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KEYNOTE SPEAKER

Rebecca Williams

Rebecca Williams is a public speaking, storytelling, and presentation expert. She grew up in a world of opera and spent her early career teaching English and exploring hot springs in rural Japan. After teaching stints in Spain, Nepal, and Australia, she started consulting on storytelling, public speaking, and leadership communications for tech companies in San Francisco. Since then, Rebecca has served as a public speaking coach at the Stanford Graduate School of Business and has trained professionals and teams at organizations including Google, Meta, and Netflix. For over 10 years, Rebecca has taught global leaders how to show up with authenticity, connect with audiences, and captivate through storytelling. She has lived in six countries, and currently calls Lisbon, Portugal home.

KEYNOTE SPEAKER

Sumea Klokic

Bright Beams for a Greener Future:
Synchrotron Techniques in Renewable Science

Sumea Klokic completed her master's degree in chemistry in 2019 and her Diploma in Technical Chemistry in 2020 at Graz University of Technology, where she also earned her PhD in Chemistry (Natural Sciences) in 2022. During her doctoral studies, she conducted her research at the Austrian SAXS beamline at the ELETTRA synchrotron in Trieste, where she continued to work as a Researcher since 2023.

Her research focuses on the structural and chemical characterization of materials used in sustainable and environmental applications, particularly in the fields of energy storage and CO_2 capture. She develops multidisciplinary approaches to monitor stimuli-driven, dynamic processes in materials by combining synchrotron-based techniques such as small-angle X-ray scattering (SAXS) and infrared spectroscopy with complementary tools like quartz crystal microbalance (QCM).

Her doctoral thesis was recognized with the prestigious Karl Schlögl Award and a DOC Fellowship, both awarded from the Austrian Academy of Sciences (ÖAW). She is also a recipient of the Otto Vogl Prize and the Advancement Award of the Austrian Chemical Society. Sumea Klokic has received multiple Best Presentation Awards at international conferences and was named an Austrian Role Model for Women in STEM, Science, and Research in 2023, an honour presented by Federal Minister MMag.a Dr. Susanne Raab as part of the "Let's Empower Austria" (LEA) initiative.

MEZeroE Open Innovation Test Bed for building envelope products: how can open innovation lead to better building envelopes?

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Innovation in construction industry is traditionally slow, with several innovative and potentially effective products that never reach the market or, even if they do so, their full potential is only partially exploited.

Within construction industry, in recent years, building envelope systems have become increasingly more complex with the development of solutions such as adaptive and multifunctional façades which serve more purposes than traditional envelopes and often embed multiple technologies. These envelope solutions may comprise several passive and active components such as advanced membranes, mechanical ventilation machines and integrated photovoltaics that must be mutually optimized to ensure a global elevated performance. To ensure that such potentially better solutions reach the market, and hence society can benefit from them, two main issues must be addressed: companies must be supported to (i) maximize technical performance and avoid conflicts between components, and (ii) certify their products to be able to sell and install such products.

To address such issues, MEZeroE Open Innovation Test Bed (OITB) offers an EU distributed network of experimental facilities and technical support, services to address certification issues and foster open innovation, and support to conduct a performance analysis of envelope products in real buildings used as living labs.

The aim of this workshop is to evaluate the strengths and weaknesses of MEZeroE OITB as currently constructed. To do so, the workshop comprises an introduction, four thematic interactive sessions, followed by a moderated discussion, and a wrap up discussion. The four sessions are about lab and technical support, services for certification and open innovation support, real-world performance analysis in real buildings, and industry perspective.

Keywords: OITB, building envelope, open innovation, testing facilities, R&D support

Acknowledgment: This work was performed with H2020 MEZeroE project which has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 953157.

WoodStock living lab workshop – co-development of European Wood Construction Observatory (EWCO)

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WoodStock is a multifaceted project dedicated to advancing climate-smart wood construction practices in alignment with the New European Bauhaus (NEB) initiative. A primary focus is the quantification and mapping of wood resources, including under-utilised wood.

As part of this project, partners are developing the European Wood Construction Observatory (EWCO), an AI-driven tool for anyone looking for information about wood and the wood construction sector. EWCO provides access to best practices, guidelines, and innovative solutions, while facilitating knowledge exchange and collaboration among stakeholders. In alignment with the NEB Academy, it ensures longevity and impact beyond the project's lifetime.

The EWCO provides comprehensive guidelines and solutions for circular and zero-waste building design, tools to expand the knowledge base in sustainable wood construction, and a platform to collect, share, and exchange best practices, including WoodStock project results. The EWCO is built with open-source data and data from project partners. At a later stage, it will use data from at least three mass-timber building projects, including the InnoRenew CoE building which is the largest wooden building in Slovenia. EWCO key features are: 1) Deep learning server, 2) Data management, 3) User interface, 4) IoT integration, and 5) AI system.

The aim of this workshop is to present EWCO to diverse groups of stakeholders, demonstrating how it works and how it can serve its users. The presentation will be followed by a guided discussion to gather feedback on participant's opinions, needs, and suggestions. This will help to further improve EWCO and make it a comprehensive and user-friendly platform.

Keywords: WoodStock, European Wood Construction Observatory, New European Bauhaus, AI tools, wood construction

Acknowledgment: The authors are grateful to the WoodStock project (GA *#101181021*), funded by the European Union under the Horizon Europe programme.

Wood education for sustainable construction – empowering professionals and students to build a more sustainable future through innovative and tailored training in circular wood and timber construction

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The WENUS project aims to enhance Vocational Education and Training (VET) in sustainable wood and timber construction by integrating circular economy principles and 3D printing technologies into the curriculum. It addresses the industry's evolving needs for green and digital skills while promoting innovation, sustainability, and efficiency. By integrating circular economy principles and sustainable practices into the wood and timber construction curriculum, the project also supports the priority of environmental sustainability and the fight against climate change.

The project partners prepared and published the WENUS Joint Curriculum, based on which they will develop the training materials. The Joint Curriculum provides a comprehensive overview of the WENUS training course, including the structure, pedagogical approach, and training methodologies. These resources aim to strengthen professional training in sustainable timber construction and related materials, supporting the transition toward a more circular and responsible sector.

