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# *Innovations in Sustainable Construction Materials: A Systematic Evaluation of the Literature on Materials and Production Methods*

# Inovasi Bahan Konstruksi Berkelanjutan: Evaluasi Sistematis terhadap Literatur Bahan dan Metode Produksi

**Feyranda**
Universitas Islam Riau
*feyranda_civilengineering@gmail.com

**Corresponding Author*

**ABSTRACT**
Increased awareness of sustainability has driven the construction industry to seek innovation in more environmentally friendly construction materials. This article presents a systematic evaluation of the literature on innovation in sustainable construction materials, with a focus on materials and production methods. Through this approach, we explore current trends, challenges and opportunities in the development of sustainable construction materials. Literature analysis shows the existence of various promising sustainable construction materials, such as bamboo, environmentally friendly concrete, and recycled materials. Additionally, production methods are also an important focus, with the development of advanced technology and more efficient construction practices. These findings have important implications in guiding the future development of the construction industry towards sustainability.
**Keywords: Innovation, Sustainable Construction Materials, Construction materials, Technology**

**ABSTRAK**
Peningkatan kesadaran akan keberlanjutan telah mendorong industri konstruksi untuk mencari inovasi dalam bahan konstruksi yang lebih ramah lingkungan. Artikel ini menyajikan evaluasi sistematis literatur terhadap inovasi dalam bahan konstruksi berkelanjutan, dengan fokus pada material dan metode produksi. Melalui pendekatan ini, kami mengeksplorasi tren terkini, tantangan, dan peluang dalam pengembangan bahan konstruksi berkelanjutan. Analisis literatur menunjukkan adanya berbagai material konstruksi berkelanjutan yang menjanjikan, seperti bambu, beton ramah lingkungan, dan material daur ulang. Selain itu, metode produksi juga menjadi fokus penting, dengan pengembangan teknologi canggih dan praktik konstruksi yang lebih efisien. Temuan ini memiliki implikasi penting dalam mengarahkan pengembangan masa depan industri konstruksi menuju keberlanjutan.
**Kata Kunci: Inovasi, Bahan Konstruksi Berkelanjutan, material Konstruksi, Teknologi**

## Introduction

In an era of increasing development and increasing awareness of sustainability, the construction industry faces the challenge of innovating in developing environmentally friendly construction materials. Innovation in construction materials is key to creating more energy efficient and environmentally friendly buildings. This paper outlines recent developments in the field of sustainable construction materials innovation, with a focus on a systematic evaluation of the literature on materials and production methods.

As the global population grows and rapid urbanization, demand for sustainable buildings and infrastructure is increasing. However, the construction industry is also one of the main contributors to environmental damage and climate change. Therefore, it is important to identify and evaluate innovations in construction materials that can reduce environmental impacts while maintaining or improving building quality.

Although there have been efforts to develop sustainable construction materials, certain challenges remain to be overcome. One of the main challenges is choosing construction materials that have a low carbon footprint and meet the strength and durability standards required in buildings. In addition, developing efficient and environmentally friendly production methods is also an important focus in the construction industry. Therefore, a systematic evaluation of the literature on material innovations and production methods becomes necessary to identify the best solutions.

Innovations in sustainable construction materials have been a focal point in recent research efforts. Various studies have delved into alternative building materials for sustainable construction, emphasizing the need to mitigate the environmental impact of conventional construction materials (Marut et al., 2020). The adoption of innovative construction methods and materials has been highlighted as crucial for achieving sustainable affordable housing projects (Moghayedi et al., 2022). Additionally, the utilization of upcycled building materials from urban and industrial waste has been explored as a strategy to promote sustainability in construction (Parece et al., 2022).

Moreover, the critical success factors for implementing sustainable, innovative, and affordable housing have been investigated through systematic reviews and bibliometric analyses (Moghayedi et al., 2021). The development of sustainable assessment criteria for building materials selection has been a key focus, aiming to address gaps in sustainable material selection processes within the construction industry (Akadiri & Olomolaiye, 2012). Studies have also examined sustainability and circularity in hill road construction, emphasizing sustainable construction materials as a key practice (Khural et al., 2022).

