Current Application Status and Future Prospects of Sustainable Building Materials

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***Abstract*—At present, the green, low-carbon, and sustainable development mode has been recognized and supported by countries worldwide. As an important industry related to the national economy and people's livelihood, the transformation and development of the construction industry have also received wide attention. The application of sustainable building materials to the construction industry is conducive to energy saving and reducing carbon dioxide emissions. To more comprehensively grasp the development status and development trend of sustainable building materials in countries around the world, and to comprehensively analyze the advantages and disadvantages of sustainable building materials, this article is intended to explore the development status and engineering characteristics of sustainable building materials. First, the development history, application methods, engineering characteristics, development and application status of some countries, and the latest research and application status of sustainable building materials were analyzed by literature review. After that, the advantages and disadvantages of sustainable building materials, the main problems and challenges in the application, and the development differences among countries were further discussed. After completing the above work, the following views were mainly formed: First, sustainable building materials have better engineering characteristics and are more friendly to the environment, but they also have shortcomings such as high cost and limited market acceptance; Second, there are differences in the promotion and application of sustainable building materials among countries in the world due to differences in culture, natural conditions, and policies, but different countries can still learn from each other; Third, the development of sustainable building materials has 3 main directions, i.e., the reuse of construction waste, the development of new building materials, and the improvement of the production process of existing building materials. The above results can provide certain references for developing countries and regions when they formulate policies and take measures to promote sustainable building materials.**

***Keywords*—sustainable building materials, application, challenge, prospects**

I. Introduction

A. Background

Civil engineering activities are one of the most important productive activities of humans acting on the natural ecosystem [1]. Among other things, the production and application of engineering materials, engineering design, engineering construction, the use of the project after completion, and the dismantling of the project after scrapping all consume a large amount of energy and constantly generate waste, and all these problems will have a great impact on the ecological environment. As people's concern for environmental protection continues to rise, sustainable development has become an important goal for the development and progress of society [2]. Therefore, a good integration of civil engineering with sustainable concepts is necessary. The adoption of sustainable building materials in civil engineering activities would contribute to energy conservation and the emission reduction of greenhouse gases in the construction industry. Sustainable building materials refer to building materials with low carbon emissions, recycled resources, and long lifespans, which are designed to achieve a balance between environmental, social, and cost benefits by optimizing the use and management of building materials and reducing the impacts of building materials on the environment and people during their life cycle [3].

Due to the above advantages of sustainable building materials, various countries/regions have gradually started to apply sustainable building materials in civil engineering construction activities since the 20th century. However, the development and promotion of sustainable building materials in different countries/regions varies greatly due to differences in their scientific and technological levels and promotion policies. Therefore, a comparative analysis of the current status of the development and application of sustainable building materials in different countries/regions, and the sorting out of the various problems encountered in the development and promotion of sustainable building materials, is a better reference for some developing countries on how to better use and promote sustainable building materials. Based on the above considerations, this article will focus on the current status and prospects of the development of sustainable building materials.

B. Research Questions

To better understand the current development of sustainable building materials in different countries/regions and to grasp their development prospects, this article plans to focus on the following issues:

(1) What are the advantages and disadvantages of sustainable building materials?

(2) What are the major difficulties or problems encountered in the promotion and application of sustainable building materials at this stage in different countries/regions?

(3) What are the differences in the development and promotion of sustainable building materials in different countries/regions?

(4) What are the developing trends or directions of sustainable building materials?

C. Research Methods and Objectives

To address the above issues, this article proposes to use the following methodology to carry out the research work.

(1) Literature reading and analysis: This article will collect a wide range of papers, academic monographs, and

internet resources related to sustainable building materials, to comprehensively sort out the advantages and disadvantages of sustainable building materials, and to grasp the current status of their promotion and application in different countries/regions.

(2) Case study: This article will introduce some typical sustainable building materials and analyze their applications in some real architectures. Also, the current status of the development of sustainable building materials, and some of the problems faced during its development will be analyzed.

(3) Data analysis: Some parameters and some data related to sustainable building materials will be collected in this article, and useful information will be extracted from these parameters and data. Then, the characteristics of sustainable building materials will be examined.

