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PERFORMANCE OF BIO-BASED BUILDING MATERIALS - PRODUCTS MEETING EXPECTATIONS

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Abstract

The use of biobased building materials is an important factor in our modern Built Environment, particularly in meeting global environmental challenges linked to continued urbanization. This increase in use comes at a time when performance expectations continue to rise. This paper will review some of the activities from a recently completed COST Action, FP1303 "Performance of Biobased Building Materials", with particular emphasis on moisture performance.

Keywords:
Biobased materials; performance; moisture, testing, modeling; COST.

1 INTRODUCTION

On 28 November 2018, the European Commission adopted the long-term strategic vision for a climate neutral economy by 2050. Europe shall lead the transition to climate neutrality by investment in realistic technical solutions while ensuring social fairness [European Commission 2018a]. This press release, in conjunction with the EU's strategy for sustainability [European Commission 2018b] means that Europe will lead the transition to climate neutrality by investment in realistic technical solutions while ensuring social fairness. One of the seven strategic building blocks identified to reach net-zero emissions is to fully utilize the benefits of the bioeconomy, where improved utilization of the biobased resources will be necessary. A transfer from carbon-intensive raw materials creates a large climate benefit as wood used in construction which will not only replace carbon- intensive materials, but also function as carbon storage. The EU strategy also points out how an increased bio-economy can create up to one million new jobs in EU until 2030. This policy also requires greater resource efficiency and improving opportunities for lesser-used timber stands.

The ambitious aims of climate neutrality come at a time when political drivers are also aiming to minimise increasing global temperatures resulting from human activities, with the increasing population becoming more urbanised – indeed it is projected that 70% of the global population will live in urban conglomerations by the same 2050 deadline.

Timber construction has long been recognised as a means of achieving low-carbon solutions for construction, and an increased understanding from architects and specifiers has led to many believing timber to be the material of choice for the 21st Century. Hence there is a growing need for timber-based solutions, preferably in ways susceptible to discolouring and degrading organisms. Discolouration by stain and mould fungi as well as fungal, bacterial, and insecticidal decay is limiting the performance of bio-based building materials. Likewise, mould plays an important role not only in outdoor environment, but also in the building envelope with partly drastic impact on the indoor air quality and thus on the health of human beings. Furthermore, the aesthetical appearance of building components (e.g. window frames, cladding) is compromised by stain, which becomes an increasing issue across Europe and worldwide. The timber industry is now seeking for effective methods and treatments to protect wood and other bio-based building materials from surface mould growth and fungal disfigurement because of the perceived threat of losing costumer preference. Previously this has been achieved through the use of wood preservation, but changes in legislation and increasing understanding of toxicity has led to the commercial developments of alternative methods.

Regardless of whether biobased materials are used in their original format, or enhanced by various treatments, their performance in use is critical in our modern society. The aim of this paper is to outline some of the key factors affecting performance of biobased materials in the modern Built Environment and some of the recent advances in testing protocols for these materials. The COST Action FP1303 "Performance of Biobased Building Materials" ran between 2013 and 2017, focusing on many of the issues facing biobased materials, such as product performance, moisture interaction, testing and modeling, design specifications, aesthetics and best practice in design and use.

2 BIOBASED MATERIALS IN THE BUILT ENVIRONMENT

The use of biobased materials has been of major importance throughout human history, mainly due to abundance, ease of use and adaptability, relative simplicity to use and sustainability. Among the advantages of these bio-based materials are that they are renewable, almost globally distributed in a variety of forms, easily sourced, readily adapted to needs of use, hydroscopic, recyclable, versatile, porous and non-abrasive. This had led to the recent expansion of what is known as the 'bio-based economy', which represents an increasing area of development globally and covers a wide range of activities incorporating biobased materials [Hannerz 2014, Isikgor 2015].

