Proceedings of CONF-FMCE 2025 Symposium: Semantic Communication for Media Compression and Transmission
DOI: 10.54254/2755-2721/2025.GL28343

A Review of Building Structural Design under the Context of Green Development Concepts

Zhaochenkun Yi

SWJTU-Leeds College, Southwest Jiaotong University, Chengdu, China
yizhaochenkun@my.swjtu.edu.cn

Abstract. Nowadays, the pressure on the global ecological environment has significantly increased, with the construction industry accounting for a large proportion of this. To address this issue, green development concepts have become the focus of industry transformation. This article focuses on reviewing green building materials and green building structure design. Green building structures optimize their properties through low-carbon material selection, modular units, and natural ventilation design to reduce energy consumption and emissions. By combining actual cases from different countries and regions, the feasibility and value of green building structures are verified. In the future, the construction industry needs to integrate green concepts and various factors, accelerate the innovation and standardization of green building materials, and promote the transformation of the construction industry towards zero carbonization.

Keywords: Green building materials, Building structure, Low-carbonization

1. Introduction

Currently, the global ecological environment is under increasing pressure. The construction industry, as a significant producer of energy consumption and greenhouse gas emissions, consumed 34% of the global energy in 2023 and contributed approximately 37% of the global greenhouse gas emissions. In 2050, the proportion of infrastructure under construction in the construction industry will reach 75%, with the goal of decarbonization of the construction industry as the main objective. This green development concept is gradually integrated into the construction field, and the application of green building materials and the design of green building structures have become the core directions of industry transformation.

Currently, green building materials are classified into four categories: load-bearing type, energy-saving type, decorative type, and eco-friendly type, which are widely used in the internal and external environments of buildings. Green building structure design also focuses on aspects such as low-carbonization, spatial layout, and energy-saving systems. Cases such as the BUMN headquarters of Cirengza in Indonesia and the ecological "multi-hall" of Meizhou Hakka Center have verified its feasibility. However, the industry still needs more systematic theories and practical guidance.

This paper aims to summarize the key points of the application of green building materials and the design of green building structures, and through the analysis of actual cases, provide theoretical

© 2026 The Authors. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/).

DOI: 10.54254/2755-2721/2025.GL28343

references for the construction industry. Its significance lies in promoting the integration of environmental protection and humanistic care in contemporary construction projects, providing new ideas for the improvement of traditional construction patterns in the construction industry, moving towards zero-carbon development, and proposing a new direction for the integration of regional culture and green concepts, promoting the harmonious coexistence of buildings with nature and cities.

2. Application of green building materials and architectural structure design

2.1. Definition and classification of green building materials

Green building materials (hereinafter referred to as green materials) refer to those materials that, throughout their life - cycle, including the entire process from raw material extraction, production and processing to recycling or degradation after their service life, can maximize the satisfaction of the functions of building structures, achieve resource conservation, protect the environment, and simultaneously reduce the impact on occupants [1].

Green building materials are mainly classified into load - bearing building materials, energy - saving building materials, decorative and environmentally - friendly building materials, and ecologically - friendly building materials according to their functional characteristics. Load - bearing building materials include recycled concrete, bamboo - steel composite materials, and low - carbon steel. They not only meet the strength and stability requirements of building structures but also have environmental protection advantages. Energy - saving building materials include thermal insulation mortar, vacuum insulation panels, and straw composite panels. Through their thermal insulation properties, they can achieve building insulation and reduce material consumption and emissions [2,3]. Decorative and environmentally - friendly building materials, such as water - based paints and photovoltaic building materials, are mainly used for interior decoration, ensuring indoor air quality and effectively dealing with pollution caused by building waste. Ecologically - friendly building materials refer to those that, by virtue of their inherent properties, can promote water conservation and ecological restoration during the construction process, such as permeable concrete and vegetation concrete [4].

2.2. Application of green building materials in engineering construction

The application of green building materials in engineering construction can be classified into the following four aspects: application in the main building structure, building envelope, interior decoration, and external building environment. The application of green building materials in the main building structure is mainly reflected in structural materials.

In concrete structures, recycled aggregate concrete (made from crushed construction waste such as waste concrete blocks and broken bricks) is used as an aggregate to replace natural sand and gravel, thereby reducing mining activities and the amount of waste sent to landfills. Meanwhile, adding admixtures such as fly ash and slag powder to concrete can effectively extend the service life and improve the working performance of concrete, while reducing the consumption of cement.