(4) Comparative analysis: To examine the capability for the reduction of carbon dioxide emission of sustainable building materials, the carbon dioxide emission ability of traditional building materials and sustainable building materials will be compared in-depth.

II. Acquired Information

A. Development of Sustainable Building Materials

At the beginning of the 20th century, based on the concept of sustainable development and environmental protection, relevant researchers proposed the concept of sustainable building materials. At this stage, the application of sustainable building materials mainly refers to the application of natural materials, such as wood and clay.

In the 1970s and 1980s, due to the Oil Crisis and the pollution of fossil fuels gradually attracted public attention, as well as the growing popularity of the concept of environmental protection made people pay more attention to environmental protection. In this stage, the construction industry began to introduce some energy-efficient, environmentally friendly, energy-saving materials, including solar panels, high-efficiency insulating materials, and so on.

At the beginning of the 21st century, there was a gradual interest in green building certification systems internationally, such as the introduction of the LEED green building certification system in the United States and the BREEM green building certification system in the United Kingdom. The emergence of the above green building certification system has strongly pushed forward the wide application of sustainable building materials. The construction industry has paid more attention to the application of recyclable and renewable materials and green building materials.

In recent years, due to the continuous improvement of the level of science and technology, new types of building materials have been appearing, such as some biodegradable building materials and renewable energy-integrated materials. The above new materials provide more material choices for the construction industry.

B. Methods of the Application of Sustainable Building Materials

In terms of ways or means of utilizing sustainable building materials, the following are currently the main ones:

(1) Ease of traditional building materials (stone, bamboo, wood, clay, etc.). Traditional building materials such as stone, bamboo, wood, clay, etc. have been widely used since ancient times because the production and processing of these materials do not generate a lot of pollution. Ancient China had a certain understanding of building materials and proposed the concept of "Five Materials", which refers to the most commonly used five traditional building materials: soil, wood, brick, tile, and stone [4]. In recent years, due to the superior environmental performance of the above materials, they have once again gained importance in the restoration of ancient buildings and the design and construction of modern buildings. For example, the "Architectural Acupuncture" project in Songyang County, China, upgraded the Heng Zhang Camellia Seed Oil Workshop. The inner circle of the building retains the original stone structure, with a mixed masonry envelope and a stone foundation, which is reinforced with locally sourced stone scraps. The interior is the larger part of the spatial transformation, the retained wooden beams are reinforced, and the demolition part of the timber is made into a new beam frame, leaving a height difference with the original roof, enriching the function of the internal space, and also better improve the natural ventilation inside the building. The renovation of the entire camellia seed oil workshop is based on the use of local building materials, reuse of waste materials, and traditional construction techniques, which are more deeply integrated into the local natural environment and effectively reduce construction costs.

(2) Utilization of recycled materials (recycled concrete, recycled steel, etc.). Many countries around the world are now actively promoting the comprehensive utilization of construction waste to promote the reduction of pollution and carbon emissions, which can also deal with huge amounts of construction waste [5]. Taking waste concrete and waste concrete recycled material bamboo skeleton permeable bricks as an example, waste concrete recycled material can be made into compliant sizes and shapes after crushing and screening by a concrete crusher and other equipment, which is suitable for various construction projects. Compared with traditional concrete, recycled material is more affordable, which can reduce the project cost and save resources to protect the environment. Waste concrete recycled material bamboo skeleton permeable brick has been an environmentally friendly building material in recent years. It carefully combines waste recycled concrete with natural bamboo to form bricks with good water permeability and load-bearing capacity, providing a sustainable and environmentally friendly solution for urban construction.

(3) Development of new building materials (low-energy building materials, materials that improve the living environment). In the previous traditional building materials, their quality cannot be guaranteed and does not meet the concept of green and non-polluting. In consideration of this condition, people tried to develop building materials, and new building materials have gradually emerged [6]. In recent years, people have tried to add different materials to concrete to improve its various properties. For example, the addition of glass fibers or steel fibers to concrete can greatly improve their tensile properties, effectively solving the problem of insufficient tensile capacity of traditional concrete.

