BOOK OF ABSTRACTS

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KEYNOTE SPEAKER

Gijs Bruggink



Gijs Bruggink has spent the past decade and a half working at the frontier of what responsible, nature-connected architecture can be. Over 13 years at ORGA architect, he has built and maintained the operational backbone of a growing, internationally active practice, while carving out a parallel career as a consultant and researcher in the regenerative built environment.

Certified as a Living Future Accredited Professional and trained in living systems thinking, he brings both organisational rigour and genuine conviction to his work. Beyond day-to-day management, Gijs has led successful architecture competitions, contributed to award-winning building projects, and spoken at international conferences.

He currently leads the research team behind the Wood & Wellbeing report on the health benefits of building with timber.

At IRIC2026 he will present about his work with wood construction, biophilic design, and designing healthy living and working spaces.

Mild Stress, Stronger Materials: Preconditioning Engineered Living Materials for Climate Resilience

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Buildings are a fundamental part of human life, providing shelter and community spaces, but the built environment burdens the climate through heavy resource use and emissions (UNEP and GlobalABC, 2026). As climate change accelerates, sustainable, eco-friendly materials are needed for both lower impact and greater durability. Engineered Living Materials (ELMs) offer a promising response: by integrating living cells into a material matrix, they enable adaptive, self-maintaining functions beyond those of conventional inert building materials. One example of ELMs is a sustainable coating for outdoor architectural surfaces, based on an engineered biofilm of Aureobasidium pullulans (Sandak et al., 2024). The coating is designed to protect surfaces through self-healing, bioremediation, and environmental adaptation. Because this material's function depends on the resilience of its living component, optimizing that resilience is central to its performance as a building material. Living systems tolerate a range of environmental conditions, but their adaptability has limits, and rapid, intense stress can outpace their capacity to respond. One strategy for extending these limits is hormesis: exposing living systems to mild stress to which they can successfully respond, leaving them better equipped to cope with more severe stress in the future. Hormesis is well documented across organisms and has been most intensely studied in agriculture to enhance crop resilience; here we explore its potential to optimize the resilience of fungal-based ELMs. The most prominent environmental stressors affecting A. pullulans coatings are rising temperatures and oxidative stress from altered UV radiation. Because these stressors are evolutionarily ancient, the response mechanisms involved, such as heat-shock and antioxidant responses, are highly conserved across kingdoms of life, offering a broadly applicable basis for stress-preconditioning strategies. Applying hormesis to ELMs therefore holds strong potential to improve the durability and resilience of living building materials, contributing to the development of climate-resilient, self-maintaining materials for future construction.

Keywords: stress preconditioning, engineered living materials, adaptation, resilience

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Smashing Desks for Science. Impact Testing and Classification of Engineered Timber Protective Desks for Earthquake-Induced Building Collapse

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In 2022, a protective shelter concept based on engineered timber desks was proposed as a temporary life-saving solution against injuries and fatalities caused by earthquake-induced building collapses (Fellin et al., 2022). Between 2023 and 2026, the concept was further developed through an extensive experimental campaign aimed at assessing its structural response (Giacobbo et al., 2025) under impact loads simulating falling structural debris. An original testing methodology and a performance-based classification system were also developed.

The test setup consisted of a drop tower equipped with an electro-pneumatic release mechanism capable of safely dropping a 210 kg cast-iron sphere from heights ranging between 0,25 m and 3,3 m. Specimens were positioned on a 30 mm thick steel plate placed on an asphalt outdoor surface. Test operations were controlled through a custom-designed electronic sequencer managing both the release system and the synchronized activation of high-speed cameras operating at up to 1000 fps. Impacts were applied at mid-span, 200 mm from the edge of the top panel. Tests started from low release heights and progressively increased until severe structural damage occurred, associated with the attainment of the defined critical survival space beneath the desk. Performance was evaluated through two main parameters: the maximum impact energy sustained in a single drop and the total energy dissipated at failure over multiple drops. The scale ranges from A, corresponding to a single impact energy of approximately 10.000 J, to E (<2.000 J).

60 mm-thick Lifeshell desks achieved classes B-C, while the 100 mm-thick desks reached class A. Earlier Lifeshell prototypes also achieved comparatively high performances. In contrast, conventional metal-framed school desks, which withstood at most two impacts from a 0.25 m drop height, were classified as E.

In all Lifeshell tests, the impacting mass never reached the protected survival space beneath the desk, demonstrating the effectiveness of the proposed system.

Keywords: Cross Laminated Timber, earthquake, impact test, dynamic test, engineered wood.

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Advanced Spatial Mapping of Wood Characteristics in Pinus sylvestris

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Evaluating wood quality quickly, reliably, and without destruction is vital for contemporary forest management, the timber industry, and the advancement of sustainable construction. Because wood naturally varies at the level of individual trees, stems, and growth rings, conventional testing approaches face major hurdles. This research aimed to create and validate a thorough, multi-scale experimental system for wood phenotyping in Scots pine (Pinus sylvestris L.) by applying cutting-edge near-infrared (NIR) spectroscopy and hyperspectral imaging (HSI) technologies. In this context, the phenotype encompasses the extensive range of measurable chemical, physical, and mechanical properties of wood.

The investigation relies on an extensive dataset of pine samples gathered from Poland and Slovenia following a standardised preparation protocol. The test materials feature tree trunk discs, breast-height blocks, powdered and ground samples, and separated earlywood and latewood strips, allowing wood characteristics to be examined at both macro- and micro-levels.

A key element of this research involved comparing how different benchtop and portable NIR spectrometers perform across various spectral ranges and measurement techniques. The resulting NIR spectra were evaluated through chemometric models that were calibrated using reference data covering the chemical makeup of wood (including lignin, holocellulose, cellulose, and extractives) as well as its physical and mechanical attributes.

