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# RASSEGNA DI ARCHITETTURA E URBANISTICA

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## *Laudato si'*
## Prospettive per un'architettura integrale

**RASSEGNA**
**DI ARCHITETTURA**
**E URBANISTICA**



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In copertina: Diga di sacchi di sabbia costruita sul delta del Gange, distretto di Chittagong, Bangladesh. Foto Courtesy Yann Arthus-Bertrand.

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# ***Laudato si'*. Prospettive per un'architettura integrale | Laudato si'. *Perspectives for an Integral Architecture***

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# Sustainable Architecture: Reuse and Recycling with Biomaterials

*Andreja Kutnar, Anna Sandak, Jakub Sandak*

## Societal challenges for the construction sector of the future

The world around us is changing dramatically. The climate alteration, immigration crisis, increasing population, polarization of the poor and wealthy in societies, overexploitation of the earth's resources, divergence, and rivalry between political systems are just some of the factors that determine the health of our society and trigger requirements for immediate mitigation. Within the world economy, the construction sector has the greatest impact and relevance. This sector is also a primary consumer of resources, emitter of pollution, and generator of waste. The (positive) alteration of the construction sector is, therefore, critical in mitigating the negative aspects of climate change and other global societal challenges.

Accomplishing the necessary societal change is perhaps the initial and probably the most challenging step. Modifying the lifestyle, particularly in the wealthy Western world, is indispensable, which is an extremely tough task to accomplish. In modern European societies there is a tendency towards complacency, often accompanied by complaints and extensive talks, while pragmatic actions and real changes that have the potential to be efficient and ground-breaking solutions are rarely implemented. Europe, with the ambition to become the first climate-neutral continent, should become a role model for the rest of the world. With the Green Deal and particularly the New European Bauhaus initiatives, an important political step has been taken. However, it is not just the members of the upper class or the politicians who need to join forces, but the whole of society. To paraphrase a famous quote, "We choose to go to the Moon," by the former president of the United States of America, John F. Kennedy, now it is time to say "We choose to reverse climate change." It emphasizes the challenge of uniting society to effectively implement the New European Bauhaus initiatives. An important question is whether we, as global citizens, are willing to consider the prosperous future of coming generations. Furthermore, are we willing to take appropriate action instead of merely "thinking" about it? And here, let us not "think" that leaving money for our children to inherit is sufficient; we must leave behind a just and environmentally sustainable world.

Another question we need to ask is are we, as a modern society ready to consider the necessity to act and work towards leaving behind a livable world? Often, this mistakenly leads to believing that being satisfied with consuming "less" is sufficient. In the context of the construction sector, "less" refers to strategies such as constructing smaller homes, opting for multistory buildings, maintaining structures more often than demolishing, utilizing reused or recycled materials.

## Sources of future building materials

While we duly advocate for transforming the built environment, we must recognize


← Ivalsa-Cnr, Casa MAI (Modulo Abitativo Ivalsa) – an example of a building constructed with reused cross-laminated panels. Image courtesy of Romano Magrone and Paolo Simeone-DUOPUU.

that this does not necessarily require building shelters using only materials found in our backyards, as our ancestors did. Human ingenuity and curiosity have opened the possibility of building with an enormous portfolio of materials of different origins, properties, impacts, and costs. However, the challenge is to consider, in each project, an optimal solution that is a compromise between functional requirements, aesthetics, costs, service life performance, and environmental impact. Here biomaterials are primary candidates for consideration. Architects and designers are embracing biomaterials not just for their sustainability credentials but also for their design versatility. Biomaterials enable a harmonious blend of form and function, facilitating structures that seamlessly integrate with natural landscapes while pushing the boundaries of aesthetic possibility. In essence, materials of biological origin represent a paradigm shift (or return?) in construction, where innovation meets ecological responsibility. As we forge ahead, these materials stand poised to redefine what it means to build sustainably - embracing nature's wisdom to create a built environment that is not just livable but regenerative.