(4) Renewable energy-using materials are used in building construction (solar panels, etc.). Solar Photovoltaic (usually

short as "Solar PV") is one of the most advantageous renewable energy applications [7]. Solar energy, as a natural and clean energy source, is an ideal type of energy source to replace fossil and nuclear energy for carbon neutrality. Photovoltaic power generation systems installed on buildings are called building photovoltaics. Building PV effectively utilizes the exterior area of the building without occupying extra spaces, thus saving land resources.

C. Engineering Characteristics of Sustainable Building Materials

From an engineering perspective, sustainable building materials have the following main characteristics:

(1) Good durability and long service life: Sustainable building materials typically have a longer service life due to performance enhancements or more advanced production processes based on traditional types of building materials. This results in less maintenance work later during the operation of a building using sustainable building materials. For example, high-rise buildings modified with high-performance concrete can maintain their structure and performance over a longer service life.

(2) Energy savings: According to relevant reports, the construction industry consumes 30% of the total energy consumed by society as a whole, while the production and transportation of building materials consumes 16% of it. Thus, the production and transportation of building materials and the construction industry consume half of the total energy consumption of society [8]. Sustainable building materials can greatly reduce carbon emissions, save resources, and protect the environment due to their low energy consumption in both production and utilization. For example, the main raw material of eco-cement is volcanic ash steel slag, and other wastes, compared with traditional cement materials, eco-cement can reduce the carbon dioxide emission by about 40%, saving energy by more than 30% in the producing process. At the same time, the engineering performance of eco-cement is not weakened when compared with traditional cement. Another example is the vacuum glass. When compared to traditional glass materials, vacuum glass has huge advantages such as longer service life, excellent thermal insulation, and heat preservation function. Also, the sound insulation effect of vacuum glass is better. Green vacuum glass can use sunlight and other natural light for indoor temperature regulation, to achieve the purpose of environmental protection [9].

(3) Renewable utilization: A significant proportion of sustainable building materials are produced from natural or renewable resources, helping to reduce environmental dependence and damage. Waste glass and waste concrete, as the most important components of solid waste, are both non-microbial degradable materials, and the application of waste glass to recycled concrete is an excellent way to deal with waste glass and has a very good prospect for development. Waste glass is used to replace a portion of the recycled concrete aggregate, and waste glass micropower is added to the recycled concrete as an auxiliary cementing material. Comprehensive utilization of waste glass and waste concrete, which is very widely adopted at present, can reduce construction costs, effectively alleviate environmental pollution, reduce the problem of land waste, and reduce the consumption of natural resources [10].

(4) Use of local materials: Incorporating local materials into the building design and construction process will help to reduce transport costs and energy consumption, while also promoting local economic development. The use of local natural and renewable building materials will better protect the environment and reduce energy consumption.

(5) Environmentally friendly: Sustainable building materials have less impact on or damage to the environment during their production and application. They can reduce pollution of air, water, and soil during their production, recycling, and disposal.

Take the new architectural coatings as an example, for the production process of new architectural coatings in cleaner, the working environment of workers will be improved, and the consumption of water, and energy will be less. Furthermore, the amount of volatile organic compounds generated during the process of construction and service period of a building using the new architectural coatings will be reduced, thus the indoor air quality can be better ensured. Another example is hempcrete which is carbon-negative and removes carbon dioxide from the atmosphere. Not only is it sustainable, but it is also self-insulating, meeting most building standards without additional insulation [11].

D. Development of Sustainable Building Materials in Different Countries

Due to the differences in geographical environments, natural resources, and scientific and technological development levels of each country or region, the research, development, application, and promotion of sustainable building materials are characterized by different features in each country or region. The current status of the development of sustainable building materials in each major country or region is described below.

