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Buildings of the future: green and energy-efficient construction processes

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Abstract: The article addresses the topic of green and energy-efficient construction processes in the context of buildings of the future, which do not have a negative impact on the environment and minimise the use of energy both in the production of building materials and during the construction process itself. The authors present green construction process definitions as well as reasons for the growing interest in this type of construction together with the main goals such construction practices seek to achieve. The requirements that need to be fulfilled for a construction process to be defined as green are presented in a subsequent section. The authors also suggest five building materials that, in their opinion, may be referred to as green and energy-efficient. These include wood, reclaimed bricks or glass, but also less common cellulose fibres and hemp.

Keywords: green construction process, energy-efficient construction process, green building materials, buildings of the future.

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1. Introduction

Construction processes have a significant impact on the natural environment. Hence, solutions are sought that deliver a certain level of living comfort whilst remaining environmentally friendly. Progress in environmental protection coupled with the development of construction processes depends on the pro-environmental awareness of current and future generations [Belniak S., 2022].

The need to reduce CO2 emissions into the atmosphere is the primary reason behind the search for green and energy-efficient building technologies. The construction industry, which also encompasses the production of building materials, is one of the primary 'polluters' of the environment. With the continued growth of the Earth's population in mind, the problem of environmental protection is becoming a key one for humanity. Therefore, the interest in green and energy-efficient construction processes is growing [Błaszczyński T., 2016].

2. Analysis of the goals and requirements of energy-efficient and green construction processes

An energy-efficient building is defined as one where the annual heating energy consumption for 1 m^2 of floor space is in the order of 50 kWh/m^2/year. A passive building is a type of an energy-efficient building, i.e. a residential building where the annual energy consumption for heating does not exceed 15 kWh/m2/year.

The term "Green Construction Process" is understood to mean construction practices utilising healthy and energy-efficient materials based on energy-efficient solutions and energy-saving and environmentally friendly construction methods and techniques, more closely integrated with nature and generating significantly less pollution than conventional construction practices.

Goals of the green construction process:

- Improve the health properties of buildings by reducing their health impairment potential.
- A significant reduction in the environmental impact of buildings and their components, i.e. minimised environmental pollution.
- Significant reduction in energy consumption during the manufacture of construction products, during the construction of buildings and during their use.
- Maximum use of renewable energy.
- Design solutions for buildings and their components which utilise vegetation as a green mantle for buildings.

Requirements for green building systems and buildings [Deccoria.pl, 2021]:

- Products made from raw materials generally considered to be natural, e.g. sand, lime, clay, gypsum.
- Low energy production and no harmful by-products discharged into the environment (use of environmentally clean technology).
- Buildings consume low amounts of energy (energy-efficient buildings).
- Buildings constructed using the above-mentioned natural products deliver a beneficial micro-climate by auto-regulating heat and moisture proportions.
- Buildings feature ample sound insulation, are fireproof, do not emit any harmful substances during a fire and are not conducive to combustion.
- Buildings are durable, long-lasting.
- Materials used for construction may be reused after demolition.

3. Analysis results – building material suggestions

➢ Wood

Wood is one of the most eagerly sought after materials in the context of the green construction process. The origin of wood, the way it is harvested and its physical properties make it the most natural and friendly material to be used on such a large scale and across such a large number of applications. This building material is used for both timber-frame structures as well as façade cladding. It is the material best suited for reuse – dismantling or reclaiming a timber house is relatively simple. Very little waste is generated during construction and it is easy to utilise.

➢ Reclaimed bricks

Despite the fact that bricks are entirely of natural origin, huge amounts of energy are consumed in their production. This means sourcing reclaimed bricks constitutes a tangible environmental benefit. In addition, it is also almost twice as cheap as buying brand new building material. The bulk of the cost

associated with reclaiming bricks stems from removing old mortar. Reclaimed bricks can be used for façades or to erect internal thermal storage walls.

- Glass

Glass is recognised as one of the most environmentally friendly materials. This is probably due to the fact that it can be remelted and refined virtually indefinitely, as it does not lose its properties. In addition, quartz sand, the world's most common sedimentary rock, together with high temperatures are used to make glass. Foam glass is one of the building materials obtained by processing glass. It is obtained by combining molten cullet with foaming admixtures. The result is a material with very good thermal and acoustic insulation properties.

- Thermal insulation using newspapers and rags – cellulose fibres

Cellulose fibre is a great alternative to traditional polystyrene or mineral wool. It is an environmentally friendly substitute, a by-product of recycling wastepaper. These fibres make a good insulating material. High-quality newspaper grade paper with boron salts is used to produce it. Such treatment means it is non-biodegradable and at the same time protects wooden structures from mould and fungal growth. This eliminates dampness and there is no need for a vapour barrier film, which contributes to the house's favourable microclimate. The material is 100% safe for health – it does not sublimate even at high temperatures and does not cause allergies.

- Hemp

Hemp building materials are growing in popularity arguably through the proportionally increasing acceptance of that material in the society. This is primarily due to the fact that hemp materials make it possible to create healthier living spaces. Hemp has good insulating properties (similar to those of straw), burns poorly, is non-toxic, and has universal applications – to make bricks, roof tiles and wall panels. Hempcrete (hemp concrete) is used for erecting walls. The fact that this material is fully biodegradable is also an important aspect. When a building/structure is demolished or raised to the ground, crushed concrete would be generated, which could then be used to fertilise or de-acidify farmland.

4. Conclusions

The green construction process is becoming a certain norm. They are not just a fringe, short-lived trend. Green innovation is becoming more popular every year. Pro-environmental efforts are one of the more popular and promising activities for global and regional economies. Therefore, we can expect a lot of green endeavours in the coming years. However, one should bear in mind that we are only dealing with actual green constructionist processes upon being presented with appropriate documents [J. Mikoś, 2000]. A system of international certificates that the Polish Green Building Council (PLGBC) maintains comes to the rescue. In order to obtain such a certificate, a facility must meet a number of requirements concerning, among other things, water and energy consumption, solutions used for various systems, use of recycled materials, location and the amount of waste generated. Factors that directly affect the well-being of residents are also taken into account, such as view from windows, use of materials that do not emit harmful substances, access to daylight and public transport. Currently, multi-criteria certification of buildings in our country is available under the following systems:

- BREEAM (Building Research Establishment Environmental Assessment Method);
- DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen);
- HQE (Haute Qualité Environnementale);
- LEED (Leadership in Energy and Environmental Design);
- WELL Building Standard;

- Green House.

The latter is Poland's first multi-criteria certificate for residential buildings. It is awarded to investment projects which deliver high environmental quality and energy-efficiency while ensuring a significant reduction in use costs [PlanRadar].

5. Discussion

We need the green construction process as excess emissions of harmful gases such as CO2 and SO2, which are by-products of heat and electricity generation, result in the depletion of the ozone layer and acid rain, which lead to subsequent unfavourable climate changes, deterioration of human health and destruction of vegetation. At the same time, natural resources of traditional raw materials used as fuel are declining and there is a steady increase in the cost of extracting, processing, transporting and distributing them. According to a report by the World Green Building Council, energy demand will increase by 50% by 2050, and buildings are responsible for 39% of global carbon emissions and 50% of global material consumption [World Green Building Council, 2020]. As many as 91% of the human population live in areas where air pollution levels exceed World Health Organisation limits. This poses huge challenges for green construction processes in terms of climate, resources and health.

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