The project was developed to modernise VET in the wood and timber construction sector. It equips learners with essential green and digital skills, addressing the industry's evolving need for sustainability, efficiency, and innovation. Grounded in circular economy (CE) principles, the curriculum integrates 3D printing technologies and Industry 4.0 tools, offering a blend of practical and theoretical knowledge to prepare learners for a more environmentally responsible and technologically advanced construction sector.

The WENUS training course consists of four modules, each comprising 15 units – Module 1: Circular Economy (CE) Principles in Timber Construction; Module 2: Advanced Materials and Sustainable Design in Timber Construction; Module 3: Industry 4.0 Technologies for Timber Construction; Module 4: Sustainable Practices and Future Trends.

This curriculum marks a step forward in preparing future professionals for an environmentally responsible and digitally advanced construction industry.

Keywords: education, VET, wood, sustainable construction, circular econom

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Bottom-up design of a life-saving technology. The lifeshell desk

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Earthquakes continue to destroy poorly constructed buildings. Lifeshell is an affordable wooden piece of furniture designed to shelter people during a building collapse. It offers a temporary solution while waiting for retrofitting. The Lifeshell desk project, developed through a citizen science approach, engages educational institutions to refine the design and its accessories, gathering input from students, teachers, and assistants.

In-school sessions (2-3 hours) combine short lessons with hands-on activities. Each begins with a brief presentation on earthquake risks and the Lifeshell concept. Students then build multi-storey structures using wooden sticks and rubber bands. Working in groups of 2-4, they test their buildings on a shake table, evaluated on aesthetics, height, and sturdiness. This is followed by a lesson on structural engineering and the causes of building failure during earthquakes.

A trainer then shows how variables like building height, mass, and oscillation frequency affect collapse, using model buildings on a shake table. Sessions conclude with a survey on the Lifeshell prototype, a Canva activity on user needs, and a Tinkercad exercise to propose design variations.

Further collaboration took place with institutions such as IED Istituto Europeo di Design, focusing on desk redesign with second-year Product Design students. Their prototypes were tested using Guillotine 2.0, a small-scale impact device with the same image acquisition system used for full-scale tests. A seminar on wood technology supplemented the design phase.

Feedback is assessed and integrated into updated Lifeshell prototypes, making the product increasingly tailored to user needs while raising awareness of seismic safety through active educational participation.

Keywords: CLT-structures, furniture, earthquake, bottom-up research, citizen science

Acknowledgment: The current Lifeshell project development is funded by the European Union - Next Generation EU*. Authors acknowledge the fundings acquired in late 2023, however they are firmly convinced that the financial resources allocated to the ReArm Europe plan introduced in March 2025 should be more effectively invested in scientific research or other initiatives aimed at ensuring peace and the quality of Life for all mankind.
*via piano nazionale di ripresa e resilienza (PNRR), missione 4 "istruzione e ricerca" - componente c2, investimento 1.1, "fondo per il programma nazionale di ricerca e progetti di rilevante interesse nazionale (prin)". Project code 2022HBXLTR, CUP B53D23006020006.

Lifeshell is under a Creative Commons Attribution 4.0 International License. This ongoing project is based also on the greatly appreciated contributions of Matilde Bognolo, Daniele Casagrande, Ario Ceccotti, Essepi srl, Wancheng Gao, Frank Lam, Gianluca Lopez, Mario Polidori, XLAM Dolomiti spa.

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https://www.lifeshell.net/

https://www.ibe.cnr.it/lifeshell/

Design of responsible tourism – pilot studies in Slovakia

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This paper presents an ongoing interdisciplinary research project Tourism design - Application of Design Thinking in Tourism Products Development, which investigates the potential of design thinking as a strategic tool in the development of sustainable tourism products in Slovak regions. The main objective is to test how professional design and participation process can support regional identity, stakeholder collaboration, and innovation in rural tourism.

The project addresses multiple levels of barriers that currently limit the success of tourism initiatives in Slovakia: institutional fragmentation, low civic trust, limited cooperation capacity, and a lack of integrative approaches. Drawing on Austrian benchmarks (Vorarlberg, South Tyrol where project field research was done), we examine how participatory methods and professional facilitation contribute to building trust and activating local potential.

Our methodology combines field-based participatory workshops with qualitative and quantitative research tools. Pilot interventions were conducted in 2 localities (Hrušov and the group of 3 small villages Motyčky, Turecká, Staré Hory) in central Slovakia, where collaborative design sessions engaged local stakeholders in co-creating tourism visions and mapping values, challenges, and development priorities.

Initial findings confirm a strong interest in community-based, low-impact tourism. Residents identified an "ideal tourist" profile (respectful, informed, value-driven), proposed heritage-inspired experiences (e.g., water and forest trails, local gastronomy, revival of crafts), and expressed the need for improved public spaces, seasonal services, and localized infrastructure. The seminars also revealed recurring issues such as intergenerational fragmentation, weak institutional memory, and a desire for coordination.

Outputs of the contemporary small interventions are pilot events that verify the abilities and potentials for sustainable tourism and strengthen the communities. It will be later reflected in the methodological framework and the role of designers in facilitating local development. It will also outline the next steps toward prototyping model tourism products and creating an open toolkit for community-led tourism innovation in rural contexts.

Keywords: community based tourism, sustainability, participation, design thinking, hospitality, facilitation

Acknowledgment: This paper was supported by project APVV-23-0631 Tourism Design - Application of Design Thinking in Tourism Products Development.

Life cycle analysis of the production of phenols and suberinic acid from spruce bark and their environmental impact when applied in secondary wood products

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Timber structures are commonly used for small residential projects but are also now used for big commercial projects such as multi-story buildings, shopping malls, sport centers, schools, and many others. Investors and developers are aware of the main risks associated with timber structures such as resistance to fire and moisture related problems. Timber elements offer the possibility to fully digitalize manufacturing processes and use prefabrication of elements in controlled conditions, which limits on-site labor and reduces the risk of weather-related problems during the construction process.