Additionally, standard NIR testing was paired with hyperspectral imaging, which made it possible to map wood properties in high resolution across entire tree-disc surfaces. Through HSI, material variations linked to growth rings, earlywood and latewood, juvenile and mature wood, and sapwood and heartwood boundaries were successfully identified. This combined approach offers a versatile framework for rapid, non-destructive phenotyping of wood and other biological substances, advancing predictive models for wood properties and presenting significant value for industrial uses.

Keywords: Near-infrared spectroscopy, hyperspectral imaging, wood phenotyping, Scots pine.

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.

Effect of Starch Concentration on Aureobasidium pullulans Growth, Pigmentation, and Development on Different Wood Species Toward Engineered Living Materials

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Aureobasidium pullulans is a polymorphic and pigmented fungus with strong surface-adaptation capacity, making it a promising biological component for engineered living materials (ELMs) (Malat et al., 2026; Sandak, 2023). However, its development on wood may depend on nutrient availability and wood species (Malat et al., 2026). This study investigated the effect of starch concentration on A. pullulans growth and pigmentation compared with yeast nitrogen base (YNB) liquid medium.

Fungal growth was first evaluated in 96-well microplates using YNB liquid medium as a reference medium and starch formulations at 2%, 4%, and 8% (w/v). Growth was monitored by absorbance at 600 nm (A600). Growth was detected in the starch formulations, supporting their subsequent evaluation on wood. Scots pine (Pinus sylvestris), European larch (Larix decidua), and sessile oak (Quercus petraea) pieces were inoculated with A. pullulans in YNB liquid medium or the three starch concentrations and incubated under controlled conditions. Surface development and pigmentation were monitored over time. At day 30, digital images were analyzed using RGB measurements from defined regions of interest to calculate a Surface Darkness Index (SDI).

Visible fungal development and pigmentation occurred on pine and larch, with surface darkening increasing with starch concentration. SDI analysis supported this concentration-dependent increase in pigmentation. In contrast, no visible fungal growth or pigmentation was observed on oak under the tested conditions, indicating a strong substrate-dependent response. The absence of growth on oak may reflect its tannin-rich phenolic content, which can inhibit fungal colonization (Zhang et al. 2029). Increased dark pigmentation on pine and larch may indicate melanization, although further confirmation is required.

These results demonstrate that both nutrient formulation and wood species influence

A. pullulans colonization. Starch represents a promising bio-based nutrient source for promoting fungal establishment and pigmentation on compatible wood substrates, providing a basis for optimizing biologically active wood-based ELMs.

Keywords: Aureobasidium pullulans; starch; engineered living materials; wood; pigmentation; Surface Darkness Index.

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Wood for Sustainable Satellite Structures in Low Earth Orbit

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The rapid growth of satellite activities in Low Earth Orbit (LEO) is drawing increasing attention to the environmental consequences of spacecraft production, operation, and end-of-life disposal. Aluminum is the predominant structural material in satellite engineering due to its favourable mechanical performance at comparatively low mass. Although considered demisable, aluminum forms oxide particles during re-entry, with potentially adverse effects on atmospheric chemistry and the ozone layer (Ferreira et al. 2024).

Renewable materials may provide an alternative pathway towards reducing the environmental footprint of future spacecraft. Wood is particularly promising due to its low density, renewable origin, and fundamentally different behaviour during atmospheric re-entry, where thermal degradation predominantly generates gaseous carbon- and water-based products rather than persistent metal oxide particles. Recent studies on wood and other lignocellulosic materials under space-relevant conditions further demonstrate growing interest in bio-based aerospace materials (Murata et al. 2024; Shimosako et al. 2024).

However, structural spacecraft applications require materials capable of withstanding launch vibrations, vacuum, thermal cycling, radiation, and atomic oxygen exposure in LEO.

The present study investigated the thermal behaviour and demisability of solid woods, commercial engineered wood products and modified wood subjected to short-term high-temperature exposure under static and dynamic conditions. Substantial thermal degradation was observed for all materials, while resin and adhesive type had a greater influence on demise behaviour than wood species. Despite compositional differences, all samples underwent complete demise during dynamic heat exposure within a timeframe relevant to the re-entry of small satellite structures. In addition, a manufactured 3U CubeSat prototype made from conventional plywood maintained its structural integrity during shaker testing under launch-representative dynamic vibration loads. These results indicate the potential of wood-based materials to combine structural functionality with complete demisability in future satellite applications.

Keywords: Space Sustainability; Wooden Satellite; Space Materials; Low Earth Orbit

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From Climate Data to Material Climate Modelling: An Integrated Digital Construction Workflow

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Timber performance in the built environment is strongly influenced by environmental exposure. However, regional climate data alone cannot describe the conditions experienced by individual timber surfaces. Building geometry, orientation, roof overhangs, recesses and shading can create spatial differences in conditions acting on wood. Translating this information into a form that supports practical design and performance assessment remains a challenge.

This work presents a BIM-based approach for converting regional climate data and building geometry into spatially resolved exposure information. The approach integrates solar radiation, temperature, relative humidity, wind speed, and wind-driven rain within a BIM environment. A geometry-based ray-tracing method estimates wind-driven rain exposure, while the variables are combined to derive a cumulative environmental dose. Keeping geometry, climate inputs and exposure results supports assessment of design alternatives.

The approach is demonstrated at two scales. A controlled study investigates how roof overhangs influence façade exposure, while a real-building application at the Biotechnical Faculty in Ljubljana demonstrates spatial variations across a timber façade. The results show that surfaces within the same building and under the same regional climate can experience different exposure conditions due to geometry and detailing.