A recent report [Turner 2017] suggested that within the United Kingdom, the average person spends 92% of their time indoors. It is logical that the indoor environments must be comfortable and enjoyable to spend time there, as well as not impacting on personal health requirements. The term indoor environment includes indoor climate (i.e. thermal, atmospheric, acoustic, actinic and mechanical environments) as well as aesthetic and psychosocial conditions. Building materials affect the indoor environment [Bysheim 2016]. Use of wood in indoor environments probably affect how rooms are perceived by users [Strobel 2017] but may also affect psychological outcomes and health outcomes [Burnard 2015, Ikei 2017]. Users of an indoor environment will be able to sense wood materials directly with multiple sensory areas (multimodal): visual, tactile, olfactory (odour). But physical properties of interior wood surfaces will also affect the indoor environment indirectly, for example when hygroscopic wood surfaces absorb and desorb moisture, balancing daily variation in humidity and temperature [Nore 2017], the amount of particles in the air or by the release of volatile organic compounds (VOC).

The use of biobased materials provides the capability to mimic and exploit properties that have evolved in nature to provide certain performance characteristics. Biobased materials have the potential to provide construction materials with the following benefits:

- The capture and storage of carbon extracted from atmospheric CO_2 through recent photosynthesis;
- Sustainable production as crops grown annually or as longer harvest-cycle foresting, including secondary products from food growth;
- Biodegradability at end of service life;
- Exceptionally low or almost zero linear coefficients of thermal expansion, often comparable or better than many man-made products;
- The property of controlling temperature and humidity in enclosed spaces as a direct result of phase changes of water and moisture within cell walls;
- High vapour diffusivity and 'Fickian' vapour dispersal;
- Relatively high specific heat capacity;
- Low thermal diffusivity;
- Excellent performance-to-weight ratios;
- Overall lower embodied energy than man-made or synthetic materials.

Due to their nature, biobased materials interact with moisture. In order to prevent premature failure of these products, various methods have been employed to limit the effects of biological decay, such as the introduction of biocidal products, as typified with wood preservation. However, increased concerns over the environmental impact of such treatments have led to alternative treatments being developed and commercialized, such as those within wood modification, which can alter the interaction of biobased products to moisture (and thus limit risks from biological degradation).

3 MOISTURE RELATIONSHIPS

An area that has seen significant activity is in understanding moisture dynamics and effects on bio-based products and how this then relates to their in-service performance. One study [Willems 2018] has suggested a moisture-sorption model based on the thermodynamics of the bonding configuration of water within cell walls. It is postulated that wood moisture at low humidity is bound to two hydroxyl groups in the cell wall, whereas as high humidity an extra water molecule will cluster at an already adsorbed molecule. It was shown that the fast and slow components of the transient moisture content were consistent with the molecular processes postulated, whilst a closed form expression for the sigmoidal adsorption isotherm based on the sorption model was given. Improving the models for sorption characteristics will help better understand the onset of decay processes and provide greater insight into laboratory and field-test evaluations. One method of assessing the sorption characteristics of wood fibres (and in particular modified fibres) is through the use of inversion gas chromatography (IGC) or Dynamic Vapour Sorption (DVS). The latter showed that there was a lower adsorption curve for the first cycle of modified wood particles, which wax suggested to be due to a softening caused by the increase in relative humidity during the process. Work has also been carried out on modified wood using Functional Data Analysis of adsorption-desorption processes [Van de Bulcke 2014] and through the use of Wilhelmy plate techniques [Sedighi Moghaddam 2014].

Another method that can be used to interpret the moisture interaction in the wood cell wall is near infra-red (NIR) spectroscopy. Studies [Popescu 2016] assessed the moisture interactions of acetylated and propionylated birch (*Betula pendula* L) wood by measuring the most sensitive band to water adsorption, located at 1920 nm. This peak is assigned to the combination of OH stretching and deformation vibrations and increases as the RH increases. The band at 1920 nm is a combination of three component bands located at 1907, 1962 and 1997 nm respectively, associated with the existence of three species of water molecules with hydrogen bond energies distributed around three maxima. This was explained in a study on Sitka spruce [Tsuchikawa 1998] as being due to: free water molecules, molecules with one OH engaged in hydrogen bonding and molecules with two OH engaged in hydrogen bonding.

