Problems and Advanced Technologies of Green Building Project Management and Materials

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Abstract. With the growing awareness of climate change, green buildings are beginning to win a place in environmental issues. The pattern of green buildings aims to establish an equilibrium between artificial architecture and the natural surroundings. This study proposes to determine problems and solutions for green building project management and green materials. The outcome of this study reveals that high-cost premium and cognitive limitations on green technologies are the main barriers to the sustainable development of green buildings. To deal with cost-related issues, experts utilize AI-based techniques to reduce energy consumption. Furthermore, in the process of civil engineering construction, construction materials determine the cost, quality, and safety of civil engineering. The main characteristics of green building materials are excellent low energy consumption, low pollution and recycling in the production process and use. The mainstream green materials classification is the four types of basic, energy-saving, recycling and health. Currently, the green materials commonly used in engineering construction mainly include ecological sand-based permeable bricks, green paint and diatom mud ecological wall. Among them, the diatom mud ecological wall is widely used in large cities because it does not cause light pollution. The most significant advantage of green materials in engineering is that they can achieve resource savings. In the selection of green materials in construction, it is necessary to fully consider and make use of the characteristics of green materials.

Keywords: green building; project management; artificial intelligence; green materials.

1. Introduction

Oxford Economics value the total global construction market was assessed at US$10.7 trillion in 2020; about 53.3% of this production was in emerging markets. Four countries – Indonesia, the US, India, and China – constitute 58.3% of the worldwide expansion in construction. Such statistics demonstrate significant construction industry development and the considerable potential of related scientific research in this area.

Environmental and sustainability issues have always been among the top concerns for global environmentalists. Since an American organization began to develop Leadership in Energy and Environmental Design (LEED) in 1993, international environmentalists have been increasingly focusing on the advantages of green buildings and the critical role they play in mitigating energy consumption and emissions of greenhouse gas. As emerging markets grow constantly, urbanization will spread further. Thus, the necessity of improving green buildings would advance with the times.

The concept of green building includes the framework and the utilization of ecologically friendly and coat-conscious processes during a building's life span: from schedule to design, execution, running, preservation, refurbishment, and destruction. LEED is a wide range of rating systems for different stages of green buildings, and there are many famous LEED Platinum certified buildings such as Taipei 101 and Shanghai Tower. After decades of advancement in green building construction, project management and materials have been two of the most vital issues. Moreover, high-cost premiums and cognitive limitations on green technology are two common challenges in managing

green building projects. Besides, the cores of green building materials are innovation, production and recycling. At this stage, the factories are mainly at the stage of innovative studies of emerging green materials, which results in reforming the manufacturing process of green materials. However, they are not equipped with extremely mature process methods in general. The main problem in the advancement of green construction materials is that the cost control used in the construction is not ideal and the output cannot keep up with the construction progress. Therefore, this study mainly focuses on green building management systems and emerging green building materials to address existing problems.

2. Green Building Project Management

Challenges in green building management incorporate high-cost premiums in construction and materials, technical difficulties in the construction process, cognitive limitations on green technology, and lack of awareness. In particular, high-cost premiums and cognitive limitations on green technology are the most urgent problems that construction industry experts need to address.

2.1. Current problems in Green Building Management

2.1.1 High-Cost Premiums

Generally, it charges more to build a natural building than a conventional one, even though green buildings usually contribute extra savings in the period of employment, maintenance, and additional cost of upgrade [1]. Furthermore, according to the statistics provided by Green Star Certification, which a New Zealand organization manages, the higher the green buildings were graded, the higher the cost premium they would produce [2, 3]. In the construction of civil engineering buildings, material technicians of green high-performance concrete at home and abroad have been developed, but the price of this type of concrete is much higher than traditional concrete. That is because the factory has invested too much money in the research of green high-performance concrete in the early stage. And many factories have monopolized unique technical knowledge and complex construction processes. So the price of green high-performance concrete materials is twice or more times than the price of traditional concrete. Thus, to obtain a high-rated green building with high performance under current rating systems, investors need to pay much more and often cannot precisely take control of the project budgets.

2.1.2 Cognitive limitations

Many studies have confirmed that the current green technologies pose significant challenges to designers, contractors, and occupants. The primary challenge is that green technologies are commonly more complicated than conventional technologies and usually quite different from them. And the minor challenge is unfamiliarity with the influences of green techniques on the ultimate output concerning green buildings.

