The InnoRenew CoE International Conference 2021

HEALTHY AND SUSTAINABLE RENOVATION WITH RENEWABLE MATERIALS

June 10-11 | Online

2021

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Keynote Address

2021

Lisanne Havinga, MSc. PhD

Assistant Professor Building Performance and Principal Scientist System Integration, Technische Universiteit Eindhoven

Lisanne Havinga is Assistant Professor at the Building Performance group at Eindhoven University of Technology (TU/e) in the Netherlands. She is also Principal Scientist System Integration of the Eindhoven Institute for Renewable Energy Systems, and part of the management team of the institute. She received her Ph.D. in 2019 from TU/e, titled 'Advancing Post-War Housing: Integrating Heritage Impact, Environmental Impact, Hygrothermal Risk and Costs in Renovation Design Decisions'. Her research focuses on developing modeling and simulation strategies to support decision-making in the energy transition of the built environment. Core topics include the optimization of renovation decisions using parametric exploration of housing variations, user behavior and renovation solutions. A holistic assessment of environmental impact, incorporating life cycle assessment and circularity, is a priority in her work. Lastly, she focuses on setting up interdisciplinary collaborations to develop multi-scale, multi-carrier, dynamic models that support system integration and decision-making across scale levels (technology-building-neighborhood-city-region-country) and sectors (mobility, industry, built environment). The evaluation of innovative technologies and their potential in addressing the key challenges of the energy transition is a priority.

In recent years, she's contributed to the development of the Climate Agreement of the Netherlands by developing 'the Renovation Accelerator', a subsidy program that was recently launched, aiming to accelerate the large-scale renovation of the housing stock. In this context, she's been an advisor and led research projects for multiple governmental organizations in the Netherlands. In addition to working for governmental organizations, she has built consortia with a wide variety of industry partners. Although she only recently was awarded her PhD thesis, she has already developed a substantial track record of publications and is already building teams of PDEngs, PhD's and postdocs on the topics 1) circularity/LCA, 2) sustainable renovation, 3) urban energy transition. She has been guest-editor for Renewable and Sustainable Energy Reviews and has authored publications for journals such as Building and Environment, Renewable and Sustainable Energy Reviews, Energy and Buildings and Journal of Cultural Heritage. She is a frequent reviewer for these and more academic journals and has been a member of several scientific committees of international conferences. She was chief editor (together with Emanuele Naboni) of the book publication 'Regenerative Design in Digital Practice'.

AGENDA

10. 6. 2021

2021

8:30 | Zoom Open

9:00 | Opening

Dr Michael Burnard, InnoRenew CoE Deputy Director

9:05-9:35 | Keynote

Lisanne Havinga, Assistant Professor, Building Performance group, Eindhoven University of Technology

9:35-11:05 | Engineering and Design

9:35 Boris Azinović, Experimental investigations of innovative seismic resistant CLT connections

9:50 Igor Gavrić, Hybrid timber-steel shear wall system for multi-story modular construction

10:05 Urban Kavka, Collecting Wood Waste Generated During Construction of InnoRenew CoE Building in Izola

10:20 Uroš Gantar, Near zero waste energy window – wooden window for reuse and cascading use

10:35 Mika Keskisalo, Form factor for efficient low carbon construction

10:50 Laetitia Marrot, Developing electrically conductive materials through thermal conversions of hemp stalk wastes

11:05-11:30 | Coffe Break

11:30-12:30 | Cultural Heritage

11:30 Janez Kosel, Growth of xerophilic fungi on model paint samples on glass and wooden supports under low humidity conditions

11:45 Ana Slavec, Social mechanisms to engage visitors in cultural heritage monuments preservation

12:00 Tim Mavrič, Towards a common framework for wood architectural heritage conservation in Slovenia – a preparatory overview

12:15 Veronika Kotradyova, Evaluation of Residential Buildings Adaptation their Interiors in a Rural Environment with a Deeper Interdisciplinary Analysis of 3 Localities in Slovakia

12:30-14:00 | Lunch

14:00-15:15 | Health and Well-being

14:00 Henrik Heräjärvi, Dependence of virgin and recycled Scots pine heart- and sapwood VOC emissions on indoor relative humidity conditions

14:15 Mateja Erce, User needs and perspectives on technologies or healthy ageing

14:30 Mark Dewsbury, Unhealthy advances in Australian building regulations

14:45 Sabina Jordan, Temperature-based approach for assessing buildings in terms of providing thermal comfort for occupants

15:00 Nastja Podrekar Loredan, Development of the School furniture suitability questionnaire (SFS-Q)

15:15-15:30 | Coffe Break

15:30-16:15 | Mixed Topics - Full Presentations

15:30 Lea Primožič, Three-pillar paradigm of sustainability and its communication in the wood industry – IKEA Group case study

15:45 Jan Vcelak, Prevention of mold formation based on continuous condition monitoring of timber constructions

16:00 Dennis Jones, The application of bicine or tricine for limiting termite attack of thermally modified wood

16:15 | Closing

AGENDA

11. 6. 2021

2021

8:30 | Zoom Open

9:00 | Opening

Dr Michael Burnard, InnoRenew CoE Deputy Director

9:05-10:20 | Mixed Topics - Short Presentations

9:05 Filip Majstorović, Strengthening of flax textile-reinforced cement-based composite materials by the addition of pozzolans

9:10 Viktor Bukovszki, Smart contract affordances for energy communities

9:15 Petra Horvat, Relevant knowledge management approaches in the civil engineering research organizations and short overview of current situation in selected Slovenian public research organizations

9:20 Anja Jutraz, Renovation of outdoor school environment to ensure healthy environment for pupils

9:25 Lei Han, Creep Behaviour of Densified Wood

9:30 Tamás Storcz, ANN Supporting EDS Building Optimisation

9:35 Kaja Kastelic, Assessing spinal posture while back supported sitting: a review of techniques used

9:40 Sidra Aslam, Mutable and Privacy-aware Decentralized Ledger for Data Management in Wood Supply Chain Environments

9:45 Esakkiammal Sudha Esakkimuthu, Optimization of polyphenols extraction from spruce bark

9:50 Ozlem Ozgenc, Increasing The Weathering Durability of The Wood Surface with Tree Bark Extractive Solution

9:55 Kelly Peeters, Extraction of phenolic compounds to determine its concentration in olive mill waste water

10:00 Vesna Starman, Education for a Sustainable Future

10:05 Erwin M. Schau, Metrics for LCA and carbon footprint of bio-based materials and processes: New indicators and normalisation factors for EN15804

10:10 Luca Versino, Perspectives of wood-based products for acoustic purposes in building

10:15 Václav Sebera, Electric guitar neck from densified poplar? Experimental and numerical analysis

10:20-10:50 | Coffe Break

10:50-12:05 | Information and Computing Technology

10:50 Richard Acquah, BIM Based Simulation Of Fire And Smoke Spread In Timber Buildings

11:05 Zsolt Ercsey, Sensitivity Analysis Supporting Building Optimisation

11:20 Kristóf Roland Horváth, Simulation Database Development Supporting Building Optimisation

11:35 Adam Katona, Evaluation and optimizationof different wind tower geometries for passiveair conduction systems with CFD simulations

11:50 Sebastjan Meža, Circular Economy And BIM In Civil Engineering

12:05 | Closing

Agenda

Engineering and Design | 9:35-10:35

2021

Engineering and Design

Experimental investigations of innovative seismic-resistant CLT connections

Boris Azinović [1], Meta Kržan [1], Andreja Pondelak [1], Jaka Gašper Pečnik [2], Vaclav Sebera [2], Igor Gavrić [2], Iztok Šušteršič [2]

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The behaviour of cross-laminated timber (CLT) buildings during earthquakes depends mainly on the behaviour of the connections between adjacent panels. If the connections between the panels are strong enough, these structures can achieve damage-free performance even during strong earthquakes. However, amplified seismic accelerations associated with rigid connections may result in occupant's injury and contents damage which is not acceptable in terms of serviceability. To improve the ductile behaviour of CLT buildings, several solutions of dissipative connections have been proposed in recent years, mainly by modifying conventional mechanical connections.

The main aim of the contribution is to present three different concepts of CLT connections examined in terms of their cyclic response:

1) Connections with flexible polyurethane-based adhesives. The main idea of the proposed solution is to dissipate seismic energy through the adhesive joints between timber elements. A flexible adhesive could be employed at the vertical joints between adjacent panels or at the interface of glued-in rods which can be used to connect various elements (e.g. foundations and walls).

2) Weakened dowel-type fasteners. The concept of the solution is to weaken the dowels at the pre-determined locations and thus provide a controlled ductile response of the connections. Such connection could be used at different locations, e.g. as foundation-to-wall or wall-to-wall connection.

