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Simple and accurate temperature correction for moisture pin calibrations in oriented strand board

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ABSTRACT

Oriented strand board (OSB) is commonly used in the residential construction market in North America and its moisture-related durability is a critical consideration for building envelope design. Measurement of OSB moisture content (MC), a key determinant of durability, is often done using moisture pins and relies on a correlation between MC and the electrical resistance (R) of the OSB between the pins. Early work on these correlations focused on solid lumber and recent correlations for engineered wood products lack data regarding the temperature effects on R. We provide data on 1001 resistance measurements in OSB, sourced from three different locations, over a wide temperature (−17 °C–70 °C) and relative humidity (35%–95%) range. This data, in conjunction with gravimetric MC readings, is used to test existing correlations and support a new simple, accurate formula for calculating MC from resistance and temperature measurements in OSB.

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1. Introduction

Oriented strand board (OSB) structural panel sheathing has been used in the North American residential construction market for several decades (see Zerbe [1] for a history of development). OSB has moisture transfer properties that differ from both plywood and construction lumber [2,3]. Moisture-related durability is a critical consideration in building envelope design, particularly when insulation levels and airtightness of wall and roof assemblies are increased or new materials are introduced. Over the last 15 years a large number of field studies in various North American climates have monitored the hygrothermal performance of wall and roof assemblies that include OSB sheathing [4–24]. The moisture content (MC) of OSB sheathing is a key criterion for evaluation of field moisture performance. Moisture accumulation in wood-based materials can lead to mold growth, fungal decay, corrosion of embedded metal fasteners, expansion-contraction damage, and loss of structural capacity. Development of mathematical models for some of these damage functions is the subject of ongoing research [25–35]. While mold growth depends on surface water activity (rather than bulk moisture content, though these are related), the other types of damage are dependent on moisture content. For example a common rule of thumb suggests keeping wood products below 20% MC to minimize risk of decay [36–38]. In addition, questions about moisture risk have driven the ongoing interest in validation and tuning of hygrothermal models as well as parametric analysis [39–48] which allow the prediction of OSB moisture performance during the design of building envelope assemblies. Verification of the models depends on accurate measurement of MC in field and laboratory studies to compare to model prediction.

A common method for measuring moisture content of wood products in the field is through use of a moisture meter, which allows immediate spot readings, or installation of moisture pins with a data acquisition system for long term monitoring. Other researchers rely on direct gravimetric measurement which requires obtaining the mass of a wood sample before and after oven drying. Direct measurement, however, can be cumbersome in practice when applied to field experiments as it relies on either cutting out a specimen or inserting and removing a wood plug from a location in the assembly that may not be readily accessible [49]. While highly accurate, the method is labor intensive and may limit the frequency and extent of data collection. But it does find use in laboratory studies such as [50] which also illustrates the use of OSB outside the North American context as an interior vapor retarder. So while direct gravimetric measurement has its place, and OSB can be used

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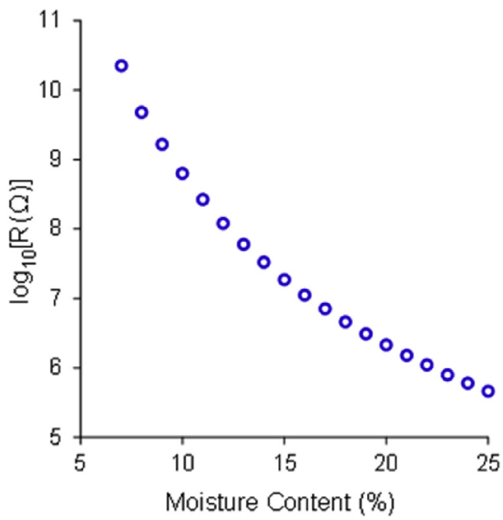

Fig. 1. Resistance vs moisture content in Douglas-fir at 27 °C (80 °F).

for applications besides exterior sheathing, our work seeks to improve the practice of using moisture pins to measure MC in OSB commonly used as exterior sheathing where the risk of moisture accumulation is elevated (relative to interior use). A number of excellent guides to these field measurements are available [51,52]. These systems measure the resistance (R) between the two pins fastened into the wood and assume a correlation between the resistance and the MC. That correlation, and the variability of wood itself, makes this method inherently less accurate than a direct gravimetric measurement of the MC. Early work by William James identified the many factors that influence moisture meter readout [53], and he presented a table with resistance at various MC points for a variety of wood species [54]. That basic correlation for Douglas-fir, which is shown in Fig. 1, provided the foundation for much current work and many commercial moisture meters.

