabilistic-based approach. This methodology offers the advantage of providing more overarching results due to the following properties:

- It accounts for uncertainties related to the boundary conditions that affect the hygrothermal conditions on the materials' surface, which are further used as the input to the mould models.
- It considers both favourable, unfavourable conditions and their interrelations as encountered in real-life application, by using a mathematical expression that generates possible patterns of the weather data in a time series containing plausible sequences, frequencies and correlations.
- It consider models' specific parameters that might affect the result of mould growth including time duration, time step, materials dependencies or other individual model parameters.

2. Material and methodology

2.1. Limitations of current approaches and opportunities associated to probabilistic approach

Many studies have compared the mould models' results in order to get an insight of their applicability and to evaluate their accuracy with each other. Generally, these studies share a similar methodology based on a deterministic approach when comparing results across models. Among other studies, are found comparing; a) basic characteristics of models such as minimum requirements for mould growth (ranges of consideration of governing parameters) [4-7], b) mould growth results exposed to specific user-defined climate scenarios [7, 8], c) mould growth compared to results from experimental research with similar exposure [8, 9] and d) mould growth results of building envelopes exposed to specific reference year(s) [10]. Both disagreements with significant deviation and agreements are reported.

The scope of mould models in the field of building engineering (including the comparison studies) is to assess the likelihood of mould growth in building envelopes, which are exposed to potential natural weather conditions and for a reasonable time duration that can reflect the actual performance. While the results of the aforementioned comparison studies might offer a valuable information regarding the differences between mould models, especially comparison studies with experimental results, they might bring inconclusive results regarding the actual application of these models in the building engineering field. These limitations are grouped as the following:

- Mould models are established by using different methodologies based on results derived from different experiments that have specific settings. From these datasets, mould models have been developed to assess mould growth occurrence for these boundary conditions and further extended to other potential boundary conditions. Due to these differences, there is the possibility that a specific climate exposure falls in 'intermitted' domain that is an exposure that may offer limited conditions for mould growth depending on the model and is treated differently based on the methodology used. For example, when using isopleths, such exposure is always treated as favourable, while when using a regression technique, it might fall outside the valid domain of the regression equation. Therefore, a specific combination of the hygrothermal conditions (i.e. change of relative humidity from 90% to 60%) might provide different growth when calculated from different models. However, this type of exposure considers the variation of the weather parameters in a non-realistic way. While user-defined exposure conditions might reveal that these models have specific domains where they contradict each other, this might be misleading and does not give conclusive results as a basis for their building engineering application since these data may not reflect reality.
- Mould growth is communicated by different rating scales or quantities in different models. The results must be carefully evaluated and interpreted when comparing models using different rating scales, even though these scales are described with similar prescriptive characteristics, which however are based on human visual judgement.
- Mould models' results are sensitive to the materials' characteristics being investigated and to its hygrothermal conditions. The latter depend on variables that have a stochastic nature including weather conditions, interior climate and material properties. These variables are also depending on stochastic parameters including the initial