The framework provides a pathway for connecting environmental exposure modelling with timber performance assessment, including service-life estimation and weather-induced colour change. Future development will extend the modelling beyond where rain reaches a surface to capture rain splash, runoff and redistribution, moisture absorption and transport within wood, and biotic influences on timber performance. This aims to bring environmental knowledge closer to practical timber design and performance decisions.

Keywords: Material climate; BIM; Environmental exposure; Timber performance, Service Life Prediction

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Thermal Behavior of Merbau Wood Extractives Throughout Enzymatic Functionalization

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Wood processing residues are a renewable source of extractives with potential for valorization in bio-based material applications. However, their complex composition may limit direct utilization. Laccase mediated functionalization offers a mild and environmentally compatible approach to modifying phenolic extractives and their physicochemical properties.

In this study, extractives from merbau (Intsia spp.) industrial residues were recovered by ultrasound-assisted extraction using an ethanol:water system and subsequently modified with laccase from Trametes versicolor. Samples collected over a five-hour reaction period were analyzed by thermogravimetric analysis (TGA) under inert and oxidative atmospheres. Fourier-transform infrared (FTIR) spectroscopy was used as complementary evidence of chemical changes during the treatment. Enzymatic functionalization produced changes in the thermal behavior of the extractives. Under inert atmosphere, the treated samples showed a redistribution of the main degradation events and more complex multistage decomposition compared with the initial extract. Differences were also observed under oxygen, where the functionalized extractives showed distinct oxidative degradation profiles depending on reaction time. The main degradation events occurred within approximately 250-500 °C, with their relative contribution and position changing throughout the treatment. FTIR analysis supported these observations, revealing changes in bands associated with hydroxyl, aromatic, and carbonyl groups. The results show that laccase mediated functionalization alters both the chemical and thermal behavior of merbau extractives. The combined TGA and FTIR approach provides complementary insight into the evolution of extractives during enzymatic modification.

Keywords: laccase, thermogravimetric analysis, wood extractives, oxidative modification, thermal degradation

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Combined Densification and Moderate-Temperature Thermal Modification to enhance Fungal Decay Resistance of Poplar Wood

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High-temperature thermal modification (TM) is widely used to improve wood durability; however, severe treatment temperatures may impair mechanical properties and limit practical applications. On the other hand, thermo-hydro-mechanical (THM) densification is an established modification method for enhancing the mechanical performance of low-density wood. This study investigated whether THM densification followed by moderate-temperature TM could provide decay resistance comparable to that of high-temperature TM. Poplar wood was processed via THM densification at compression ratios of 30%, 50%, and 70% and then subjected to TM at 180 °C. Uncompressed wood thermally modified at 180 and 210 °C was used as the reference material. Equilibrium moisture content (EMC), thickness swelling, fungal decay resistance, and chemical-structure changes were evaluated. A 16-week decay test was conducted according to EN 113-2: 2020 and ATR-FTIR spectroscopy was used to characterize chemical-structure changes before and after decay. The 70% compression followed by TM at 180 °C (THM70) exhibited significantly lower mass loss than the other compressed groups, and showed no significant difference from uncompressed wood treated at 210 °C (HT210). This result demonstrates that high-ratio densification combined with moderate-temperature TM can provide decay resistance comparable to that achieved by high-temperature TM. Among the THM specimens treated at 180 °C, THM70 had the lowest EMC, though its EMC remained higher than HT210 group. After the decay test, thickness swelling showed a nonlinear response. Thickness swelling in the 50% compression group exceeded that of the 30% compression group, but did not differ significantly from that of the 70% compression group. ATR-FTIR analysis indicated that decay-related changes were mainly associated with hemicellulose absorption band. After 16-week decay, both the THM70 and HT210 groups exhibited relatively smaller changes in this band. Overall, THM densification combined with moderate-temperature TM provides a promising approach for enhancing decay resistance of poplar wood.

Keywords: poplar; wood densification; thermal modification; white rot; decay resistance; thickness swelling

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Heat transport in PCM-impregnated poplar: effects of thermal treatment, specimen orientation and silica nanoparticl

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The thermal performance of wood impregnated with a phase change material (PCM) depends on the heat-transfer pathways that connect its storage capacity to the surrounding environment. This study investigates the combined influence of thermal treatment, specimen cutting orientation and silica addition on heat transport in poplar impregnated with CrodaTherm 24W. Its distinctive contribution is to evaluate dilute nanoparticle modification of the impregnation fluid as a means of tuning heat transport within a bio-based host. Reference poplar and wood treated at 180 °C and 200 °C are examined as radially and transversely cut pellets after 100 thermal cycles. Silica nanoparticles are dispersed in molten PCM by ultrasonication at 0.5 wt% of the impregnation fluid, forming a nanofluid that is subsequently used for impregnation. The resulting composites are compared with matched formulations without nanoparticles. Silica addition is associated with higher conductivity in every matched comparison, with increases of approximately 5–26%. This enhancement at low loading highlights the potential of modifying the PCM phase to improve heat conduction through the impregnated wood. The contrast between specimen cuts exceeds the nanoparticle-related increment, identifying specimen orientation as a major factor in thermal design. The 200 °C radial specimens exhibit the largest relative enhancement, whereas transverse reference specimens achieve the highest absolute conductivity. Thermal treatment therefore affects both baseline heat transport and the response to the modified impregnation fluid. Relative conductivity enhancement and the ratio between specimen cuts provide complementary measures of the silica nanoparticle contribution and orientation-dependent heat transport. The findings show why selecting a formulation solely by its percentage improvement can obscure its actual heat-transfer capability. They inform the design of wood-based storage elements by distinguishing conductive access to stored heat from resistance to heat transmission through a building component.