Biomaterials are a gift from nature and require land, water, sunlight, and time to generate solid resources that are a perfect fit for numerous applications in construction. Even if the quantity of virgin biomass created annually in the world is enormous, the recycling of biomaterials is extremely important to increase the carbon storage period before its release during composting or burning. In general, biomaterials are a perfect fit for the circular economy paradigm and can undergo several 9R strategies (Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, and Recover). It is especially relevant when new approaches for biomaterials modification and functionalization are available, such as engineered living materials or chemically/physically/mechanically treated biomaterials.

However, it must be mentioned here that, even though biomaterials are superior resources for the construction sector, due to their nature, these materials may alter during

↑ Gris+Dainese Architetti, Hotel De Len, Cortina d'Ampezzo (BL), 2020. An example of a building constructed with reused timber, serving as human-friendly interior elements that improve the well-being of guests. Image courtesy of Helenio Barbetta.

their service life. Frequent mechanisms for biomaterials deterioration are aging, weathering, and decay. Another issue is the possible contamination of biomaterials by impregnates, coatings, or dirt that can occur at the production or use phase. All of these make recycling and/or reuse problematic in real-world implementation. Sophisticated techniques for quality assessment and treatment of reclaimed residuals are needed to ensure conformity with future use requirements. It is currently a subject of intensive R&D initiatives in numerous institutions and universities.

## Engineered living materials

In the quest to transform our built environment sustainably, engineered living materials (ELMs) emerge as pivotal players. These innovative materials, drawn from biological sources or inspired by natural processes, offer a compelling array of advantages. Imagine a building material grown rather than mined or manufactured. Engineered living materials harness the power of nature, tapping into renewable resources and reducing our dependence on finite materials. They embody a philosophy of biodegradability, designed to gracefully return to the earth at the end of their useful (for humans) life, minimizing waste and environmental impact. But their impact extends beyond mere sustainability. Engineered living materials can actively contribute to energy efficiency in buildings. Some provide exceptional insulation, keeping interiors cool in summer and warm in winter, while others leverage natural processes for passive heating and cooling. This dual capability not only enhances comfort but also reduces reliance on energy-intensive heating and cooling systems. Crucially, ELMs can be engineered to sequester carbon dioxide, turning buildings into carbon sinks rather than sources. By capturing and storing carbon during their growth or production, they offer a pathway to carbon neutrality or even a carbon-negative state, a transformative prospect in the fight against climate change.

## Education – the way to change the current status-quo

In many of the underdeveloped nations, there is a higher tendency to repair, reuse, and recycle materials and products as they have limited access to technologically advanced options. In wealthier societies, as in Europe, the extraordinary and readily available technological development and globalization have enabled the majority of citizens to fulfil their materialistic desires by simply purchasing products or services. There is less need to be innovative with "backyard materials." However, to catalyze a transformation in the construction sector, it is necessary to re-think life expectations and desires. It is necessary to change the negative perceptions attached to labels such as "recycled" or "reused" biomaterials.

Ironically, the amazing developments in our society and the narrowing of the social "specialization" of expertise have made us in general a less skillful society. The launch of the New European Bauhaus Academy in Europe addresses this important challenge, particularly in the construction sector. Proper use of biomaterials in buildings requires a broad knowledge of ma-

↑ Philippe Samyn and Partners, European Council, Bruxelles, Belgium, 2016. The European Council building with glazed double façade made from restored windows. Image courtesy of Marcin Brzezicki.

terial science, engineering, and manufacturing. However, given the incredibly fast technological development, school-acquired knowledge quickly becomes outdated.

At the core of several legislative efforts lies research and development initiatives. Governments invest in cutting-edge technologies and sustainable practices, driving innovation in recycling techniques for biomaterials and engineered living materials. These investments propel forward the industry, pushing boundaries and paving the way for greener, more resilient buildings that are in harmony with their natural surroundings. Education emerges as another cornerstone of legislative support. Workshops, seminars, and certification programs educate architects, engineers, and builders about the benefits and methodologies of integrating biomaterials in efficient and beautiful projects.

### Pioneers, and early adopters as a key for promoting the sustainable construction sector

Here the challenge is to encourage as many entrepreneurs as possible, to create new and ground-breaking solutions for building with materials that have minimal environmental impact yet can be used to build fast and cost-effectively, thus constructing long-lasting but aesthetically appealing structures. As in every technological contest, pioneers are the key driving force in discovering and shaping new concepts and prototypes. They are responsible for refining the prototypes into positive showcases that, after continuously evolving, may become inspirations for construction technologies of the future. It is critical however to support these innovators and pioneers and ensure enough followers to create the critical mass required to broaden such positive impact technologies. This is a mission for researchers, architects, and engineers, who must be supported by politicians and decision makers.