1) United States

As the government of the United States and the United States Green Building Council (USGBC) have promoted the industrialization of green building, the technology and market for the green building industry have grown significantly in the United States. According to Freedonia, the green building market in the United States has been growing rapidly in recent years as a result of the green industrialization of the construction industry, with demand for new green materials growing at 11% per year, reaching a value of $60 billion in 2015. By 2018, the green building market in the United States had already surpassed 100 billion dollars. The United States is also placing a strong emphasis on building sustainability. In terms of the use of sustainable building materials, the United States has widely adopted wood for the construction of residential buildings.

Leadership in Energy and Environmental Design (LEED) is a green evaluation standard system proposed by the US Green Building Council., including the source and procurement of building materials, building materials composition analysis, waste management, and renewable programs are all covered, realizing the evaluation of the whole life cycle of building materials.

2) United Kingdoms

The United Kingdom's Building Research Establishment

Environmental Assessment Method (BREEAM) is the world's first green building assessment system, developed by the United Kingdom Building Research Center in 1990 [12]. In the 21st century, more and more people in the United Kingdom have further established the strategic thinking of sustainable development, and energy conservation and environmental protection have become a political trend in the United Kingdom. The British government's vigorous promotion and the society's high level of environmental awareness have led to greater development of energy conservation and green buildings [13]. Innovative projects in the UK such as solar roof tiles, wind energy walls, and the integration of solar technology through the exterior of buildings integrate renewable energy directly into the building fabric. The above methods and new products demonstrate the UK's cutting-edge in renewable energy and building integration.

3) China

With the acceleration of urbanization, the scale of construction in China has continued to expand, and the accompanying increase in energy consumption and carbon emissions in the construction sector has made the problem of high energy consumption and high emissions increasingly serious. China has begun to pay more attention to the sustainability of buildings and has enacted numerous laws and regulations to promote the high-quality development of sustainable buildings [14]. At the national level, the Ministry of Housing and Urban-Rural Development of China has released the Green Building Evaluation Standards, and the provinces, cities, and autonomous regions have also developed their evaluation standards for green building according to their local situation.

As for the materials, the preservation of traditional building culture in China has led to an emphasis on traditional building materials and construction techniques. The addition of solar photovoltaic panels to roofs is a common practice in areas of China that are rich in solar energy resources. Besides, China's focus on promoting low-carbon cities, green transportation, and the use of renewable energy has also promoted the development of sustainable building materials.

4) Australia

Australia has a long history of market economy in the implementation and supervision of technical construction regulations and has formed a mature standardization management system adapted to the market economy, which is supported by legal, administrative, organizational, managerial, and technological support, and has formed a standardized system and an effective management mechanism. The technical control model that has been adopted is a combination of technical regulations and technical standards, and in terms of the management system, the relationship between the government and standards organizations is unambiguous, which is conducive to management and complementarity [15]. Traditional building materials used by local aboriginal people have been emphasized in recent years in Australia's Green Star assessment system. This system evaluates buildings and encourages the use of green building materials, energy-saving equipment, and environmentally friendly designs. Buildings in the arid regions of western Australia emphasize the application of water-saving building materials or water-saving equipment, including rainwater collection systems, irrigation systems, and low-water-consumption equipment.

5) Singapore

Singapore's development vision of a "Garden City" was established at the dawn of its independence. In the process of sustainable development, Singapore has continued to explore and practice the concept of a "city in a garden", and is on track to build a "city in nature" [16]. Intelligent buildings and energy-saving technologies: Singapore has widely adopted intelligent lighting systems, automated control systems, and high-efficiency air-conditioning systems to improve the energy efficiency and sustainability of buildings. Green certification and standards: Singapore has introduced a series of green certification systems, such as Green Mark certification, to encourage the construction industry to adopt sustainable building materials and design concepts. It helps to improve the environmental friendliness of buildings. The relevant departments of the Singaporean government have provided strong support in the implementation of green buildings and sustainable development by formulating a series of goals, strategies, and incentives to propel Singapore to become one of the most carbon-efficient countries in the world.

E. Latest Research and Application of Sustainable Building Materials

The latest research and application of sustainable building materials have become the focus of the field of architecture. Scholars and professionals in the construction industry are actively engaged in research to explore the performance, sustainability, and application potential of sustainable building materials. The latest research and application of sustainable building materials are summarized below.