The application of green building materials in the building envelope is mainly manifested in wall insulation, door and window materials, and roof structures. For wall insulation, materials such as rock wool boards or vacuum insulation panels are used. These materials can reduce the wall thickness while enhancing the insulation effect, and are often used in high - rise buildings or the renovation of old residential areas. Low - E low - emissivity glass is commonly used for doors and

DOI: 10.54254/2755-2721/2025.GL28343

windows. The surface coating of this glass can reflect infrared rays, helping to maintain indoor temperature in winter and block out high outdoor temperatures in summer, thus reducing the energy consumption of air conditioners or heaters [5]. In roof structures, the composite insulation process of extruded polystyrene boards and polyurethane spraying is widely adopted. The composite insulation layer formed can effectively reduce the heat transfer coefficient of the roof.

The application of green building materials in interior decoration is mainly reflected in the floor, walls, and ceilings. Recycled tiles and bamboo - wood composite floors are mainly used for the floor, which helps to reduce the use of natural raw materials and the waste generated from construction projects. For wall decoration, diatom ooze and water - based paints are used to replace traditional solvent - based paints. These materials can effectively absorb harmful gases such as formaldehyde, ensuring clean indoor air. Recycled gypsum boards, which are made from industrial by - product gypsum instead of natural gypsum, are selected as ceiling materials, thus reducing resource exploitation.

The application of green building materials in the external building environment is demonstrated in ground paving and pipeline construction. Permeable concrete is often used for ground paving. Its porous structure allows more rainwater to infiltrate, enhancing the drainage system and helping to alleviate urban waterlogging. Recycled plastics, such as recycled PVC and PE plastics, are used for pipelines, which helps to reduce white pollution and the consumption of petroleum as a raw material.

2.3. Green building structural design

Green buildings are centered around the concept of sustainable development, aiming to minimize resource consumption and maximize resource utilization efficiency, thus achieving harmonious coexistence between buildings and nature [6]. Green building structural design does not exist in isolation but permeates the entire process of building design and construction. It is mainly manifested in three aspects: low - carbon structural design, space optimization, and energy - saving system design.

In the field of low - carbon structural design for green buildings, the main focus is on low - carbon treatment of material selection and assembly methods. In terms of material selection, building materials with low energy consumption, low material consumption, and high performance are selected [4]. Through recycling, renewability, or long service life, the exploitation of natural resources and the generation of construction waste are reduced. For the assembly method, pre - fabricated modular units in the factory are adopted, and only on - site splicing and installation are required, effectively reducing construction waste and construction energy consumption caused by traditional pouring processes [7]. For large - span structures, lightweight design is adopted, replacing traditional concrete beam structures with cable - membrane structures or grid structures to reduce material consumption, improve light transmittance, and lower daytime lighting costs.

In space optimization for green buildings, it mainly includes building - environment integration and building lightweighting. Regarding building - environment integration, it is reflected in combining the topographical and geomorphic features of the region, adopting specific structural forms to reduce the invisible burden of the building structure. At the same time, an integrated design of the entire building is carried out to hide redundant components and reduce building material consumption. For building lightweighting, it targets horizontal components such as floors and roofs, and designs with hollow or honeycomb structures are adopted to reduce material consumption.

In the field of energy - saving systems for green buildings, the structural design of the building itself is utilized to achieve the effect of reducing operating energy consumption. Specifically, when

DOI: 10.54254/2755-2721/2025.GL28343

designing the exterior wall, the insulation structure is integrated to avoid the increase in structural load caused by additional insulation layers in the later stage. For structural openings, under the premise of meeting the basic requirements of wind and earthquake resistance, natural ventilation paths are preferentially designed. These paths can serve as evacuation channels and guide airflows through the interior of the building, reducing mechanical ventilation energy consumption [4]. Photovoltaic panels are directly used as part of the structural components to generate a portion of electrical resources using solar energy, thereby reducing energy consumption [3].

3. Real-world cases of green buildings

According to the 2023 data, the construction industry currently accounts for 34% of global energy consumption and contributes 37% of global greenhouse gas emissions. It is estimated that by 2050, 75% of the infrastructure is yet to be built. To achieve the goal of carbon reduction by 2050, the world is promoting building decarbonization through measures such as improving energy efficiency and increasing the use of renewable energy. Therefore, real-world cases are selected for detailed analysis.

3.1. Case of the BUMN headquarters in Cilacap, Indonesia

The headquarters of a state-owned enterprise, BUMN, in Cilacap, Indonesia, is selected as the first case because the building is located near a high-risk production area, making it highly representative. The building has a total floor area of 7,257 square meters and a total of five floors. It scored 85 points in the Greenship EB assessment, which is higher than the threshold for platinum certification. As shown in Table 1, the building meets 3 out of the 4 feasibility requirements of GBCI (floor area of 11,665 square meters ≥ 2,500 square meters, consent to data disclosure, and possession of an AMDAL environmental permit) [8].

