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H_2O_WoodController: "Development of a safety-related monitoring system to detect moisture-induced problems in timber structures"

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1 Summary

In cooperation with Miebach Engineers and PROGEO Monitoring GmbH, scientists of the Fraunhofer Institute for Building Physics IBP and Rosenheim University of Applied Sciences developed an area-based wood-moisture-content measurement system for monitoring timber structures, entitled "H_2O Wood Controller". The functional principle is based on the electrical resistance of a cable cross-section.

2 Background

For many years now, monitoring safety-relevant components of motor vehicles has been common practice. In the construction sector, however, similar screening systems have scarcely been used or have not been available at all. In view of many negative past and present examples, however, the necessity of monitoring buildings and structures becomes clearly evident. Every year, damages that have not been detected cause renovation costs running into billions. Lacking effective structural monitoring, even the collapse of buildings cannot be excluded. Most of the building damages affecting wooden structures can be attributed to the penetration of moisture or to the impact of moisture loads which occur on account of special physical conditions (for instance, due to the extreme conditions prevailing in indoor ice rinks and indoor swimming pools). Regarding the great variety of potential causes of damage (e.g. aging of sealing materials, errors in planning and mounting, changes of use and inappropriate user behaviour), it is almost impossible to predict where damages will occur. For these reasons, fullest possible surveillance of structural conditions should be ensured.

3 The research project "H_2O WoodController"

The "H_2O WoodController" method enables experts to conduct comprehensive and cost-efficient analyses of a building's structural condition. In the following section, the functional principle of the sensor will be described, using the example of a recently developed sensor segment made of glued laminated timber (GLT).

The GLT sensor segment consists of three layers of spruce wood. By inserting wire mesh, the glued joints become electrically conductive. The wire grids are contacted via cables and connected to a newly developed resistance meter. The central layer of the GLT sensor segment is considered an electrical conductor. The wood moisture content is determined on the basis of the "cable resistance".

- Decreasing "cable resistance" = increasing wood moisture content
- Increasing "cable resistance" = decreasing wood moisture content

It is possible to detect potential moisture-induced damages in a building by tracing an interruption of the conductive layer inside the GLT sensor segment.

4 The research work

In the case of the "sensor segment", the central layer of the sensor field (solid spruce wood) is regarded as an electric conductor, whose electric conductivity varies depending on the respective moisture content.

Using equation $\boldsymbol{R = \frac{\rho \times d}{A}}$, the cable resistance R in Ω of any given material can be calculated for any given dimensions, where:
ρ = specific resistance in Ωmm²/m,
d = thickness in m,
A = area in mm².

The specific resistance for the temperature and moisture conditions specified can be calculated by transposing the equation for ρ, via the measured resistance R. The traceability of the measured resistance values to the specific resistance holds the advantage that the dimension A of the sensor fields can be varied as required, particularly with regard to practical applications as a large-scale wood-moisture monitoring system.

To determine the specific resistance of spruce wood, 16 sensor segments were prepared (dimensions: 260 × 100 mm, total thickness: 15 mm). These sensors were exposed to different climatic conditions while the electrical resistance was continuously measured. Several gravimetric measurements were performed in order to determine the wood moisture content. Using a final kiln-drying test, it was hence possible to determine the exact wood moisture content of the sensor segments during the gravimetric measurement, and the specific resistance could be allocated to the wood moisture content.

The approximate equation $R_{spez.}$ = 2E-0.5 u -10 describes the relation between the wood moisture content and the specific resistance of spruce wood at a temperature of 20 °C.