Many timber projects already have a monitoring system which can identify moisture-related problems in the timber structure. Currently there are several types of sensors available that can be integrated into the structure to monitor increased moisture, potential leaks, condensation or other events. Prefabrication enables sensor integration where sensors become part of the timber element and can directly measure the conditions. The relevant parameters to measure would be relative air humidity, temperature, and wood moisture content. By processing the data, it is possible to detect any abnormal situation to which the timber element was exposed, and the relevant data are recorded in the sensor internal memory.

Prefabrication processes allow sensors to be integrated directly during manufacturing of timber elements. The sensors can work in stand-alone data logging mode and monitor parameters during stocking, transportation and on-site construction. If online data transfer is not possible, they are stored in the internal memory of the sensor and once it connects to any central unit sensor, it will synchronise data history with the cloud and switch to real-time monitoring. After building commissioning the same sensors will work in the local network providing real-time data to facility management or building owner.

The possible system solutions for monitoring life cycle timber elements, covering all life cycle phases of the elements will be presented together with requirements for the necessary data and communication infrastructure.

Keywords: timber element parameter monitoring, wood moisture content, sensor

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Processing heritage timber for structural reuse in floor systems

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The structural reuse of timber offers considerable environmental benefits and aligns with the EU's circular economy goals. However, its potential remains largely underexploited due to challenges related to e.g., quality assessment, strength grading, dimensional irregularities, contamination, service damage, and cost-prohibitive processing needs.

This paper presents the initial phase of a research project aimed at integrating reclaimed timber into dowel-laminated timber (DLT) floor systems without gluing or extensive processing. The study focuses on a specific case involving timber recovered from the renovation of a former Servite Monastery in Koper, Slovenia. This building, which holds significant cultural and historical value, underwent renovation and reconstruction in recent years. This process led to the extraction of a substantial quantity of large timber beams.

The study focused on processing these beams for structural reuse. Each beam was subjected to a detailed workflow including visual inspection to assess surface-level defects, 3D scanning to generate digital twins, and the manual removal of nails. Nail withdrawal strength was measured as part of a broader investigation into its potential use as an indicator for timber mechanical performance. The beams were then milled into sawn boards, and the recovery rate of structurally usable boards was recorded.

The findings contribute valuable data to the understanding of structural reuse potential of reclaimed timber. The study also offers practical insights into the workflow needed to prepare such timber for reuse in modern engineered timber products and structural systems, including considerations for material assessment, digital documentation, fastener removal, and strength estimation.

Keywords: reclaimed timber, reuse, dowel-laminated timber, circular economy, heritage buildings

Acknowledgment: This research was funded by the Horizon Europe ERA Fellowships project EcoDLT (GA # 101180622).

Structural and cultural barriers to timber use in the mediterranean: a multidisciplinary investigation

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Although timber is widely acknowledged as one of the most sustainable structural materials, timber construction systems (TCS) are still not widely used in mainstream construction, particularly in Mediterranean regions. TCS can serve as long-term carbon sinks, providing a workable plan to cut emissions and totally reorient the industry's climate responsibility (Churkina et al., 2020). This doctoral research aims to investigate the causes of TCS's limited diffusion, focusing on social perception, regulatory frameworks, and market readiness.

The study is organized in four steps: exploration, systematization, gap analysis, and strategy development. A multidisciplinary methodology is adopted, combining architectural theory, environmental psychology, policy and economic analysis, with a particular focus on innovation and technology adoption models. The practical phase includes different categories of expert interviews (EI) to conduct a filtered systematic literature review (SLR).

Preliminary findings from EI and SLR suggest that technical challenges are being progressively addressed but cultural and awareness issues remain significant barriers. These partial insights highlight the need to explore behavioral and attitudinal dimensions more deeply, underlining the need for a structured survey to investigate user perceptions and acceptance.

The survey design integrates validated constructs from the Revised New Ecological Paradigm scale to assess ecological orientation (Dunlap et al., 2000) and adopts a hybrid framework combining the Diffusion of Innovation and the Technology Acceptance Model to evaluate perceived drivers and inhibitors of timber adoption. This approach enables a nuanced understanding of the socio-cognitive factors influencing material choices in construction.

This research is particularly relevant in light of the EU's climate neutrality targets and the New European Bauhaus initiative, which promotes high-quality, climate-responsible construction materials such as timber (European Economic and Social Committee, 2023). By focusing on the Mediterranean context, the study aims to develop context-sensitive strategies to support broader TCS adoption.

Keywords: timber construction, sustainable architecture, innovation barriers, user perception

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Life cycle assessment of the construction process in a mass timber structure

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The application of green materials in the building industry is the norm rather than the exception and reflects an attempt to mitigate the sector's environmental impacts. Mass timber is growing rapidly in the construction field because of its long span, speed of installation, lightness and toughness, carbon sequestration capabilities, renewability, fire rating, acoustic isolation, and thermal resistance. The endeavor of this research is to quantitatively assess the ability of this green material to leverage the abatement of carbon emissions. Life cycle assessment (LCA) is a leading method for assessing the environmental impacts of the building sector. The recently completed Adohi Hall mass timber building on the University of Arkansas campus was used as a case study in an investigation to quantify greenhouse gas (GHG) emissions throughout the construction phase only. The energy used in building operations is the most dominant source of emissions in the building industry and has galvanized research on increasing the efficiency of building operations, but reduced emissions have made the impacts of embodied carbon (EC) components more noticeable in the building life cycle. While most studies have focused on the manufacturing stage, only a few to date have focused on the construction process. Consequently, few data are available on the environmental impacts associated with the installation of mass timber as a new green material. The present study began with the quantification of the materials and an inventory of the equipment used for construction. Then, this study determined the EC associated with running the equipment for building construction. Based on data collected from the construction site, the results of this study indicate that earthwork ranks first in carbon emissions, followed by mass timber installation and construction. In third place is ready-mix poured concrete and rebar installation, followed by Geopiers.