Comparative studies into preservative-treated wood indicted far greater MCs and days exposed to levels above 25%, which was associated with the sorptive properties of salts present within the treatment. A comprehensive review [Thybring 2013] has assessed the decay risk according to levels of moisture exclusion efficiency (MEE) and anti-swelling efficiencies ASE and ASE* (an alternative measure of ASE, where the volume increase resulting from various wood modification methods has been deducted from the dry volume of the unreacted wood). Through the analysis of modification methods undertaken (Table 1), it was possible to estimate threshold levels for MEE, ASE and ASE* as well as the respective weight gain required for each treatment (a weight loss when considering thermal modification).

Tab 1: Estimated threshold conditions for decay in various wood modifications [Thybring 2013].

Modification	**Threshold (WPG)**	**MEE**	**ASE**	**ASE***
Acetylation	20%	42%	63%	60%
Furfurylation	35%	40%	74%	?
DMDHEU	25%	43%	45%	43%
Glutaralde-hyde	10%	24%	50%	48%
Glyoxal	>50%	?	?	?
Thermal modification	-15%	42%?	46%?	?

3.1 Relevance of moisture thresholds

It is commonly accepted that for biological degradation by fungi to occur, there needs to be air oxygen, slightly acid conditions, favourable temperatures and water which is available as free water in the cell lumen for the degrading processes [Stienen 2014]. Typically, the fibre saturation point (FSP) for European-grown wood species lies around 30 % MC [Popper 2009]. However, this FSP varies between different wood species as well as between treatments and modifications. Several studies showed that different chemical and thermal wood modification processes lead to a reduced equilibrium moisture content [Rowell 2006, Larsson 1994, Metsä-Kortelainen 2006]. Further work has looked at the moisture requirements necessary for colonization and groqth of brown and white rot basidiomycetes for both untreated and modified wood species [Meyer 2015, Meyer 2016], whilst a recent publication has reviewed laboratory conditions used to assess moisture thresholds [Brischke 2017].

3.2 Climatic conditions and hazard mapping

As biobased materials are used a variety of conditions, their service life will vary. To aid users and specifiers, a range of use classes have been defined within the standard EN335 [CECN 2013] and listed within Table 2.

Tab 2: Summary of use class definitions

Use class	**General service conditions**
1	Interior, dry
2	Interior or under roof, not exposed to weather, possibility of condensation
3	Exterior, without soil contact, exposed to weather. If class divided:
	3.1 limited moist conditions
	3.2 persistently moist conditions
4	Exterior, in contact with soil or freshwater
5	Permanently or regularly immersed in salt water

As can be seen from UC2, UC3.1 and U3.2, there are a range of conditions to which samples are exposed, with the severity to service life predictions related to macro and microclimatic conditions. Early work focused on conditions in the United States [Scheffer 1971], where four different sites were initially evaluated in terms of the effects of temperature and local rainfall on the hazard potential of timber samples, according to Equation 1:

$$\text{Climate index} = \frac{\sum_{\text{Dec}}^{\text{Jan}} [(\text{T}-35)(\text{D}-3)]}{30} \qquad (1)$$

in which T is the mean day temperature of the month (in Fahrenheit) and D is the number of days with more than 0.1 inch of rain per month. This original data showed the decay hazard ranged from 0.0 for Yuma, Arizona to 137.5 for West Palm Beach, Florida, whilst within continental USA three distinct climate zones were noted, indicating three levels of above ground decay potential. The concept of the Scheffer Index has been further applied to a range of regions, including Europe, as shown in Figure 1 [Brischke 2011].