3) Steel angle brackets with PUR isolation. The isolated angle brackets have already been previously developed (by companies Getzner and Pitzl) to reduce vibration and improve sound isolation of buildings. The cyclic response of angle bracket connections was investigated and based on the results some improvements were given for the use of connections in seismic areas.

Keywords: cross-laminated timber (CLT), connections, cyclic tests, polyurethane, flexible adhesive, isolation

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Hybrid timber–steel shear wall system for multi–storey modular construction

Igor Gavrić [1], Iztok Šušteršič [1], David Močnik [2], Boris Azinović [3]

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Modular construction is becoming widely present on the construction market not only in form of temporary facilities but also as permanent single-family homes, multi-residential buildings, tourist facilities, office buildings and public buildings such as schools and daycares. This is mostly due to significant developments of modular building technologies in recent years, which enable larger and taller modular buildings, meeting all building regulations and standards, as well as enhanced living quality in terms of energy performance, acoustics, room sizes and indoor quality. Due to easy transportation and fast assembly time, it can assure rapid response to natural disasters (earthquakes, floods, landslides, etc.), refugee crisis or health crisis (pandemics) in terms of providing temporary or permanent accommodation to the affected population, or even relocation of these facilities to a different location according to the needs.

On the other hand, modular structural systems usually consist of more flexible and less resistant slender structural elements which are separated from each other in individual modules, therefore the global continuity of the entire building's structural system may be compromised, especially in the lateral direction. In this study, the development of a seismic-resistant timber-steel hybrid shear wall system for multi-storey modular buildings in moderate to high wind and seismic areas is presented. The main aims were to increase the vertical and lateral strength and stiffness capacity of the current modular unit solutions with environmentally friendly timber structural elements. The main lateral load resisting system consists of a steel frame with infilled light timber frame shear walls. After a preliminary analytical and numerical analysis, full-scale monotonic and reverse cyclic tests according to EN 12512 standard on two sets of hybrid shear wall systems was performed to determine their seismic behaviour properties. The proposed solution shows potential for application in multi-storey modular buildings.

Keywords: hybrid timber-steel shear wall, hybrid structural system, multi-storey modular construction, lateral load resisting system, seismic resistance

Acknowledgement

This work was supported by the Ministry of Education, Science and Sport of the Republic of Slovenia and the European Regional Development Fund, European Commission (project WOOLF, grant number 5441-2/2017/241). The authors gratefully acknowledge receiving funding from the Horizon 2020 Framework Programme of the European Union, H2020 WIDESPREAD-2-Teaming (#739574) and the Republic of Slovenia for funds from the European Regional Development Fund.

Collecting Wood Waste Generated During Construction of InnoRenew CoE Building in Izola

Urban Kavka [1], Richard Acquah [1], Andreja Kutnar [1], Eva Prelovšek Niemala [1], Erwin M. Schau [1]

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Management of wood waste generated from construction activities can be a challenging task. Waste wood is more often than not mixed with other materials, such as different metals, thermal insulations, concrete or just plain dirt. The presence of any non-wood substance is greatly affecting the reusability and recyclability of the waste. If not appropriately managed, the wood waste can be dangerous to humans and the environment. The status quo is that wood waste is incinerated with or without energy recovery, oftentimes with unsuitable cleaning. Therefore, one should take into account all wood waste generated from construction activities and apply proper classification to minimize the environmental impact and improve decision making. The purpose of this study is threefold: to extract data about the actual wood waste, to compare these data with the bill of materials (BoM) of the life cycle assessment (LCA) and to develop ideas on future reusability of collected wood waste.

Wood waste generated from the construction site was collected, measured, classified and sorted manually. The majority of the wood waste was quantified volumetrically by measuring all three dimensions of each specimen; however, smaller residues were measured using a scale. All wood collected was grouped into three categories based on the type of wood and further into eight sub-categories based on the type of contaminants that were present.

Data collected was analysed and was compared to results from the BoM of the building. Wood reused at the building site made a direct comparison difficult. However, a significant amount of reusable and also recyclable wood waste from the construction site has been prevented from incineration. Proper wood waste management plays a significant role in reducing the adverse effect that wood waste from construction can have on the environment and allowing for more sustainable construction.

Keywords: wood waste, recycling of wood, construction waste, classification of wood waste

Acknowledgement

The authors acknowledge the European Commission for funding the InnoRenew project (grant agreement #739574) under the H2020 Widespread-2-Teaming programme and the Republic of Slovenia (investment funding from the Republic of Slovenia and the European Regional Development Fund).

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Near zero waste energy window: Wooden window for reuse and cascading use

Uroš Gantar [1], Barbara Šubic [1], Nejc Starman [1], Liza Križnar [1], Luka Kramarič [1]

1. *M SORA d.d., Industrijska ulica 13, Žiri, Slovenia*

M SORA, a Slovenian company producing wooden windows, developed "Near zero waste energy window". It represents a wooden window, designed with an aim for reuse and cascading use of the product — either as a whole or as separate components.

Different strategies, both innovative and traditional, were adopted in the development. Design recommendations from the literature were complemented with internal innovative ideas.

Regarding material, recovered wood is used for both sash and frame elements. An innovative patented process of wood mineralization is applied for protection, instead of less eco-friendly and conventional synthetic coatings. The standard vacuum-pressure impregnation process is most suitable for that. Mineralization extends both lifespan and fire safety class of windows. The use of potentially harmful components was avoided at all costs. Minimizing the total number of materials is essential for simplification of design.

Instead of glued corner connections, mechanical connections in the form of wooden screws are chosen for wooden joints. Dry glazing instead of conventional silicone joint is adopted to join wooden frame and glass. It not only simplifies the assembly process but also allows easier separation of components and possible in-situ replacement of damaged parts with spare parts. The geometry of wooden profiles is simplified with emphasis on rectangular surfaces, instead of curved ones. It allows a bigger cross-section when combined for reusability.

All presented strategies are complemented with IoT sensors for wood moisture and deformation monitoring. Sensors enable more user-friendly window monitoring, consequent lifespan extension and inclusion in smart homes.

With all strategies in mind presenting "Near zero waste energy window", our goal is to produce more sustainable, smart, and simplified window elements. Window elements can also be larger and more modular, which allows us to make more transparent building envelopes with healthier building environments.

Keywords: recovered wood, windows, design for recycling and reuse, circular economy

Acknowledgement

This work was supported by the Ministry of Education, Science and Sport of the Republic of Slovenia, and by the European Regional Development Fund, European Commission (project WOOLF, grant number 5441-2/2017/241).

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Form factor for efficient low carbon construction

Mika Keskisalo [1], Mikko Matveinen [2]

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When aiming to reduce the carbon footprint (Co2e) of a single construction project, it is essential to set the goals at the early stages of the planning process. However, setting these early design goals is only a first step and efficiently comparing different design options at early stages can be difficult for the draft/ preliminary design phase when it's missing detailed information concerning material choices. One way of estimating the overall effect of buildings carbon footprint and energy efficiency is by using building form factors to compare different design solutions. There are already few form factor estimation methods for energy efficiency in use (Lylykangas, K., Lylykangas et.al 2015), but for GWP (Global Warming Potential) or carbon footprint estimation, there are no applicable methods developed.

However, based on our recent study form factor can be assessed by comparing completed design solutions and their carbon footprint. By using groupings based on construction classifications (Construction 2000 Classification, 2010), we can make a comparison in regard to carbon footprint for different design options. In this study, it is shown how to use building form factor for low carbon construction by means of case studies estimating building carbon footprint using EU Level(s) and showing the basis of methodology (Keskisalo & Matveinen, 2020). The proposed form factor weighted by sub-values for GWP is at early stages, but it can be shaped to be more accurate with more studies and data of the completed building.

Keywords: form factor, LCA, building design, architecture, EU Level(s)

Acknowledgement

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Developing electrically conductive materials through thermal conversions of hemp stalk wastes

Laetitia Marrot [1,2], Kevin Candelier [3], Jérémy Valette [3], Charline Lanvin [3], Barbara Horvat [4], Lea Legan [5], David B. DeVallance [1,2]

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This study focuses on innovative ways for the valorisation of hemp by-products (i.e., hemp stalks) from the cannabidiol industry through thermal conversion. Successive chemical extractions and Scanning Electron Microscopy along with Energy-dispersive X-ray Spectroscopy Chemical were used to characterize the elemental composition of hemp stalks. The chemical characterization of the hemp biomass and its biochar was completed with proximate and elemental analyses. Kinetic of decomposition during thermal conversion was investigated through thermogravimetric analysis of the hemp biomass. Raman spectroscopy and CO2 gas adsorption were performed to assess the carbon structure and porosity of the biochar. In this study, the energy production measured through calorific values, and the electrical conductivity were the properties of interest. Two ways to value the hemp biomass were clearly identified, depending mainly on the chosen carbonization temperature. Carbonization temperatures between 400˚C-600˚C allowed to produce hemp biochar classified as lignocellulosic materials with a good potential for solid biofuel applications. Specifically, the resulting carbonized biochar combined low moisture content (higher fuel quality), low volatile matter (so likely to show lower particle matter emissions), limited ash content (low risk of fouling issues during the combustion), high carbon content (suggesting strong energy density) associated with fairly high higher heating values and optimized energy yield. Carbonization temperatures between 800˚C-1000˚C led to carbon materials with interesting electrical conductivity, opening opportunities for biochar use in electrical purposes. The electrical conductivity was related to the higher order in carbon structure observed in biochar produced at high temperature, and to the surface area associated with biochar microporosities, with higher surface area resulting in higher conductivity.

