Healthy Residential Buildings

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Healthy residential buildings represent the future of construction concerned with the environment, which is increasingly emphasized. This is directly related to the research and development of environmentally friendly building materials, which on the one hand meet the specific requirements of the builder, and on the other hand do not harm the environment. It has possibility of achieving increased variability in healthy residential buildings via the customization of recycled polyvinyl butyral using smart technologies for sustainable design.

Keywords: variability ; customization ; FMD ; sustainable material ; BIM

1. Introduction

The design of healthy residential buildings is one of the EU's environmental objectives [1]. In the current period where there are extensive discussions taking place on emissions and many searches for ways to eliminate adverse environmental pollution factors, building healthy residential areas is very important. Many studies deal with this issue [2]. Several experts share the same approaches to achieving this goal [3]. The choice of suitable environmentally safe materials is one way to achieve this goal [4]. In addition, examining the effects of individual building materials on human health and their environmental impacts should be a priority [5]. However, knowledge of the properties of the current materials is not enough. It is essential to seek and develop other environmentally suitable building materials that will have the desired properties and positive impacts on human health [6]. Adjusting the individual components with which we can produce Teito building materials should be a further step, supported by a specified objective in healthy housing. Therefore, the development, testing, and implementation of components and materials should be supported to the greatest extent in construction. Sustainable construction is based on multiple pillars. Sustainable and suitable materials are one of them. Therefore, the adjustment and selection of materials should occur based on predetermined parameters that reflect the requirements and characteristics of healthy housing [2][7][8].

Implementing so-called healthy and environmentally safe materials is often the most challenging step, which presents multiple barriers. Therefore, it is crucial that the planning and design of buildings be carried out to support the selection of such materials, and to allow their straightforward implementation. Intelligent and knowledge technologies represent an effective tool, as they achieve these ends. BIM (building information modeling) technologies are not used to their maximum potential. However, the development and implementation of BIM and knowledge technologies holds excellent potential for the intelligent design of buildings, and specifically when choosing materials with specific properties [9][10]. This would allow the selection of specific properties of building materials and their adaption to the needs of the building. Building knowledge databases and technologies and implementing information can help in the sustainable design of buildings in terms of the materials required. Thus, the entire building's materials may already be selected based on concrete parameters. This represents a second dimension to achieving an increase in the variability of healthy residential buildings. Therefore, linking these two approaches (on the one hand, the development and adaptation of materials addressing the requirements of health and safety materials; on the other hand, the development and use of knowledge technologies for intelligent and sustainable design) is likely to be the most effective way to achieve our goal.

In terms of defining a general approach to intelligent design for all types of construction projects, the constructions for which the verification will be performed must be selected carefully. In terms of the researched material (as described in the following sections), and the construction and implementation of a methodology for the intelligent design of healthy buildings, it is possible that the results will not be the same for all types of construction projects. Specific construction projects include, for example, civil engineering works, or transport constructions, where the assessed material's expected positive effects on health, and the method of intelligent design, may be different, given the different natures of the buildings (residential buildings, office buildings, commercial buildings).

It is important to realize that, in the context of intelligent design and increasing the variability of healthy residential buildings, recycled materials are the way to a better climate. Using recycled polyvinyl butyral (PVB), which has a carbon

footprint that is 25x lower than PVB resin, helps us reduce our environmental footprint while increasing the healthiness and safety of our products.

2. Intelligent Design of Healthy Buildings through BIM and Knowledge Technologies

As part of our and European legislation, the trend is focused on reducing the amount of waste, especially via prevention. The preferance for waste recovery over landfilling, which is only a temporary solution, plays an essential role in deciding on the further technological processing of raw material waste. The main goal is to choose a method of recovery that does not threaten people and does not burden the environment (water, soil, air). This solution cannot be random. Multiple studies and waste management approaches argue that there must be set processes and system solutions involved. This also reflects our understanding that a system or methodology must be designed to achieve healthy buildings, or that can addres how to proceed when in the project stage of designing buildings. Knowledge technologies can be an effective tool in the intelligent and systematic use of new, healthly building materials. Progress in information technology and systems can improve the processing and use of recycled materials to the greatest extent possible. Developing such materials (recycled polyvinyl butal) and the subsequent incoproation of findings into knowledge systems should be a priority. On this basis, we can make intelligent propositions pertaining to healthy buildings and material health (**Figure 1**).