Keywords: reclaimed timber, reuse, dowel-laminated timber, circular economy, heritage buildings

Acknowledgment: This research was funded by the Horizon Europe ERA Fellowships project EcoDLT (GA # 101180622).

Moisture management in timber structures – new techniques and challenges

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Timber structures nowadays are used for small residential projects and also for big commercial projects such as multi-story buildings, shopping malls, sport centers, schools, bridges and many others. Investors and developers are aware of the main risks for timber structures such as resistance to fire and moisture related problems.

Big timber projects already have a monitoring system which can identify moisture related problems in timber structures. Currently there are several types of sensors available that can be integrated into the structure to monitor potential leaks, condensation or other events. The sensor can work on principles of measured wood resistance, detection tapes, or large area membranes with sensing capability. Combination of several different sensing technologies in one monitoring system might be the next improvement in monitoring applications.

As the architects introduce new types of engineered wood products and new types of timber structures that are used for increasingly challenging applications even in harsh environments, the monitoring projects have also become more complex, and combination of several technologies in one system is a must. The typical values measured by the integrated sensors are presence of water, moisture, relative humidity, dew point, absolute humidity, and temperature. In most cases, the instant value will not be sufficient to reliably detect the anomalies. In most cases, trends in these parameters are more important than the instant value itself for avoiding false positive alerts and warnings. Therefore, long term monitoring of the continuous parameter value is more advantageous than reading a single value.

New monitoring technologies combining wired, wireless spot sensors together with large area timber protection membranes with integrated sensing offer increased detection capabilities. Increasing the detection area while reducing the overall investment costs may be key for monitoring systems in large timber projects. New technologies for large area monitoring, together with combined moisture detection systems, will be introduced in this work.

Keywords: wood moisture, control & monitoring, timber buildings

Improving public health through built environment interventions: a literature review

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The built environment is designed for people, yet its profound impact on human health is often overlooked. Urban planning can, among other things, reduce air pollution, improve access to green spaces, promote physical activity, reduce health inequities, and enhance overall well-being. This review aims to explore the impact of built environment interventions on health outcomes, highlighting the need for integrated approaches that connect public health with urban planning and design.

This literature review synthesizes findings from various reports and peer-reviewed publications in English, published between 2020 and 2025, all examining the impact of built environment interventions on human health.

Built environment interventions were categorized into several groups, including transport and pedestrian infrastructure (sidewalks, bike lanes, etc.), parks and natural areas (including water features), urban planning measures aimed at reducing air pollution, neighborhood improvements, better access to services (including health clinics, grocery stores, public transport), and other improvements of public spaces. The health outcomes associated with these interventions included increased physical activity, improved mental health, lower rates of obesity and cardiovascular disease, and an overall enhanced quality of life. For example, studies have shown that improving walkability and access to green spaces can lead to significant improvements in both cardiovascular and mental health (de Sa et al., 2022; Hunter et al., 2019; Zhang et al., 2022).

The findings emphasize the importance of an innovative approach in which public health is fully integrated into the urban design process. Effective interdisciplinary and multisectoral collaboration among urban planners, public health professionals, municipalities, and local communities is essential. Participatory design methods, combined with long-term monitoring and evaluation, are crucial for developing inclusive, sustainable, and health-promoting built environments that address the diverse needs of all population groups.

Built environments should be designed to support public health. A comprehensive approach that links urban planning with public health is crucial for creating equitable and resilient communities. Future urban development should integrate public health perspectives to enhance population well-being and maximize long-term health benefits across all population groups.

Keywords: built environment, urban planning, interventions, public health, health outcomes

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From objective measurement to subjective evaluation: assessing buildings for wellbeing

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Evaluating buildings is a common practice, but the goals and methods of evaluation vary. Assessing the structural capacity and performance of a building is critical for the safety of future and current occupants. The methods for this type of assessment are well established and are a standard part of the design process. In contrast, evaluations related to health, wellbeing, and comfort are only well established in part – for example, protocols to evaluate thermal comfort, are well established in ISO 7726 (and ASHRAE 55). Yet many other factors like visual, aural, and olfactory comfort remain underdeveloped or under development.

An inherent challenge in establishing these types of assessment is requisite merging of objective measurements and subjective evaluation. Comfort necessarily is a subjective attribute, but subject evaluations must be linked to objective information about the environment to be interpreted and, ideally, acted upon to improve building conditions. In addition, the varied purposes of built space complicate the design of tools for both subjective and objective evaluations. The EVOLVE tool, for example, is designed specifically for retirement homes, but does not apply to offices (Lewis et al., 2010). Fit for purpose tools for objective assessment, combined with measurements of the building exposome must be combined with subjective evaluation tools that are validated to provide reliable building assessments for health, wellbeing, and comfort.

Deploying these measurement instruments robustly requires a sound and complete method that has been validated. This presentation will discuss the combination of tools under investigation within the BuildWell project, including a novel objective assessment tool and post-occupancy evaluation instrument to gain more complete understanding of the effects buildings have on their occupants.

Keywords: wellbeing, buildings, assessment, evaluation

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Enhancing timber design with RevitWoodLCC: BIM-Based service life modelling tool

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Timber plays a key role in sustainable construction, but its biological durability depends heavily on environmental exposure, detailing, and material selection. While the majority of research has focused on modelling the service life of timber, practical implementation of these advances within industry-standard technologies like BIM remains limited. This study introduces RevitWoodLCC, a BIM-integrated plugin for Autodesk Revit that enables automated prediction of the service life (onset of decay) of wood construction components. Using dose-response models and ISO 15686 methodologies, the plugin incorporates wood species, treatments, climate data, exposure factors, and design details directly within the BIM environment. Results are visualized using color-coded overlays, allowing designers to identify high-risk areas and optimize detailing for durability. Application to a real-world case study demonstrates the tool's capability to support project-specific decision-making in timber design. RevitWoodLCC bridges the gap between material durability science and digital design practice, empowering stakeholders to deliver longer-lasting, more sustainable wood structures.