Keywords: hemp, pyrolysis, carbonization, thermal conversion, biochar, electrical conductivity

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Agenda

Cultural Heritage | 11:30-12:30

2021

Cultural Heritage

Growth of xerophilic fungi on model paint samples on glass and wooden supports under low humidity conditions

Janez Kosel [1], Jakub Sandak [2,3], Anna Sandak [2,4], Lea Legan [1], Klara Retko [1], Maša Kavčič [1], Črtomir Tavzes [1], Miklos Krész [2,3], Polonca Ropret [1]

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In museums, xerophilic fungi can grow and thrive on a wide range of art objects. Their dispersion is affected by the regular movement of museum staff and visitors, and by the ventilation system. Many works of art, such as panel paintings and polychromed wooden sculptures, are composed of an array of different organic substances, including traditional cellulose-based support materials, protein-, lipid-based and other types of adhesives, binders, coatings, and colouring agents, which all represent nutrient-rich media prone to colonization by xerophilic fungi (Grabek-Lejko et al., 2017). In contrast, the presence of metal ions (e.g., lead, zinc, chromium, etc.) in some pigments' chemical composition can increase the resistance of a paint layer to biodeterioration. Surprisingly, the xerophilic potential of fungi isolated from museums' indoor environments has never been addressed properly. To assess this fungal trait, most studies only use simple selective solid media with high concentrations of sodium chloride or glucose, which lower the water activity of a medium (Koutsoumanis and Sofos, 2005). Therefore, our aim was to carefully investigate 11 fungal strains isolated from cultural heritage institutions' interiors for their potential to grow on painted heritage items at low relative humidity (xerophilic potential). The isolates were inoculated onto model samples made of wooden and glass supports coated with a layer of egg tempera paint. Different paints, prepared with egg binder and assorted traditional artists' pigments (lead white, Prussian blue, carmine lake and verdigris) were investigated. Model samples were subjected to 50, 60 and 70 % relative humidity. Fungal development was carefully monitored by fluorescent microscopy. Our results show that relative humidity of 50 or 60 % can still support mould growth and biodeterioration (incubation of 3 months), especially in the case of paints on wooden supports containing Prussian blue pigment. Indeed, wood, by absorbing moisture (hygroscopic material), enables the development of favourable microclimatic conditions for mould growth.

Keywords: Aspergillus, Penicillium, xerophilic fungi, pigments

Acknowledgement

The authors gratefully acknowledge receiving funding from the InnoRenew project under the Horizon2020 Widespread-2-Teaming program (grant agreement ID: 739574; start-up project 6.1. Advanced materials for cultural heritage storage). Authors from the Institute for the Protection of Cultural Heritage of Slovenia also acknowledge funding from the Slovenian Research Agency (grants J7-1815 and BI-RS/20-21-013).

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Social mechanisms to engage visitors in cultural heritage monuments preservation

Ana Slavec [1], Vesna Starman [1], Nežka Sajinčič [1], Gertrud Fabian [1], Laszlo Hajdu [1,2], Miklos Kresz [1,3], Anna Sandak [1,2], Jakub Sandak [1,3], Črtomir Tavzes [1,3,4]

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In the outdoor environment, cultural heritage monuments are exposed to several natural and anthropogenic factors that cause their deterioration. Increasing urbanization and mass tourism exacerbate the situation; however, tourism is also an important tool for enhancing and preserving cultural heritage, especially through contemporary information-communication technologies that provide additional opportunities for visitor engagement (Ismagilova et al. 2015, Ursache 2015). Moreover, there is a trend towards gamification of experiences for visitors to cultural heritage sites (Cirulis et al. 2015, Xu et al. 2017), including location-based or geolocation games (Maia et al. 2017).

To better understand the perceptions and values of different visitor groups regarding cultural heritage and to develop a strategy for engaging target groups in heritage conservation, we conducted four focus groups in two Slovenian cities. Participants were selected using a screening questionnaire that asked about their travel habits and use of mobile apps when visiting monuments. In both cities, there was one focus group with users of geolocation games and one with non-users. In all groups, topics of mobile photography of cultural heritage sites, use of visitor apps for specific locations, and geolocation apps were discussed.

The findings helped us to understand patterns of mobile technology use and develop a proposal for a social mechanism to engage the public in cultural heritage preservation in the form of a game to increase visitor interaction with cultural heritage and promote it on social media. The findings were applied to the development of an information plate and informational videos for the outdoor bronze statue of the composer Giuseppe Tartini in Piran, Slovenia.

Keywords: cultural heritage, focus groups, gamification, ICT, tourism

Acknowledgement

The authors gratefully acknowledge the European Commission for funding the InnoRenew project (grant agreement #739574) under the Horizon2020 Widespread-2-Teaming programme and the Republic of Slovenia for funds from the European Regional Development Fund. The authors also acknowledge the financial support of the Slovenian Research Agency for funding the project Protection of bronze monuments in the changing environment (J7-9404).

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Towards a common framework for wood architectural heritage conservation in Slovenia: A preparatory overview

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The conservation of wooden architectural heritage in Slovenia has not yet been the subject of a comprehensive critical analysis. On the one hand, Slovenia is a country that has been historically rich with forests, which results in centuries-long traditions of wood use and timber construction. Additionally, the diverse geography and diverse cultural influences result in a sizable measure of regional variation across the country's territory, which additionally enriches these traditions. On the other hand, there is a considerable variation of conservation approaches that derive from the diverse basic education fields from which practitioners emerge, ranging from art history, through ethnology, to architecture and engineering. Because of these diversities, there exist also diverse and divergent approaches used by practitioners to address the problem of conserving historic wooden structures. Thus, there exists the need to analyze, compare and critically evaluate the current approaches to achieve a common framework for wooden architectural heritage conservation in Slovenia. This should include conservation guidelines emanating from common principles, that will take the nature of wood as an organic and renewable building material into account. However, to achieve this goal it is of paramount importance to have a full overview of the international theoretical and regulatory framework for wooden architecture conservation that has been developed through the main international scientific and professional forums of the field – UNESCO, and its official advisory body ICOMOS. Additionally, the Slovene legal framework for cultural heritage protection must be thoroughly considered and understood, since it represents the basis of all heritage conservation in Slovenia. A short overview of the existing literature will also enlighten the best practices developed in the past. These overviews will lead to a discussion on possible approaches towards a unified conservation framework for wooden architectural heritage in Slovenia, with the main challenges exposed.

Keywords: conservation, wooden architecture, wooden heritage

Acknowledgement

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Evaluation of Residential Buildings Adaptation their Interiors in a Rural Environment with a Deeper Interdisciplinary Analysis of 3 Localities in Slovakia

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The paper aims to analyze and evaluate the most common construction interventions in the reconstruction of residential buildings in the Slovak rural built environment, which point to what the users themselves are undergoing more fundamental modernization in vernacular architecture and how it is implemented. The text analyses the current housing needs and economic decision-making factors, which often do not take into account the preservation of cultural heritage and elements of regional identity, but reflect the current socio-economic situation in Slovakia. Most of the original vernacular architecture is not protected by the state institution for preservation of monuments. These objects are transformed by significant, often insensitive reconstructions or even demolished and substituted by contemporary buildings designed without local context, but according to the socio-economic situation and performance comfort needs. What are these most usual building and functional changes – adaptations and transformations of housing objects and their interiors?

The text contains the results of qualitative research in 3 selected localities – Záhorská Bystrica, Hrušov (Hont region) and Štrba, which underwent a transformation that was mapped during field research of the Identity SK project and then compared with the state up to the mid-1950s that was analyzed in the archive of the Slovak National Museum in Martin. The contemporary state – form and volume of the construction modifications of the exterior and interior and their causes were recorded and examined in more depth. This analysis can be used to better guide professionals and owners/users in the adaptation of objects of vernacular architecture for contemporary housing while maintaining the regional identity and supporting the authenticity and authenticity of the particular region that can support conscious tourism as part of regional development and socio-cultural sustainability.

