Modeling biodegradation of timber - Dose-response models for above-ground decay and its climate-dependent variability

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1. PROPOSED APPROACH TO SERVICE LIFE DESIGN OF WOOD COMPONENTS

A proposed principle for a performance-based service life design model is described in terms of climatic exposure on one hand and resistance of the material on the other hand. The design model is based on a clearly defined limit state, which could be onset of decay alternatively a specified acceptable degree of decay. The performance requirement in a certain situation could e.g. be that onset of decay is not accepted during a specified service life. Since most factors affecting the performance are associated with uncertainty, the probability of non-performance must be assessed so that it can be limited to an accepted maximum level. The advantage with the approach is that exposure can be described as a function of global climate, component design and surface treatment in a general way independent of the exposed wood material. Likewise, the resistance of different types of materials can be expressed in terms of response to quantified micro-climate conditions independent of practical design situations.

2. PERFORMANCE MODELS AND CLIMATE MODEL

A performance model shall be able to predict violation of the limit state as a function of all relevant influencing parameters.
Two different models are compared, the dose-response model presented by Brischke and Rapp (2010) (abbreviated model I) and a new, simplified dose-response model (abbreviated model II). In model II, the moisture content (MC) induced dose is represented by a quadratic function of MC and the temperature induced dose by a linear function of temperature. The limit state function in model II is given as a function of wood moisture content and temperature.
In the climate model, wood moisture content is calculated from the global climate data. Moisture content depends on the relative humidity and is increased due to precipitation.

3. RESULTS AND CONCLUSIONS

By calculating the daily dose and accumulating the dose for one year a measure of the risk of decay is obtained. This is made for several sites, and the results in terms of dose-days can be compared

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between the different sites. To be able to compare different sites, the dose was transferred to a relative dose by dividing it by the dose for the “base-station” Uppsala.

A map over Sweden showing the relative doses calculated with model II for 35 sites is shown in Figure 1. Values below 1.0 show less risk for rot compared to Uppsala, values higher than 1.0 higher risk for rot compared to Uppsala. Border lines for different climate zones can be drawn according to those relative doses. Highest risk for decay is in climate zone 1 – the coastal region in the south of Sweden, lowest risk in climate zone 5 – the inner parts of Northern Sweden. A comparison of the relative doses calculated with the two different models was made. In general, the models show comparable results. In total, the ratio between model II and I gives an average of 0.95 with a coefficient of variation (COV) of 0.20.

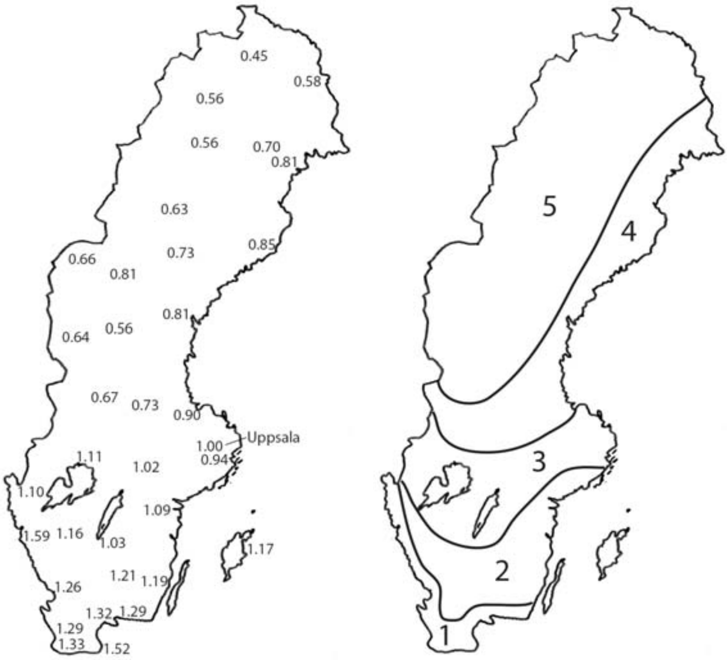

Figure 1 – Relative doses for 35 Swedish sites (left) and climate zones according to relative doses (right); calculated with model II. Relative dose compared to Uppsala. Upper limits of relative doses can be proposed for the different climate zones.

Furthermore, calculations resulting in relative doses with both models using simulated climate data were made for different sites in Europe. Even here, the two models give concordant results. For 22 of the European Sites, also measured wood climate was available from tests by Brischke (2007). Even here, the agreement between models I and II is good, as is the agreement between relative doses calculated with Meteonorm-climate and measured wood climate (pine sapwood).

The two described dose-response models can describe risk for decay of timber exposed outdoors above ground. Despite the differences in the moisture-induced and temperature-induced doses, and the model for the total daily dose, the two models give concordant results when decay risk is simulated for different sites in Europe. Differences in results are obtained mostly for dry sites, where higher doses are found in model II.

The models can be used to classify risk for decay caused by climate variability in Europe. As the results from simulations using Meteonorm weather data and from measured wood climate are concordant, in the future, simulated weather data may be used to specify decay risk for different sites in the world. However, improvements in the models, both the dose-response model and the climate model transferring macro climate to wood climate should be made. Evaluating sites in terms of their relative decay potential needs to be replaced by quantifying factors for the service life to be expected under certain reference conditions. Therefore a series of studies is ongoing within the Swedish WoodBuild program.