The Impact of Ecological Bricks on Urban Sustainable Development

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Abstract. With the growing emphasis on sustainable development, recycling construction waste into ecological bricks has become a crucial approach to achieving sustainability. This paper analyzes the production processes, application status, and impact of ecological bricks on urban sustainable development through literature review and case studies in China. The findings indicate that there is still significant potential for the broader adoption of ecological bricks in China. Both the central and local governments in China have provided substantial policy support to promote their use, which also contributes to urban sustainable development. Based on this analysis, the paper recommends that, given the high ecological benefits of ecological bricks, the government can encourage their adoption through subsidies and procurement to address market failures caused by externalities.

Keywords: Ecological Bricks, Sustainable Development, Ecological Industry

1 Introduction

With the acceleration of urbanization, the accumulation of construction waste and the excessive consumption of natural resources have become major obstacles to urban sustainable development. Against this backdrop, ecological bricks, as an environmentally friendly building material made from construction waste and industrial byproducts, have garnered increasing attention due to their resource recycling and low-carbon emission characteristics. Despite their significant environmental and economic advantages, the widespread adoption of eco-bricks still faces challenges such as high costs and insufficient market acceptance.

This study employs literature review and case analysis to examine the production processes, industry status, barriers to adoption, and the impact of ecological bricks on urban sustainable development. Based on the literature, the production of ecological bricks not only effectively utilizes construction waste but also significantly reduces energy consumption and carbon emissions. Moreover, their strength and durability surpass those of traditional bricks. However, their higher production cost remains a major constraint on large-scale adoption, particularly in developing countries, where their use lags behind that in developed nations. To promote the use of eco-bricks, the Chinese government has provided strong policy support through subsidies, industry standard

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formulation, and government procurement. Empirical data from China demonstrates that ecological bricks, as a representative of green building materials, play a pivotal role in enhancing urban sustainability.

Based on this, it is recommended that the government further strengthen its support for the ecological brick industry by reducing production costs through financial subsidies and tax incentives, while also enhancing public environmental awareness campaigns to improve market acceptance. These measures will help address market failures in the promotion of ecological bricks and drive cities toward greener and more sustainable development.

This rest of this paper is structured as follows. Section II summarizes the relevant literature about ecological bricks. Section III analyzes the Chinese government policy in promoting the usage of ecological bricks, and its role in sustainable development. Section IV concludes.

2 Literature Review

2.1 Production Process of Ecological Bricks

The manufacturing of eco-bricks emphasizes environmental friendliness, typically using waste materials or recycled resources as primary raw materials, such as discarded ceramics, waste glass, and construction waste. Through high-temperature firing or other specialized processes, these waste materials are processed into bricks with high strength and durability. Therefore, the production of eco-bricks not only reduces the accumulation of waste materials but also achieves resource reuse. Ecological bricks primarily use cement as the binding material, solidifying industrial or construction waste through hydration reactions to form non-fired bricks. For example, Zhao et al. used red mud and calcium sulfoaluminate cement as raw materials to produce non-fired bricks, reducing cement consumption [1]. Silva et al. prepared non-fired bricks using sand, coal tailings, and hydrated lime as the binding material. By establishing a cubic model, they calculated that under a mix ratio of 90% tailings and 10% hydrated lime, the strength of the non-fired bricks could reach 15.79 MPa [2]. Although other binding materials can perform similarly to cement, current non-fired processes still predominantly rely on cement as the primary binding material.

According to a report by Chongqing Jiuran Building Materials Co., Ltd. (2025), the production of 1 million ecological bricks can consume 2,000 tons of construction waste, reduce soil extraction by 10,000 cubic meters, and protect approximately 5 acres of land resources [3]. The production process eliminates the need for high-temperature sintering, with energy consumption being only 30% of that for traditional bricks, significantly reducing carbon emissions. Ecological bricks exhibit a strength 1.5 times that of conventional bricks, with compressive strength exceeding 15 MPa, fully meeting various construction requirements. Their unique porous structure provides excellent thermal insulation performance, with a thermal conductivity as low as 0.15 W/(m·K), improving building energy efficiency by over 30%. In terms of durability, ecological bricks demonstrate outstanding performance. After 1,000 freeze-thaw cycles, their strength loss is less than 5%, far surpassing traditional materials. With exceptional

