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Integration model of hygrothermal analysis with decay process for durability assessment of building envelopes

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Abstract

In this study a numerical simulation model that integrates hygrothermal analysis with the decaying process of wood structures caused by moisture accumulation is presented. This simulation model can quantitatively predict both hygrothermal conditions within the building enve lopes and the progress of decay in wood structures under vari able conditions. The fol lowing are characteristics of the simulation model used in this study: (1) the development of wood decay represented by a differential equation with a variable of mass loss of wood substance and (2) the addition into moisture balance equations of biochemica l reactions within wood decay. He nce, the simulation model enables assessment of the long-term performance of building envelopes with regard to both durability and drying pote ntial. Rate consta nts of the wo od decay and a coefficient of the moisture production for the model were determined by the mass loss data of small wood samples in decay tests using *Fomitopsis palustris*, a brown rot fungus. Additionally, numerical simulations using the mode l were imp lemented to underst and both t he decaying process and moisture accumulation within building e nvelopes. The results numerically demonstrated importan t phenomenon that the moisture production by biochemical reactions of wood d ecay helps to maintain the decaying process.

Keywords

building envelope,
hygrothermal analysis,
durability assessment,
wood decay,
biochemical reaction

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1 Introduction

Moisture accumulation with in the b uilding envelopes of wood-frame construction significantly affects problems related to durability such as decay, mould, and termites. To avoid these types of moist ure-related damage, various building components and wood preservatives have recently been developed and appl ied in the construction process. However, corrosion of me tal fasteners embedded in preservative-treated wood is a significant durability problem in terms of assurance of structural resistance (Zelinka et al. 2011). It follows therefore, that appropriate moisture control design in b uilding envelopes is desirable to better ensure durable structures and to ext end the service life of wooden products.

To ensure the appropriate moisture control design, advanced hygrothermal analysis models that can accurately predict temperature and moisture behavior within building envelopes have been develo ped (Hens 19 96). Nofal and Kumaran (1999, 2011) proposed a unique durability assessment system that links the hygrothermal analysis model with biological damage models. Viitanen et al. (2010) also proposed an empirical model for wood decay development incorporated into the hygrothermal analysis. These models can also calcul ate the extent of long-term deterioration of material properties caused by wood rot fungi and/or mould fungi under various climate conditions. Similarly, Krus and Sedlbauer (2005) implemented damage analysis and linked the hygrothermal model with the damage predictions. In these models, the calculate d temperature and moistur e profiles are applied to a prediction of the extent of biological damage.

However, these studies did not completely s imulate the decaying process of wood in terms of the moisture balance.

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