The correlation for Douglas-fir at 27 °C (80 °F) can be expressed[1] as:

$$\log_{10}(MC) = 2.971 - 2.086 \log_{10}[\log_{10}(R)] \tag{1}$$

This correlation, like much of the work on moisture meters, is valid near room temperature. When moisture meter users want to find MC at different temperatures a correction is applied, which is often based on the extensive work of Pfaff and Garrahan extending the original work by James [55–57]. Their correction factors for species and temperature include a large number of wood species but did not cover engineered wood like OSB. Dissatisfaction with the complicated form of the Garrahan temperature correction, along with the two step nature of the calculation, was a significant motivation for undertaking our study. We want a simple and direct correlation that always includes temperature. There has not been enough attention paid to the temperature effects on moisture meters and very little published data exists supporting the temperature correction factors in engineered wood products. For example, moisture meter correction factors for untreated and ACQ treated plywood were provided by Boardman et al. [58] but did not include temperature compensation. Correction factors for OSB by Carll et al. [5] and Maref et al. [59] similarly were developed only at room temperature.

[1] This fit minimizes the error in prediction for MC based on James' data [54] and differs slightly from the fit provided by Straube et al. [52] which apparently minimized the error in $\log_{10}$(MC).

The lack of temperature correction factors for moisture content of engineered wood products introduces an unquantified measurement uncertainty in field investigation of new assemblies. Temperature correction can be particularly important for wall sheathing in cold climates and roof sheathing in any climate. The observation that the electrical conductivity of wood increases with increasing temperature has been known for over 50 years [53]. Further this suggests "that in wood the mechanism of conduction is by charge carriers whose number or mobility is increased by thermal activity" [53]. Recent work by Zelinka et al. [60] advanced understanding of electrical conductance of wood though a percolation model that explains conductivity due to water pathways when the MC is 16% or more. Below the percolation threshold the conduction mechanisms are still not clear, and empirical models that reflect diffusion theory and Arrhenius equations provide some guidance on how the conductance responds to temperature (pg. 175 Hummel [61], see also [62,63]). Given this background, further work on temperature correction is warranted, especially for engineered wood products.

The present study is part of a larger effort to understand the effects of external insulation on OSB drying in a variety of test walls. To get accurate measurement of the MC of the OSB we compiled a number of OSB moisture pin correlations recently in use, including the method used by the moisture pin equipment manufacturer. Fig. 2 presents these OSB correlations at room temperature, along with James' Douglas-fir data for reference [54]. Although the correlations all indicate that OSB is more conductive than Douglas-fir lumber, they differ considerably when used to predict OSB moisture content. For example, a resistance reading of 1 MΩ (10^6 Ω) would yield an OSB moisture content of about 17% using one correlation but about 21% using another correlation. The reasons for this large variation are not clear. The form of the correlation may not reflect well the underlying physics, or the fit may have been taken on too few samples, or the samples themselves may have differed because of different OSB manufacturing techniques and wood species used. We set out to improve on these existing correlations while also establishing a better understanding of how OSB sourced from

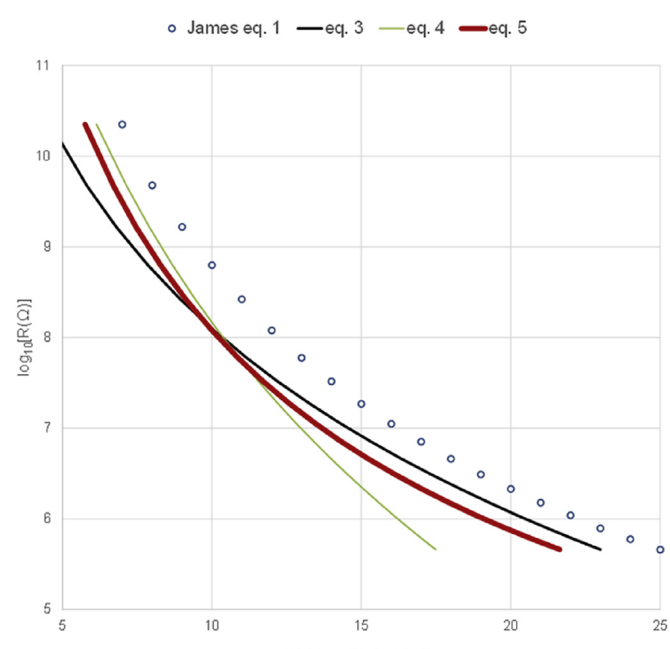

Fig. 2. Resistance vs moisture content given different correlations for OSB, with Douglas-fir reference [54].