Keywords: vernacular architecture, reconstruction, adaptation, regional development, comfort, contemporary housing, socio-economic situation

Acknowledgement

This work was supported by Project APVV 16-0567 Identity SK – common platform of design, architecture and social sciences.

Agenda

Health and Well-being | 14:00-15:15

Health and Well-being

Dependence of virgin and recycled Scots pine heart- and sapwood VOC emissions on indoor relative humidity conditions

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Wood contains hundreds of different extractives, and some volatile organic compounds (VOCs) emit already in room temperature. VOCs are important quality parameters of materials used indoors since they may contribute to human health and surely contribute to well-being. Standard emission tests of materials are carried out in a constant relative humidity (RH) of 50% and temperature (T) of +23 ˚C, thus not accounting for the hygroscopic behaviour of wood. While the indoor T remains quite constant throughout the year, the RH typically varies from approximately 15% (winter) to 80% (late summer) between the seasons. Due to its hygroscopicity, the moisture content (MC) of wood follows the indoor air RH, reaching <10% in the dry season and >15% in the humid season. Our hypotheses were that a) VOC emissions change seasonally due to RH variations, and b) VOC emissions from recycled wood are lower than those from virgin wood. The experiment was carried out comparing Scots pine wood that had been stored indoors for 15 years ("recycled wood") and recently sawn "virgin wood"; both heartwood and sapwood in both groups. Emissions were recorded from a total of 20 specimens in RH conditions ranging from 20 to 80 per cent imitating the indoor air seasonal RH variations. Our results confirmed the hypotheses that indoor air RH, as well as the storage history of the specimen, play a great role both in the total VOC emission level and the composition of VOC's emitted. The understanding created contributes to the development of VOC test methods of hygroscopic materials. Information produced can be applied in the selection and branding of wooden low-emission furnishing materials for allergy homes or other emission sensitive spaces.

Keywords: emissions, indoor air, recycled wood, Scots pine, VOC

Acknowledgement

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User needs and perspectives on technologies or healthy ageing

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Older adults are the most vulnerable and fastest-growing age group in Europe. Ageing introduces psychosocial and physical challenges that should be addressed (ten Bruggencate et al., 2019; Zallio and Berry, 2016). WHO views Healthy Ageing as a solution to these challenges, and considers older adults to be active participants in managing their health and well-being.

The paradigm involves them in defining their needs, which is important to increase the older adults' connectedness, meaningfulness, and independence (ten Bruggencate et al., 2019). Their health, well-being and social isolation can be improved with health-related technologies and building solutions (Zallio and Berry, 2016). However, a lot of older adults are not willing to use or adopt smart technologies (Zallio and Berry, 2016) due to individual differences and needs, which are usually not addressed by technology alone.

To address this knowledge gap, interviews were conducted to identify older adults' needs and willingness to accept and adopt technology in their life that will help them stay independent longer. The goal of the study was to examine their physical and psychosocial needs as well as technological requirements so these could be addressed by a combination of new and existing solutions prepared as part of the Pilots for Healthy and Active Ageing Horizon 2020 project.

A sample of 64 older adults completed a two-part questionnaire with the support of a researcher. The first part examined physical and psychosocial well-being by asking close-ended questions from previously validated scales. The second part examined participants' attitudes towards using technology in healthcare using a modified version of the Health Care Barriers Instrument (LeRouge et al., 2014) supported with demonstration videos of selected technologies. The results of the study demonstrate the barriers to technology adoption and the need to involve older adults in the design and selection of solutions they will use.

Keywords: older adults, building solutions, technology acceptance, well-being, independence

Acknowledgement

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Unhealthy advances in Australian building regulations

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Housing in Australia is mostly low rise, detached dwellings, with a timber-framed structure (Nolan and Dewsbury, 2006). Due to Australia's generally temperate climates, national building regulations requiring the insulation of houses was not introduced until 2003. The primary focus of these new regulations was to reduce greenhouse gas emissions that are associated with energy used to heat and/or cool houses (ABCB, 2003). Since 2003, there have been three significant enhancements to the energy efficiency requirements requiring greater levels of envelope insulation and air-tightness (Ambrose, et al, 2013; Ambrose and Syme, 2015). The Australian regulations have included the establishment of the Nationwide House Energy Rating Scheme, (NatHERS), which initially set the bar at 4 Stars in 2003, followed by 5 Stars and 6 Stars. It is planned that the national residential energy efficiency building regulations will advance to 7 Stars in 2022. However, the singular focus on reducing greenhouse gas emissions, without due consideration of hygrothermal design principles has created an influx of housing constructed in the last fifteen years that has shown unwanted surface condensation, interstitial condensation and mould growth (Dewsbury and Law, 2016; Law and Dewsbury, 2018; Nath et al., 2019). The team at the University of Tasmania has explored steady-state, hybrid and transient hygrothermal simulation methods, settling on the transient WUFI suite of hygrothermal simulation tools in 2018. One of the key challenges facing the national building regulatory framework is the diversity of hot-humid climates to cool-temperate climates that span between the northern and southern reaches of the continent. Attempting to have all jurisdictions agree on the need for regulatory development poses significant challenges for forward-thinking manufacturers, researchers and regulators. This paper will report on the Australian experience to date, current areas of research focus at the University of Tasmania and plans for ongoing improvements to bio-hygrothermal simulation and national regulatory improvement.

Keywords: condensation, mould, hygrothermal, bio-hygrothermal, energy efficiency, timber-framed construction

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Temperature-based approach for assessing buildings in terms of providing thermal comfort for occupants

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Buildings have been essential to human existence for centuries, as they are intended for physical and psychological protection. It is also known that they can have a significant impact on the user, as people in modern societies spend 80 to 90 percent of their time indoors. Therefore, the quality of buildings is very important for their well-being, comfort and health. In addition to the influences due to personal responses of the users, the basic principles of their thermal comfort affected by age, gender, clothing, activity, or even cultural habits are mostly related to environmental factors. Among them, the temperatures play a key role in ensuring a balance between produced and emitted body heat. In order to achieve thermal comfort in buildings, in addition to appropriate humidity and air velocity, it is necessary to pay attention to the adequate air temperatures and the radiant temperatures of surrounding surfaces. When planning thermal comfort, temperature comfort can be assessed in a variety of ways. One of them is based on a calculated estimate of the percentage of time in which indoor operating temperatures exceed the temperature limit for user comfort. The presented research is based on the analysis of simulated temperatures of a modelled living room in a lightweight residential building with an extremely high proportion of glazing. The results showed that without mechanical cooling, there is a pronounced daily summer overheating, regardless of the intense shading of the glazed surfaces. The analyses of the calculations also showed that due to the relatively small thermal accumulation capacity of the lightweight structure and large windows, the surface temperatures have a relatively small influence on the operating temperature. At the monthly level, the calculated average operating temperature differs from the average air temperature by a maximum of 0.2K Thus, in this case, the air temperature can be taken into account when estimating the time when the temperature exceeds the limit of user temperature comfort, especially when observing on annual level. In addition, the results at selected values for thermal comfort limit temperatures (24, 25, 26 and 28°C) showed extremely large differences in the calculated annual assessment of the overheating rate. Therefore, the choice of the appropriate thermal comfort limit temperature is crucial.

Keywords: thermal comfort, building assessment, overheating, operative temperature, numerical simulations

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Development of the school furniture suitability questionnaire (SFS-Q)

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Suitable school furniture is important to ensure students maintain proper posture, diminish risks for musculoskeletal discomfort and pain, and promote students' well-being in the classroom. When assessing the suitability of school furniture, characteristics like a student's posture and dimensional compatibility can be measured objectively. However, students' feeling of discomfort and their satisfaction with the furniture when performing school tasks, can only be assessed subjectively. This study aimed to develop a questionnaire to assess perceived school furniture suitability. The questionnaire was developed in English and consists of three parts. In the first part, questions related to numbness and/or pain in nine body regions (neck, shoulders, upper back, elbows, wrists, lower back, buttocks, knees, and ankles) are included on the eleven-point pain numbered rating scale (NRS-11), which has been recommended for acute pain assessment in children and adolescents (Birnie et al., 2019). The second part of the questionnaire asks about comfort when performing school tasks, such as writing, reading, and listening, on a seven-point rating scale. The third part of the questionnaire asks about satisfaction with tabletop materials, with the overall aesthetic appearance of the school furniture, and with the position of the school furniture in the classroom, on a seven-point rating scale. The last two open-ended questions ask about positive and negative perceived features of the furniture. The questionnaire will be available in online and paper versions. To the best of our knowledge, this will be the first questionnaire that will comprehensively assess the suitability of school furniture, including information on students' pain, comfort while performing school-related tasks, material suitability, and aesthetics of the furniture. Future studies are planned to assess the validity and reliability of the questionnaire.