Armed with knowledge, professionals can be empowered to make informed decisions that prioritize environmental stewardship without compromising structural integrity or aesthetic appeal. Public procurement policies can further amplify these efforts. Governments should lead by example, implementing procurement strategies that favor sustainable construction practices. Through public projects, from municipal buildings to urban developments, authorities must showcase the transformative potential of biomaterials, setting a precedent for the private sector to adopt.

### Politics and regulations

To implement a broader use of recycled biomaterials into practice, it is important to adopt legislation that will formally enable the utilization of different technological solutions. In the evolving landscape of architecture and construction, the integration of reusing and recycling practices, particularly with biomaterials and engineered living materials, is not just a matter of innovation but of necessity. As the global community confronts pressing en-

↑ Encore Heureux, Le Pavillon Circulaire, Paris, 2015. The Circular Pavilion with a façade made of reclaimed old wooden doors. Courtesy of the authors.

vironmental challenges, governments around the world are stepping up to harness the power of legislation in fostering sustainable building practices. Therefore, legislative frameworks are not merely bureaucratic mandates but visionary roadmaps for a sustainable future. By fostering collaboration between policymakers, industry leaders, and the public, the legislation creates an ecosystem where innovation flourishes and sustainable practices thrive. As cities evolve and skylines transform, the integration of reusing and recycling practices with biomaterials becomes not just a regulatory requirement but a collective commitment to safeguarding our planet for generations to come.

### Societal marketing

Effective communication of success stories of pioneer buildings made from recycled/reused biomaterials is critical to convincing conservative investors to adopt such environmentally friendly solutions. The ultimate goal would be cities where skyscrapers rise not only as symbols of progress but also as examples of sustainability. Here again, legislation plays a pivotal role, laying down the groundwork for architects and developers to rethink traditional building materials and construction techniques. Mandatory standards and building codes set by authorities require the incorporation of recycled content and encourage the adoption of biomaterials derived from renewable sources. These regulations not only ensure compliance but also stimulate creativity, challenging designers to explore new frontiers in material science. In this regulatory framework, financial incentives become catalysts for change. Governments offer grants, tax breaks, and subsidies to incentivize the use of biomaterials, especially if these are recycled or reused. These financial boosts alleviate the initial costs associated with sourcing and integrating biomaterials, making sustainable choices economically viable for stakeholders across the industry.

Beyond financial support, robust waste management regulations reshape construction practices from the ground up. The legislation mandates the segregation and recycling of construction waste, ensuring that materials like reclaimed wood, and bio-based composites find new life in architectural masterpieces. This systematic approach not only reduces landfill waste but also cultivates a circular economy where materials are continuously repurposed and reused.

### Circular economy in the construction sector

In the pursuit of sustainable architecture, maximizing the use of materials through multiple cycles, known as cascade use, is essential. Architects should design buildings with components that can be easily disassembled and reused, embracing modular construction and standardized connections. They should prioritize durable materials that maintain quality over time and conduct lifecycle assessments to gauge environmental impact. Collaboration with suppliers ensures responsible sourcing and facilitates material reuse. Simultaneously, stringent adherence to regulatory standards limits toxic chemicals in construction, promoting transparency through labels and certifications. These efforts safeguard both environmental and human health, forging a path toward a truly sustainable built environment.

Another important aspect is a way to quantify the impacts, functionality, and environmental friendliness of buildings. Several certification schemes were established recently, and more credits are awarded to such projects thanks to the extensive use of virgin/reused/recycled biomaterials.

### Best practices for reusing or recycling biomaterials in construction

As mentioned, the best way to change the perception of recycling or reuse of biomateri-

↑ University of Primorska with InnoRenew CoE (renovation), Servite Monastery, Koper, Slovenia. Koper's Servite Monastery is an example of an ongoing reconstruction project of cultural heritage objects where the reuse of building materials is fundamental for preserving the authenticity of the building. Image courtesy of Eva Prelovšek Niemela.

als in architecture is to educate people, preferably by presenting success stories of existing buildings or concepts. There are several such wonderful projects all around the world, demonstrating best practices. Some of these are listed below to illustrate the challenge and inspire further developments.