2.2. New Technologies for Green Building Project Management

2.2.1 State of the Art

As humans have used buildings for years, the structural properties have decayed, the internal layouts get reorganized, and the function of the inner space has transformed correspondingly over time. In addition, the internal and external climate parameters (e.g., temperature, humidity, aerosol concentration) have been modified due to the changes in surrounding buildings and variations in urban climate. As a result, the buildings' lifespan usually cannot reach modeled expectations.

With the continuous development of artificial intelligence (AI)-based techniques in construction, building management is developing much more effectively. AI technology allows the construction industry to be more sustainable and environmentally friendly, so the widespread utilization of green buildings is more likely to become a reality [4]. Measurement of the building management system performance relies mainly on four stages: collecting large amounts of data, data analysis, processing,

and providing streamlined suggestions to the managers. Moreover, the developers utilize the building management systems to finish repetitive decision-making to save considerable labor costs. For instance, the systems are responsible for adjusting air conditioning power according to the personnel density in different areas and adjusting the running speed of the passenger elevators in keeping with the occupation mode.

The existing research mainly focuses on four areas: 1) Building automatization system, 2) fuzzy rules and text mining, 3) big data and data mining, and 4) intelligent optimization. This study introduces these four areas in the following (Table 1).

2.2.2 Artificial Intelligence Systems

(1) Building automatization system

A building automation system is an ideal method to provide a wide range of data that could be collected and analyzed during building operations and maintenance. The system also plays a critical role in daily building monitoring and management, saving tremendous energy and cost [5]. Demand-Side Management has become an increasingly crucial concept based on its combination with a building automation system. Therefore, a complete energy production and storage system, such as Energy Production System Management, has been developed to improve energy efficiency [6]. In addition, with the improvement of building automation systems, a knowledge-based intelligent system has been proposed to help occupants track and manage their energy consumption in time and deliver potential measures to assist them in saving energy [7].

(2) Fuzzy rules and text mining

When green building associations such as LEED work on rating green buildings, it is laborious to manually determine the weight among technical, environmental, social, and economic aspects [8]. Therefore, fuzzy rules and knowledge discovery have been widely applied in green building rating systems, enabling each aspect's corresponding weights to be more meaningful and explainable [9]. For example, Nilashi et al. utilized the Analytic Hierarchy Process (AHP) and fuzzy logic to establish a text-based expert system based on the Fuzzy Analytic Hierarchy Process (FAHP) as a tool to evaluate the properties of green buildings [10]. Moreover, as for the application of knowledge discovery, it is necessary to identify which situations occupants are wasting energy, which could be described by SWRL (Semantic Web Rule Language) [11]. Then operators could provide the occupants with more energy-saving potential.

(3) Big data and data mining

A variety of sensors collect a significant amount of data throughout the construction and operation of green buildings, so operators apply big data and data mining to offer energy-saving recommendations to residents and to specify upgrading plans for managers. Liu et al. made a visual analysis of the knowledge evolution of green buildings. According to the study, the United States, China, and the United Kingdom occupy the dominant market of green buildings. In addition, life cycle assessment (LCA) and assessment tools are high-frequency words in green building research [11]. Son et al. proposed a methodology to forecast green building projects' expense and arrangement property based on the text-based description throughout the pre-implementation planning stage. The results of this study fully verified that the expense and arrangement property of green building projects is exceptionally reliant on the accuracy of the description in the pre-implementation planning stage [12].

(4) Intelligent optimization

Intelligent optimization could use AI technology to seek Pareto optimal solutions for green building project management compared to conventional methods. The main objective of intelligent optimization in green building project management is to provide maximum customer comfort with minimum energy consumption [13]. It also means that the building utilizes intelligent optimization to manage the internal ecological microenvironment by offering the customers the best combination of indoor experience and energy consumption.

Table 1. A summary of AI-based techniques for green building management

Research areas	Research goals	AI-based techniques	Surveyed Literature
Building automatization system	Utilize sensor-based data to enhance energy efficiency by offering advantageous advice	Demand-Side Management, Knowledge-based Intelligent System	[5-7]
Fuzzy rules and text mining	Apply fuzzy rules and knowledge-based methods to establish rating systems and assess the performance of green buildings	Analytic Hierarchy Process (AHP) of the fuzzy logic model, knowledge-driven energy analysis	[7, 9]
Big data and data mining	Use big data and data mining to plan and schedule to analyze trends and promote decision making	Visualization based on bibliographic data, Pre-project planning based on data mining	[11-12]
Intelligent optimization	Take advantage of intelligent optimization to reduce energy consumption while improving customers' comfort	Graphical user interface according to customer s' preferences	[13]

2.3. Green Technology Promotion

Given that green building has become a relatively new notion worldwide, it is essential to communicate the goals and emerging concepts of green technology to all green building practitioners and occupants to accomplish successful project implementation. The lack of information exchange among individuals in the project and lack of awareness of communication have become obstacles to green building project management.