Figure 1. BIM-compatible knowledge database design.

The proposal in **Figure 1** was created based on a survey carried out to monitor several projects of different natures. They were mainly residential buildings, and concerned sustainability, healthy environments, the quality of materials, price, and the method of material and parameter selection. Based on this, the resulting design also needs to be verified (i.e., the exact method of intelligent design, through a knowledge-based BIM database). The selection of reference construction projects on which this proposal is being verified is currently underway. In terms of the widespread use of intelligent modeling and simulation, it is interesting to verify this on several types of construction projects. Based on the comprehensive representation of construction projects, it will be possible to define more clearly for which types of construction, and which parameters related to the perception of quality and safety requirements, it will be most appropriate to apply the given model.

Intelligent design has several benefits, which are reflected in different types of construction projects. The material in question (PVB) can also be used in various types of construction. From this point of view, based on the experiences derived from research and practice, it can be stated that this method can be applied in almost all types of construction projects, and offers similar results, not only in terms of intelligent design but also in terms of the use of the material in question. Some limitations to specific requirements can also be encountered here. These mainly involve engineering projects and transport constructions, where the use of the mentioned material is not determined by its properties to the same extent as in residential constructions. However, suppose we address healthy buildings (often residential buildings and commercial, public buildings, office buildings, etc.). In that case, this method of intelligent design and the use of PVB

will not give fundamentally different results, and they will be comparable. Of course, this is also subject to verification in specific construction projects.

BIM technology plays a significant role in intelligent design. BIMs are amongst the leading information technologies, and are an essential element of intelligent building modeling and design. BIM technologies using the information model of buildings work with the information that is the basis for finding the optimal model, and thus adhere to the research goals. The BIM application speeds up the building design process, contributes to digitization, and increases intelligent design.

The proposed knowledge database will contain multiple tracked and desired parameters. The basic concept is that each item (structural element or material) contains the information. Clearly, they must also be defined, and relationships between them must only pertain if the building and health benefits are intelligent. As part of this process, in the following, the selection of the structural material (also examined in the form of the recycled polyvinyl butyral) is described by the specified parameters and a knowledge system comprising this information and bonds (**Figure 2**).

Figure 2. Specified parameters and a knowledge system comprising information and bonds.

These steps describe how the system can work methodically. The basis is a clear definition of the objective, including the specification of requirements. Creating a knowledge base for intelligent building design is a complex process defined by the relationships between the items. The acceptance of these defined links manifests the knowledge of the system. After the information is input, these processes acquire a knowledge character that filters and defines the monitored parameters. The knowledge system connected to the BIM environment can select the most suitable group of materials and structural elements that will lead to the design of a healthy building, using selected materials that meet the requirements for healthy living. Recycled polyvinyl butyral, which we have examined, may also be used as an item that meets these requirements as part of this selection.

The intelligent design of healthy buildings is based on advanced technologies that allow multiple processes to be performed automatically. Thanks to progress, knowledge databases and BIM technology are becoming an important tool that automates selected processes. The user (designer or even the investor) does not have to know all the materials, prices or quality properties. It is enough for them to clearly define the requirements of the output. In the case of the main goal, the design of a healthy building will have specific parameters in terms of the environment. Based on these requirements, according to the proposed method and the use of BIM technology and knowledge databases, the system will automatically design only combinations of materials (for example, in this research represented by recycled polyvinyl butyral) that meet health parameters. This level of intelligent building design will allow for automating many processes during the design phase, saving time, money, and even human capital. The main benefit is that this method of design will achieve the implementation of a healthy building, with all the attendant requirements.

3. Conclusions

Constructions concerned with the environment bring with them several challenges that project managers have to face. One of the challenges is to satisfy the specific requirements of the customer—to customize the final construction, wherein the customer has the choice of not only the appearance and dimensions of the building, but in this case the specific properties of the building as well, i.e., the material. The use of recycled PVB in the intelligent designing of healthy residential buildings will comprehensively reduce the use of fossil fuels for producing resin materials, and consequently reduce the CO_2 emissions and energy consumption involved in the manufacturing of new materials. We aimed to

incorporate the results of the experiment into a knowledge system connected to the BIM environment, which can select the most suitable groups of materials and structural elements that will lead to the design of a healthy building, using selected materials (PVB) that meet the requirements of healthy living.

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