Keywords: thermal conductivity, PCM-impregnated poplar, thermal treatment, specimen orientation, silica

Thermal treatment effects on PCM-impregnated poplar and beech for building thermal energy storage

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Bio-based composites combining wood with a phase change material (PCM) offer a route to integrate thermal energy storage into renewable building materials. The wood provides a supporting matrix, while the PCM introduces a latent heat reservoir near room temperature. The distinctive contribution of this study is to examine species selection and thermal treatment as complementary design variables for balancing latent storage and sensible thermal mass in CrodaTherm 24W-impregnated poplar and beech. Reference wood and wood treated at 180 °C and 200 °C are compared using pellet specimens cut radially or transversely relative to the fibre direction. All specimens are characterised after 100 thermal cycles. Differential scanning calorimetry, solid- and liquid-state specific heat capacities, and bulk density are combined to evaluate storage per unit mass and volume. Here, solid and liquid refer to the state of the impregnated PCM. The calorimetric results show a larger latent storage contribution in poplar, while the denser beech reference provides greater volumetric sensible heat capacity. In poplar, latent capacity varies non-monotonically with treatment severity, with the 200 °C condition exceeding both the reference and 180 °C conditions. Its sensible heat capacity follows a different pattern, showing that latent and sensible contributions require separate assessment. Density further changes the separation between treatments when storage is expressed per unit volume. These results establish complementary criteria for selecting wood hosts for applications constrained by component mass or thickness. The study provides a material-level basis for designing thermal buffering elements near room temperature, linking treatment-dependent storage behaviour to the temperature interval available for charging and discharging.

Keywords: thermal energy storage, phase change materials, thermally treated wood, poplar and beech, volumetric storage capacity

Co-creating Energy Transition Pathways in Monument-Protected Urban Areas: Insights from a Citizen Science Project in Koper Old Town

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The study investigates how Positive Energy Districts can be developed in heritage-protected areas, aligning energy transition goals with the preservation of cultural heritage. It focuses on the historic centre of Koper, Slovenia, a densely built urban area protected for its cultural heritage significance.

Using a citizen science approach, the project involved diverse stakeholders in co-producing knowledge through a mixed-methods design. Data collection included an online survey of property owners, in-depth interviews, and two focus groups: one with heritage conservation professionals and one with representatives of organisations managing public buildings in Koper's historic centre. The project concluded with a co-creation workshop where interview results were presented and participants discussed potential future solutions.

Findings reveal significant implementation barriers to improve the energy performance of historic buildings. Property owners highlighted financial constraints, complex administrative procedures, fragmented ownership structures, and uncertainty regarding permitted interventions. Conservation professionals emphasized the need for case-specific solutions, better communication with owners, and stronger integration of climate adaptation into heritage management. Managers of public buildings reported challenges arising from insufficient renovation funding, lengthy procedures, public procurement requirements, and restrictions on renewable energy technologies and insulation measures in protected buildings.

The results show that the primary challenges are not only technological but also institutional and social. Participants called for clearer guidelines, more accessible funding mechanisms, and greater involvement in decision-making processes. The project provides empirical evidence for the development of agent-based models of stakeholder decision-making and demonstrates the value of citizen science in reconciling heritage conservation and energy transition goals. It also offers practical insights for designing sustainable, socially acceptable renovation pathways in historic urban areas across Slovenia and Europe

Keywords: citizen science, cultural heritage, energy renovation

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Learning from positive deviance: What private forest owners reveal about long-term decision making

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Climate transformation requires decisions that prioritize future benefits despite immediate costs. This creates a particular challenge for effective mitigation and adaptation: humans tend to favor immediate benefits over future value (Green & Myerson, 2004). Private forest owners represent a form of positive deviance from this general tendency. As forest management is inherently long-term oriented and unfolds across generations, they offer a valuable empirical setting to gain insight into which structural and psychological factors shape long-term thinking. Additionally, the barriers and enablers surrounding forest owners' intended and implemented actions can be examined against the intrapersonal, social, and structural mechanisms identified for the intention-behavior gap (Fielding & Hornsey, 2026), potentially confirming or extending this framework.

Using qualitative content analysis of semi-structured interviews with private forest owners in Austria and Slovenia, we examine their decision contexts, concrete actions, and psychological aspects shaping their preferences. Patterns across the coded material are subsequently used to identify key characteristics and strategies of long-term oriented decision-making, which can then be abstracted from the specific forestry setting and applied to other decision contexts.

Preliminary results indicate that private forest owners do not necessarily perceive economic and ecological value as competing priorities. Despite economic pressure and uncertainty, biodiversity and resilience are pursued alongside maintaining value for future generations and a desire to make a difference. The emerging themes already suggest a differentiation between Strategic System-Thinkers, who question established practices and consider broader system effects, and Unorthodox Stewards, who value self-efficacy over monetary goals and are driven by personal norms.

Keywords: long-term decision-making, private forest owners, climate change mitigation, climate change adaptation, climate transformation

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Resilient Theatre: Participatory Construction in Lviv, Ukraine

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Reconstruction in war-affected contexts requires more than restoring physical infrastructure to include the creation of spaces that consider the social aspect of rehabilitation. Participatory approaches to architecture offer opportunities to address these needs by involving communities directly in shaping their built environments. The Resilient Theatre project explored this approach through the construction of an open-air theatre at the Unbroken rehabilitation centre in Lviv, Ukraine. The intervention brought together veterans, internally displaced persons, local community members, architects, researchers, and cultural practitioners in a process of co-creation, combining participatory design, hands-on construction, and theatre. Wood was selected as the primary construction material due to its renewable character, local availability, and workability, enabling participants with different levels of construction experience to contribute to the building process.