(1) Reuse of construction waste: The construction or demolition of buildings generates huge amounts of construction waste, much of which can be recycled. In recent years, the reuse of construction waste has attracted wider attention and become one of the research hotspots in the field of sustainable construction materials. Researchers are committed to developing efficient recycling technologies for waste construction materials, including concrete recycling, reprocessing of waste wood, and recycling of waste steel. In the case of building materials made from waste wood, for example, it is common to use waste wood and wood-processing plant trimmings to make recycled building materials that are roughly the same strength as new wood. Recycled wood is made by cutting waste wood into pieces 40 mm long, 5–15 mm wide, and 1–5 mm thick, applying adhesive, and then steam-heating and compressing the pieces. It can be used to make building materials such as pillars and beams for houses. For the utilization of waste concrete, recycled aggregates of different strength grades of waste concrete can be used in road projects with different grade requirements. Waste concrete with low strength and many impurities can be used as road bedding; recycled aggregates from waste concrete after screening can be mixed with other road construction materials to be used as road base layer; well-graded recycled aggregates can be used to formulate

pavement concrete [17].

(2) Development of new building materials: Advances in science and technology have driven the development of new building materials to better respond to the new requirements of sustainable development in the construction industry. New building materials are a new category of building materials based on traditional building materials, including new wall materials, thermal insulation materials, waterproof sealing materials, and decorative materials. Due to the special characteristics of its material, fair-faced concrete can be directly applied to the building surface or facade, which makes the building surface or fa çade reflect the beauty of the building without the need to use other building materials, saves the cost of construction, and at the same time saves the step of removing the decorative materials on the surface of the building to avoid the generation of construction waste. Al-Mg-Mn roofing has a long service life, so it is widely used in the roofing of buildings with long service life, effectively solving the problem of poor durability caused by rusting and corrosion of metal roofs, and the application of Al-Mg-Mn roofing does not need to replace the roofing frequently, which not only reduces the use of resources, but also saves the cost of labor, and at the same time, it makes the building lighter, more comfortable, and more durable, so, in recent years, it has become the preferred material for roofing materials of green buildings. Therefore, in recent years, aluminum-magnesium-manganese roofing has become the first choice of roofing material for green buildings [6].

(3) Improvement of processes for established building materials: To better enhance the sustainability of traditional building materials, researchers are working to improve the production processes of such building materials to reduce energy consumption and environmental pollution. Taking Autoclaved Aerated Concrete (short as "AAC") as an example, it is a kind of lightweight and porous building material, that is made of raw materials such as cement, lime, gypsum, sand, aluminum powder, and other raw materials through autoclaved aerated process. Compared with traditional concrete, it has the advantages of lightweight, heat preservation and insulation, acoustic and sound insulation, and good anti-seismic performance, and is widely used in construction projects [18].

III. Present and Future Problems

A. Pros and Cons of Sustainable Building Materials

In subsection II.C, their views on sustainable building materials are summarized and analyzed by reading relevant papers, internet materials, etc., which involve more comparisons with traditional building materials. On this basis, this paper forms its views on the advantages and disadvantages of sustainable building materials, which are described as follows.

Sustainable construction is widely used for its superior environmental performance and engineering performance. Its environmental superiority is mainly reflected in the application of green raw materials in the production process, and the production process focuses on the improvement of the production process to achieve the optimization of the production environment and protect the health of workers. Secondly, sustainable building materials also advocate the use of raw materials and finished products according to the "principle of proximity", minimizing the increase in carbon emissions caused by long-distance transportation. In addition, some sustainable building materials have good thermal insulation and moisturizing properties, which can reduce the energy consumption of the building during the operation phase. The superior engineering performance is reflected in the good durability, which can effectively reduce the operation and maintenance workload of the building in the later stage, in addition, the superior performance of sustainable building materials can also help to improve the indoor environment of the building.

While sustainable building materials offer many of these advantages, they also come with some disadvantages. In terms of cost, some new sustainable building materials may require more investment in research and development costs, and may also require longer research and development and testing time, and some sustainable building materials that rely on improvements in the production process may also result in an increase in cost due to improvements in the production process.