Keywords: service life prediction, timber durability, building Information modelling (BIM), revit plugin, environmental exposure

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Behavioural modelling within the scope of positive energy districts in heritage areas: a conceptual use case in Slovenia

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Reducing greenhouse gas emissions by lowering energy demand and promoting green energy generation in the built environment, particularly for space heating/cooling, presents a major challenge in achieving climate neutrality by 2050, as set by the European Union. Meeting these ambitious goals in the cultural heritage-protected areas and within the tight timeframe requires a multi-faceted approach. The MONUPED project explores the possibilities and prepares digital tools that would facilitate these efforts, supporting different stakeholders of the process. Several factors influence homeowners' decision to make energy-related refurbishment, such as socio-economic factors, dwelling conditions, and availability of subsidy programs. Residents of heritage-protected areas may face additional barriers of complicated bureaucratic procedures of strict preservation regulations and technological challenges often associated with high costs. Agent-based modelling was used in this work to investigate the decision-making processes of homeowners in the Koper Old Town, Slovenia, concerning energy-efficient building renovation, retrofitting or refurbishment. To capture the renovation behaviours of homeowners in the historic city centre, with many buildings designated as protected cultural heritage, and to evaluate the potential impact of these renovations on lowering energy demand, we are developing a simulation model using a theoretical framework based on the Theory of Planned Behaviour and the dynamics of "small-world" networks (Preisler et al., 2017; Rai and Robinson, 2015). Cadastral data, including parcel and building information, along with demographic data and findings from empirical studies, which guide the definition of agent behavioural rules and the assessment of energy-related parameters, were integrated to empirically ground the model. Policymakers seeking to encourage energy-efficient renovations are the primary stakeholder group of this tool, as the outputs of the proposed model provide insights into the expected renovation dynamics and energy demand reduction potential offering valuable guidance for setting up subsidy schemes and/or regulatory changes.

Keywords: energy positive districts, agent-based modelling, building retrofitting, cultural heritage preservation

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Bayesian analysis in wood science: what can we gain?

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Bayesian analysis is an approach to reasoning about our world, and especially about our scientific work, based on Bayes' theorem. Bayesian analysis differs from the more common frequentist approach to statistical analysis in that it tries to directly model uncertainty rather than the long-term error rate over many repeated experiments. To do this, Bayesian analysis incorporates prior knowledge into our reasoning about data. Bayes' theorem, though published by Thomas Bayes in 1763, didn't receive significant attention until later in the 18th century when Pierre-Simon Laplace began formalising and working with theorem to solve statistical problems in a Bayesian way. Nonetheless, the term Bayesian analysis was infrequently applied until the 1950s. Even then, the approach was not widely adopted until recently, when computational power became abundant and inexpensive. More and more researchers are implementing Bayesian analysis in their work, yet it's adoption in wood science has been limited.

To illustrate the usefulness and intuitive nature of Bayesian analysis, we will compare the process and outcomes of Bayesian analysis with frequentist analysis for three studies. These studies are, a study on the fracture in beech-adhesive bondlines at different temperatures (Pečnik et al., 2023), an ongoing study on bending strength in finger jointed timbers, and a study on stress experiences and recovery in rooms with different types of wood furniture (Burnard and Kutnar, 2020).

Keywords: Bayes' theorem, analysis, data, visualisation

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Preliminary analysis of spectroscopic techniques for determining wood chemical composition

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The objective of this research is to integrate genetic studies with advanced spectroscopic techniques to deepen the understanding of tree adaptation mechanisms to local environmental conditions. This knowledge has the potential to significantly enhance sustainable forest resource management and support effective tree breeding programs in response to environmental changes.

A unique set of wood samples was collected from 50-year-old Scots pine (*Pinus sylvestris L.*) trees representing various national populations from Poland. All trees were planted simultaneously and cultivated under identical silvicultural, climatic, and soil conditions at the experimental forest site in Rogów. Additionally, three Scots pine populations from Slovenia were included as a genetically distant reference group.

A measurement protocol was developed using near-infrared (NIR) spectroscopy for rapid, accurate, and non-destructive phenotyping and prediction of wood quality parameters. The instruments used included the Bruker Optics MPA II FT-NIR, MicroNIR OnSite-W by VIAVI Solutions (USA), and NeoSpectra FT-NIR by BUCHI (Switzerland). These NIR measurements were complemented by hyperspectral imaging, performed by scanning wooden disks using Specim (Finland) FX17 and SWIR cameras, operated via LUMO software.

Chemical analyses were conducted to assess compositional variation within the samples. These included Soxhlet extraction for determining extractive content, the Klason method for lignin quantification, and procedures for holocellulose and cellulose determination. Elemental analysis was also performed to measure nitrogen, oxygen, hydrogen, and carbon content by FlashSmart™ Elemental Analyzer (Thermo Scientific, USA).

Data preprocessing and chemometric analysis were carried out using EVINCE (Predictera, Sweden) and the PLS Toolbox for MATLAB (Eigenvector Research, USA).

This study serves as a pilot investigation aimed at evaluating the effectiveness of hyperspectral imaging techniques and exploring their correlation with the chemical properties of the analysed wood samples.

Keywords: *Pinus sylvestris*, chemical composition, NIR-HIS spectroscopy

Acknowledgment: The authors gratefully acknowledge receiving funding from "Spectroscopic Methods for Rapid Phenotyping of Trees Reflecting their Ecological Resilience" (acronym DENDRO-SPEC), co-financed by the National Science Centre Poland (NCN) No. UMO-2021/43/I/NZ9/02809 and the Slovenian Research Agency (ARRS) N4-0274.