weather resistance, their service life can exceed 100 years, substantially reducing building maintenance costs. Although the initial investment for ecological bricks is 15%-20% higher than that for traditional materials, their life-cycle cost advantages are significant. Energy-saving properties lower operational costs, while durability reduces maintenance expenses, resulting in overall long-term savings of more than 30%. With the tightening of environmental policies and growing consumer awareness of sustainability, the market demand for ecological bricks is rapidly increasing. By 2025, the global ecological brick market size is projected to exceed $50 billion, with an annual growth rate of over 20%. This not only creates substantial commercial value but also drives the entire construction industry toward green and low-carbon transformation.

2.2 Current Status of the Ecological Brick Industry

In developed countries, governments support the reuse of construction waste through legislation and policy measures to conserve resources and protect the environment. For example, the UK has established specialized calculation methods to determine the landfill recovery rate of construction waste, which now serve as the basis for government monitoring of waste reduction efforts nationwide. The UK's "Waste Framework Directive" set a target to recycle over 70% of construction and demolition waste by 2020. By 2019, the country's construction waste recycling rate had already reached 93%, far exceeding the initial goal (Ren Xintong, 2019) [4] .

The United States leads the world in the construction waste recycling industry, with recycled construction waste products widely applied in both construction and transportation sectors. Annually, the U.S. generates approximately 800 million tons of municipal solid waste, about 40% of which is construction waste. After sorting and processing, around 70% is recycled, while the remaining 30% is primarily used for landfill projects such as parking lots and sports fields (Li Nan et al., 2009) [5]

Over the past few decades, China's building materials industry has consumed vast amounts of natural resources and emitted substantial industrial waste, ultimately causing severe environmental pollution. Ecological bricks, however, can repurpose traditional industrial waste into valuable resources, simultaneously conserving stone and clay materials used in brick production—a dual benefit. Yan (2024) conducted economic and environmental benefit analyses, revealing that the cost of ecological bricks is approximately 646.59 CNY/m³, with CO_2 emissions during production around 561.75 kg/m³. Compared to traditional sintered bricks, each cubic meter of green eco-bricks produced saves 276.33 kWh of electricity, 99.48 tons of standard coal, and reduces CO_2 emissions by 2.6×10^5 kg [6]. Driven by rising environmental awareness and policy support, China's ecological brick industry has entered a rapid development phase in recent years. In 2023, the market size of ecological bricks in China reached approximately 45 billion CNY, a 12% year-on-year increase (Boiyan Consulting, 2024) [7]. In contrast, the market size of China's brick and tile industry in 2022 was about 450 billion CNY, with eco-bricks accounting for 10% of the sector (China Research Network, 2025) [8]. The primary raw materials for ecological bricks include industrial waste such as fly ash, slag, and metallurgical residues, which are abundant and low-cost. In 2023, China's fly ash output reached 200 million tons, with about 15% utilized

in eco-brick production. Advances in production technology have steadily reduced manufacturing costs. By 2023, the average production cost of ecological bricks dropped to 15 CNY per square meter, an 8% decrease from 2022. Despite progress, China's construction waste recycling rate in 2025 is projected to be around 50%, lagging behind developed countries, indicating significant growth potential for ecological bricks (Huajing Industrial Research Institute, 2025) [9].

2.3 Barriers to the Widespread Adoption of Ecological Bricks

Compared to the production cost of traditional red bricks at approximately 200 CNY/m³, ecological bricks cost around 650 CNY/m³, making cost the primary challenge for their promotion. Although eco-bricks have significant environmental advantages, their development, production, and application costs are often higher than those of traditional building materials. The production of ecological bricks typically requires higher initial investments, which poses considerable economic pressure for many construction companies and developers [10].

