Guest Editor Preface

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It is a great pleasure that I preface this special issue of the Journal of Sustainable Architecture and Civil Engineering, which comprises invited papers submitted to the 5th Forum Wood Building Baltic, organized between 27 – 28 February 2024 in Tallinn, Estonia.

The Forum Wood Building Baltic 2024 conference was a fantastic opportunity for scientists and practitioners to meet and exchange experiences and to learn from the best within the field. The conference was organized by Tallinn University of Technology, the Estonian Academy of Arts and Forum Holzbau in collaboration with Estonian Association of Civil Engineers and Estonian Woodhouse Association.

Forum Wood Building Baltic is the main conference for architecture and engineering topics of wooden buildings: design for manufacturing and assembly, building physics, energy performance, fire safety etc. in the countries around Baltic Sea. The conference is a part of the international organization Forum Holzbau. The overarching theme of Forum Wood Building Baltic 2024 was integrated design where different disciplines came together to cooperate and push the boundaries of innovation in timber construction. Scope of the conference were: regenerative and circular architecture, prefabricated timber-based renovation solutions, process innovation in design and construction of wooden buildings, timber structures (Eurocode 5), fire safety in timber buildings, building physics of timber structures, and zero emission wooden buildings (LCC, LCA).

This special issue includes nine articles, which cover different aspects from renovation and service life of materials to timber structures and building physics.

The urgency for the deep renovation of existing building stock is highlighted by directives, national policies, thematic contexts, municipal objectives, and local considerations. The current annual renovation rate of 1% is evidently inadequate, prompting us to explore ways to enhance efficiency. It is widely recognized that focusing solely on improving energy performance can limit potential future investments that could enhance the quality of life in the buildings under consideration. To apply the principles of the New European Bauhaus (NEB) to contemporary renovation initiatives of modernist apartment buildings, Truu et.al. suggested rephrasing the acronym as Neighbourhoods as Ecosystems for Better living (NEB'). Urban transformations, particularly in well-established privately owned neighbourhoods, require an integrated, cross-scale perspective on social-ecological-technological systems. This necessitates collaboration among various urban stakeholders, including national and local governments, the private sector, and civil society, with private individuals remaining at the core of the model as decision-makers. To effectively organize neighbourhood renovation, a comprehensive set of tools is needed, beginning with decision support tools that assist private owners in assessing cost-benefit ratios, as well as evidence-informed policies and reprogrammed incentives at the municipal level.

Construction and demolition waste accounts for more than one-third of the total waste generated in the European Union. In order to achieve sustainable renovation, it is important to consider elements that promote reuse or recyclability. Nigumann et. al. have developed a circular deep renovation solution that utilizes prefabricated modular external additional insulation elements, with the aim of creating a nearly Zero Energy Building (nZEB). The potential for disassembling

and reusing materials has been developed and demonstrated for both a prototype and a complete deep renovation. The analysis shows that the prefabricated modular solutions have greater potential for circularity compared to the traditional ETICS. The overall cost of the circular prefabricated renovation amounts to 505 €/m². Following the renovation, the building meets the requirements for nZEB without any performance gap. The deep renovation of the buildings contributes significantly to achieving the goals of decarbonizing the building stock.

In order to effectively accomplish the objectives of deep renovation, it is necessary to identify common damages, determine renovation needs before initiating the renovation process, and evaluate current renovation practices. Põdra et. al. conducted an analysis of a database comprised of building survey and consultation reports for over 200 wooden log houses. The findings revealed that the external walls, roofs, and foundations were the building elements most requiring renovation, with 77%, 63%, and 63% of the buildings, respectively, in need of such repairs. Excessive moisture was identified as the primary cause of damage to these vulnerable structures. The renovation solutions proposed by consultants, aimed at improving energy efficiency, indoor climate, and moisture safety, were generally deemed inadequate in achieving the goals of decarbonizing the building stock, promoting health, and ensuring long-lasting buildings. Furthermore, the varying levels of education and work experience among consultants, designers, and craftsmen highlight the necessity for educating and training.

The service life of building materials and products are of utmost importance in meeting the requirement for sustainable use of natural resources. Various coatings are available to protect surfaces against environmental and biotic degradation, as well as to provide an aesthetically pleasing layer. Sandak et al. have proposed an innovative bioinspired concept for protecting materials utilizing fungal biofilm. The type of material and the climatic conditions at the exposure site have an impact on fungal colonization and the diversity of microorganisms. Generally, materials with commercial coatings are less susceptible to fungal infestation. It is anticipated that this novel approach to material protection will revolutionize traditional material concepts, leading to the development of engineered living materials capable of interacting, adapting, and responding to environmental changes.

