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Biobased building materials – directions and development prospects

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Abstract: *Biobased building materials – directions and development prospects*. Market of building biomaterials is a dynamically developing branch of the construction sector. The design of buildings and the use of building biomaterials should take into account all factors influencing biomaterials throughout the life cycle of an engineering facility, so that the building can be characterized by high strength and durability. Many political organizations and others promote ecological houses made of building biomaterials as future-proof solutions in construction sector. Building biomaterials are a basic element of green construction, they enable safe disposal, reuse and they are a storehouse of carbon dioxide, which is emitted in the production of conventional materials. Diversified directions of development of ecological and new building materials create potential prospects for their application. The main factor that limits this development is the conservativeness of the construction industry.

Keywords: biobased building materials, timber, lignocellulosic materials, ecology, timber constructions

INTRODUCTION

Conventional techniques and building materials used leave a significant carbon footprint. Statistics show that the construction industry consumes 40% of the energy produced, emits 35% of greenhouse gases, and consumes 50% of the raw material mass, which is intended for the production of materials of all industries in the world [3]. The growing tendency to erect buildings with a low impact on the natural environment is a response to the need to develop environmental awareness. Building ecological engineering facilities is possible thanks to increasing the availability of building biomaterials and developing new ones. An example is the production of wood, which consumes 10% of the energy needed to produce the same amount of steel [8]. The aim of the study was to review building biomaterials available on the current market in terms of their environmental performance and their application in construction as opposed to conventional building materials. The most important factors that should be considered when designing buildings with the use of building biomaterials are presented.

MARKET OF THE BIOBASED BUILDING MATERIALS

Biomaterials are made of one or more substances of plant origin. Building biomaterials include both unprocessed materials and those processed using renewable polymers [4]. The concept of biomaterials is understood more broadly than just in terms of their construction, because they consist of a number of activities closely related to the production, application, transport, appropriate purpose, and the future use of biomaterial in its current or other form. The characteristics and description of the currently used building biomaterials concern:

a) construction biomaterials - they form a structure or its elements,
b) functional biomaterials - perform functions other than constructional.

One example of biomaterials is glued laminated timber, which made it possible to use wooden elements in spans that were impossible to achieve for solid timber. The aim is to eliminate wood anisotropy and structure defects in the production phase. Apart from BSH, glued laminated timber also includes LVL (Laminated Veneer Lumber) - laminated timber made of 3 mm thick veneers [9]. Cross-laminated timber (CLT) enables the construction of multi-storey buildings and could be an ecological alternative to reinforced concrete and steel structures [5].

The possibilities of glued laminated timber have already been presented in many spectacular constructions, such as the roofing in Hanover at the EXPO 2000 fair or the Metropol Parasol in Seville (Figure 1).

A) B)

Figure 1. A) Roof at EXPO 2000 in Hanover built with BSH and LVL, **B)** Metropol Parasol in Seville built with LVL (zueblin-timber.com; architektura.info)

Wood-based materials are most often plate (but not only) elements that consist of pressed shredded wood elements, often (but not always) with the addition of binding substances. Wood-based materials used in construction industry can be divided into wood-based panels and wood-based construction materials. The most commonly used chipboard in construction is OSB (Oriented Stand Board). It is a more economical substitute for plywood. Hard boards are used as a material for the webs of I-beams together with construction timber or LVL laminated veneer (Figure 2A). Wood-based construction materials include, for example, Instrallam (LSL) or Parallam (PSL), which allows the use of lower-quality raw materials in the form of parallel-fiber strands (Figure 2B).

A) B)

Figure 2. A) STEICO I-beam consisting of HDF web and LVL laminated veneer (steico.com), **B)** Rectangular parallam beam - PSL (weekesforest.com

Wood modifications enable failure-free use of wood in outdoor conditions, ensuring its high resistance to moisture and dimensional stability. For example, Accoya wood is characterized by increased biological resistance, reduced swelling and shrinkage properties by 70-80% compared to untreated wood [6]. The development of materials science has led to the development of multi-component materials called biocomposites. The biocomposites include WPC (Wood Plastic Composite) and sandwich composites.
Functional biomaterials include the commonly used mineral wool, hemp concrete, straw cubes and wood-based insulation materials, i.e. soft fiberboard (LDF), fiber mats, porous fibreboards.

Due to the possibility of advanced prefabrication of building partitions made with the use of biomaterials, work on the construction site can take place regardless of weather conditions (no wet works), faster (transport and assembly of ready-made components) and with a lower risk of human error caused by the installation of many small components.

