Guest Editor Preface

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It is a great pleasure that I preface this the second 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, to exchange experiences and learn from the best within the field. The conference was organized by the Tallinn University of Technology, the Estonian Academy of Arts and Forum Holzbau in collaboration with the Estonian Association of Civil Engineers and the 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. The scope of the conference was: regenerative and circular architecture, prefabricated timber-based renovation solutions, process innovation in the 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 eight articles, which cover different aspects of hygrothermal performance of timber structures, renovation, durability, circularity, life cycle assessment and life cycle cost.

Prefabricated additional insulation elements have been proven successful in the renovation of apartment buildings. Pihelo and Kalamees designed an additional thermal insulation element specifically for the renovation of high-rise apartment buildings and evaluated its hygrothermal performance through field measurements in a wall prototype and hygrothermal modelling. The findings indicate that the hygrothermal performance and moisture dry-out of the external wall are primarily influenced by the thermal resistance and water vapour permeability of the wind barrier layer and the presence of an appropriate vapour control layer. The results of the hygrothermal performance analysis are presented in the form of a red-yellow-green "traffic light" system, considering the risk assessment for mould growth. The drying process of the initial moisture can extend beyond 3 years, depending on the building type and materials used. This study emphasizes the significance of tailored solutions and careful moisture safety management in the renovation of high-rise apartment buildings, especially when implementing prefabricated additional insulation elements.

Prefabricated insulation elements can also be utilized for roof renovation. During renovation the precipitation can cause moisture accumulations in the attic structures. Although a temporary roof can be used by onsite manual renovation, installing prefabricated roof elements under such conditions is challenging, if not impossible. Therefore, when renovating the roof, it is crucial to incorporate moisture safety measures. Kodi et al. conducted a case study on a building that was renovated to near-zero energy standards using prefabricated insulation elements, without implementing proper moisture safety measures resulted moisture and mould damage. Different moisture safety strategies were analysed: employing a full temporary roof or by avoiding rainfall during installation, localizing water damage, active ventilation. In cases of localized moisture damage, the recommended amount of ventilation airflow during summer is 0.5–0.55 l/(s·m²). Heating is required during cold periods. The existence and proper implementation of a moisture safety strategy are important for achieving desired energy performance goals while ensuring the durability of the building and occupant health. This strategy should be applied throughout the site management chain, from the main contractor to the skilled worker.

Proper moisture control is important to ensure the long-term integrity of the elements. Birkeland et al. investigated the moisture properties of laminated veneer lumber (LVL). The correlation between moisture sensor readings and the actual moisture content determined from accurate weighing of the samples was compared. The results show that the moisture content determined by the resistance method were too high compared to the more accurate gravimetric method. Conversely, the measured values were too low for the pine samples. LVL also had a faster moisture sorption than pine under the same moisture conditions. The glue between the veneer layers affects the electric conductivity of the wood in LVL and interrupts the readings. The glue might also affect the moisture sorption.

The use of bio-based materials has gained popularity thanks to their small carbon footprint. Blommaert et al. studied the durability of traditional insulation materials in timber frame constructions and Cross Laminated Timber (CLT) constructions in the climate in Brussels. The objective was to find out to which extent this durability depends on various levels of climate change impact we might face based on future greenhouse gas concentrations. The results show that climate change has a negative effect on durability and that this effect is higher for cellulose than for traditional insulation materials such as mineral wool or polyurethane foam. To reduce the risk of degradation (and hence to increase the durability of the structure), this effect of climate evolution has to be considered when designing the wall build-up. The study concluded that further research is necessary to consider other aspects (such as water and air leakage, façade cladding and built-in moisture) potentially impacting the durability of the used materials in various circumstances.

The sustainable use of natural resources is one basic requirement for construction works. Buildings must be designed, constructed, and demolished in a manner that includes practices such as the reuse or recyclability of the materials and parts after demolition, durability of the construction works, and use of environmentally compatible raw and secondary materials in the construction works. Tuksam and Pihlak have developed a design method that introduces a versatile and holistic construction system, departing from traditional orthogonal designs. They employed algorithmic tools to streamline the design process and effectively manage the complexities associated with working on smaller elements. The results of their research demonstrate the potential for automating and pre-rationalizing the design process, granting designers more freedom beyond the constraints of orthogonal designs and shell structures. The applications of this methodology range from creating shelters and facade systems to building extensions and potentially even large-scale construction systems. The implications of this study on the environmental impact of CLT construction go beyond dealing with offcuts which, according to various sources constitute 5-20% of the produced material.

Circularity in architectural design can involve extending the service life of a building frame, whilst forests grow back and store more carbon. Schwarzschachner et al. studied the circular design of buildings with prolonged biogenic carbon storage. Static and dynamic life cycle assessment (LCA) has been carried out to assess different scenarios, modelling and quantifying its potential benefits regarding whole life carbon. Results showed that total emissions, considering a reference service life of 50 years, are 2.84 kg CO_2-eq./m² floor area/year, considering biogenic carbon storage and carbon sequestration in re-growing forests. An increase of the building lifetime to 80 years aligns with a longer rotation time of forest trees, resulting in whole life carbon of -0,09 kg CO_2-eq./m² floor area/year. Extending the life of a building and thereby the environmental benefits of biogenic carbon storage in wood products can significantly help to decarbonize the construction sector, and today's wood construction products in these buildings can be the material banks of the future.

Life Cycle Cost (LCC) is one of the basic indicators for sustainability assessment and cost effectiveness applicable in construction, making it possible to optimize the entire life performance of buildings and other structures. A major weakness in LCC is the lack of detailed and relevant information on service life estimates, and the expected maintenance, repair, or replacement intervals. Modaresi and Landaas provided a platform for LCC calculation rules for timber buildings, by employing a refined technical service life estimation. The improved service life input dataset enables more precise LCC estimation for wood-based products. The model serves as a flexible tool, enabling users to examine the impact of material choices on the cost of both the load-bearing elements and the building envelope, as well as on the maintenance expenses throughout the building's service life.

Preserving the built heritage, maintaining the original exteriors of historic apartment buildings, and achieving today's living standards and ambitious environmental objectives require a multidisciplinary approach encompassing cultural, economic, legal, social, environmental and historical factors. Liina et al. identified the need for renovation, assessed the justification of the renovation requirements, and evaluated the effectiveness of the renovation solutions implemented of historic apartment buildings. Results showed that in studied heritage area only 30% of the investigated buildings' large areas (i.e., roof, façade, windows) retained their original materials, while 44% were primarily replaced with new materials. More specifically, 74% of the windows were replaced with a new material – transitioning from wooden frames to plastic frames. According to the building survey, almost half of the façades and plinths were in a condition requiring renovation in the near future. The study underscores the necessity for a shift in Estonia's authorized heritage discourse. Rather than primarily imposing restrictive measures on construction and renovation projects, the focus should pivot towards effective communication of historical values. It is crucial to provide respective support and guidance (not restrictions) to building owners, designers and builders. The discourse on heritage preservation should advocate for and endorse deep renovations, ensuring that the quality of the historic urban environment is conserved during the renovation process.