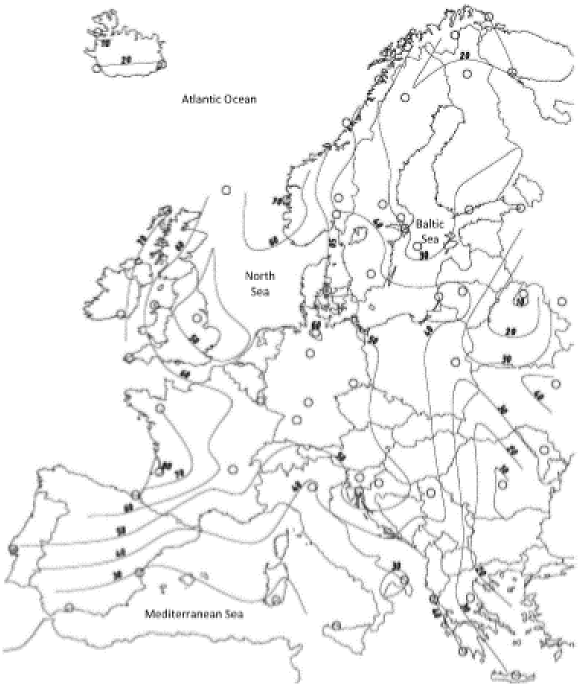

Fig. 1: Relative decay potential for Europe defined in terms of Scheffer's climate index for various European sites [Brischke 2011].

As these studies have developed and expanded, the effect of wind driven rain has become more apparent and led to its inclusion in hazard assessment. As a result, the relationship between rain fall sum, rain fall intensity, wind speed, and wind direction have been assessed to create wind driven rain maps. These studies are helping in developing better methods for assessing risks to timber components in use (e.g. cladding). A decay risk model based on laboratory data was used [Viitanen 2010] to estimate wood decay across Europe. As a result, it was possible to determine the mass of Scots pine (*Pinus sylvestris*) sapwood as a result of brown rot decay related to the level of exposure to rain (Figure 2) and for similar wood samples protected from rain (Figure 3). Since the data in Fig. 3 was only based on relative humidity and temperature data, no capillary uptake of moisture could be attributed via this model. The model appeared to deliver conservative results for sheltered wood. When wood was protected from rain – and provided there was no external moisture source – less mass loss was expected from a biological viewpoint since the presence of liquid water inside wood was an essential requirement for its degradability by fungi.

Work [Frühwald Hansson 2012] developed a dose based decay hazard map, further describing the relationship between weather conditions, relative humidity, temperature and precipitation with wood moisture content and wood temperature. Mapping of the data collected from 206 sites across 38 European countries, standardized to a fixed location, selected to be Uppsala in Sweden. Thus values below 1.0 were deemed to have lower decay potential compared to Uppsala, and higher values experiencing greater decay.

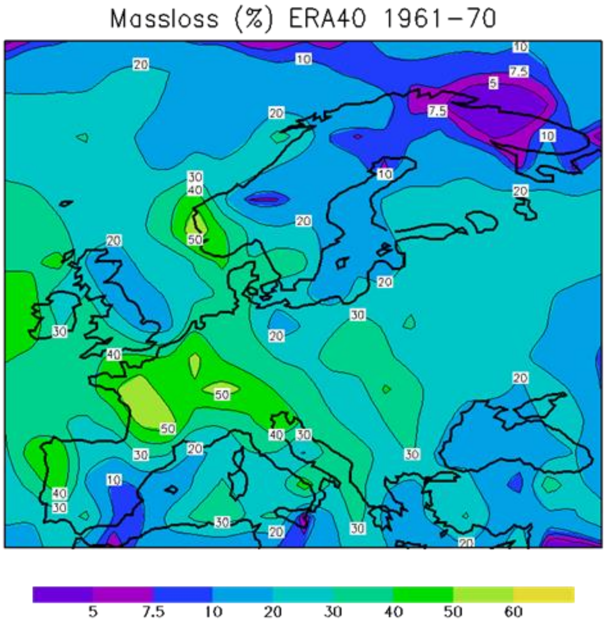

Fig. 2: Modelled mass loss (in %) of small pieces of Scots pine sapwood exposed to rain over a period of 10 years in Europe [Viitanen 2010].