Keywords: ergonomics, chair, classroom, desk, students, subjective assessment

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Agenda

Mixed Topics - Full Presentations | 15:30-16:15

2021

Mixed Topics - Full Presentations

Three-pillar paradigm of sustainability and its communication in the wood industry: IKEA Group case study

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Sustainable development promotes economic and social developments by understanding and protecting the environment. Therefore, we need to understand the concept of sustainability as the three-pillar paradigm – economic, environmental, and social. To reach a sustainable oriented society, we need to think about our planet's limitations in all our current actions, and we need to be aware that the resources we are using today are not permanent. An important shift in people's perceptions is needed; hence, we need to invest in creating more awareness about the importance of sustainability with different stakeholders. Appropriate marketing and communication strategies can make a great difference. One solution towards a sustainable society is by using renewable materials. Wood as such has many positive environmental impacts, and thus, organizations dealing with it have a lot of potential to improve their communication about its sustainability to promote sustainability practices in the wider area. We believe it is important to understand how the wood industry is integrating the sustainability principles and how they are communicating them on their online channels (website). In this study, the online sustainability communication of the wood industry will be explored with qualitative content analyses. Further, we will learn which of the three pillars of the sustainability paradigm is communicated the most. The study will be based on the case study of the IKEA Group.

The topics of interest will be defined to be covering all three concepts of sustainability, and for each topic, codes were previously defined. The results demonstrated the differences between the online communication of the three concepts of sustainability and delivered the basis for further research and development of better communication of overall sustainability in the wood industry.

Keywords: sustainability, communication, wood sector, online communication

Acknowledgement

Authors gratefully acknowledge the European Commission for funding the InnoRenew project (grant agreement #739574) under the Horizon2020 Widespread-2-Teaming program and the Republic of Slovenia (investment funding from the Republic of Slovenia and the European Regional Development Fund).

Prevention of mold formation based on continuous condition monitoring of timber constructions

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Wood as a construction material is more and more used not only for single floor buildings but also for tall buildings. The legislation in EU countries is changing, and as a result, it allows using wood for multi-storey buildings constructed partially or fully from the wooden material. The EU statistics show that in reality fire is less dangerous for timber construction than water. Timber constructions deserve at least the same prevention against water which is currently applied as prevention to fire. Wood as a renewable construction material is used for residential as well as commercial buildings. The total number of new buildings made from wood is still quite low, on average 15% in the EU. The leader of the constructions from wood is Scandinavia (85%).

Long-term exposure of wood to high humidity level causing the formation of mold at a first stage and fungi and insect decay in a longer perspective. Because of sorption isotherms for various species of wood, the ambient humidity higher than 80% will cause mold formation on the surface of the timber construction.

A mathematical model of the mold growth on building materials was developed in VTT by Vitanen and others (Viaten et al., 2015; Dietsch et al., 2014; Skaar, 1988; Siau, 1984). It well describes the influence of temperature and humidity on the risk of mold formation on the surface of various building materials covering gypsum, concrete, mortar, plywood, or softwood. To reliably determine the risk of mold formation it is necessary to record the values of humidity and temperature directly in the building structure. The values of humidity and moisture inside the wall structure might be very different from values obtained in the interior of the buildings

The work is focused on practical use of mathematical mold growth model applied to the data from the timber construction of a wooden building. Since for some timber building, the data are available for more than four years, the model will be applied for long periods to observe long-term behaviour of the construction including small common accidents (leaks) included in the dataset. The obtained results will be discussed in the presentation.

Keywords: wood, timber construction, mold, SHM

Acknowledgement

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The application of bicine or tricine for limiting termite attack of thermally modified wood

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Construction with timber is increasing in popularity, driven by sustainability agendas, ease of construction, aesthetics and human health. This increase in popularity coincides with European regulations, and particularly the European Green Deal, which was adopted by the European Parliament in January 2020. These new initiatives are seeing the use of wood in construction becoming more acceptable globally, resulting in their use in regions susceptible to decay from fungi due to high moisture levels, or from predating insects.

Termites (Blattodea; formerly Isoptera) are consumers of cellulose and lignocellulose found in dead wood, grass, microepiphytes, leaf litter, and sometimes cultivated fungi. Some 3,000 species of termites are recognised, most living in tropical and temperate regions in the USA, Central America, most of South America, southern Europe, Africa, Middles East, Southern Asia, Japan and Oceania. Of these, the species most responsible for structural damage are Coptotermes formosanus Shiraki, Coptotermes gestroi (Wasmann) and Cryptotermes brevis (Walker) (Rust and Su, 2012). Of these 3,000 species, only 83 are considered to present a risk to wooden structures and furniture (Rust and Su, 2012). Europe lies on the border of traditional termite presence, but global warming is recognised as widening their distribution, particularly into more northerly areas.

The desire to incorporate wood in modern construction has led to a considerable increase in the use of wood modification techniques, especially thermal modification. However, thermally modified wood has poor performance against termites. The concept of using a combined chemical and thermal modification has been undertaken through the impregnation with either bicine or tricine prior to modification. This paper considers the effects of these chemicals on the activity of termites and considers their mode of action in terms of termite survival and on their effects on the symbiotic protists present within the termite gut.

Keywords: thermally modified wood, bicine, tricine, termites

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Agenda

Mixed Topics - Short Presentations | 9:05-10:20

2021

Mixed Topics - Short Presentations

Strengthening of flax textile-reinforced cement-based composite materials by the addition of pozzolans

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Cement-based matrices were reinforced with flax textile and the effect of partial substitution of cement by metakaolin (MK) was investigated in terms of final material strength and fibre-matrix bond properties. Results indicated that the strength of material generally increased with the increase in MK content. An optimum replacement of Portland cement with 30% metakaolin amount was concluded from the study. It was found that MK initiates pozzolanic reaction within the cement-based matrix, and thus reduces calcium chloride content, which is harmful to natural fibres. MK also served as a filler material due to its particle fineness, which reduced matrix porosity and improved the fibre-matrix interfacial bond and resulted in an increase in flexural strength and energy absorption capability. The study included finite element analysis (FEA) to predict mechanical behaviour and properties of cement-based matrices with and without reinforcement using flax textiles, namely flexural strength. The FEA reflected boundary conditions of the experiment and used damage mechanics principles employing the microplane material model of cementitious matrix. The FEA was compared and verified by the obtained experimental results.

Keywords: textile-reinforced concrete, pozzolans, natural fibres, light-weight structures, cement-based composites

Acknowledgements

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Smart contract affordances for energy communities

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Energy communities – voluntary collaborations on energy production and management – are promising social innovations to democratize and decarbonize energy systems and enact their sustainable transition from the bottom-up. However, their social scalability is limited due to actors collaborating mainly in social networks, many potential beneficiaries and supporters are not reached or see too high risks, participant base remains too homogenous to realize full potential, interactions become tedious after a certain size. This presentation takes a socio-technical perspective to explain the role smart contracts – self-executing contracts, with a high level of confidentiality – can play to alleviate these barriers. It showcases prototype functionalities of smart contracts for three use-cases: collaborative renewable energy production, pooled energy efficiency investment, and flexibilities trading. This is a work-in-progress demonstration to discuss these functionalities through the lens of affordance theory, to spark debate on how smart contracts, as technical innovation, can contribute to accelerating energy communities – social innovations – from niches into regimes in the energy sector.

Keywords: energy community, smart contract, energy transition, affordance, demand response, renewable energy

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Relevant knowledge management approaches in the civil engineering research organizations and short overview of current situation in selected Slovenian public research organizations

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Knowledge management (KM) was developed in the 1950s in private companies and in recent years also research organizations started to use this approach, considering knowledge as a valuable asset (Nonaka, 2007; Nonaka and Takeuchi, 2020; North and Kumta, 2018). Civil engineering (CE) is one of the oldest engineering disciplines and includes a broad range of different disciplines, e.g., mathematics, physics, chemistry, material science, and others. Due to the progress in all involved disciplines knowledge base of CE is rapidly changing and increasing. Therefore, KM practices that are systematic, modern and tailored to the specific needs of the field are needed.

In this presentation, a literature review of relevant approaches to KM with the aim to assure sustainability of the obtained knowledge, to keep track of the acquired knowledge, to ensure its transfer, and to identify knowledge gaps and ways to fill them will be presented. Special emphasis will be given to KM practices in CE and the life cycle of knowledge. Additionally, current approaches to KM in selected Slovenian public research organizations (PRO) will be discussed based on the content analysis of their 2019 and 2020 annual report. The Slovenian PRO were selected by comparing: 1) the research fields that they are registered for at the Slovenian Research Agency (SRA), 2) the number of employees and 3) the number of researchers registered at the SRA. The analysis included No. of national and international research grants, No. of publications relative to No. of a) researchers, b) PhD students ("young researchers" supported by SRA), c) PhD graduates, and composition of their annual funds.