Given the relatively high production costs of ecological bricks, their use may still be beneficial when considering the environmental benefits they bring. Therefore, incorporating the externalities generated during the production and use of ecological bricks into decision-making is a crucial aspect of promoting their widespread adoption. To account for the externalities of ecological bricks, the first step is to raise societal awareness of environmental protection, encouraging the use of recyclable materials and advocating for clean, eco-friendly materials in every aspect of daily life. Second, in promoting new environmentally friendly materials, it is essential to strengthen communication with relevant construction material departments, optimize industry standards to meet increasingly stringent environmental requirements, and establish practical management measures. Additionally, governments should incentivize and support enterprises involved in the manufacturing and production of ecological bricks. With the advancement of new eco-friendly building materials, more people are recognizing the performance advantages of energy-saving and sustainable materials. Thus, during the production and promotion of ecological bricks, preventive measures should be implemented, and effective mandatory laws and regulations should be established. Only through multi-faceted constraints can the goal of building a sustainable and environmentally friendly society be achieved as soon as possible [11].

3 Case Study

3.1 How Government Policies Promote the Development of Ecological Bricks

The Chinese government has been increasingly strengthening its support for green building materials, providing solid policy guarantees for the industry's development. The "14th Five-Year Plan for the Construction Industry" released in 2021 explicitly states that by 2025, green buildings should account for over 70% of newly constructed buildings. Additionally, China has introduced a series of policy measures, including green building material certification standards, tax incentives, and financial subsidies,

to promote standardized development in the industry. At the central government level, three rounds of pilot cities for government procurement supporting green building materials to enhance construction quality were designated in 2020, 2022, and 2024, covering all provinces in China and nearly all economically developed cities. Following the central government's designation of these pilot cities, local governments at various levels actively implemented supporting measures, including establishing industry standards for green building materials, addressing information asymmetry between consumers and manufacturers, and leading by example through large-scale government procurement of green building materials.

Beijing has actively organized green building material enterprises to participate in green product certification, extensively promoted knowledge about green building material certification, and implemented quality improvement initiatives for small and micro enterprises. The city has provided free training programs to enterprises, gradually enhancing both consumers' and businesses' awareness and application levels of green building materials. Furthermore, Beijing has vigorously promoted the use of green building materials, primarily by leveraging government-funded construction projects to demonstrate leadership. These projects take the lead in procuring and utilizing green building materials, creating a favorable atmosphere for their widespread adoption. This approach effectively guides and encourages more construction projects to select green building materials.

The Shandong Provincial Department of Finance has facilitated the selection of appropriate green building materials for all parties involved in construction projects by establishing the Shandong Green Building Materials Information Database. This initiative has further promoted the application of green building materials and served 126 green building material suppliers. The province has launched the Shandong Green Building Materials Service Platform, which integrates green material procurement requirements throughout the entire project lifecycle. This platform standardizes green building material procurement transactions and creates an "Internet + Green Building Materials Management" model, providing fundamental support for the digital management of the green building materials industry. Additionally, Shandong Province directly provides financing support to green building material enterprises, while actively promoting green material procurement in government projects. As of March 2025, the total value of green building materials procured by Shandong's government agencies reached 7.856 billion yuan.

Foshan City has launched the nation's first green building materials e-commerce platform, which is interconnected with the Foshan Green Building Materials Product Catalog platform. This integration enables unified display of product and supplier information, policy notices, and green building material classification catalogs, facilitating efficient access and selection for pilot project construction units, contractors, and the general public, thereby significantly enhancing the precision and effectiveness of green procurement. Furthermore, Foshan promotes green building material usage through government procurement. Notably, the city provides financial support to green building material enterprises during procurement processes. Specifically, small and medium-sized green building material enterprises participating in government procurement can apply for unsecured loans from financial institutions through the Guangdong

Provincial Government Procurement Network by presenting their winning bid notices or government procurement contracts. As of August 2024, Foshan has facilitated 446 contract financing transactions, accumulating a total financing amount of 228 million yuan.