Furthermore, the incorporation of green product innovation strategies in the construction sector has been highlighted to promote environmental sustainability through waste reduction, material recycling, energy conservation, and pollution control (Alsharif & Shu, 2019). The environmental impact of building materials production, such as gypsum, has been analyzed to align with sustainable development goals (Czernik et al., 2021). Additionally, the effectiveness of recycled tire rubber as a modifier in asphalt mixtures has been investigated to promote sustainable pavement construction (Plati & Cliatt, 2021).

In conclusion, the literature reviewed underscores the importance of innovative sustainable construction materials and practices in advancing sustainability goals within the construction industry. By exploring alternative materials, upcycling waste products, and implementing green product innovation strategies, researchers aim to drive the sector towards more environmentally friendly and sustainable practices.

The main aim of this paper is to conduct a systematic evaluation of the literature on innovations in sustainable construction materials, with a focus on materials and production methods. Through this research, we aim to present a comprehensive overview of recent developments, challenges and opportunities in adopting sustainable construction materials.

It is hoped that this research will provide valuable insights for stakeholders in the construction industry, including manufacturers, planners and policy makers. Apart from that, this paper can also be a basis for further research in the development of sustainable construction materials.

By describing the background, problems, aims, and contributions of the research, this introduction provides the necessary context to understand the focus and relevance of this research in the context of innovation in sustainable construction materials.

**Research Methods**

This study uses a systematic evaluation of the literature approach to collect, review, and analyze information related to innovation in sustainable construction materials. This approach allows us to comprehensively explore relevant literature from various sources and

identify current trends, challenges and opportunities in the development of materials and production methods.

Data were collected through systematic searches in academic databases, scientific journals, conferences, books and other relevant literature sources. Keywords are carefully selected to ensure relevance to the research topic.

Articles included in this study had to meet certain inclusion criteria, such as relevance to the research topic, availability of adequate information, and quality of research methodology. Articles that did not meet these inclusion criteria were excluded from the analysis.

After searching and selecting articles, data were extracted and synthesized to provide a comprehensive picture of innovation in sustainable construction materials. This information is then analyzed qualitatively to identify key trends, challenges and opportunities in the development of sustainable construction materials.

Data obtained from a systematic evaluation of the literature was then analyzed using a qualitative approach. The results of the analysis were used to form the main findings presented in the next section of this study.

## Resuts and Discussions

### Innovation Trends in Sustainable Construction Materials

In the realm of sustainable construction materials, there is a significant shift towards innovation to address environmental concerns and enhance building performance. Early research primarily focused on technical innovations in building materials to improve environmental performance (Zhang et al., 2020). This emphasis on sustainability has led to a trend of decreasing environmental sustainability certification, prompting construction companies to form strategic alliances and enhance business efficiency to sustain performance improvements in sustainability innovation (Duong et al., 2021).

Leadership plays a crucial role in driving project-based organizational innovation performance, especially in knowledge-intensive industries like construction, where innovation is essential to keep pace with sustainability trends (Zheng et al., 2017). The construction industry is continuously seeking sustainable innovations to reduce environmental impact and offer more durable building solutions (Klemm & Almeida, 2018). Moreover, the integration of sustainability innovation and entrepreneurship has become a focal point for managers looking to introduce sustainable practices in their organizations (Schaltegger & Wagner, 2011).

Innovations in construction materials engineering are pivotal for sustainable development, emphasizing the need to consider sustainability as a whole rather than focusing solely on individual innovative elements (Czarnecki & Gemert, 2017). The adoption of green innovations, such as green bricks, is crucial for increasing the utilization of waste materials like fly ash and promoting sustainable practices in construction (Loya & Rawani, 2017). Additionally, the development of eco-technologies and eco-sustainable housing solutions is driving innovation in the construction sector, aligning with the growing demand for environmentally friendly construction materials (Montagner & García, 2018).