Keywords: sustainability of knowledge, civil engineering, public research organizations, content analysis

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Renovation of outdoor school environment to ensure healthy environment for pupils

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INTRODUCTION. Urban planning and public health are strongly associated and the literature indicates that urban planners/architects usually do not collaborate with public health experts. The outdoor school environment, an extension of the indoor learning environment, is designed for the most vulnerable population, children, therefore special attention has to be paid to its design and renovation. A healthy outdoor environment seeks high-quality outdoor air, make play areas supportive of physical development and safe to use, protect children from ultraviolet radiation and other environmental factors (Wargo J, 2004) Different dimensions of renovation school environment have to be addressed: urban planning, architecture and interior. Quality outdoor school environment influences different dimensions of health and better school facilities can be a decisive factor for a healthy community (Alternmueller-Lewis, 2012).

AIM. The main aim of this paper is to prepare a recommendation for the renovation of the school environment from an urban planning view.

METHODS. We conducted a comprehensive literature review, research on environmental and other parameters, and development of a new renovation model for an outdoor school environment.

RESULTS AND DISCUSSION. First, environmental parameters will be explored (e.g., air quality), and secondly, different elements of urban planning will be discussed: location, connectivity, accessibility, choice of materials, the flexibility of use, use of materials, natural elements, design of playgrounds, etc. The result of this paper presents a comprehensive plan for the renovation of the outdoor school environment, with a focus on human health.

CONCLUSION. To conclude, a comprehensive approach is needed in the planning process of healthy school buildings, which is based on interdisciplinary collaboration between different stakeholders, from planners to users.

Keywords: public health, urban planning, outdoor school environment, air quality

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Creep Behaviour of Densified Wood

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Due to the reproducibility, good workability, suitable mechanical properties, and attractive aesthetic appearance, timber is widely used in the building industry. Among those properties, mechanical properties are important for the useability of timber in construction applications. It is well known that there is a positive relationship between wood density and its mechanical properties. That means the thermo-hydro-mechanical (THM) densification, i.e. transverse compression of the wood cells only by using additional temperature, moisture and mechanical action to increase its density without structural fracturing is a practicable method to increase the performance of low-density species and thereby improve its mechanical properties. The previous studies on wood densification mainly focused on the influence of process parameters on wood physical and mechanical properties and how to use post-treatment to reduce the set recovery. This study is in the field of increasing the use of densified timber in construction applications and thereby strengthen the competitiveness of wood as a construction material. In construction, however, densified timber normally needs to be exposed to long-term loading which may lead to creep deformation and reduction of load-bearing capacity. There is an obvious risk of reduced serviceability and safety of constructions containing densified wood. Studies of creep characteristics of densified wood are rare, and therefore the purpose of this study was to fill the gap in knowledge if the field of densified under bending load. Scots pine specimens subjected to THM densification, THM densification with a post-heat treatment, and THM densification combined with phenol resin impregnation were loaded under 3-point bending under the 35% of maximum stress level at 20 and 65% RH. Results from these tests will be presented.

Keywords: heat-treatment, resin impregnation, Scots pine

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ANN Supporting EDS Building Optimisation

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Energia Design Synthesis (EDS) is a method to design buildings considering both energy efficiency while offering the best comfort. Earlier as part of the method, based on geometry, energy and climate-related rules, all potentially optimal building configurations were generated, and complex energy and comfort simulations were performed to identify the optimal design solution for some simple classes of problems. For the investigated simple classes, serious limiting architectural rules had to be considered to evaluate each potentially feasible situation.

To broaden the range of the covered cases, the EDS method is extended, and some artificial intelligence-based techniques are applied. Here, based on the dataset of some previous complex dynamic thermal simulations performed, an artificial neural network is built and optimised. On the elaborated dataset, precision and recall are determined. With the help of supervised learning, further cases with not yet investigated input parameters can be predicted and, in addition, future optimization can be carried out with considerable savings in simulation modelling and computation expenses.

Keywords: deep neural network, building simulation, Energia Design Synthesis

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Assessing spinal posture while back supported sitting: A review of techniques used

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Background: Prolonged sitting has been identified as a risk factor for spinal health. Ergonomic advice suggests preserving natural spinal curvatures while sitting and using a backrest. Assessment of spinal posture while back supported sitting is not possible using traditional posture evaluation techniques (e.g., 3D optical motion detection system), since the back of the seated person is not visible. This study aimed to identify techniques used for the assessment of spinal posture while sitting on a chair with a backrest.

Methods: A systematic search of the bibliographic database PubMed/MEDLINE was performed in September 2019 and was updated in February 2021. The search syntax included terms "sitting" and "spinal posture", and related synonyms. The study was included if lumbar posture while back supported sitting was reported. No criteria regarding study design were applied. Only studies published after 2009 were included.

Results: The search yielded 1,894 hits. After titles and abstracts were screened, 44 studies met the inclusion criteria. Techniques used to assess lumbar posture while back supported sitting were x-ray or magnetic resonance imaging (57%), accelerometer (14%), electromagnetic sensor (11%), inertial measurement unit (7%), strain gauge sensor (7%), optic fiber sensor (2%) and flexible ruler (2%).

Discussion and conclusions: More than half of identified studies used imaging techniques that are limited to the clinical environment and expose participants to radiation. For the ergonomic assessments, small sensors placed over the skin of the back might be a more promising technique. However, those techniques might be prone to bias, due to the contact of the participants back and the geometry of the backrest of the chair. To further develop the field of sitting ergonomics and to better understand spinal posture while sitting, there is a need for future development and validation of posture evaluation techniques suitable for back supported sitting assessments.

Keywords: ergonomics, chair, spinal alignment, comfort, lumbar posture, musculoskeletal health

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Mutable and Privacy-aware Decentralized Ledger for Data Management in Wood Supply Chain Environments

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Wood supply chain (WSC) actors need to store, update, and access data about wood products for traceability purposes. Besides, they need to protect data from unauthorized access and, sometimes, to preserve anonymity (Abeyratne and Monfared, 2016). Typical solutions rely on a centralized third party, which brings security issues such as single point of failure (SPOF). Distributed Ledger Technology (DLT) such as blockchain solves the SPOF problem with data replication on distributed nodes and ensures trust through cryptographic signatures (Toyoda, et al., 2017). However, blockchain relies on full disclosure of immutable data, thus making privacy management and data modification major concerns (Biryukov, et al., 2014).

In this work, we design a decentralized framework that provides data mutability and privacy management while avoiding the SPOF problem. We combine blockchain, Distributed Hash Table (DHT), role-based access control, and multiple encryption mechanisms to provide an end-to-end solution for decentralized data management for the wood supply chain. We designed and implemented a protocol that stores metadata and pointers on the blockchain whereas actual WSC data are encrypted and stored off-chain on a DHT.

Our framework relies on a set of components that apply necessary operations at runtime to protect data. The privacy component implements role-based access control and filters incoming requests. The encryption component decides when data is written, how it should be stored based on meta-information, and when data is read, how to encrypt it.

We implemented a Python prototype and are evaluating the performance of our solution. We expect the overall average time overhead to be reasonable when compared to a typical solution. Further work includes integrating key management solution into our framework as it is the main limitation with respect to fault tolerance and scalability.

Keywords: distributed ledger, wood supply chain, privacy, security

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Optimization of polyphenols extraction from spruce bark

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Spruce is a widely used raw material in the pulp and paper industry and produces a considerable amount of biomass waste. As with most woody biomass used for pulp and paper, the removed bark from Spruce ends up being a low-value by-product. In spruce, the bark constitutes 10-15% total weight of tree stems and is detrimental in the pulping process and has to be removed before processing. Once removed, the bark is generally used as an energy source. Extraction of commercially viable compounds from the bark before burning is an interesting value-added option. The bark is heterogenous both morphologically and chemically and contains cellulose, hemicelluloses, pectins, lignin and various extractives in different proportions.