Some of the sustainable building materials have higher upfront construction costs, for example, installing solar photovoltaic meters on the building facade, although it can reduce electricity consumption during the use of the building, the purchase and installation of solar panels in the early stage requires more investment.

The market acceptance of some sustainable building materials may not be high, and some consumers are prone to adopt a wait-and-see attitude when it comes to the adoption of sustainable building materials due to a lack of understanding of such sustainable building materials.

As mentioned above, sustainable building materials have superior engineering and environmental performance, but at the same time, there are some drawbacks. In my opinion, the advantages of sustainable building materials are incomparable to those of traditional building materials, and even if there are some disadvantages, they can be overcome through relevant measures or methods to maximize their superior performance. Therefore, it's believed that the application of sustainable building materials will be an important direction for the development of the construction industry.

B. Major Challenges in the Application of Sustainable Building Materials

Lack of unified standards and certification system. As mentioned in subsection II.D, some countries have separately formulated standards or evaluation systems for the identification of green building materials or sustainable building materials, but there is a lack of unified standards or certification systems. Differences in the identification of green building materials or sustainable building materials in different countries and regions may affect the import and export of such building materials to a certain extent and may affect consumers' judgment and identification of green building materials or sustainable building materials.

(1) High cost: Taking into account the information provided in Chapter 2 and the development of sustainable building materials in some countries. It can be assumed that high cost is one of the biggest challenges in the process of

promoting the application of sustainable building materials. In particular, the research and development of new sustainable building materials requires large capital investment and time costs, which leads to high prices of finished products compared with traditional building materials, thus affecting consumers' choice of use.

(2) Technological difficulty: Although some sustainable building materials have good engineering performance, their production processes are complex and technically difficult, and the promotion of such sustainable building materials will be constrained by technical difficulties.

(3) Strength of policy support: National policy support is crucial for the development of sustainable building materials. Formulating some incentive policies, providing tax benefits, etc., will help push the development of sustainable building materials in a country or region. In Chapter 2.4, through collecting relevant information, it can be understood that China, the United States, Singapore, and other countries have formulated corresponding supportive policies for the development of sustainable building materials in their countries and achieved better results.

C. Development Differences of Sustainable Building Materials Across Countries

In the development and application of sustainable building materials in different countries and regions, due to the differences in economy, scientific and technological level, policies, and other aspects, there are obvious regional differences. Generally speaking, their differences are reflected in the following aspects

(1) Culture and geography: Cultural and geographical factors may influence the preferences of people in different regions when choosing building materials. Culture influences people's choices, while geography tends to lead to different needs for building materials. For example, traditional Chinese culture considers bamboo to be an "elegant" plant, so sustainable building materials made from or partly from bamboo are more acceptable to Chinese consumers. An example of the impact of geography is Japan. Japan is an earthquake-prone country, there is a higher demand for sustainable building materials with good seismic performance. New sustainable materials with good anti-seismic performance tend to be easily accepted by Japanese people.

(2) Policies and regulations: The United Kingdom is one of the first countries in the world to study green buildings. The Building Research Establishment Environmental Assessment Method (BREEAM) developed by the United Kingdom's Building Research Organization appeared in front of the world in 1990 and was the first assessment system developed for green buildings in the world. The system appeared in the world in 1990, and it is the first assessment system developed for green buildings in the world. The Leadership in Energy & Environmental Design Building Rating System (LEED) of the United States was the first to be implemented in 1998, and it was developed and implemented by the U.S. Green Building Council. At present, there are three major green building evaluation systems in Australia, the first one is the Australian Building Greenhouse Rating Scheme (ABGRS); the second is the National Built Environment Rating Scheme (NBERS); and the second is the Australian Built Environment Rating Scheme (NBERS). The first is the Australian Building Greenhouse Rating Scheme (ABGRS); the second is the National Built Environment Rating Scheme (NABERS); and the third is the Green Star Certification (GSC). In 2008, the German Sustainable Assessment and Certification System (Deutsche Gesellschaft für Nachhaltiges Bauen, hereinafter referred to as DGNB) was developed and launched by the German Sustainable Building Council in cooperation with the German government as a sustainable green building assessment and certification standard.