For green building project implementation to succeed, high-level communication is essential for individuals in the project compared to conventional construction projects. The reason for this is that each project team member's deep understanding of green buildings is crucial to constructing an impressive building. Therefore, at each meeting, the project leader should ensure that each member is fully aware of the green technology used in the project and comprehends how the corresponding green technology will affect the final project.

3. Green Materials

3.1. The Properties of Green Building Materials

The properties of green building materials are like this:

(1) In manufacturing building materials, trash is mainly used presently. For example, slag and garbage can be used to replace those natural resources which are not renewable [14];

(2) In the material manufacturing process, it is firstly required to choose the way of low energy consumption of the manufacturing process and pollution-free technologies to achieve the goal of carbon neutrality as much as possible [15]. In addition, it needs to avoid harmful chemical substances such as formaldehyde and halogenated solvents, as well as aromatic hydrocarbons and other items, without mercury and compound additives in the product;

(3) In product design, it is necessary to avoid harm or to affect people's health;

(4) Lastly, building materials could be recycled and optimized.

3.2. Classification of Green Building Materials

There are roughly four green building materials: essential, energy-saving, circular, and healthy.

3.2.1 Basic Type

Under the primary conditions of harmlessness to the human body, the harmful chemicals can be reduced for use to meet people's basic needs [16]. In production and use, it is necessary to prevent the production of harmful substances with excessive content, such as formaldehyde and ammonia.

3.2.2 Energy-Saving Type

The product manufacturing process requires low energy consumption to avoid high-temperature incineration and low-temperature synthesis. It can adopt production processes and equipment that reduce heat loss and promote thermal efficiency in the production process. At the same time, energy savings can be achieved by using products such as selecting more than 30% insulation materials. Nevertheless, the most critical thing is that the development of other new green materials needs to be strengthened, such as solar energy, hydrogen energy, and other economy-friendly energy.

3.2.3 Recycling Type

It is suggested to choose new processes and technologies and utilize more waste aggregates, such as waste residue and waste ore, garbage, to achieve recycling. For example, in Japan, the sludge from sewers is made for ecological cement, and using waste incinerated slag ash makes ceramic building materials, ensuring that the recycling rate is greater than 90% of the reuse to decrease the environmental pollution.

3.2.4 Health Type

Nowadays, people's quality of life is improved much more, so it is also necessary to enhance the quality of materials. Hence, manufacturers should aim to refine the living conditions and people's living quality. When using new green products, more efficient functions could be achieved, such as antibacterial and mildew prevention, tempering temperature or insulation, and radiation protection against ultraviolet rays and radiation.

3.3. Green Building Materials

3.3.1 Ecological Sand-Based Permeable Bricks.

The ecological sand-based permeable brick is through the infiltration principle of "destroying the surface tension of water," which effectively solves the contradiction between "penetration and strength" and "penetration and water retention" of traditional permeable materials through pores. The technical problem is that it has good permeability and breathing capacity, which can quickly penetrate rainwater into the ground to supplement soil moisture and groundwater and fully retain water and maintain soil moisture. To achieve cooling and noise reduction, it is worth improving air quality and the living conditions of urban ground plants and soil microorganisms [17]. Recent studies have found that it can even effectively solve the problem of water accumulation in the southern inland urban areas.

3.3.2 Green Paint

The existing green paint types are as follows: solid content solvent-based paint, water-based paint, powder-based paint, and fluid solvent-free paint. Among them, dust coating is a relatively advanced coating in China, an absolute zero VOC coating in theory. The more common dust coating on the market is shell powder and diatom mud, generally used in applying walls and other planes.

3.3.3 Diatom Mud Ecological Wall

Diatom mud wall material is a new type of environmentally friendly wall material. There is also a strong light absorption. Now the big city has a relatively sizeable environmental problem which is light pollution, now the diatom mud ecological wall is widely used in large cities because it does not lead to light pollution, which can even wholly avoid static electricity with a good sound assimilation effect and thermal insulation effect, and also can prevent fire flame.

3.4. Application of Green Building Materials

The most significant advantage of green building materials in engineering is that they can achieve resource savings. Nowadays, many conventional materials are non-renewable. With the rapid advancement of material science, more and more renewable materials can be selected for this scarce building material to replace them in construction. The green materials are environmentally friendly and cannot be replaced by other materials, such as the most used insulation glass and composite panels.