3.2 The Impact of Green Building Materials on Urban Sustainable Development

Driven by strong government policies, growing environmental awareness among consumers, and accelerated technological innovation, China's green building materials market has been expanding steadily. According to data from Puhua Industry Research Institute, the market size of green building materials in China reached 202.41 billion yuan in 2023, representing a year-on-year growth of 19.17%. It is projected that by 2025, the market size will exceed 300 billion yuan, maintaining a compound annual growth rate of over 10%. As measured by Du (2019), China's sustainable development index and green building index have shown an upward trend, according to Figure 1 [12]. The green building index is calculated using two key indicators: the total area of green buildings and the proportion of green building area.

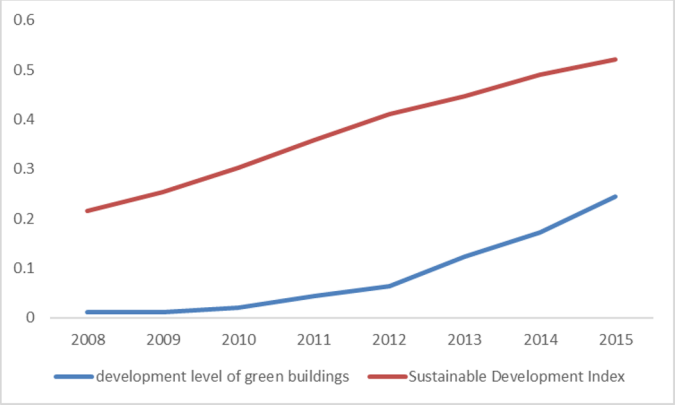

Fig. 1. China's Green Building and Sustainable Development Index

At the provincial level, China's green building index and sustainable development index in all provinces show an upward trend, according to Figure 2 and Figure 3. Calculating the correlation between the provincial green building index and sustainable development index yields a result of 0.51. While this does not imply causality, the relationship between these two variables can still be explained based on the aforementioned theories and policy practices.

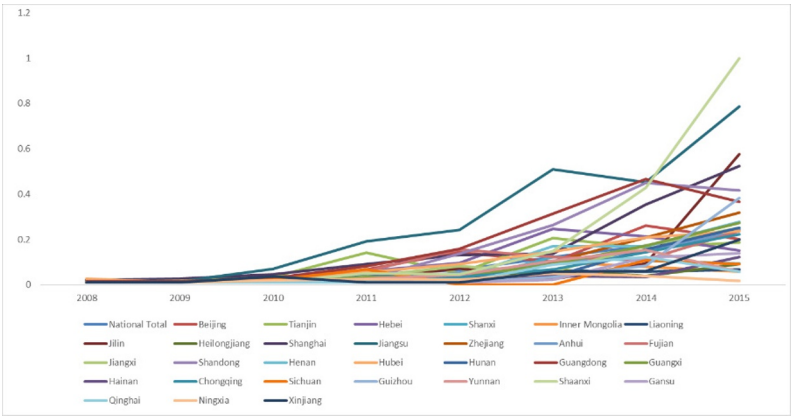

Fig. 2. Green Building Index by Province in China

The development of green buildings can enhance the level of sustainable development. Green buildings and the eco-friendly materials they utilize help cities achieve construction waste management, sustainable production of building materials, and avoidance of resource waste such as stone and mineral resources during urban development, which undoubtedly benefits economic sustainability. Additionally, the concept of harmony between humans and nature advocated by green buildings can also shift the perspectives of businesses and individuals, thereby better promoting the principles of sustainable development.

