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A Risk-Based Approach for Quantifying Durability and Life-Expectancy of the Wall-Foundation Construction Detail in Timber Buildings

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1 Introduction

Understanding and predicting the durability of timber is of paramount importance for a more reliable, extensive and efficient use of this material in constructions.

Because decay caused by biotic attack is one of the most critical concerns in the long-term performance of wood, durability at the material level has been deeply investigated. In-ground and above-ground behaviour of wood has been studied through field and laboratory testing. Prediction models have been also developed to predict decay caused by fungal attack or to predict mould grow (Brischke *et al.*, 2014). The prediction of timber decay in building structural components has instead been investigated by only but a few researchers.

Recently, the increasing availability of timber-based products for a diverse range of building solutions has stimulated researchers into approaching more sophisticated tools to map timber moisture distribution over time. The Heat, Air and Moisture (HAM) analysis is one of the tools adopted to predict timber moisture content with precision (*e.g.*: Chung *et al.*, 2019).

The Wall-Foundation Detail (WFD) in timber buildings can have quite different geometries, materials, wall stratigraphies and boundary conditions. The combination of these characteristics can create a very large number of possible configurations that escalates the effort of performing HAM analyses. With reference to the durability of this construction detail, finding the most critical combinations can be very important to approach this problem effectively. Another key issue to be solved when studying this detail is how to model water intrusion. Guidelines for modelling water intrusion in walls where the problem can be schematized as one-dimensional can be found in Lstiburek *et al.* (2016). An equivalent of the above-mentioned guidelines for the two-dimensional problem is not available yet and because the WFD is essentially a two-dimensional problem, its study demands bigger efforts in order to run numerical analyses.

The paper presents a methodology to categorise the WFD of timber structures in relation with the durability of the timber structural element. This method permits to assign a risk class to the detail, based on decision trees that considers the most significant issues related to timber durability accounting for fungal attack. Risk classes are used both to identify the most critical configurations and to associate to them a decay estimation function that at this preliminary stage was taken from literature (*i.e.*: Leicester *et al.*, 2008). Three case studies (Gaspari *et al.*, 2020) are then introduced to compare the results of this preliminary decay prediction.

The methodology proposed herein is part of the TSafe project where reliable strategies for the risk assessment of timber structures are used to create decision-making tools useful to every party involved in the construction of timber structures. The purpose of the TSafe project is to combine numerical simulations, such as HAM analyses, with artificial intelligence and machine learning algorithms to extract simple and applicable rules from complex problems solved numerically (*e.g.*: Glavind *et al.*, 2019).

2 Conclusions

This paper proposes a methodology to categorise the Wall-Foundation Detail (WFD) of timber structures in relation with the durability of the timber structural element. Risk classes were defined looking at the prominent standards that treat the topic of the durability of timber. The risk classes can be assigned to the WFD via decision trees designed to consider the main aspects that can affect the durability of this construction detail in relation with fungal attack. This was the first step to develop a reliable method capable of predicting the life-expectancy of timber construction details. Future research steps, as a part of the TSafe project, will involve more sophisticated tools such as Heat, Air and Moisture analysis, machine learning and a combination of both. For a preliminary validation of the overall analysis approach, three case studies were selected and studied using the methodology proposed herein. A good correspondence was observed from the comparison between the results of the proposed methodology and the onsite inspections.

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