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Experimental investigation on the effect of detail design on wood moisture content in outdoor above ground applications

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ABSTRACT

An essential part of a performance-based service life design format for wood exposed in outdoor applications is the effect of proper detailing in terms of avoiding moisture traps. Models for predicting degradation and non-performance caused by decay are functions of arbitrary climate history of combined moisture content and temperature. Therefore it is crucial to be able to predict the behaviour of different detailing in terms of moisture content exposed to outdoor climate. An experimental study was made with continuous moisture content measurements of different details. The different detail set-ups are selected to represent a wide range of sawn timber dimension details of non-treated Norway spruce. Hourly moisture content values are recorded by a wireless monitoring system and the climate is monitored using a weather station. A simple horizontal board with no detailing is chosen as reference detail. This is, apart from a vertical board and sheltered details, what can be expected to be a good detail in terms of not trapping water. The remaining details show higher moisture content levels. It was found that the ratio between moisture content in a detail and in the reference detail showed a reasonably constant value over time. Consequently the behaviour of an arbitrary detail can be estimated by scaling the behaviour of the reference detail up or down using a constant value. Depending on the design the constant will be higher for more water trapping details and vice versa. This is important information and input for evaluating and developing details with acceptable performance.

1. Introduction

The key issue for wood in outdoor applications is durability and one of the key parameters for durability is the detail design, i.e. the importance of minimizing higher moisture content levels in the material. Traditionally the effect of detail design is quantified in terms of best practice and experience and it is often presented in terms of implicit prescriptive rules. A modern definition of durability is: The capacity of the structure to give a required performance during an intended service period under the influence of degradation mechanisms. This definition calls for a design tool where the expected performance can be specified in quantitative terms. As a result, the design can be optimised for the intended design situation and any change of design will be associated with a certain change in performance. It should be possible to compare different approaches of designing a product with respect to its required service life. There are several drivers for service life design, e.g. the need to estimate life cycle costs, new and improved methods for modelling degradative processes and new and improved protection methods. For design of wooden components in outdoor above ground applications, an important requirement is to limit the risk for decay or even onset of decay during the intended service life of the structure.

In general, performance-based design tools are based on performance models which can be expressed in a quantitative and probabilistic format. This concept is established in structural design applications since several decades [1,2]. For service life design, the challenge is to find predictive models based on material parameters and exposure. Furthermore, the models should be calibrated against the performance of existing design so that they provide realistic measures of service life. The service life is determined by several factors such as design, material, construction method, workmanship, repair and maintenance.

For other structural materials such as reinforced concrete and steel, performance models for service life design are available. To say that they are established and widely used is an overstatement but the tools are available in some format. Examples of two very different methods are the fairly simple factor method (ISO 15686 [3–5]) on the one hand and a more complex probabilistic method [6] which is too elaborate to be used in standard applications. Both

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methods require information and decisions to be made that are rarely available for standard applications. A more engineering level performance-based design tool for timber was developed in Australia [7]. The model is mainly based on a large field testing program at different exposure sites in Australia using wood species typical for Australia.

In the European research project Woodexter a performance-based design model was developed [8,9]. The basic concept is to define a model based on separate variables representing the climatic exposure on one hand and the material resistance on the other hand, see Fig. 1. A limit state is defined which represents onset of decay. This approach has the advantage that the exposure can be expressed as a function of global and local climate, component design and surface treatment in a general way independent of the exposed material. The material resistance can in the same way be expressed in terms of response to quantified and standardized climate conditions independent of the design situation. Based on this model a prototype engineering design guideline was developed with application on wood in outdoor above ground applications [8,9].

This study focuses on the exposure side, i.e. the effect of detail design and moisture trapping. In a more general context this can be regarded as micro climate conditions. Poor design will lead to long periods of high moisture levels while good details are characterized by

- protection and sheltering where possible,
- incoming water is not trapped,
- quick drying out.

These are obvious measures to take but there are no quantitative measures available enabling objective comparisons between different detail designs.

Historically, experimental field studies of wood in outdoors above ground applications rarely recorded the climate exposure continuously and if so only as average values not focussing on moisture traps [10]. Furthermore, climate data in terms of air temperature, relative humidity, precipitation etc. is missing which means that the relation between weather data and micro climate at the detail cannot be evaluated. Lately, more focus has been on actually learning about the relation between weather data and material climate, e.g. how does a rain event of some intensity and duration affect the "material climate" in terms of duration of and increase in moisture content in the component [11–14].

The present study deals with continuous moisture content measurements of different detail set-ups representing a fairly wide range of possible design situations. Weather data (temperature, relative humidity, rain, wind speed and direction) are also recorded at the test site. The main objective is to make relative comparisons between the material climates in terms of moisture content in different details. The absolute moisture content level is less important in this context.

2. Material and methods

2.1. Test material

The material in the study was chosen to be representative for what is normally used in outdoor wood above ground applications in northern Europe. Depending on availability and tradition the chosen material would differ depending on geographic location. However, the study is focused on relative comparisons between different detail design, and not on the specific material property. The effect of material could be evaluated separately by comparing a specific reference detail using different materials.

In this study Norway spruce (*picea abies*) was chosen. This is the most common material chosen for non-preservative treated above ground applications in Scandinavia, e.g. claddings. The material was taken from a local material supplier. So, the exact history of the material is not known. Again, this can be accepted since the study is focused on finding relations between different details and not on absolute values.

Three different dimensions were used:

- Panel boards, fine sawn on one side, planed on the other three. Dimension 22 by 95 mm^2
- Beams, planed. Dimension 45 by 95 mm^2
- Beams, planed. Dimension 95 by 95 mm^2

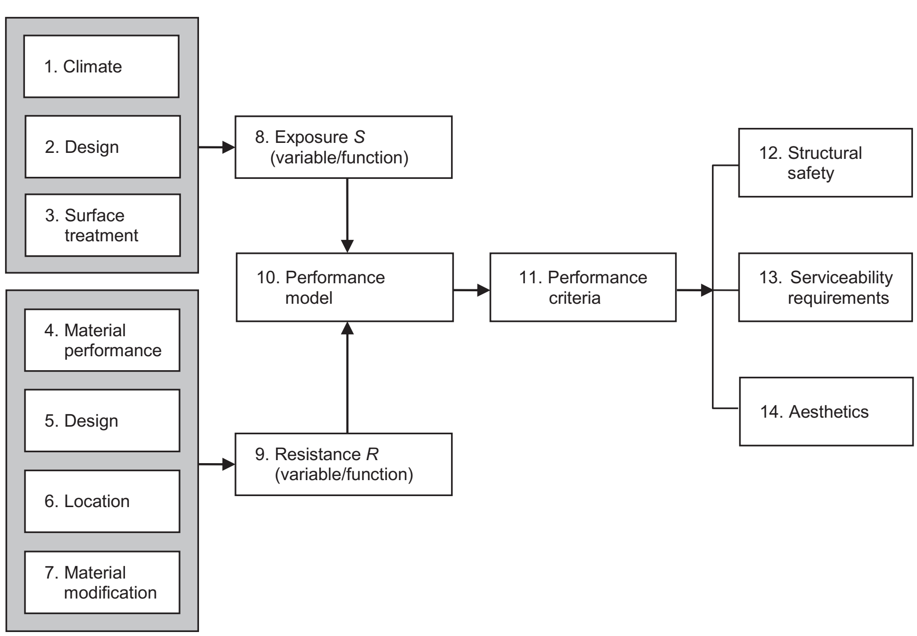

Fig. 1. Principle for performance-based service life design.