Spruce bark is a renewable source of biologically active compounds. More than 60 antioxidant compounds isolated from spruce bark including piceid, astringin, quercetin and resveratrol. These polyphenolic compounds showed anti-inflammatory, anti-tumor, antioxidant, antiaging properties, and therefore, are potential ingredients for cosmetics, food and pharmaceutical industries. The present study focused on the extraction of polyphenols from dry bark using hot water extraction and magnetic bead adsorption and separation methodology. The extraction efficiency of polyphenols from the bark was evaluated by adjusting extraction time, particle size (>38µm,>106µm,>150µm, >425µm) and different concentrations of magnetic beads (Fe3O4, Fe3O4 modified with citric acid). The leached polyphenols from the magnetic beads were identified and quantified using HPLC-DAD-ESI-MS/MS. The results indicated that polyphenol extraction improved with larger particle sizes and high temperatures (90˚C). Additionally, the polyphenols with the highest peaks were identified as amurensin, 5-hydroxyconiferaldehyde, poncirin, gentisic acid, gallic acid, epigallocatechin, vanillic acid, dihydrorobinetin, rutin and erybradein B. The results of the research indicated that there exists future potential in extracting viable polyphenol compounds from Spruce bark using hot water extraction at high temperatures on larger bark particles.

Keywords: bark, polyphenols, extraction, HPLC-DAD-ESI-MS/MS

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Increasing the Weathering Durability of the Wood Surface with Tree Bark Extractive Solution

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The increasing environmental concern has increased the demand for natural products. Wood is biodegradable, renewable, and sustainable material in the world. It is used in lots of areas, from handicrafts to construction industries. However, wood has some disadvantages; for example, it can be degraded by biotic and abiotic factors under the appropriate conditions (Schmidt, 2006). Therefore, wood's service life is limited and results in a financial loss for both manufacturer and consumer. For this purpose, some wood preservatives have been developed to improve wood properties. However, environmental concerns have restricted preservatives to be harmless. Meanwhile, natural preservatives are easily decomposed in nature (Onuorah, 2000).

In recent years, environmentally friendly wood surface preservatives have been preferred to decrease the weathering effects and improve the wood service life. Moreover, the wood preservatives containing tree bark extractives have become prominent for researchers (Galinane et al., 2015). Bark extracts containing phenolic compounds, flavonoids, lignans, tannins improved weathering resistance of wood (Grigsby and Steward, 2018). In this study, ten different tree bark extracts (fir, Calabrian pine, black pine, chestnut, spruce, cedar, beech, oak, alder, scotch pine) were evaluated as wood surface preservatives. Tree barks were extracted in 1% NaOH solution. Scotch pine and spruce wood surface protected with bark extracts were exposed to artificial weathering for 480 h. The color changes were investigated to determine the weathering performance of bark extracts.

Moreover, the changes on the wood surface were also evaluated with microscopic and macroscopic evaluation. According to the results, the color changes were low in the extracts having high antioxidant capacity. The microscopic results also showed the differentiation on the wood surface after weathering. Likewise, in color changes, macroscopic evaluations demonstrated the color changes. Finally, the obtained results showed that bark extracts have the potential as wood surface preservatives.

Keywords: Tree barks extract, NaOH solubility, artificial weathering, color changes, wood surface

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Extraction of phenolic compounds to determine its concentration in olive mill wastewater

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Olive oil is the principal fat source of the traditional Mediterranean diet and due to its high content of polyphenols, has been credited with numerous human health benefits. The traditional olive pressing and the three phases continuous systems produce three streams: olive oil, olive pomace, and olive mill wastewater (OMWW). OMWW is known to be one of the most polluting effluents produced by the agro-food industries (Azaizeh, 2012). It exhibits high toxicity towards plants, bacteria, and aquatic organisms due to its composition of organic substances and phenolic compounds (Kalogerakis, 2013).

Our research aims to use this rich source of natural antioxidant phenolic compounds, present in OMWW, as basic ingredients in other industries (e.g. food supplements, food additives, beauty products). Before finding a method to separate the phenolic compounds from the OMWW, it is important to know the phenolic profile inside the OMWW because the phenolic content can vary greatly based on the genetic and environmental factors of the olives. Analysis of biophenols in OMWW generally parallels that for phenols from other sources, and a variety of procedures have been reported. Most rely on maximizing the recovery of one compound, hydroxytyrosol, and thus the complexity of the phenolic compounds may be underrepresented.

Several extraction techniques (ethyl acetate liquid-liquid extraction, filtration, liophilization with methanol extraction, use of enzymes, ultrasonification, acidification) were compared and evaluated on the recovery of forty-five different phenolic compounds. Phenolic compounds were characterized using a high-pressure liquid chromatography system with a diode array detector interfaced with a qTOF mass spectrometer (HPLC-DAD-ESI-QTOF). It was found that the ethyl acetate extraction technique, which is most commonly used, performed poorly in comparison with a technique using liophilization followed by methanol extraction.

Keywords: extraction techniques, HPLC-DAD-ESI-QTOF, olive mill wastewater, phenolic compounds

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Education for Sustainable Future

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The COVID-19 pandemic revealed our fragility and our interdependence with nature. It is evident that we have to change the way we think and act as individuals and societies. We have to reset our educational goals to achieve different types of skills that are needed for such a mentality shift. Educational scientists claim that 4Cs (creativity, critical thinking, communication, and collaboration) learning and innovating skills are required.

Education institutions have the responsibility to develop knowledge and awareness and take action to transform society into a more sustainable one. This presentation will focus on which sustainability competences a student must obtain at the end of schooling and how these competences can be acquired efficiently. The competences that are required for sustainable citizens and pedagogical methods to be applied will be discussed. Learning for sustainable development requires a shift in the traditional education methods and involvement of different stakeholders in educational activities.

Keywords: sustainable development, learning and teaching methods innovating and soft skills

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Metrics for LCA and carbon footprint of bio-based materials and products: New indicators and normalisation factors for EN15804 and bio-based materials

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Life cycle assessment (LCA) and the EU-recommended Environmental Footprint (EF) are well known and accepted tools to measure a comprehensive set of environmental impacts throughout a product's life cycle. However, it is still a challenge to environmentally optimize and compare bio-based processes and products with similar fossil-based counterparts. More detailed lifecycle-based metrics and normalisation factors for climate change could help in this regard.

Based upon the recommendations for LCA impact assessment, the EU Environmental Footprint (Zampori & Pant, 2019) and EN15804+A2 (2019), together with data on greenhouse gas emissions from credible sources, sub-indicators for climate change (-fossil, -biogenic, and -land use change) and associated normalisation factors are developed. Also, new metrics for biobased products and processes are suggested. Results are applied on a case study with industry relevance in the transition to a climate-neutral society where heat from natural gas or wood chips in three different boilers are investigated.

The climate change metrics and normalisation factors are valuable in LCAs and carbon footprints where bio-based carbon emissions are involved and can be used by decision-makers to improve insight into the carbon footprint and environmental performance of wood, other bio-based products, and comparisons between these and their fossil counterparts. The proposed metrics improve communication and interpretation of the LCA and carbon footprint results for customers and other stakeholders. This presentation will show the method development and discuss the results of the case study with industry application.

Keywords: densified poplar, orthotropic material model, finite element analysis, electric guitar, acoustics

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Perspectives of wood-based products for acoustic purposes in building

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Acoustics is key to well-being in indoor environments. For instance, acoustic comfort reduces the stress level and contributes to focus attention, whereas poor acoustics can result in headaches, sleep disorders and loss of productivity (Cowan J.P., 2016).

Wood-based products are widely used to improve the acoustics of indoor environments, especially in large rooms such as conference halls, restaurants and open space offices. In such spaces, sound absorption and sound insulation are the main acoustic properties required. These properties are limited in wood; therefore, they have to be conferred to wood and its derived products, and various methods are today well-established on the market (Negro et al., 2020). Common examples are sound-absorbing perforated panels used as ceiling coverings or wooden floorings paired with sound-insulating materials. Further, proper acoustic design shall consider not only the use of single products but also the building as a whole, as it happens for cross-laminated timber structures.

The contribution illustrates the use and market perspectives of wood-based products for acoustic purposes in building. To this aim, the European legislation was examined (Rasmussen, 2018), the main products on the market were analyzed, and the scientific literature was reviewed. Based on the information gathered, a SWOT analysis (Strength, Weaknesses, Opportunities and Threats) was carried out.

Overall, it can be stated that acoustic wood-based products have relevant future potential. This also considering the increasing attention towards the use of sustainable materials and the acoustic comfort in a building. To exploit entirely such potential, specific solutions have to be fine-tuned also considering the installation of these products. Finally, their acoustic properties shall be assessed together with other elements relevant to well-being, such as aesthetic appearance, that are key to the use of wood in indoor environments.