(3) Technology level and research & development investment: There are differences in the level of science and technology and economic strength of different countries, so there are also huge differences in the research and development and application of sustainable building materials. For example, the United States and China are in the leading position in solar energy technology, so new building materials related to solar energy utilization have been more widely used in these two countries. On the other hand, some developing countries with relatively poor economic and technological levels may face technical and economic problems when they try to develop and apply sustainable building materials.

(4) Market acceptance: Market acceptance reflects the degree of awareness and acceptance of sustainable building materials by the people of a country or region. In some countries, people generally have a higher level of understanding of new technologies and materials due to the relatively high level of education. People in these countries are more likely to accept some newly emerged sustainable building materials. Comparatively speaking, in some countries or regions with relatively poor education levels, residents are more likely to be conservative in their choice of building materials.

In general, when developing and utilizing sustainable buildings, each country tends to take into account its development, geography, natural resources, economic level, and other factors to formulate a development model suitable for its own country, reflecting regional characteristics.

D. Development Directions of Sustainable Building Materials

It is generally recognized that sustainable building materials have three directions, including the reuse of construction waste, the development of new building materials, and the improvement of manufacturing processes of building materials. Based on the understanding of the development and application of sustainable building materials in different countries around the world, sustainable building materials also have the following more specific development directions.

(1) More attention will be paid to the traditional and regional building materials. For example, in China, the use of traditional timber-framed buildings to preserve and pass on indigenous architectural culture is becoming more common. In Australia, for example, more attention is being paid to traditional building materials such as rammed earth used by Aboriginal people. It is believed that more and more countries will focus on traditional or regional building materials in the future.

(2) Countries generally tend to guide the development of sustainable building materials from the level of policies and regulations. As mentioned in Chapter 3.3, the development of sustainable building materials can be well promoted through policy guidance, and it is believed that more countries or regions will formulate relevant incentive policies in the future.

(3) More attention will be paid to the improvement of the working environment. In the future, construction material manufacturers will not only focus on the quality of their products, but will also pay more and more attention to the working environment of production workers, and commit themselves to improving the working environment.

(4) The integration of intelligent technology. The research on sustainable building materials will gradually incorporate intelligent technologies, such as the incorporation of intelligent sensing technologies and adaptive control technologies, which will help to realize the intelligence of buildings and provide a better living experience. It is believed that this will be an important research and development direction for new sustainable building materials.

IV. Conclusion

This paper analyzes the development history of sustainable building materials, common application methods, engineering characteristics, and the development and application status of sustainable building materials in some countries in the world based on the reading of related papers and internet resources, and analyzes the advantages and disadvantages of sustainable building materials, the main problems and challenges in the process of popularizing and applying them, and the research development and application differences of sustainable building materials in some countries, as well as the latest research progress and development trend of sustainable building materials, and puts forward some of his personal views on the development and application of sustainable building materials. It also analyzes the advantages and disadvantages of sustainable building materials, the main problems and challenges in the process of promotion and application, the research development and application of sustainable building materials in some countries, and the latest research progress and development trend of sustainable building materials, and puts forward some of its personal views on the development and application of sustainable buildings.

(1) When promoting and applying sustainable building materials, different countries mainly adopt the formulation of relevant laws and policies, while some countries tend to consider local culture and traditional building materials in the selection of sustainable building materials.

(2) Generally speaking, sustainable building materials have outstanding performance in environmental protection, resource conservation, improvement of living environment, and enhancement of building quality, but there are also problems such as high upfront costs and low market acceptance.

(3) The development of sustainable building materials mainly focuses on the use of traditional materials, policy guidance, improvement of the working environment of production workers, and the integration of intelligent technology.

In general, despite the shortcomings of sustainable building materials, their superior environmental-friendly performance and engineering performance still make them the first choice of materials for the current and future construction industry. In addition, the experience of various countries in the development and promotion of green building materials shows that the formulation of relevant incentive policies, the rational use of traditional or regional building materials, increased investment in research and development, and the popularization of relevant knowledge can provide a good impetus to the promotion and development of sustainable building materials, to make sustainable building materials better used in construction.