A preliminary investigation of miswak (*Salvadora persica*) extractives for novel applications

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Miswak (*Salvadora persica*) has been widely researched for its use in oral hygiene, valued for its antimicrobial and therapeutic properties (Nordin et al., 2020). Although its use has primarily been limited to dental care, the rich chemical profile of miswak suggests broader potential (El-Sherbiny et al., 2023). This preliminary study aimed to explore the functional properties of miswak wood extractives to assess their potential for alternative applications in the building sector. Miswak wood was subjected to ultrasound-assisted extraction using an ethanol:water (90:10) solvent system. The extractives were analysed for total phenolic and flavonoid content, antioxidant activity (DPPH assay), and antimicrobial properties against selected bacterial strains. Furthermore, the extractives were exposed to controlled UV irradiation, and changes in their chemical profile were evaluated using FTIR spectroscopy. The extractives showed significant inhibitory activity against Gram-positive bacteria (*S. aureus, S. epidermidis*) and yeasts (*C. albicans, C. glabrata*), with lower activity observed against the Gram-negative bacteria *E. coli* and *P. aeruginosa*, as well as *S. pyogenes*. These organisms represent a clinically relevant and microbiologically diverse test panel. Additionally, extractives exhibited antioxidant activity with positive correlations between total phenolic and flavonoid content. UV-induced changes in the chemical profile and antioxidant potential suggested possible light-induced transformations, and the need for further research on miswak extractives as potential UV filters. Given their antibacterial and antioxidant properties, the extractives may be explored as natural preservatives or bio-based protective solutions. The "green" extraction method used in this study offers an efficient and sustainable way to obtain miswak extractives without reducing their bioactivity. These findings highlight multifunctional bioactivity of miswak extractives and support their potential in material science.

Keywords: extractives, miswak, wood, spectroscopy, renewable materials

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Analysing, harmonising and visualising statistical wood waste data

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Accurate monitoring of wood waste flows is crucial for assessing potential carbon storage and implementing advanced circular bioeconomy strategies. However, at least in Slovenia; available statistical data on wood waste remains fragmented, inconsistent, and difficult to integrate. This presentation addresses the challenges of such data analysis and harmonisation through the example of the official datasets of the Slovenian Environmental Agency (ARSO), which document waste generation, collection, and treatment. Additionally, an interactive data visualisation framework is also presented that could provide a user-friendly platform for tracking and analysing resource flows and volumes.

The investigated raw datasets presented several technical challenges, such as inconsistent templates across the years, missing values, and a methodological shift in granularity—becoming less detailed. To overcome these discrepancies, standardised methods were used for handling missing data and systematic approaches were implemented to harmonise inconsistent lassification schemes, maintaining analytical continuity despite structural changes in the data. Building on this data foundation, an interactive visualisation tool was developed using R and Plotly. It provides a dashboard that organises data analysis into four distinct modules-overview, generation, collection, and treatment-allowing users to explore data hierarchically from national trends to waste-type and regional breakdowns. Features such as interactive filtering, contextual hover details, and temporal comparisons provide a flexible analytical environment.

The developed tool provides both researchers and policymakers with an accessible platform for analysing wood waste streams, linking harmonised data to interactive exploration. It can serve as a precursor to more precise carbon flows tracking, with the potential to improve the efficiency and accuracy of the national carbon emissions/storage reporting.

Keywords: wood waste, data visualization, material flow, reverse supply chains, carbon reporting

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Eco-friendly wood insulation phase change solutions

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Wood-based composites offer a sustainable and environmentally friendly alternative for building insulation, addressing the significant challenges posed by traditional materials such as fiberglass and polyurethane foams. This project aims to enhance the thermal performance and durability of wood by exploring advanced thermal and chemical modification techniques. These modifications will improve the porosity and microstructure of the wood, facilitating the integration of phase-change materials (PCMs) that can significantly increase energy density and enhance thermal regulation in buildings. Additionally, the project focuses on improving the hydrophobic properties of wood to minimise moisture absorption, which is crucial for maintaining the structural integrity and performance of the composites. Nanoparticle-doped PCMs will be synthesised and integrated into the modified wood to further enhance thermal conductivity and stability. Thermal treatments of the PCM-impregnated wood, aim to prevent moisture absorption and improve long-term durability. The research will involve comprehensive testing of the treated wood for thermal performance, leakage, and durability under various conditions and create demonstration pieces for service life assessment. The outcomes of this project are expected to provide valuable insights into the development of effective, eco-friendly building materials with superior thermal management and longevity, thereby contributing to the advancement of sustainable construction practices.

Keywords: composite, insulation, phase change material, wood

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Melanin from black yeasts: extraction, characterisation and inter-species comparison

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Fungal melanin is a complex biopolymer synthesised by various fungi, particularly black yeasts, where it plays an important role in virulence. While it is known that melanised fungal cells exhibit increased resistance to host immune defences, it is still uncertain whether melanin poses a direct threat to human health. Therefore, the main objective of this research is to investigate the role of melanin in fungal virulence. While the biotechnological potential of melanin, such as increased durability, bioremediation and environmental resistance, is well known, its antimicrobial properties have not yet been thoroughly explored. Understanding the behaviour of fungal melanin is crucial to ensure the safety and efficacy of melanin-based biotechnological products, such as engineered living materials (ELMs), especially in the human environment.

The first step in our study was to define and optimise a protocol to isolate the melanin particles produced by three black yeasts: *Aureobasidium pullulans*, *Aureobasidium melanogenum*, and *Exophiala dermatitidis*. There are numerous protocols for the isolation of melanin from fungi, bacteria, and cell lines; however, ultrasound-assisted extraction (UAE) yielded the highest recovery of melanin particles. In the next step, we characterised the isolated melanin particles using Fourier transform infrared spectroscopy (FTIR). While all three spectra showed typical melanin-associated absorption bands, distinct differences in peak positions and intensities indicate variations in melanin structure and composition between the three species

Keywords: melanin, fungi, black yeasts, virulence, FTIR, ELMs

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Extremotolerant fungi: phylogenomics and physiology of *Parengyodontium* spp

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Certain fungal species, such as *Parengyodontium spp.*, inhabit particular ecological niches. Their presence on monuments, and in places with biomineral precipitation suggest they may play a larger role in biodeterioration than previously thought. Studying the conditions that promote their growth and understanding the mechanisms by which they degrade materials is crucial for the effective conservation of built heritage.