A central aspect of the project was the integration of construction and theatrical practice. Rather than treating building as a process that precedes the occupation and use of a space, the project brought these activities together on the same site. Collective work sessions (toloka), theatre workshops, and rehearsals took place during construction, allowing participants to engage with the emerging space. The construction site became a meeting place for those designing and building the theatre and those preparing to perform in it. Through this, participants began to establish relationships with the space and with one another. The process thus extended beyond the production of a physical structure, creating opportunities for participants to become involved in shaping both its material form and its emerging social and cultural life. The theatre was collaboratively constructed and activated through a public performance. The completed structure remains available for future community activities.

The project illustrates an approach to participatory architecture in which construction and cultural activity become interconnected practices of making and inhabiting space. Future research combining participant interviews and longitudinal assessments of space use could investigate how participation in these processes relates to perceived agency, social connectedness, and place attachment. Such research could contribute to understanding how collective making using bio-based materials, cultural participation, can form socially responsive architectural practices in contexts of reconstruction and recovery.

Keywords: participatory architecture, timber construction, war

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Understanding Long-term Housing Decisions: Homeowners' Values and Climate Choices in Austria and Slovenia

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The built environment is an essential target for climate-change mitigation and adaptation. Residential buildings and construction account for nearly 40% of global energy-related greenhouse-gas emissions while also being important determinants of social and health equity (Bentley et al., 2025). Consequently, homeowners' decisions concerning heating systems, renovations, energy efficiency, and other long-lived investments are central to creating a sustainable and climate-resilient built environment. Such decisions require homeowners to negotiate immediate costs and constraints against benefits that often materialize over extended time horizons. Hyperbolic discounting suggests that individuals favor immediate rewards while assigning less value to future benefits (Green & Myerson, 2004). While rational choice, bounded rationality, and behavioural economic approaches offer important explanations for such behaviour, they provide a more limited account of the processes and factors shaping long-term decision-making and how concrete characteristics and outcomes of housing decisions become connected to homeowners' broader goals.

This study examines high-impact, long-term housing decisions among homeowners in Austria and Slovenia using soft-laddering interviews. Soft-laddering interviews are used to elicit means–end chains linking perceived attributes of mitigation and adaptation measures to their functional and psychosocial consequences and, ultimately, to homeowners' underlying values. This approach allows us to move beyond identifying isolated barriers and drivers by examining how homeowners construct reasons for or against long-term housing investments.

Preliminary analysis indicates that climate-relevant housing decisions are embedded in multiple, interconnected considerations rather than being driven by environmental concerns alone. Energy efficiency and financial characteristics emerge prominently at the attribute level, while recurring consequences include financial savings, energy self-sufficiency, comfort, convenience, and reduced resource use. These outcomes are associated with broader goals including environmental responsibility, autonomy, wellbeing, security, and family-related considerations. Renewable-energy decisions, for example, are linked simultaneously to environmental benefits, financial savings, and greater self-sufficiency, while building automation combines efficiency considerations with savings, convenience, and thermal comfort. By revealing the value-based pathways through which homeowners evaluate high-impact housing decisions, the study provides a more differentiated account of long-term decision-making in the residential built environment. The findings can contribute to refining existing decision-making frameworks and inform policies and interventions that connect climate-resilient housing measures more closely to the consequences and values shaping homeowners' decisions.

Keywords: homeowners, built environment, climate change mitigation, climate change adaptation, long-term decision making

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Demountable CLT–Concrete Composite Floor Systems

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Timber–concrete composite (TCC) systems combine the low environmental impact of timber with the high stiffness and strength of concrete. TCC is a sustainable alternative for reinforced concrete floors; however, as timber and concrete are connected permanently in conventional TCC floors, they are associated with a high level of waste creation at the end of service life. Therefore, their integration into circular construction requires connection solutions that enable disassembly, reassembly, and reuse while maintaining structural performance.

This research focuses on the development and characterization of demountable cross-laminated timber (CLT)–concrete composite floor systems. The proposed connector consists of a notch ed with a threaded insert system that enables controlled tightening, assembly, disassembly, and reassembly. The study aims to characterize the mechanical behavior of this connection concept and quantify the effects of tightening level and disassembly–reassembly cycles on the structural response of CLT–concrete composite floors.

The research adopts an integrated experimental and analytical methodology. At the connection level, axial pull-out tests on threaded inserts embedded in CLT are performed to determine the allowable tightening range based on withdrawal resistance. Subsequently, shear tests are conducted to evaluate the effects of tightening condition and disassembly–reassembly cycles on shear stiffness, strength, ductility, and failure modes. At the system level, full-scale CLT–concrete composite floor specimens are tested under vibration and bending loading to assess the influence of connection conditions on natural frequency, effective bending stiffness, interface slip, and load-carrying capacity.

The findings will contribute to a better understanding of composite action in demountable CLT–concrete floor systems and further adjustment of analytical models based on Eurocode 5 γ-method formulations.

Keywords: design for deconstruction, demountable notch connections, tightening effect, composite action, analytical modeling.

Framework For Converting Reclaimed Timber Beams Into Structural Timber Products

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Reuse of timber in structural applications is a strategy that can contribute to reducing the negative environmental impact of the building and construction sector (Patrizi et al. 2026). Nevertheless, the widespread reuse of timber is currently limited. This is partially because existing strength-grading and design standards, as well as processing approaches, aredesigned for virgin resources and may not be directly applicable to reclaimed timber (Rebhi et al. 2026). Even though some aspects of these challenges have been addressed in previous research, the collective effectiveness of existing knowledge, assessment methods, and processing technologies for reclaimed timber has rarely been evaluated within a unified framework under operational conditions.