Keywords: acoustics, building, sound absorption, sound insulation, wood-based products

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Electric guitar neck from densified poplar? Experimental and numerical analysis

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Electric guitar necks (EGNs) are usually made of hardwoods (i.e., maple, ash, etc.), including protected exotic species coming from overseas (mahogany, etc.), due to their aesthetics, high stiffness and density. Additionally, EGNs typically include a truss rod – a metal bar stiffening the neck against bending caused by string tension. In order to reduce the environmental impact of guitar production, we believe that EGNs can be made from local and fast grown plantation wood modified using a thermo-hydro-mechanical (THM) process. This approach for EGN production may be (i) more convenient due to higher mechanical properties of densified wood while preserving similar vibrational performance; (ii) more economical due to using local and cheap resources and absence of a truss rod; (iii) more environmentally friendly due to reduced logistics and energy costs. To analyze the hypothesis resulting from (i), we performed both experimental tests and numerical analyses. Experiments consist of poplar wood densification (dens. ratio 1.5) to obtain the elastic orthotropic material model of densified poplar suitable for finite element analyses (FEA). We aim to perform compression tests accompanied with digital image correlation, which will provide a set of elastic material coefficients – 3x normal elastic moduli (EL, ER, ET) and 3x Poisson's ratios (μLR, μRT, μLT); shear elastic moduli (GLR, GRT, GLT) were calculated theoretically. Developed material models were employed in FEA of (i) guitar neck deflection induced by string tension and (ii) modal analysis of a neck including sensitivity study for the role of density and elastic moduli on eigenfrequencies. FEA will use the following material scenarios: poplar, densified poplar, and maple. Preliminary results of the FEA with maple properties are shown in Figure 1. Figure 1a shows how deflection and PS1 changes with change of EL – deflection decreased 40 % and PS1 increased ~ 11 % as EL increased from 12.4 GPa to 22 GPa. Figure 1b shows the eigenfrequencies decrease with density but increase as EL increases (1st freq 17.4 %, 2nd freq. 21.4 % and 3rd about 27 %).

Keywords: densified poplar, orthotropic material model, finite element analysis, electric guitar, acoustics

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Agenda

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2021

Information and Computing Technology

BIM-based simulation of fire and smoke spread in timber buildings

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Wood can perform exceptionally towards fire resistance when used properly in building design even though wood itself is combustible. Because of the combustibility of wood, there are still uncertainties and misconceptions associated with its use as a construction material. One of the ways to clear uncertainties and increase stakeholders' confidence in the use of timber and wood-based composite building elements in construction is through experimental research. Advanced computer technology has made available several computational techniques in the field of building design. Two of these techniques which are gaining popularity are Building Information Modelling (BIM) and Computational Fluid Dynamics (CFD). Though these techniques have proofed to be efficient, fast and have long term cost efficiency, its integration needs further exploration.

The purpose of this study is to simulate the spread of fire/smoke based on information stored in a BIM model. The underlying goal is to validate the information stored in a BIM model and demonstrate how this information can be used in building physics simulations.

This study has a three-step approach. The first step was to extract a section of an already developed BIM model of the Innorenew CoE building complex in Izola, Slovenia. The next step was to export the extracted model and its thermal properties to a CFD software for the simulation. Pyrosim, a Graphic User Interface for Fire Dynamic Simulator (FDS) and Smokeview is used. The third step was to perform the simulation and analyze the results.

The limitation was the inability of Pyrosim to read the thermal properties from the BIM model. This limitation was overcome by developing a Dynamo script that extracts the thermal properties from the BIM model and exports it into Pyrosim. For better integration, further work is needed to enable Pyrosim to read the thermal properties from Revit. Also, a plugin can be developed for Revit to streamline the integration workflow of Revit-FDS/Smokeview and Pyrosim.

Keywords: wood, fire and smoke simulation, Building Information Modelling, computational fluid dynamics, Pyrosim, Revit

Acknowledgement

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Sensitivity Analysis Supporting Building Optimisation

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Design of buildings has evitable importance from worldwide energy consumption point of view as well as people's quality of life point of view. Energia Design Synthesis (EDS) method considers both; i.e. it is a unique technique ensuring de facto optimal buildings performing highest energy efficiency while offering best comfort. As part of the method, first geometry generation rules complemented by energy and climate-related rules are determined; then all feasible and potentially optimal building combinations are generated, and other cases are excluded. As an extensive preparatory work, a large number of complex dynamic thermal simulations (IDA ICE) were performed. Based on the simulation data, some parameters were selected, that are considered to be of the highest importance from both energy and comfort point of view. Nevertheless, based on the results of the simulations, a good practice is to judge the most influential parameters and their dependencies. General sensitivity analysis can be considered as a potential tool to support this process, i.e., it allows us to identify the most important parameters in relation to the overall building performance. Here, for this case Sobol' indices are applied, which is a variance-based statistical technique for global sensitivity analysis. During the work individual importance of the selected energy and comfort design variables as well as their joint effect is measured and evaluated. Besides the building envelope determining variables of wall window ratio, orientation and structures, diverse energy and comfort performance related design variables of the building geometry were assessed and prepared for the analysis. The most relevant design variables affecting thermal and visual comfort as well as energy efficiency were selected for future development of the optimization method.

Keywords: sensitivity analysis, building simulation database, evaluation

Simulation Database Development Supporting Building Optimisation

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More than 40% of the worldwide primary energy consumption is dedicated to the building industry. An incomplete optimisation content in the architecture design process may cause fundamental problems of sustainable building development. Most studies focus only on particular subsystems (e.g., insulation, shading, heating generation, etc.) or optimize geometry by only modifying some basic parameters of oversimplified rectangular spaces (e.g., aspect ratio, height, etc.), while the overall complete building optimisation, including comprehensive geometry generation, is yet to be solved. Moreover, most building energy optimization studies deploy stochastic evolutionary strategies (e.g., generative algorithms) to randomly generate building cases with a limited number population and generation, all possible design cases are not considered and therefore the optimum is still not guaranteed.

To overcome some shortcomings, the patented Energia Design Method that facilitates sophisticated energy, climate, comfort, lighting, aerodynamics, life cycle assessment simulation techniques were extended and first the algorithmic generation of all potentially optimal building cases considering the most decisive passive design variables was completed for some classes of problems. After selecting one of the simplest class, namely a residential building of average size and having six different zones, the particular work considers further steps in the form of a robust and significant simulation design and database implementation. For this simple case, more than 5000 simulations were performed, and from thermal and visual comfort as well as energy efficiency point of view, the most crucial six features were selected and summarised. The current presentation specifies the details of the work and evaluates the simulation results from the architecture point of view.

Keywords: building simulation, database, optimisation, evaluation

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Evaluation and optimization of different wind tower geometries for passive air conduction systems with CFD simulations

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During the lifecycle of a building, it consumes a significant amount of energy. According to contemporary researches almost 40% of the energy produced by humanity used for building constructions, maintenance and demolitions. (Pérez-Lombard et al., 2008) The HVAC – heating, ventilation and air conditioning are even standing out from the above-mentioned category. (Chenari et al., 2016) Papers are already proving that natural ventilation can be a good solution for moderating the energy demand of buildings. (Chen et al.) The study presents different geometry variations in a passive air conduction system based on two wind towers which are responsible for the ventilation and comfort level of a new winery in Hungary. The topology was developed after aerodynamic experiences and was investigated via CFD – computational fluid dynamics – simulations. The results proved that this method can reduce the construction costs, by selecting the simplest acceptable type which also efficient enough to achieve remarkable energy and costs savings during its lifetime.

Keywords: natural ventilation (NV), computational fluid dynamics (CFD), wind towers, optimization, passive air conduction system (PACS), building simulation

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Circular Economy and BIM in Civil Engineering

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Since the early 1980s, researchers from the field of IT in architecture, engineering, and construction (AEC), strive to develop tools that could assist architects, builders, surveyors, and other stakeholders. Despite slow its adoption, IT support in a form of Building Information Modelling (BIM), has lately been established as an invaluable business enabler, facilitating stakeholder communication, information collection and exchange, improving the quality of design solutions, and overall efficiency in construction projects. Naturally, at the same time, other fields of AEC also achieved significant breakthroughs. As important, we can highlight the development of new more sustainable circular business modes, which seek to establish more sustainable development by the means of reduction of the consumption of primary virgin construction materials through reuse and recycling.

In the CINDERELA project, we address the two exposed research areas reciprocally. To demonstrate the benefits of IT, a two-stage BIM implementation strategy has been established, firstly, at the project level and running in parallel with the secondary raw material (SRM) development on a product level. In this paper, we primarily focus on the product level, where we represent the development of a BIM Library – the information database, structured in the form of objects developed in the Industry Foundation Classes (IFC) format. The library is being used to populate the CINDERELA One-Stop-Shop service (CinderOSS) with the goal of diffusion of the SRM-based construction product. We highlight the challenges associated with the development of a properties dataset that promotes circularity and environmental indicators of innovative construction products. Following this path, the CINDERELA project is promoting circular economy business models.

Keywords: IT, construction, BIM, circular economy

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