Table 1. Feasibility result on the BUMN head office [8]

No.	Feasibility	Meet		Description
		Yes	No	
1	A minimum building area of 2.500 m^2	√		Building area (NLA) = 11.665m2
2	Willingness to sign an agreement letter that allows all buildings data to be studied by GBC Indonesia in a case study	√		
3	Posses the Environmental Management Implementation Report (UKL/UPL) endorsed by BAPEDAL	√		Has an AMDAL with Environmental Permit No. 660/529/30/Year 2016, issued by Cilacap Regent on June 13, 2016.
4	Posses a Certificate of Acceptability to Function (SLF) issued by the Local Government		√	It canot be shown/ proved

As shown in Table 2, the building performs well in three aspects in the Greeship EB rating: Energy Efficiency and Conservation (EEC), Water Resource Conservation (WAC), and Indoor Health and Comfort (IHC). In terms of Energy Efficiency and Conservation (EEC), the adoption of an 18kWp solar power generation system can meet 1.3% of the building's energy consumption needs, correspondingly reducing CO_2 emissions by 1.3%. From 2019 to 2022, the building's Energy Performance Indicator (IKE) was lower than 200 kWh/m^2 year, far superior to the standard of 250

DOI: 10.54254/2755-2721/2025.GL28343

kWh/m^2. year for office buildings. Meanwhile, the Building Automation System (BAS) is utilized to achieve real - time energy monitoring of air - conditioning and lighting, further reducing energy waste. In the area of Water Resource Conservation (WAC), sensor faucets account for 83%, and the building's average daily water consumption is 13.4L per person, far less than the water consumption standard for office buildings. Through measures such as using reclaimed water for toilet flushing and irrigation and controlling water usage, significant water resource conservation effects are demonstrated. Regarding Indoor Health and Comfort (IHC), the indoor temperature of the building is stably maintained at 24 - 27°C, the relative humidity is kept at 60% ± 5%, the illumination in the working area reaches 350 lux, and the noise is controlled at 40 - 45 dB. Moreover, in the feedback received, 80% of the respondents indicated that the working environment is very comfortable, realizing the concept of "people - oriented" in green buildings [8].

Table 2. Detailed scoring for greenship NB & EB [8]

Categories	Maximum Value	
	NB (FA) Ver. 1.2	EB Ver. 1.1
Appropriate Site Development/ ASD	17	16
Energy Efficiency & Conservation/EEC	26	36
Water Conservation/ WAC	21	20
Material Resource and Cycle/ MRC	14	12
Indoor Health and Comfort/ IHC	10	20
Building Environment Management/ BEM	13	13
Total	101	117
Predicate	Platinum: > 74 Gold: 58-73 Sliver: 47-57 Bronze: 35-46	Platinum: > 83 Gold: 66-82 Sliver: 53-65 Bronze: 41-52

This building comprehensively showcases the application of green building design in three aspects: low - carbon structural design, human - habitat synergy, and energy - saving systems, adhering to the fundamental concept of "putting people first".

3.2. Case of hakka center in Meizhou, China

According The ecological "multi - museum" green building complex of the Meizhou Hakka Center is selected as the second case. The reasons are that this building complex meets the growth demand of industrial tourism in Meizhou, undertakes the inheritance of Hakka culture, responds to green and sustainable development, and is located on the south side of Jianying Park, boasting excellent site conditions [9].

The project location and site conditions provide key supporting elements for the green building design and the realization of industrial tourism functions. In terms of ecology and environment, the building is situated in an open space on the south side of Jianying Park in Jiangnan District, Meizhou. It is surrounded by green trees, with good air quality, low building density, and a quiet environment. There is a large public leisure and fitness space on its east side, forming a dual ecological buffer pattern of "park + square", which can not only provide a comfortable sightseeing environment for tourists but also highly conform to the green ecological theme of the building.

DOI: 10.54254/2755-2721/2025.GL28343

In terms of transportation, Jianying Avenue lies on the west side of the site, and the Green Axis Garden Square is on the east side, with well - developed surrounding transportation facilities. In terms of culture, the building breaks through traditional thinking by integrating cultural inheritance with green building design. It incorporates the drainage system into the Hakka concept of "landscape" architecture, where "water" corresponds to the rainwater harvesting system (RWHS) in the atrium fountain square of the building. The rainwater from the roof is collected, stored, and reused, which not only achieves the goal of water conservation but also inherits the Hakka people's cherish for water resources, providing a new idea for green buildings. Meanwhile, green materials such as building - integrated photovoltaics (BIPV) are adopted to improve indoor comfort and achieve a balance between "energy - saving" and "experience" [9].