This research aims to establish an integrated framework for converting reclaimed timber beams into structural timber products through comprehensive material assessment, optimized processing, and second-life valorization in engineered wood products. The framework seeks to maximize material recovery and the ability to estimate the structural performance of the resulting products by enabling informed selection of processing pathways and intended application. The research is structured across three interconnected levels. At the beam level, reclaimed timber will be evaluated non-destructively to identify wood species, geometry, external and internal defects, contaminants and fasteners, mechanical properties, density andmoisture content. At the board level, the effects of processing strategies on board properties and material recovery will be investigated. At the engineered wood product level, target structural product(s) manufactured from reclaimed timber will be experimentally evaluated to assess their performance and the ability of analytical models to predict that performance using data obtained non-destructively during the beam- and board-level assessments.

By establishing relationships between the properties of reclaimed beams, processing strategies, board performance, material recovery, and final product performance, the research will provide a comprehensive framework for decision-making throughout the reuse pathway. The framework will support the optimal use of reclaimed timber in structural applications.

Keywords: reuse, reclaimed timber, engineered wood products, decision-making framework

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Can acoustic metamaterials embedded in CLT panels improve low-frequency sound absorption and acoustic comfort in timber buildings?

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Low-frequency noise is difficult to control because of its long wavelengths and low atmospheric attenuation during propagation, and because it transmits more readily through lightweight building elements. Timber buildings are lighter and less stiff than heavyweight structures, so they can show lower sound insulation at low frequencies and be more susceptible to low-frequency excitation. Under strong excitation, transmitted low-frequency sound can induce structural vibration in building elements. Such noise increases disturbance and annoyance, is often perceived indoors as a persistent hum, rumble or vibration, and can interfere with sleep, relaxation and concentration under continuous exposure (Caniato et al., 2016). Effective low-frequency absorption remains challenging for conventional absorbers: porous materials such as foams require a thickness related to a fraction of the incident wavelength, so the quarter-wavelength principle implies much greater thickness at lower frequencies. Below 120 Hz, this may require large amounts of material and space that are difficult to accommodate in modern buildings, increasing material use, embodied carbon and environmental impact. Conventional absorbers, commonly mineral fibres or polymer foams, are typically available in thicknesses more effective at medium and high frequencies, limiting space efficiency, material efficiency and sustainable acoustic solutions. Acoustic metamaterials offer a more compact and potentially sustainable approach, combining resonant mechanisms, thermoviscous losses and extended, often coiled or labyrinthine, propagation paths within a small volume. By increasing the effective acoustic path length and concentrating energy dissipation, they can target specific low-frequency ranges at much smaller thickness than conventional absorbers (Chai et al., 2026). This research implements the acoustic metamaterial concept directly within CLT panels and evaluates panel-scale performance. The sound absorption coefficient of the fabricated panels will be measured in a reverberation room. Listening tests with subjective evaluations will investigate how this low-frequency absorption influences participants' acoustic comfort, providing objective and perceptual evidence.

Keywords: acoustic metamaterials; low-frequency sound absorption; cross-laminated timber (CLT); acoustic comfort; subjective listening tests

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Fire Performance of Scots Pine Wood Modified with a Bio-Based Fire Retardant

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The incorporation of wood and bio-based materials into the construction sector represents a promising approach to reducing its annual CO2-eq emissions in Europe (Haisma et al., 2023). Nevertheless, the widespread application of these renewable materials remains limited by certain inherent properties, including their susceptibility to humidity and inadequate fire performance. In response, numerous fire-retardant treatments have been investigated to reduce the flammability of wood (Lowden and Hull, 2013). Among these, phytic acid (PA), a naturally occurring compound characterised by its high phosphorus content, has emerged as a promising bio-based fire-retardant candidate (Wang et al., 2022).

This study examined the influence of phytic acid impregnation, applied at a concentration of 10 w/w% in an aqueous solution, on the fire performance of Scots pine wood. The reaction to fire of the different groups was evaluated under heat fluxes of 25 kW·m^{-2} and 50 kW·m^{-2}. Under the 25 kW·m^{-2} heat flux, the PA-impregnated groups did not ignite, suggesting that their critical heat flux exceeded 25 kW·m^{-2}. Despite the absence of ignition, these groups produced the highest quantities of smoke, which was attributed to continuous charring throughout the entire depth of the specimens. At a heat flux of 50 kW·m^{-2}, the PA-impregnated groups exhibited comparable heat release rate behaviour, characterised by delayed ignition, a substantial decrease in the peak heat release rate, and the release of almost no heat. However, although PA effectively enhanced the reaction to fire of the impregnated groups, it also resulted in an undesirable increase in VOC production. Since higher smoke density and toxic gas emissions can considerably impede evacuation during a fire, a subsequent study will examine potential methods for inhibiting smoke generation in PA-treated wood.

Keywords: cone calorimeter, bio-based fire-retardant, reaction to fire, phytic-acid

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From Forest to Building: Responsible Wood Sourcing and Supply Chain Traceability in Sustainable Construction

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The growing use of wood and other renewable materials in the built environment is increasingly recognized as a strategy for reducing the environmental footprint of the construction sector. Timber-based construction can lower embodied carbon emissions while simultaneously storing biogenic carbon throughout a building's lifespan (Peñaloza et al., 2016; Dzhurko et al., 2024).

While advances in mass timber and bio-based construction have accelerated the adoption of wood in sustainable buildings, the environmental performance of timber products depends not only on material characteristics but also on the responsible management of the forests from which they originate. As demand for renewable materials grows, issues such as biodiversity conservation, legal harvesting, sustainable forest management, and supply chain transparency become increasingly important.

The presentation examines the role of forest certification and chain-of-custody systems in supporting sustainable construction. It discusses how responsible sourcing frameworks can provide assurance that wood products originate from responsibly managed forests and remain traceable through processing, manufacturing, and distribution stages. Particular attention is given to the role of supply-chain verification systems in supporting transparency, sustainable procurement, and regulatory compliance in increasingly complex timber value chains.