Comparison of data across different sites and countries allowed for isoplethic mapping as shown in Fig 4, where the darker red colours depict the areas of greatest decay risk and dark blue those of lowest decay risk.

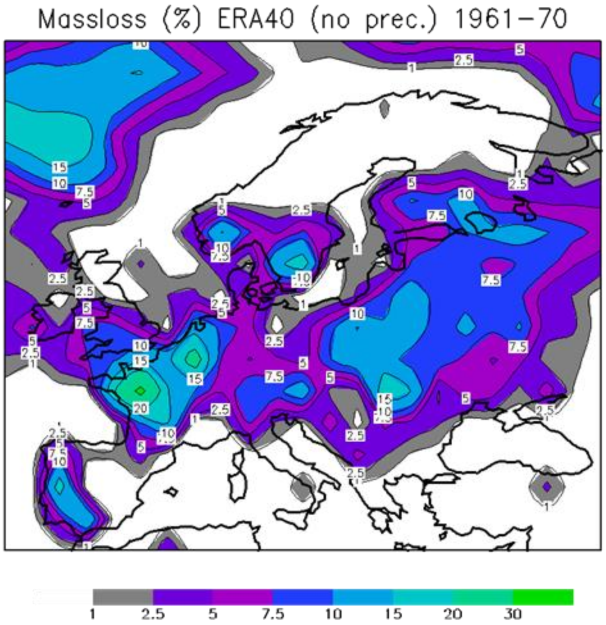

Fig. 3: Modelled mass loss (in %) of small pieces of Scots pine sapwood protected from rain over a period of 10 years in Europe [Viitanen 2010].

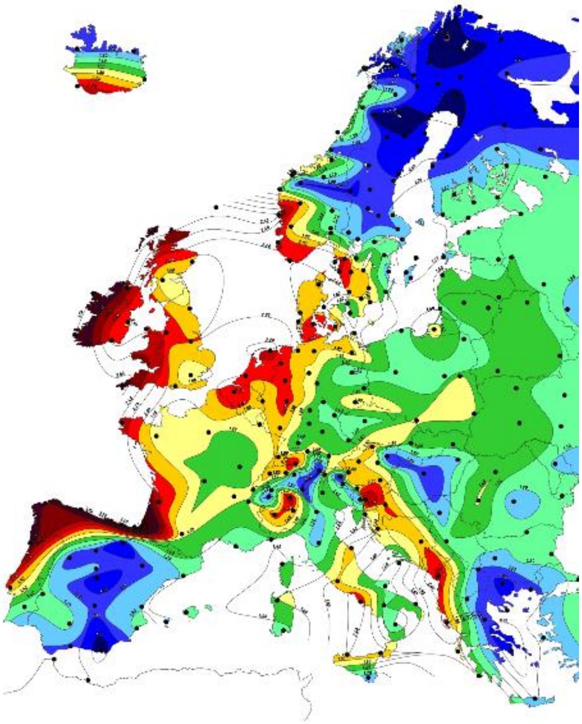

Fig 4: Relative decay potential for Europe relative to Uppsala, Sweden [Frühwald Hansson 2012].

4 MODELLING OF PERFORMANCE

Predicting the performance of bio-based building materials requires modeling the onset and development of fungal decay and other types of biotic degradation. The mathematical background for any performance prediction is therefore a performance model.

Mathematical models are widely used in natural sciences to handle different variables, such as input variables, state variables, exogenous variables, random variables, and output variables. As an example, engineering models frequently work with limit states (Limit state design, LSD), and therefore the limit state theory is already established in numerous building codes around the world. The service life of structures can be determined using several approaches that have been classified by the Joint Committee on Structural Safety (JCSS). The most complicated approaches comprise of so-called Level III calculations, where for each variable of the structure (e.g. strength, stiffness, durability, loads) the actual or an estimated statistical distribution of the parameter is used. For wood, such distributions are often unknown or have a high uncertainty level. The consequences of these uncertainties are that extremely high safety levels are aimed for, which often are not supported by practical evidence from existing buildings. According to the JCSS Model Code, three levels of calculations can be made with respect to the safety of a structure. Level I is fully deterministic and undertaken using methods such as Load and Resistance Factor Design (LRFD), Level III is fully probabilistic and dependent upon extensive numerical calculations such as Monte Carlo simulations, whereas Level II makes use of partial safety factors determined by Level III calculations, and that allow for some statistical variations to be included in the analysis, as well as being giving a basis for design codes based on Level I calculations.