3.3. Chapter summary

In summary, the two cases verify the application and value of green building structures from different regions and usage scenarios. Green buildings should combine the technical and practical aspects, adopting a "skills + intelligence" management model to improve the operational efficiency of green buildings. On the other hand, attention should be paid to the integration of regional cultures and green concepts, so that green buildings are not only an application for environmental protection but also a manifestation of cultural inheritance and urban characteristics, ultimately promoting the global construction industry towards carbon neutrality.

4. Conclusion

This paper conducts a comprehensive review of building structural design under the concept of green development. It systematically outlines the definitions, classifications, and corresponding practical applications of green building materials, and delves deep into the underlying logic of green building structural design. Additionally, it discusses the practical value and significance of green buildings in combination with real - world cases. Research indicates that green building materials can be classified into four categories according to their functions: load - bearing, energy - saving, decorative and environmentally friendly, and ecological. Their application in buildings and their external environments has achieved remarkable results. For example, renewable materials such as recycled aggregate concrete can reduce the degree of exploitation at resource origin, and special structural materials such as permeable concrete can effectively alleviate urban waterlogging problems. Green building structural design effectively reduces the overall energy consumption and carbon emissions of buildings through low - carbon material selection, spatial layout, and the integration of energy - saving systems. Based on the cases of the BUMN Headquarters in Cilacap, Indonesia, and the ecological "multi - museum" in Meizhou Hakka Center, green buildings not only save and protect energy but also achieve harmonious coexistence between humans and the environment. Moreover, they can endow buildings with cultural value according to the regional cultures of different areas.

In the future, the development of green building structural design can be deepened in two aspects. On one hand, strengthen the integration of "energy - saving + intelligent" technologies, promote the widespread application of building automation systems and their in - depth combination with green structural design to enhance the efficiency of the entire building lifecycle and operation. On the other hand, thoroughly explore the integration path of regional culture and the green concept, enabling green buildings to inherit local characteristics and showcase urban individuality. Meanwhile, with the global promotion of low - carbon and carbon - neutral goals, the innovation,

DOI: 10.54254/2755-2721/2025.GL28343

research and development, and standardization construction of green building materials should be accelerated to reduce the actual application costs in construction. This will promote the large - scale transformation of green buildings, help the global construction industry completely overcome the high - energy - consumption drawbacks of traditional buildings, and transform towards carbon neutrality, thus constructing a new sustainable development pattern featuring harmonious coexistence between buildings, nature, and humanity.

References

[1] Gan Z, Shen XY, Xie Y. (2024). Discussion on the development and application of green building materials in construction engineering. Jushe, (25), 39–41.
[2] Cai XL. (2025). Discussion on the application of green building materials in civil engineering construction. Ceramics, (06), 200–202. https: //doi.org/10.19397/j.cnki.ceramics. 06.033.
[3] Vijayan S. D., Devarajan P, Mohanavel V., Sankaran V., Kannan S., Ahsan S.M. (2025) A Review of Sustainable Implications of Energy-Efficient Buildings in the Environment.Advances in Civil Engineering 2025, 2025 (1): 9584777-9584777.
[4] Jin J, Lu C. (2023) On the Application of Green Building Materials in Construction Technology of Building Projects. World Journal of Innovation and Modern Technology, 6 (6).
[5] Huang XF. (2025) Application of green building materials in civil engineering construction. Popular Standardization, (12), 80–82.
[6] Cholponbai N.T., Chen D., Asulbekovna S.K., Ji L, Zhao YH. (2024) Green Architecture: Green Building Concepts to Ensure a Green Future. E3S Web of Conferences, 53302032-02032.
[7] Liu Y. (2024) A Review of Innovative Design Strategies for Prefabricated Green Buildings. Journal of World Architecture, 2024, 8(1): 91-96.
[8] Vitriana V, Ferry H, Rina K. (2025) Lesson learned from implementation of green building concepts towards sustainable development: A case study of a state-owned enterprises (BUMN) head office in Cilacap. E3S Web of Conferences, 605.
[9] Chiu CY, Liu JJ, Cai CF, Zhong YM, Luo ZW, Chen XL, Lin YY. (2025) Green architectural design for the ecological “multi-pavilion” of the Meizhou Hakka Center. E3S Web of Conferences, 618.