1) IVALSA Housing Module MAI. The MAI structure, is located in San Michele All'Adige, Italy. MAI is the acronym for "Modulo Abitativo IVALSA," a pioneering project where cross-laminated timber (CLT) panels, which served as structural elements of the experimental timber building Casa SOFIE, were reused. It is the first example of an architectural project where CLT panels were dismounted and reshaped to meet the needs of other buildings. MAI is a structure made up of five prefabricated and transportable modules (the base is 2.5 × 4 meters with a height of 3.5 meters) which are assembled and hooked together to form a single, fully furnished five-room building. The 33 square meter apartment consists of two bedrooms, a bathroom, a kitchen, a living room, and two 16 square meter external terraces.

2) Hotel De Len. The reconstruction of Hotel De Len in Cortina d'Ampezzo, Italy, focused on the use of reclaimed wood as an element of well-being. The design paradigm included both the use of recovered wood and the human–wood relationship. The second is a critical part of creating comfort and maintaining a connection to nature indoors. In 2022 the hotel was recognized among the 42 best new hotels according to National Geographic and was a winner of the Snow Queen category, which is dedicated to hotels situated in the mountains.

3) European Council and Council of the EU. In the context of sustainable development,

during the construction of the European Council building, they opted to refurbish the old but effective window frames. The double-glazed façade combines an outer layer constructed from recycled windows sourced from demolition sites, featuring clear single glazing, with an inner layer of pristine double glazing. This design serves as a vital acoustic barrier against traffic noise on Rue de la Loi in the European Quarter of Brussels, Belgium while also providing thermal insulation for the interior space.

4) Circular Pavilion in Paris. The structure was designed by studio Encore Heureux and erected in the center of Paris, France. The exterior of the 750-square-foot polygonal cafe and event space was clad with 180 reclaimed doors obtained from a public housing project located in the city's 19th arrondissement. The pavilion was showcased during the Paris Climate Agreement talks in December 2015. It also serves as an experiment in using reclaimed materials to shape the design process and foster connections between the construction industry and public services.

5) Koper's Servite Monastery. The Servite Monastery in Koper, Slovenia was built in 1492 and was declared a cultural monument of national importance in 1999. It is currently undergoing gradual renovation and reconstruction. As in any cultural heritage project, innovative technologies for reusing original elements are broadly implemented to preserve these for future generations. It includes advanced technologies to characterize the existing structure and the innovative use of renewable materials. This project is an example of adapting all the principles of REED, the New European Bauhaus, and state-of-the-art sustainable solutions for cultural heritage renovation/restoration. Special efforts are directed toward proper communication, with the public involvement of stakeholders at all stages of renovation.

## Concluding remarks

Resolving societal change, particularly in the affluent Western world, is one of the most challenging yet essential steps toward a sustainable future. In our comfortable, resource-abundant society, we have lost many practical skills necessary for sustainable living. Europe, which aims to become the first climate-neutral continent, has taken a significant step with the New European Bauhaus (NEB) initiative. Its extension, namely NEB Academy seeks to address this skill gap.

In summary, the path to a sustainable built environment, and especially the recycling and reusing of biomaterials is complex and multifaceted. It requires collective societal effort, innovative materials, supportive legislation, and a commitment to future generations. By fostering collaboration among policymakers, industry leaders, and the public, we can create a sustainable future where innovation and ecological responsibility go hand in hand. However, the collective efforts to mitigate environmental impact are futile unless all of humanity participates. The socially and economically costly improvements in the European construction sector's carbon footprint are rendered ineffective when military conflicts generate massive pollution. It is estimated that the war in Ukraine has resulted in the emission of 175 million tons of CO2 to date, while armed forces worldwide are responsible for more than 5% of global greenhouse gas emissions. These figures overshadow the gains made through sustainable practices in other sectors, highlighting the urgent need for comprehensive international cooperation to effectively address the climate crisis.

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