IMPORTANT FACTORS WHEN DESIGNING USING BIOBASED BUILDING MATERIALS

Designing buildings with the use of building biomaterials should take into account all factors influencing the biomaterials throughout the life cycle of the building, so that the building can be characterized by high durability and strength. These factors affect the aesthetic values and properties of building biomaterials.

Intended use is one of the basic and first factors that should be taken into account when designing using building biomaterial in a building structure. Application for constructional or non-constructional purposes should be taken into account in order to select properly treated and secured construction biomaterials with specific mechanical properties.

Building biomaterials consist partly or entirely of natural raw materials and they are therefore susceptible to environmental influences. The influence of atmospheric conditions such as UV radiation or water significantly reduces the visual attractiveness of the biomaterial, causing stains, oxidation, discoloration, etc. The limits of aesthetic requirements are usually reached before the material loses its functionality. The deterioration of the aesthetics does not always mean the deterioration of the physical and mechanical properties of the material [2]. Some of the wood colors do not deteriorate its properties, e.g. blue stain or wood fading under the influence of sunlight, and some of them may significantly deteriorate it or constitute the initial stage of wood decomposition, e.g. red sapwood (initial stage of rot). The building biomaterial can be properly protected with paint and varnish coatings or impregnated with chemical agents. Nowadays, the use of unprotected wood outdoors may be intended to achieve the effect of aging wood (Figure 3).

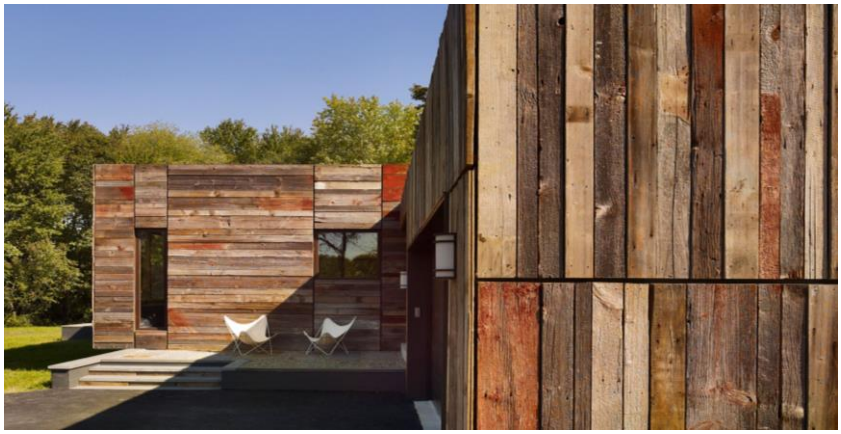

Figure 3. The use of wood of various species for building facades (inhabitat.com)

Due to the fact that wood is also used as an energy raw material, there is a misconception that this material makes a building more vulnerable to fire. A fire is an accidental event, and the choice of material almost never influences the start of the fire, wooden buildings do not catch fire more often than those made of conventional building materials. Building materials, however, influence the rate of fire development and its spread to other rooms. The fire safety of building biomaterials should be taken into account at the design stage when adjusting the load capacity based on the cross-section of the element, taking into account the target fire resistance time. In wooden elements, the load-bearing capacity in a fire increases with their size increase, therefore, for example, glulam is difficult to ignite, and if it is successful, it burns slowly [1]. In addition, wood under fire conditions still fulfills its structural function, in contrast to steel, which deforms under the influence of high temperatures (Figure 4). There are also flame retardants that can limit the spread of a fire or delay its start.

Figure 4. Steel and wood under fire conditions (setragroup.com)

RECYCLING AND ECOLOGY

All processes, starting from obtaining the raw material, through the production and use of ready-made building biomaterial, require interference with the natural environment. The environmental aspect of the material is influenced by: the method and quantity of raw material obtained, its transport, mechanical, chemical and thermal treatment, transport of building materials to the construction site, use / application of the material itself after production, repair and storage or recycling. In addition, during use, the material may affect the environment through, for example, the emission of chemical compounds. It can be concluded that the ecological significance of the material determines its life cycle. Currently, the goal is to achieve a closed loop of material life (Figure 5), while many conventionally used materials have no chance of achieving it. The Life Cycle Assessment (LCA) tool is used to assess the life cycle, which can be applied to each material, taking into account its use, disposal and reuse [7].