In contrast, biological models tend to display full life cycles or degradation processes, respectively. This stands to some extent in contrast to the limit state concept if it is not regarding the full life span of a building component.

Alternatively, dose-response functions can be used to describe the change in effect on an organism caused by differing levels of exposition (= dosage) to a stressor after a certain exposure time. Biodegradation of bio-based building materials can be understood as a negative growth process – the (positive) growth of and degradation by decay organisms causes a reduction of strength and biomass, with consequences for serviceability as well as safety against failure. The principle of a dose-response relationship is displayed as a sigmoid graph [Brischke 2014] representing the full life span of bio-based building component starting slowly with an initial lag phase before onset of decay (e.g. limit state 1) and finally ending with an approximation to complete failure (limit state 4). Such a dose-response relationship might be considered as an ideal or normal scenario. Nevertheless, degradation processes and thus performance of building components over time can significantly deviate from this normal case depending on the material, the degrading agents, component dimension and design as well as many other factors. Such deviations should not be ignored, as this can lead to overestimating or underestimating the performance of a material from extrapolation of decay data.

4.1 Exposure, decay, and resistance models

The performance prediction of wooden structures is generally a three-step approach, whereby a design solution is considered successful if the exposure dose over time stays equal or below a critical dose characterising the resistance of the material in use. In order to achieve this, the following need to be considered:

Resistance models

A resistance model should allow for quantifying the resistance of a material against the various deteriorating agents based on the material inherent protective properties, wetting ability and susceptibility to crack formation and ageing. Work has developed [Brischke 2015] on using laboratory and field test data to predict the material resistance of a variety of naturally durable wood species on the base of a dose-response concept.

Decay models

The input variables for decay models are material climatic parameters such as ambient humidity, wood moisture content and temperature. Early work [Viitanen 1997] developed a decay model of brown rot fungi which cause damage in building components. The model is based on the effect of ambient humidity (RH), moisture content of wood, temperature (T) and exposure time (t). The aim of the model is to evaluate the decay risk in different structures exposed to elevated humidity exposure. This work continued into the studies on effects on wind driven rain and protection of samples in service as well as defining critical doses, decay onset, failure and specific mass losses [Viitanen 2010].

One of the earliest and most comprehensive attempts to model decay and other damage of wood was undertaken within the Australian ‘TimberLife’ project [MacKenzie 2007], which developed a basic model for timber decay above ground in terms of decay depth over time. The rate of decay was defined according to Equation 2:

$$r = k_{wood} k_{climate} k_p k_t k_w k_n k_g \qquad (2)$$

in which r is the decay rate, k_{wood} is a wood parameter, $k_{climate}$ is a climate parameter, k_p is a paint parameter, k_t is a thickness parameter, k_w is a width parameter, k_n is a fastener parameter and k_g is a geometry parameter, with various k factors published in CSIRO Manual Number 4 [Wang 2008]. Furthermore, a time lag before the onset of decay was also determined and implemented into service life determinations.

Exposure models

The final step in performance modelling is to predict the material climate within a wooden component from external factors such as climate, design, and potential surface treatments [Niklewski 2016]. Whilst the majority of exposure models describe the diffusion processes in wood in the hygroscopic range, the more crucial way of moistening wood exposed outdoors is the capillary uptake of liquid water, e.g. due to rain or condensation. Later approaches have aimed on combining the two principal ways of wetting, diffusion and capillary condensation as well as water vapour desorption during re-drying.