To evaluate the condition of old timber and prevent unnecessary demolition in the context of circular use of structures, it becomes essential to possess knowledge about the properties of such timber. While there are numerous standards available to assess the quality of freshly sawn timber, there is currently no standardized system to evaluate the strength properties of aged timber. Kauniste et al. conducted both destructive and non-destructive testing, along with visual assessment, to determine the potential utilization of timber sourced from a wooden building approximately 120 years old. The obtained results were then compared with a Nordic standard for grading freshly sawn timber, as well as two established Italian standards for visually assessing aged timber. The findings revealed that the grading standards significantly underestimated the actual strength of the wood. Furthermore, none of the visual assessments overestimated the strength of the specimens.

Cross Laminated Timber (CLT) is a sustainable structural material that can be used as a replacement for concrete in order to minimize the embodied emissions of buildings. In their research, Böhm et. al. investigated the elastic limit load capacity and bending stiffness of a composite beam with a non-rigid composite joint, using 4-point bending tests and vibration tests. The composite beams deformed linear-elastically until the yield strength of the steel was reached. It is worth noting that the screws did not fail and only underwent elastic deformation. Among the composite beams tested, those with a higher stiffness share of CLT achieved a higher elastic limit load capacity when compared to beams with a lower stiffness share. Furthermore, the bending stiffness of the composite beams was found to be approximately twice that of beams without a composite

effect. In future studies, the obtained results will be validated using numerical models, and an analytical calculation approach will be developed. This approach aims to provide comprehensive validity for all spans, shear connector stiffnesses, and both continuously and discontinuously spaced connectors.

With the TS3 technology, timber components are bonded together in a statically loadbearing manner at the end grain surfaces. Two-component polyurethane resin is used for gluing, which is currently a challenge on the construction site, the processing temperature set by the cast resin manufacturer is at least 17 °C, because especially in Scandinavia, but also in the Baltic countries and Central Europe, such a temperature is hardly or only rarely reached during the coldest seasons of the year. Lins et.al. investigated whether the casting resin reaches the specified final strength at lower curing temperatures only after a longer curing time or remains significantly lower. Results showed, low curing temperatures have a negative effect on the mechanical properties not just for the pure casting resin strength and hardness but also for the bonding strength. In the future, it is planned to describe the non-linear temperature effect more precisely and prepare a corresponding project proposal that takes the temperature effect into account.

In the Northern climate, it is crucial to have a building envelope that possesses good thermal insulation and low embodied emissions in order to counterbalance and mitigate the overall carbon footprint of a building. Traditional construction materials, including timber and clay, have proven to yield favorable results in terms of embodied emissions in life cycle assessment. Päätalo et al. have developed a novel prefabricated wall element that combines a lightweight timber frame with light clay (λ=0.077 W/(m·K). The incorporation of the timber frame structure effectively mitigates thermal bridges caused by timber, while also creating gaps within the structure that facilitate a better integration of the clay mixture with the timber structure, thereby preventing detachment. Furthermore, the wall elements have demonstrated resilience during transportation, exhibiting minimal visible damage and abrasion during both transportation and lifting/settling processes. The potential for industrial application through prefabrication appears promising, despite the varying technical properties of the specimens, which underscores the need for meticulous quality control measures.

Highly insulated building structures arise new challenges for hygrothermal performance of building envelope. Due to low heat flux temperature behind the wind barrier and in ventilation cavity are lower that increase relative humidity. Viljanen et. al. evaluated the possibility to improve the hygrothermal performance of such roofs in a Nordic climate by using different control methods for the ventilation rate of the roof and by using thermal insulation above the roof sheathing. Results showered that a high level of built-in moisture in a wooden roof element leads to a risk of mould growth in the middle area and in the outflow area of the roof. Thermal insulation above roof sheathing does not prevent mould growth risk in a roof with high amount of built-in moisture. The use of adaptive roof ventilation as it decreases the probability of mould growth in the roof.

The end-grain bonding of timber components using the Timber Structures 3.0 technology (TS3) is an advancing construction method in timber engineering. This technology allows the realisation of any plate size by bonding plates on-site where low temperatures influence the performance. Lins and Franke investigated On-site application of end-grain bonded timber under low curing temperatures. They concluded, that it is feasible to predict the needed heating wire configurations according to environmental factors and enable an informed design of the heating wire system. By authors, the heating wire method is a feasible approach, despite the substantial extra workload associated with milling, installation, heating wire adjustment, and quality assurance. Since these endeavours are comprehensive, researchers are continuously exploring alternative methods for achieving bonding at lower ambient temperatures with less complexity.