When choosing green materials, it is suggested to consider and use the characteristics of green materials fully. For example, when designing the exterior walls and roofs of buildings, it is suggested that it not only needs to do an excellent job of thermal insulation to improve the comfort of the house but also to prevent water leakage and avoid water leakage in the house [18]. Therefore, choosing the hollow block material for the design is impossible. At the same time, using dark paint should prevent the house from absorbing too much light, which could affect the roof insulation of the building and the effect of external wall insulation and heat insulation. For the purpose of better implementing the concept of energy conservation and environmental protection, it is necessary to combine high-tech technology to choose cleaner and pollution-free energy in the process of designing buildings. It is also worthwhile making full use of the construction waste generated by the city, acting more effectively when reprocessing and recycling. More importantly, it is necessary to guarantee that the selection of building materials is reasonable to meet people's comfort, energy efficiency, and environmental conservation requirements. It is expected to be fully utilized so as not to cause a waste of resources [19]. In selecting materials, it is also required to pay attention to the basic properties, such as fire and heat insulation and sound insulation, and combine these characteristics to make full use of materials to achieve carbon neutrality, zero emissions, and zero pollution.

In short, adopting green building materials is an inevitable trend of development in the new era, which is conducive to the rapid development of social modernization and ecological and environmental protection. In the application process of civil engineering materials, it is necessary to have a deeper understanding and analysis of their characteristics. Therefore, for the current situation of green materials, it needs constantly explore new energy-saving and green environmental protection materials in line with market development. It meets the environmental needs of modern building materials and can effectively promote the construction industry's sustainable development.

4. Conclusion

This study mainly discusses green building project management and green materials, which are the cornerstone of green building development. The green building project management framework requires green buildings to be environmentally friendly and resource-efficient both in the structure design and in the application of processes during a building's life span: from schedule to design, execution, running, preservation, refurbishment, and destruction. Under the green building project management framework, there are many concepts, such as rating systems for green buildings, building information system (BIM), and LCA.

Rating systems generate comprehensive ratings considering green buildings' design, construction, operation, and maintenance. A well-known rating system is LEED, developed by an American organization. Moreover, fuzzy rules and text mining are used to measure the weight of various factors considered in rating systems for green buildings, and the most common method is FAHP. BIM is a life-cycle management system for the built environment that includes digital technology support for the entire generation and management of buildings. Moreover, the most commonly used technology of BIM for green building project management and green materials is the building automatization system, which is applied to collect and analyze a large amount of data accumulated throughout building generation and operation to minimize energy consumption. With the application of more big data and data mining in green building project management, the development tendency and concentration of green buildings are becoming more apparent. For example, a study demonstrates that LCA and assessment tools have been the most crucial research topics in the past decades [11].

However, an increasing number of environmentalists are beginning to doubt whether green buildings depart from the original purposes of green buildings. The main reason is the high-cost premium caused by the rating systems of green buildings, which is the main challenge in project management and emerging green materials. The principal solution to the obstacle of high-cost premium is to apply various artificial intelligence technologies (building automatization system, fuzzy rules, text mining, big data and data mining, and intelligent optimization). These technologies lead to less energy consumption and optimization of resource allocation. Another obstacle to green building project management is that practitioners are unfamiliar with emerging green technologies. The solution is for the project leader to explain the green technologies used in the project clearly and justify the impact on the final project output.

As for green building materials, the main properties are low energy depletion, low contamination, and they do not affect people's health during production and use. The main advantage is using some waste to recycle and achieve the goal of carbon neutrality as much as possible. The four types of basic, energy-saving, recycling and health are the mainstream green building materials classification. Nowadays, people's quality of life has improved, so manufacturers gradually began to manufacture many healthy materials to meet people's expectations of living quality. The goal of producing new green materials to improve the quality of green products is to meet health needs effectively. At present, the green building materials commonly used in engineering construction include ecological sand-based permeable bricks, green coatings, and diatom mud ecological walls. The prominent role of ecological sand-based permeable bricks is promoting air quality and improving the living conditions of urban ground plants and soil microorganisms. Green coatings refer to energy-saving, low-pollution coatings. Diatom mud wall material is a new environmentally friendly wall material with solid light absorption. Especially in large cities, diatom mud ecological walls can reduce light pollution, which city dwellers generally prefer. The most significant advantage of green materials in engineering applications is that they can achieve resource savings with low energy consumption. Replacing conventional materials with renewable materials causes producing many green building materials now. And these materials often possess properties others cannot replace, which are proved to be more robust than previous materials. Otherwise, the selection of green materials needs to be fully considered and then utilized in the construction of green buildings. In this way, the most significant advantages of green materials could be brought into full play.

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