Linking the three general steps of modelling – usually represented by at least three different (sets of) models is the final challenge and requires a lot of adjustment with respect to the variety of different design solutions, materials and ways to modify and preserve the latter as well as local climate divergences, e.g. due to topographic peculiarities of a location. Furthermore, the mould and decay models can be connected to hygrothermal models like WUFI simulation for evaluating the potential risk of mould and decay to develop.

4.2 Design Guidelines

Within the European research project ‘WoodExter’ a first technical guideline for design of wooden constructions with respect to durability and service life has been produced in Europe [Thelandersson 2011]. The guideline is based on a limit state described as "onset of decay", i.e. equal to decay rating ‘1’ (slight attack) according to EN 252 (CEN 2015).

On an engineering level the design condition is formulated as shown in Equation 3:

$$ISd = ISk\gamma d \leq IRd \qquad (3)$$

in which I_{Sk} is the characteristic exposure index, I_{Rd} is a design resistance index and γ_d depends on a consequence class, which refers to the expected consequences if the limit state is violated. The design is accepted if the condition in Eq. 3 is fulfilled, otherwise it is not accepted. The exposure index I_{Sk} is determined by:

$$I_{Sk} = ks1 \cdot ks2 \cdot ks3 \cdot ks4 \cdot I_{S0} \cdot ca \qquad (4)$$

in which I_{S0} is the basic exposure index depending on geographical location/global climate, k_{S1} is the factor describing the effect of local climate conditions (meso climate), k_{S2} is the factor describing the effect of sheltering, k_{S3} is the factor describing the effect of distance from ground, k_{S4} is the factor describing the effect of detailed design, and c_a is the calibration factor to be determined by reality checks and expert estimates.

The WoodExter approach closely follows the factor method idea according to ISO 15686-1 [ISO 2011], but also incorporates an engineering approach with clearly defined limit states and can be fed by dose-response models.

Work in the subsequent Swedish research program ‘WoodBuild’ saw further efforts being made to develop performance models (regarding fungal decay as well as mould growth). Starting from the WoodExter approach a new design guideline was developed which considered results from various field studies and monitoring projects of timber structures in service [Isaksson 2014]. Modifying factors describing the effect of different design details are based on long-term measurements and observations on real buildings.

4.3 Weathering

Weathering is a general term used to define the slow degradation of materials exposed to climate parameters. Every material exposed to weathering is degraded by various environmental agents, and its selected properties are consequently deteriorated. The intensity and extent of the degradation depends on several factors and its kinetics may vary in different biobased materials and exposure locations

The rate of weathering varies within one type of biobased material, its function within a structure, architectural solutions, surface finishing technology applied, but most of all on the specific local conditions and weather history. The most important factors affecting weathering kinetics are solar radiation and stresses imposed by cyclic wetting (moisture), together with temperature changes, environmental pollutants and actions of certain micro-organisms. Unfinished raw bio-materials may weather most rapidly as a result of gradual changes to its unprotected physical/chemical structure. However, the surface erosion rate is generally slow, being ~6 mm per century in case of typical softwood species exposed in a mild climate zone [Williams 2005]. Despite this slow rate of weathering, the aesthetical aspects of a product can significantly limit acceptable service life based on consumer perception.

The quantitative description of the surface degradation progression along the weathering duration is a required step for the numerical model development. The concept for calculation of weathering coefficient has been reported [Sandak 2015], whereby a customised algorithm for multi-sensory data fusion and computation of a weathering indicator normalised the raw data (parameters) p_i as obtained by each sensor i and summarises these, considering their importance (weight) w_i. The W_{ind} computation algorithm is mathematically expressed in Equation 5:

$$W_{ind} = \frac{\sum w_i \cdot p_i}{\sum w_i} \tag{5}$$

The resulting W_{ind} can be considered as a weighted average indicating the state of the surface degradation, where $W_{ind} = 0$ corresponds to a non-weathered sample and $W_{ind} = 1$ to its terminal state. The weathering indicator method is a simple technique usable to combine information from various sources. Nevertheless, it is frequently applied to directly model the effect of the weather on a single property, such as CIE L*a*b* colour change (ΔE), surface corrosion, glossiness or surface free energy.