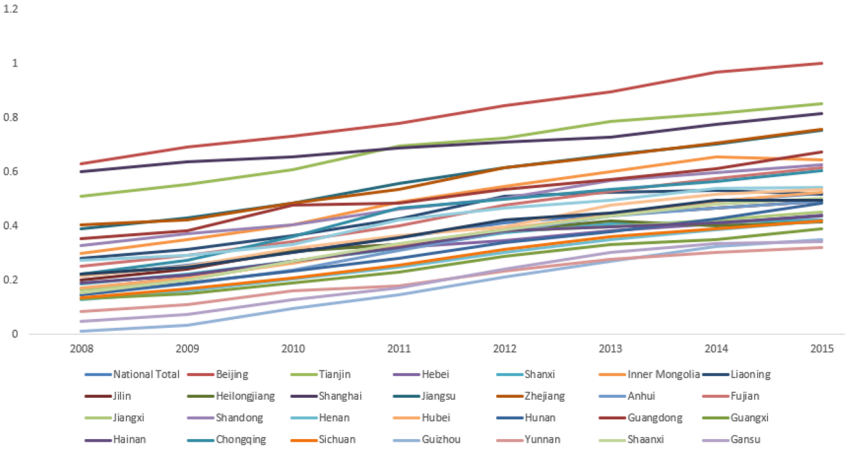

Fig. 3. Sustainable Development Index by Province in China

Green buildings are a requirement of sustainable development. Sustainable development is a model aimed at balancing the needs of the present generation with the rights of future generations. Its core lies in harmonizing the relationship between the economy, society, and the environment, ensuring that development does not exceed the car-

rying capacity of the Earth's ecosystems. From the perspective of building material resources, while the extensive use of stone and cement has contributed to urban construction, resource consumption must be moderated. To ensure the sustainable use of resources for the future, we should prioritize recycling, which is a key reason for adopting green building materials. From the perspective of construction waste management, indiscriminate landfilling of such waste would inevitably lead to shortages of urban and arable land. To achieve sustainable urban development, proper handling of construction waste is essential. Producing ecologic bricks from construction waste is a crucial aspect of advancing sustainable development.

4 Conclusion

This study reveals the significant role of ecologic bricks in promoting urban sustainable development. Through analyzing their production processes, industry status, and case studies, it demonstrates that ecologic bricks can effectively utilize construction waste and industrial byproducts, significantly reducing resource consumption and carbon emissions. Although ecologic bricks offer outstanding environmental benefits and long-term cost advantages, their higher initial production costs remain the main obstacle to large-scale adoption. Compared with developed countries, China has made progress in ecologic brick applications, but there is still a considerable gap in adoption rates. Therefore, this paper proposes the following policy recommendations to promote the application of ecologic bricks in China:

In terms of industrial policy, incentive measures should be adopted. First, the government can leverage subsidies and tax incentives. Given that the initial investment cost of ecologic bricks is higher than that of traditional materials, the government should continue to make financial subsidies for ecologic brick manufacturers and alleviate corporate burdens through preferential tax policies. This not only helps reduce the market price of ecologic bricks but also encourages more enterprises to engage in the R&D and production of green building materials. Second, government procurement policies should be optimized. Mandating a higher proportion of ecologic brick usage in government-funded projects can boost market confidence through stable demand.

In terms of regulation, efforts should be made to strengthen the formulation of industry standards and improve the certification system. On one hand, a robust industry standard and certification system for green building materials should be established to ensure product reliability and enhance consumer trust. On the other hand, the government should exercise its market oversight function by intensifying regulatory efforts to prevent low-quality products from entering the market and harming consumer interests.

In terms of public awareness, efforts should be intensified to promote publicity and education. First, extensive publicity campaigns should be conducted through various channels such as media and social platforms to highlight the advantages of ecologic bricks and their importance for environmental protection, thereby enhancing public awareness and acceptance of green building materials. Second, activities such as expert lectures and thematic seminars should be organized to raise the environmental consciousness of architectural designers, developers, and the general public.

In terms of technology, scientific research and innovation should be encouraged. Special funds should be established to support collaborative research projects between universities, research institutions, and enterprises on ecologic bricks, exploring new methods and technologies to reduce costs and improve performance. Deep integration of industry, academia, and research should be promoted to accelerate the transformation of scientific achievements into practical productivity. At the same time, the construction waste recycling system should be improved to ensure a stable supply of raw materials and reduce transportation costs.

Finally, the government can leverage regional pilot programs by drawing on successful experiences from Beijing, Shandong, Foshan, and other areas to formulate tailored policies. Examples include providing low-interest loans to ecologic brick manufacturers or establishing digital trading platforms for green building materials.

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