The presentation further explores how responsible sourcing contributes to broader sustainability objectives within the built environment, including climate mitigation, biodiversity protection, and stakeholder confidence. In parallel, emerging research highlights the growing interest in wood-based and biophilic design approaches that may enhance occupants' well-being and strengthen human connections with natural materials (Xing et al., 2025; Ryan et al., 2014).

Drawing on international examples from timber construction and certified forest product supply chains, this contribution argues that responsible sourcing should be considered a fundamental component of sustainable building strategies, complementing innovation in materials, building performance, and circular economy approaches.

Keywords: sustainable construction, timber buildings, responsible sourcing, traceability, forest certification

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From Nanoscale Structure to Long-Term Stability in Y6-Based Organic Solar Cells

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Organic solar cells (OSCs) are promising technology for next-generation renewable energy due to their potential for lightweight, flexible, and low-cost photovoltaic applications. Despite significant advances in device efficiency long-term stability remains an important challenge for their wider deployment. Understanding how changes in the nanoscale structure of the active layer influence device stability is therefore essential for improving their performance over extended operation (Kang et.al, 2023). Here, we investigate the relationship between active-layer morphology, composition, and stability in PTQ10-based OSCs by comparing binary and ternary blend systems (Fürk et al., 2023). Although Y6 and Y-Pr share a similar conjugated backbone, differences in their end-group chemistry lead to distinct molecular packing and phase behaviour. Atomic force microscopy (AFM) and grazing-incidence wide-angle X-ray scattering (GIWAXS) results show that incorporating Y-Pr (20 wt%) reduces domain size and modifies phase separation, resulting in finer nanoscale features. Thermal ageing at 65 °C under inert conditions demonstrate enhanced stability in ternary systems, which remain above 80% of their initial performance after 1440 hours, compared to the binary blend. To probe these effects, we employ a combination of synchrotron- and lab-based techniques, including GIWAXS, AFM, infrared (IR), and Raman spectroscopy, to monitor structural and chemical evolution during thermal ageing. Device performance is tracked alongside these measurements to establish correlations between morphological changes and stability. By correlating thermal exposure with morphological and chemical changes, this work aims to identify structural factors that influence stability in binary and ternary OSCs. These insights can help clarify degradation mechanisms and guide strategies for improving the operational stability of OSCs.

Keywords: organic solar cells, clean energy, nanoscale morphology, stability

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The impact of relaxing video games on stress

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Stress is one of the major challenges to psychological well-being in the 21st century, making effective strategies for managing everyday stress increasingly important. Video games are among the most common leisure activities, and a growing body of research has examined their potential positive effects on psychological well-being and stress management. The aim of the present study was to examine whether short-term play of a relaxing video game is more effective in reducing subjective stress than passively watching a nature video. We also examined differences in immersion, cognitive effort, and affective response between the two interventions. The study included 50 participants in a within-subject experimental design, in which each participant completed both interventions in a counterbalanced order. Subjective stress, mood, and affective response were measured before and after each intervention, while immersion and cognitive effort were only assessed following each intervention. Both playing a relaxing video game and watching a nature video significantly reduced subjective stress, with no statistically significant difference in stress reduction between the interventions. Compared with watching a nature video, playing a relaxing video game resulted in greater immersion, greater cognitive effort, and higher affective arousal. However, immersion was not significantly associated with stress reduction. These findings indicate that short-term play of a relaxing video game can reduce subjective stress to a similar extent as passively watching a nature video. At the same time, the findings suggest that stress-reducing effects of relaxing video games cannot be explained by immersion alone, pointing to the potential role of other psychological mechanisms. This provides a basis for further research into the use of relaxing video games as a potential tool for managing everyday stress.

Keywords: relaxing video games, stress reduction, immersion, nature video, affective response

Designing robust occupant wellbeing studies with simulation and piloting

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Occupant wellbeing studies, including those investigating the role of wood products and materials in buildings, are complex due to the range of influences on wellbeing, person-to-person variation, amongst other factors. Experiments are further complicated by divergent views on theoretical foundations relied upon and lack of interdisciplinary collaboration needed to ensure robust experimental design and execution. In a recent review, Cavaliere et al. (2026), recognised the need for a methodological framework that supports quality and comparability of studies. They also recognise the complexity inherrent in the studies being conducted and make suggestions to handle such complexity through categorisation of experimental factors.

Additional tools to ensure robust studies rest in following a structured approach to experimental design that includes simulation studies and pilot testing prior to finalising and executing experiments. Working through these step helps the researcher to understand not only the processes involved in an experiment, but also to critically examine the factors that may produce effects and the relationships between them. Prior to simulation, researchers can create directed acyclic graphs (DAG) to map the relationship between the variables in their study. Generative statistical models can then be developed that mimic based on the DAGs and existing knowledge. These models are then run and re-run with varying inputs to test plausible effect sizes, estimate sample sizes, and explore potential relationships between variables. Pilot studies built around the final models can then be run to validate the models or iteratively adjust and improve them. Finally, analysis of the experiment is both straightforward and deeper as alignment with the theoretical simulation model can be investigated directly.

Keywords: experimental design, interdisciplinary research, simulation, DAGs

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Using UV and X-ray light to modify materials properties

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When considering the irradiation of materials with UV or X-ray light, the first association is often with radiation damage - for example, the fading of textile colorants under sunlight or the degradation of electronic components in space due to ionizing radiation. However, irradiation does not necessarily have detrimental effects. Under defined conditions, UV and X-rays can induce structural and chemical changes in materials, modifying their properties in a predictable and controllable manner. These radiation-induced transformations are deliberately exploited in microfabrication processes, enabling the localized modification and patterning of materials. This approach makes it possible to develop novel microsensors and devices that, among many other applications, could contribute to transforming sustainable architecture by turning static structures into smart, self-optimizing systems.