5 PERFORMANCE BY DESIGN

Since all biobased building materials are susceptible to degradation by various biotic agents, there is a need to carefully select materials for use, how they are treated, how they are incorporated into building design and how they are maintained. In the first instance, this means moisture, temperature and oxygen level should be kept below minimum or above maximum for activity or even survival of any respective attacking organisms.

In a broader sense, the choice of materials, e.g. wood species of different durability for differently severe exposure conditions can also be considered as part of the design process and therefore being ‘protection by design’. Purpose related selection of building materials, the use of building components in adequate dimension, and the consideration of physical properties such the anisotropic deformation of timber due to swelling and shrinking should be part of the building conception (conceptual protection).

Usually protection by design is used synonymous with “moisture protection” to avoid any moisture-induced risk for decay or any other kind of biotic attack. Hereby, two principle rules are followed: 1.) Keeping water away from the structure, and if this is not possible 2.) Removing water from the structure as fast and as effective as possible. It is agreed in general that biocidal treatment is applied for wood only, if wood cannot be protected by construction measures.

Besides numerous design solutions water can be kept away from organic building material by application of coatings and covers (physical protection). Coatings have long been used efficiently for moisture protection of timber products such as window joinery or claddings. However, their efficacy strongly depends on their own robustness and climate. As soon as a coating becomes defective, its protective character can turn into the opposite since defective coatings act as water traps. For example, thick organic coatings were found very effective in UK and Northerner Europe. On the other hand, in much warmer and sunny southern Europe they were found considerably less efficient.

6 PERFORMANCE AND STANDARDISATION

In the context of constantly increasing expectations of customers and end-users regarding information about the service life of wood-based products or commodities in real-use conditions (indoor, outdoor, above-ground or in-ground contact, etc.), a specific CEN/TC 38 working group was created in 2010, fully dedicated to this topic (WG 28 – “Performance classification”). The future of sustainable wood products clearly relies on having a system of standards that can adapt to real-world practice and provide better service life or performance classification information. Moreover, evaluation of the performance of wood and wood-based materials will provide the wood sector with data supporting essential requirements of Construction Products Directives/Regulations (CPD/CPR).

Performance can be determined either by an adequate set of laboratory tests including relevant ageing procedures or by field tests simulating in-service conditions. If field test data are available, they shall take precedence over the data from laboratory tests. If no data from field tests are available, a provisional classification using the data from laboratory tests is acceptable. EN 252 [CEN 2014] provides a method which can be adapted to assess the performance of wood and wood-based materials to withstand bio-deterioration (decay fungi and subterranean termites) over time. The principle of the test consists in half-burying stakes manufactured with the material to be tested in the ground of an experimental field, alongside with stakes made of a non-resistant wood species used as references. Comparison between the time before failure of the wood-based material under test and a reference wood species or material can be a possible assessment criterion.

An additional CEN Technical Committee, CEN/TC411 was set up in 2009 to specifically define standards concerning terminology, methods, criteria, guidance and tools (on, for instance, product declarations), applicable to biobased products, as well as standards for horizontal aspects, including sampling, biobased content, application of LCA, sustainability criteria for biomass and final products, and end of life and biobased (carbon) content. CEN/TC 411 also intends to develop a certification scheme (or schemes) for biobased products, identifying which characteristics can or should be assessed and how they should be reported. These standards will play an important role in the uptake of bio-based products, both in consumer markets and in public procurement, by enabling clear communication about the benefits of bio-based products.

7 SUMMARY

Increased interest in the use of biobased materials within modern construction is placing ever increasing demands on product performance. This paper provides an overview of some of the recent advances reported as part of COST FP1303 “Performance of Biobased Building Materials” and in the wider scientific literature, focusing on how testing, modelling and design all need to come together and provide data suited to new standardisation methods across Europe and globally. As the understanding of product performance increases, so will the robustness of test data and associated models, leading to greater consumer confidence in biobased products.

8 ACKNOWLEDGMENTS

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