This work aims to elucidate the phylogenomic relationships between 50 *Parengyodontium* strains isolated from various environments over the world and assess their extremotolerance. Whole-genome sequencing and bioinformatic analyses were used to clarify species boundaries. Growth experiments were conducted under extreme physiological conditions to assess tolerance to salt, pH, and temperature. Strains were cultured in liquid media containing selected mineral salts (magnesium sulfate heptahydrate, calcium chloride hexahydrate, sodium chloride, and magnesium chloride hexahydrate) at varying molar concentrations and pH values. Growth response was measured using a microplate reader (Synergy H1, Biotek). Additionally, temperature tolerance was assessed at 5, 15, 25, 30, and 37 °C, and morphological features were examined via slide culture microscopy.

The results revealed a clear phylogenomic distinction between *Parengyodontium album*, *P. americanum*, and *P. torokii*, including the possible reclassification of certain strains previously misidentified as *P. album.* Physiological tests demonstrated that low-temperature tolerance and the ability to grow in high-salt environments are key distinguishing traits between these species with *P. torokii* showing greater adaptation to cold and higher salt tolerance.

These findings highlight the extremotolerant nature of *Parengyodontium* strains and their adaptability to the harsh environmental conditions often present in deteriorated materials.

Their resilience and ability to metabolise diverse substrates likely contribute to their persistence and damaging effects on materials surfaces.

Keywords: *Parengyodontium* spp., fungi, phylogeny, salts, extremotolerance

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Polyphenolic extracts from agroforestry residues as adhesives for sustainable particleboards

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The particleboard (PB) industry plays a crucial role in the wood-based economy but continues to rely heavily on synthetic resins, which raise environmental and health concerns [1]. Bio-based adhesives, particularly those derived from tannin-rich lignocellulosic residues, present a promising alternative. Tannins, classified as hydrolysable or condensed, differ in chemical structure, reactivity, and adhesive performance. Understanding these differences is essential to improving the bonding efficiency and mechanical properties of PBs made with natural adhesives [2,3].

This study investigated three categories of lignocellulosic residues as tannin sources: (1) forestry residues (bark from poplar, eucalyptus, acacia, and pine), (2) winery industry residues (grape stalks, vine pruning, and canes), and (3) nut-based agro-industrial residues (shells from hazelnut, almond, and walnut). The raw materials were dried, milled, and sieved, followed by alkaline extraction. Extracts were then spray-dried to produce powdered adhesives.

The chemical characterization of extracts included total phenolics, flavonoids, sugars, and compound identification by HPLC. Cure kinetics were evaluated using ABES. Laboratory PBs were produced using poplar wood particles and the bio-adhesives (10% resin solids, 650 kg/m^3, 8 mm) pressed at 160 °C for 5 minutes. Mechanical properties were assessed according to European standards and compared with PB type P1 specifications (EN 312:2009).

Results showed that winery residues, especially grape stalks and vine prunings, were rich in flavonoids like catechin and epicatechin. Nut shells contained phenolic acids and hydrolysable tannins, while forestry extracts varied by species-acacia was rich in catechins, pine in condensed tannins, and poplar in sugars. Condensed tannins and flavonoids improved curing and bonding performance, while higher sugar and hydrolysable tannin content reduced adhesive efficiency.

In summary, the chemical profile of biomass extracts strongly influences adhesive and board performance. Selecting appropriate biomass sources allows for the development of efficient, sustainable adhesives, supporting a transition away from synthetic resins in the PB industry.

Keywords: particleboard, bio-adhesives, agroforest residues, tannins

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Adhesion and biofilm formation of *Aureobasidium pullulans* on wood analyzed by multi-modal microscopy

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Aureobasidium pullulans is a highly adaptable and polymorphic black yeast belonging to the phylum Ascomycota (Zalar et al., 2008). It is commonly found in diverse ecological niches, including soil, plant surfaces, wood, air, and even in extreme environments such as saline waters and cold climates (Andrews et al., 2002; Botić et al., 2014; Gunde-Cimerman et al., 2000; Wang and Pecoraro, 2021). Its metabolic versatility enables the production of various compounds, most notably pullulan, an extracellular polysaccharide with numerous industrial applications in the food, pharmaceutical, and biodegradable packaging industries (Prasongsuk et al., 2018). Previous studies have shown that *A. pullulans* have a broad spectrum of recombinant and polyextremotolerant genes that contribute to its remarkable resistance to environmental stress (Gostinčar et al., 2019).

To investigate the adhesion capacity of *A. pullulans* to wood, we analysed three strains isolated from a wooden façade (IN-007), dried olives (IN-515), and glacial ice with sediment (IN-517) on pine wood samples. Initial morphological assessment by light microscopy (LEICA DM 2700 M) revealed several morphological forms of strains, including yeast-like cells, pseudohyphae, hyphae, and chlamydospores. After inoculating *A. pullulans* strains onto pine wood, adhesion to the wood was assessed after washing with distilled water. Each strain was monitored for seven days at 25 °C and 75-80% relative humidity. Optical digital microscopy (Keyence VHX-6000) and fluorescence microscopy (EVOS M7000, ThermoFisher Scientific) were used following Calcofluor White staining. Results showed a clear increase in fungal density and surface coverage over time.

These findings confirm the strong adhesion and biofilm-forming ability of *A. pullulans* on wood surfaces paving the way for the development of quantitative assays using specific fluorescent dyes to evaluate fungal adhesion. Furthermore, this work provides a foundation for the development of protective biologically inspired living coatings to enhance the durability and performance of various façade materials in architectural applications.

Keywords: *Aureobasidium pullulans*, adhesion, biofilm, wood surface

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Optimisation of *Aureobasidium pullulans* biomass production for use in living coating

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The ARCHI-SKIN project aims to develop living fungal coatings for various architectural surfaces, including wood, concrete, and plastic. These coatings will serve as a sustainable, self-renewing protective layer that provides UV protection, bioremediation, and antimicrobial properties. Based on preliminary screening, *Aureobasidium pullulans* was selected as the organism of choice (Butina et al. 2023). This globally distributed fungus inhabits diverse environments, ranging from the phyllosphere to marine and hypersaline habitats. It thrives under extreme conditions that are inhibitory to other microorganisms. *A. pullulans* exhibits several characteristics that make it suitable for biotechnological applications. It forms biofilms on wood and other architectural surfaces, making it particularly promising for use in living coatings. Additionally, it is non-pathogenic to humans, further supporting its safe deployment in the built environments.