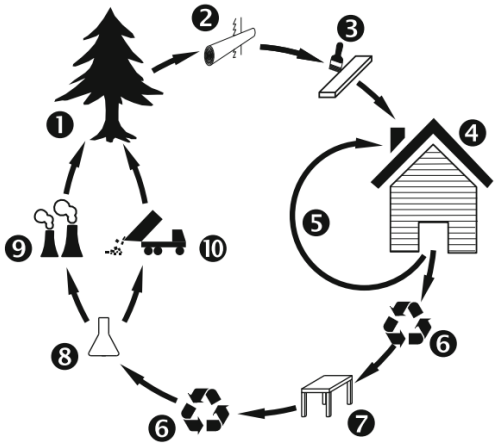

Figure 5. Life cycle of a renewable material. 1) obtaining the raw material; 2) primary processing; 3) secondary processing; 4.5) use phase, reuse; 6) recycling; 7) re-use; 8) cascading into third use; 9) production of energy; 10) storage, closing the circuit 0

Table 1. Possible technologies for processing waste from building biomaterials 0

Processing technology	Raw material flexibility	Process efficiency	Market value of the end product
Combustion	High	Low	Low
Digestion	Low	Medium	Medium
Fermentation	Low	Medium	High
Pyrolysis	High	Medium	Medium
Gasification	Medium	Medium	Medium
Platform particles	Medium	Medium	High
Condensation	Medium	Low	High
Composite manufacturing	High	High	High
Litter for animals	High	Medium	Low
Pelletization	High	High	High
Conversion by insects	Medium	Medium	High
Conversion by fungi	Medium	Medium	High

Various types of recycling and possible waste processing technologies for reuse play a very important role in reducing the amount of waste (Table 1.). According to the recycling concept, when the material ceases to fulfill its original function, it should find a new use before it is converted into energy (the last stage of the material life cycle). When recycled building materials are used, the emission of carbon dioxide stored in the biomaterial is delayed until the element is no longer able to perform any function and must be disposed of.

There are different types of green building certification available to inform the consumer about the environmental properties of the product. Among the many assessment methods, the most commonly used are: BRE environmental assessment (BREEAM) and the multi-criteria assessment system LEED. BREEAM is the most commonly used method of environmental assessment of a building, it is used to describe the environmental performance of a building. BREEAM uses a transparent scoring system and facilitates the setting and maintenance of high technical standards with quality assurance and environmental certification.

CONCLUSIONS

The market for building biomaterials is diverse and would be able to largely replace the market for conventional materials. Architects and designers should take into account in their building designs all the important factors affecting the entire structure, and in particular building biomaterials, during the construction of a building as well as its operation. After the construction life has expired, building biomaterials can be transformed and reused. After the construction life has expired, building biomaterials can be transformed and reused. The impact of building biomaterials may not only be neutral to the environment, but also have a positive effect on them. The large share of building biomaterials in the circular economy, bioeconomy and low-carbon economy is very important in the time of the climate crisis. By increasing the availability and making consumers aware of the possibilities offered by building biomaterials, it is necessary to redefine conventional building solutions.

REFERENCES

Brandon D., Ostman B., *Fire Safety Challenges of Tall Wood Buildings. Phase 2: Task 1 – Literature Review*, 2016

Grabowski W., Jasiczak J., Katzer J., Lipczyńska I., Lis Z., Macieik L., Maliszewski G., Małasiewicz A., Mieczkowski P., Piasta J., Piasta W., Rapp P., Romanowski A., Rucińska T., Rudnicki T., Stefańczyk B., Szaflik W., Weryński B., *Budownictwo ogólne, tom 1, Materiały i wyroby budowlane*, Warszawa, 2005

Hager I., Materiały budowlane i zrównoważony rozwój, 2016

Jones D., Brischke C., *Performance of Bio-based Building Materials*; Woodhead Publishing Series in Civil and Structural Engineering, 2017

Larasatie P.,Guerrero J. E., Controy K., *What does the public believe about tall wood buildings?* An exploratory study in the US Pacific Northwest., 2018

Ramage M., Burridge H., Busse-Wicher M., Fereday G., Reynolds T. Shah D., Wu G., Yu L., Patrick Fleming P., Densley-Tingley D., Julian Allwood J., Paul Dupree P., P.F. Linden P. F., Scherman O., *The wood from the trees: The use of timber in construction*, 2017

Raugei M., Gala A. B., *Introducing a new method for calculating the environmental credits of end-of-life material recovery in attribuional LCA*., 2015

Sandak A., Sandak I. Brzezicki M., Kutnar A., *Bio-based Building Skin*, 2019

Tarabasz J., *Drewnopochodne tworzywa konstukcyjne: LVL, PSL, LSL, Scrimber.*, Warszawa 2006

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