Conflict of Interest

The author declares no conflict of interest.

References

[1] J. X. Gao, *Theoretical Exploration of Sustainable Development*, Beijing China Environment Press, 2009.

[2] S. S. Cai, "Effective integration of construction civil engineering and sustainable development," *Sichuan Building Materials*, vol. 11, pp. 71–72, 2022.

[3] X. H. Luo, "Sustainable development of green concrete building materials," *Management & Technology of SME*, vol. 07, pp. 155–157, 2022.

[4] C. Wang, "Study on the residential materials and reuse of traditional villages in western Beijing," *North China University of Technology*, vol. 1, p. 129, 2021. DOI: 10.26926/d.cnki.gbfgu.2021.000355

[5] Y. Q. Wu, "Bamboo skeleton permeable brick with recycled material from waste concrete and its properties," *China Construction Metal Structure*, vol. s2, pp. 56–58, 2023. DOI: 10.20080/j.cnki.ISSN1671-3362.2023.09.020

[6] H. Peng and F. Z. Ren, "Application of new building materials in engineering construction," *Jiangsu Building Materials*, vol. 05, pp. 17–19, 2023.

[7] Y. Sun, "An analysis of the current situation and development prospects of solar photovoltaic technology application in urban buildings," *Green Building*, vol. 06, pp. 20–23, 2023.

[8] J. K. Ren, "Environmental impacts, significance, and development direction of green buildings," *Green Environmental Protection Building Materials*, vol. 03, pp. 30–31, 2019. DOI:10.16767/j.cnki.10-1213/tu.2019.03.020

[9] Application status and development trend of new green building materials. (n.d.). ZhiHu column. Retrieved December 20, 2023. [Online]. Available: https://zhuanlan.zhihu.com/p/300651146

[10] W. S. Deng, "Research on the application of waste glass materials in recycled concrete," *Papermaking Equipment & Materials*, vol. 11, pp. 78–80, 2022.

[11] Pathways to Carbon Neutrality in Buildings, Top 10 Recyclable Building Materials for Use in Buildings_Concrete_Bamboo_Materials. (n.d.). Retrieved December 20, 2023. [Online]. Available: https://www.sohu.com/a/540201741_121119000.

[12] M. Y. Peng, Z. M. Pan, Y. M. Xu, and Q. X. Sun, "Practices and implications of sustainable building in Europe," *Construction Science and Technology*, vol. 21, pp. 68–71, 2010. DOI: 10.16116/j.cnki.jskj.2010.09.019

[13] K. Lan and Q. M. Li, "Study on green building development in the United Kingdom," *Journal of Xi'an University of Architecture & Technology (Social Science Edition)*, vol. 05, pp. 29–33, 2012. DOI: 10.15986/j.1008-7192.2012.03.002

[14] J. Z. Zhang, "Green building development in a dual-carbon context," *Jiangsu Building Materials*, vol. 05, pp. 113–114, 2023.

[15] M. N. Bi, "The development of Australia's building technical regulations system and the implications for China," *Standardization of Engineering Construction*, pp. 77–81, 2018. DOI: 10.13924/j.cnki.cecs.2018.11.017

[16] X. L. Zhao and W. C. Xue, "Strategies and implementation paths for sustainable green building development in Singapore," *World Architecture Review*, vol. 05, pp. 19–22, 2022. DOI: 10.14080/j.aw.2022.04.001

[17] W. D. Li, "Recycling of construction waste," *Journal of Tangshan University*, vol. 06, pp. 44–46, 2011. DOI: 10.16160/j.cnki.tsxyxb.2011.06.008

[18] Autoclaved aerated concrete application-Baidu library. (n.d.). Wenku.baidu.com. Retrieved December 20, 2023. [Online]. Available: https://wenku.baidu.com/view/71f2c3edde88d0d233d4b14e852458fb770b38c2.html?_wkts_=1700642103980