Fermentation is the standard approach for cultivating *A. pullulans* to produce large amounts of biomass. Selected strains of *A. pullulans* with high potential for producing extracellular polymeric substances (EPS), such as pullulan, were cultivated in a laboratory-scale bioreactor (Elara ST, Solaris lab). The fermentation process was closely monitored and regulated in real time, with critical parameters such as pH, temperature, and dissolved oxygen (DO) used to control the kinetics of cell growth. The batch fermentation process was optimised to evaluate the effects of different *A. pullulans* strains and bioprocess conditions on biomass yield, with the goal of maximising biomass production for downstream use in biobased coating.

Initial optimisation focused on determining the optimal percentage of dissolved oxygen (DO%) as well as agitation and aeration rates. It was found that a lower DO% was sufficient to sustain the fermentation process, the agitation could be maintained at a constant rpm, and the aeration rate could be reduced. The aeration source was changed as a further optimisation step.

These results form the basis for the biomass in the ARCHI-SKIN project, where the fungal biomass serves as the core component of the living coating.

Keywords: biobased coating, optimisation, fermentation, *Aureobasidium*

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From digital model to living surface: BIM-informed microbiome mapping on wooden buildings

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This study explores the intersection of building science and microbiology by using Building Information Modelling (BIM) to guide microbial mapping on a wooden structure. BIM is a tool for exposure dose mapping developed for the WoodLCC demonstration house, incorporating material properties, design detailing and weather exposure data including solar radiation, temperature, and moisture from rainfall and humidity. The resulting BIM-based map identified most vulnerable areas to environmental stress and potential decay. Based on these insights, representative sites were selected for microbial sampling, encompassing a variety of orientations, exposure levels, and protective conditions. Swabs collected from these locations were analysed to assess microbial colonisation and its potential role in the degradation or protection of spruce wood. By correlating environmental exposure with microbial presence, bioreceptivity of investigated surfaces, and wood decay, the study provides a deeper understanding of wood durability in outdoor conditions. This interdisciplinary approach highlights how digital tools like BIM can inform biological investigations, ultimately supporting the development of more sustainable and resilient timber construction through targeted protective strategies. This research also forms a foundational step toward the goals of the ARCHI-SKIN project, which aims to develop a living coating system based on Engineered Living Materials (ELMs). It is based on a technically applicable, controlled, and optimised fungal biofilm that can effectively protect various building surfaces. By understanding how natural microbial communities interact with environmental stressors and wood substrates, we can inform the design of engineered biofilms that not only enhance service life performance but also enable functionalities such as self-healing, moisture regulation, and surface renewal. The integration of BIM with microbiome analysis opens new possibilities for adaptive, biologically augmented building facades in sustainable architecture.

Keywords: BIM, bioreceptivity, microbiome, living coatings, biofilm, ELMs

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Fungal biomineralization of mycelium-based composites via calcium oxalate formation

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Mycelium-based composites made from fungal biomass and lignocellulosic residues are emerging as sustainable alternatives to synthetic materials in construction, interior design, and packaging. A unique feature of some fungi, including white-rot species often used in such composites, is their ability to produce calcium oxalate biominerals. Fungal biomineralisation occurs when metabolic activities alter the local environment, leading to the precipitation of minerals like calcium oxalate on hyphal surfaces, a process well documented in soil, wood, and built environments where oxalate formation can influence material properties (Gadd, 2021). However, to our knowledge, mineralised mycelium composites have not yet been developed using fungi to produce minerals in situ during their growth.

Here we present initial results demonstrating the potential of selected white-rot fungi to produce calcium oxalate crystals during growth on nutrient media, which is an important first step toward biomineralising mycelium composites. We monitored oxalate crystal production by *Trametes versicolor, Gandoderma lucidum,* and *Fomes fomentarius* grown on four commonly used media with differing nutrient compositions, using optical microscopy while systematically measuring colony diameters to track growth rates under controlled conditions. Our observations revealed variation in crystal morphology, abundance, and distribution across media and fungal species, with some cultures producing dense crystalline layers on hyphae while others showed rare, scattered crystal formation.

To confirm crystal identity and quantify mineral production, FTIR measurements are ongoing, while Raman spectroscopy and XRD are planned. These will provide critical evidence to determine whether the observed crystals are indeed calcium oxalate and assess their structural properties. Moving forward, this approach aims to translate fungal biomineralisation from controlled media to the growth of mineralised mycelium composites, reducing the need for external chemical treatments. Such materials could combine the lightweight, biodegradable nature of mycelium composites with enhanced fire resistance, addressing sustainability challenges in the construction sector and beyond.

Keywords: fungi, biomineralisation, mycelium composites, calcium oxalate, sustainable materials

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Considerations on the Oak wood veneers colors

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The color of European oak wood is a key aesthetic attribute of the natural veneer, influenced by both its micro- and macrostructural elements. Notable differences in color can be observed between earlywood and latewood, as well as among other anatomical features such as wood rays. These variations are not only dependent on the anatomical section of wood (radial, or tangential) which change the area shear of different elements of wood structure. They are also significantly affected by the growth conditions of the tree, including site-specific environmental and soil factors. The overall perception of wood color results from the combined visual contribution of these diverse structural components, depending at the same time on the averaging area given by different measuring devices (colorimeters, spectrometers) as mentioned by Defoirdt N. et al. (2012). This study investigates the oak wood color quantification as an average of sophisticated multicolor material, analyzing also the distribution and variability of color values in different structural features. The findings aim to enhance the understanding of wood color formation and support the development of more precise approaches to its characterization and classification.

Keywords: natural veneer, oak wood color, veneer quality

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