In this communication, a selection of research activities conducted in the field of advanced materials irradiation at the Graz University of Technology outstation at Elettra synchrotron will be presented. First, the X-ray irradiation of Metal Organic Frameworks (Tu et al., 2020) and Trimethylsilyl cellulose to fabricate innovative microsensors will be described. Subsequently, a novel microfluidic device specifically designed for the study of photoactive systems will be reported (Marmiroli et al., 2026) . Finally, the available facilities and procedures for accessing UV and X-ray irradiation capabilities will be outlined.

Keywords: UV/X-ray irradiation, microsensors, functional materials, microfabrication

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From Structure to Function: Leveraging Synchrotron Science in Correlative Multi-Technique Studies of Responsive Materials

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Responsive materials undergo structural and chemical changes upon stimulation by light, temperature, pressure or chemical environments (e.g. gases). Such responses are crucial for applications ranging from mechanical actuation and energy storage to molecular transport, sensing, and adaptive behaviour. Understanding how structural changes translate into function remains challenging across multiple length and time scales, highlighting the need for correlative approaches bridging molecular and macroscopic responses.

Here, the potential of synchrotron-based methods is highlighted through the combination of time-resolved X-ray scattering and diffraction with infrared spectroscopy and complementary techniques. These measurements connect molecular-level chemical changes with the evolution of structure, morphology, and mesoscale organization across diverse responsive systems, including crystalline materials, thin films, biomolecular assemblies, and proteins. Following structural transformations in real time reveals how composition, local environment, morphology, and structural dynamics govern functional responses.

More broadly, these results demonstrate how correlative synchrotron methods can identify the structural origins of dynamic behaviour, quantify response kinetics and reversibility, and establish structure-function relationships. These insights inform the experimental direction and capabilities of the HB-SAXS beamline at Elettra Sincrotron Trieste, supporting advanced approaches for studying dynamic materials across multiple length and time scales.

Keywords: synchrotron radiation, correlative characterization, stimulus-responsive materials, x-ray scattering, dynamics

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From Thin-Film Architecture to Function: Controlling Dynamics in Flexible MOFs for Environmental Sensing

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Metal-organic frameworks (MOFs) are crystalline materials offering high porosity, structural tunability, and responsiveness to external stimuli, making them attractive for environmental sensing, separation, and monitoring. Their integration as thin films offers a promising route towards functional devices but requires reproducible fabrication strategies with precise structural control and advanced characterization techniques capable of tracking structural changes under external stimuli. In these surface-anchored architectures, crystallite size, crystallographic orientation, and film uniformity emerge as important factors influencing structural stability and dynamic response.

Here, we demonstrate a spin-assisted layer-by-layer liquid-phase epitaxy (LbL-LPE) approach that enables control over these parameters, using $Zn_2(BDC)_2(DABCO)$ as a model system (Afanasenko et al., 2026). The films are characterized using synchrotron grazing-incidence wide-angle X-ray scattering (GIWAXS), scanning electron microscopy (SEM), and grazing-incidence infrared spectroscopy (GI-IR). The method enables rapid and reproducible growth of homogeneous films under ambient conditions, without elevated temperatures or toxic solvents, while minimizing chemical consumption.

Our results show that crystallographic orientation is critical to MOF thin-film stability, with highly oriented films showing enhanced resistance to humidity-induced degradation. Crystallite size further influences azobenzene infiltration and the resulting photoresponsive behaviour, highlighting the role of thin-film architecture in governing structural stability and dynamic response. Combined with SEM and GI-IR, synchrotron GIWAXS provides a powerful approach for resolving these structure–response relationships. These insights establish a foundation for the rational design of responsive MOF thin films for environmental sensing applications.

Keywords: metal-organic frameworks (MOFS), thin films, photo-switching, crystallographic orientation, GIWAXS

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Nanostructure-Dynamics seen by Coherent X-Ray Pulses

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Understanding the structure and dynamics of matter at the nanoscale is one of the key challenges in condensed matter physics today, holding great potential for society and technology, e.g., advancing drug delivery in the human body and developing new functionalities in quantum materials. Depending on the type of nanostructure and excitation used, these dynamics may span several orders of magnitude in time, starting with phenomena like mechanical stress in solids and thermal diffusion in colloidal systems at nano- to microsecond time scales, down to the laser-driven excitation of electrons and consecutive heat transfer in solids at femto- to picosecond time scales. Particularly important for developing new functionalities in materials is to control these dynamics, and therefore, to understand the influence of external parameters like temperature, pressure or electric field.

One of few experimental techniques capable of measuring the nanostructure and dynamics of matter at its natural length and time scales is X-ray Photon Correlation Spectroscopy. XPCS utilizes the exceptional coherence properties of 4th-generation synchrotron sources, which enables correlation-function analysis of the so-called speckle patterns of the sample's nanostructure, obtained in small-angle x-ray scattering geometry at varying delay times. Thanks to non-invasive probing and the possibility of having spacious sample environments under normal conditions, XPCS experiments allow to study realistic scenarios (in-operando, on-chip…) and to systematically vary external parameters during one synchrotron beamtime.

In this talk, the principles of XPCS will be introduced and two XPCS experiments will be highlighted: single- and multi-pulse based XPCS, which allows to cover fast but also a wide range of times in correlation functions, and 3D XPCS, which allows to measure densely packed soft-matter systems.

Keywords: coherence, x-ray photon correlation spectroscopy, 4th generation synchrotron, nanostructure, dynamics

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