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Wooden basements; hygrothermal performance analysis using in-field measurements and numerical simulations

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ABSTRACT

Basements represent an essential component of modern building design, serving as foundational structures with multifaceted roles in both residential and commercial constructions. The use of wood as a natural and cost-effective material for basement construction plays a significant role in shaping the future, demanding well-established concepts to ensure sustainability. This paper presents an investigation of the hygrothermal behavior of basements built with wood elements, utilizing a combined approach of in-field measurements and numerical simulations. The variations in the temperature and relative humidity in different parts of the construction are monitored through a full-year measuring campaign in a reference building located in Switzerland. The measured data are used to first, analyze the performance of the structure in real operative conditions, and second, to validate the numerical model employed for the long-term performance evaluation of the building. Further numerical simulations are carried out to examine the reaction of the construction to various critical conditions. The results of the in-field measurements and numerical simulations ensure the applicability of using wooden elements in the basement structure under the conditions investigated in this study. The results revealed that the wood moisture stays below 18% as the limiting value specified by the standards. It is also shown that the wooden basement examined in this research has a satisfactory long-term performance with no concerns regarding moisture-related issues in terms of wood decay and mold growth. The risk analysis also demonstrated that the impact of the high initial moisture in the wooden elements on the hygrothermal performance of the assembly is higher compared to the high moisture load in the indoor space and the presence of a moisture source in the cold side of the insulation layer. The outcomes of this study contribute to the advancement of sustainable building practices, enhancing energy efficiency, and improving the resilience of wooden basements.

1. Introduction

Nowadays, the function and design of basements have considerably changed compared to their original use for food storage and supplies. Due to population growth and improved building techniques, there is a growing desire to use basements as living and office spaces like the rest of the building. In this sense, basements offer several advantages such as the expansion of useable living space, natural thermal and sound insulation, and enhancing overall energy efficiency by reducing heat loss in the winter and heat gain in the summer.

For many decades, concrete has been a popular choice for basement construction due to its load-bearing capacity and moisture resistance [1]. Numerical simulations have been employed in previous studies to investigate both the thermal and hygrothermal performance of concrete basements. Pallin [2] performed hygrothermal simulations on a concrete basement wall with a primary focus on examining the effects of outward drying having different types of soil and indoor climates. The simulations indicated that minimal precipitation could reach the insulation/drainage board if there was a positive drying potential. The research by Fedorik et al. [3] examined the hygrothermal conditions inside three concrete basement walls built between the late 1950s and the 1990s. The simulation results obtained in the study confirmed prior research findings, emphasizing that exterior thermal insulation for basement walls remains the most durable and effective solution. By

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