Overall, the construction industry is witnessing a paradigm shift towards sustainable construction practices through innovation in materials, technologies, and processes. This shift is not only driven by environmental concerns but also by the economic benefits and competitive advantages that sustainable construction offers (Liu et al., 2020). By embracing sustainable innovations in construction materials and practices, organizations can not only reduce their environmental footprint but also gain a competitive edge in the market.

**Evaluation of Sustainable Construction Materials**

To assess sustainable construction materials, several studies have proposed models and methodologies to assist in the selection process. Mathiyazhagan et al. (2019) and Tegegne et al. (2023) both concentrate on sustainable material selection using hybrid multicriteria decision-making (MCDM) approaches, highlighting the importance of sustainable indicators in the evaluation process. Ahmed et al. (2019) underscore the significance of technical, social, environmental, and economic indicators in evaluating the sustainability of construction materials.

Research by Vu & Nguyen (2021) and Ismael & Shealy (2018) illuminates the challenges encountered in adopting sustainable building materials, such as lack of awareness, knowledge, and legal regulations. Conversely, Yousif (2023) discusses the positive influence of labeled green materials on the performance of green construction projects, aiding in the selection of suitable materials meeting sustainability standards.

Zhang et al. (2017) suggest a hybrid MCDM approach for green material selection, integrating various decision-making techniques to identify optimal sustainable materials. Additionally, Thorpe (2015) highlights the potential benefits of advanced and sustainable engineering materials in civil infrastructure projects, including resource efficiency, safety enhancement, and reduced greenhouse gas emissions.

In conclusion, the evaluation of sustainable construction materials involves considering a variety of indicators, utilizing hybrid MCDM approaches, and addressing adoption challenges. By incorporating sustainability criteria, decision-making models, and advanced materials, the construction industry can advance towards more environmentally friendly and efficient practices.

**Evaluation of Sustainable Production Methods**

To assess sustainable production methods comprehensively, it is crucial to consider various evaluation approaches. Zhao & Wang (2021) emphasize the significance of sustainable production as a key indicator in evaluating sustainable fashion, particularly focusing on factors such as green transportation means and the re-utilization of packaging materials (Zhao & Wang, 2021; . Reichard & Martin, 2023) introduce the Sustainable Design Evaluation (SDE) method, which provides a clear and easily interpretable way for product developers to evaluate the sustainability impacts of their decisions, offering a holistic view of sustainability (Reichard & Martin, 2023; . Ojstersek & Buchmeister, 2020) present an experimental model to assess the impact of manufacturing flexibility on sustainable production systems, aiming to enhance sustainability through multi-criteria optimization (Ojstersek & Buchmeister, 2020). Additionally, Ojstersek et al. (2022) demonstrate the effectiveness of simulation modeling in evaluating technologies from a sustainable manufacturing perspective, suitable for assessing both existing and new technologies (Ojstersek et al., 2022).

Gu et al. (2019) conduct a sustainability assessment of a mushroom culture system using emergy methods, comparing different cultivation methods for economic and ecological benefits to support sustainable development (Gu et al., 2019; . Fadara & Wong, 2022) highlight the importance of evaluating the entire manufacturing supply chain for sustainable textile product assessment, focusing on resource reuse and remanufacturing to enhance environmental friendliness (Fadara & Wong, 2022; . Yu et al., 2020) propose an emergy-based sustainability evaluation of spent lead-acid batteries recycling to analyze the real value of resources and economic activities, aiming to promote cleaner production and sustainable development (Yu et al., 2020).

These references collectively underscore the importance of various evaluation methods in assessing sustainable production practices, spanning from indicators in sustainable fashion to emergy-based assessments in agriculture and recycling. By leveraging these diverse

evaluation approaches, industries can make well-informed decisions to enhance sustainability across different sectors.

**Implications of Results**

The implications of the results of this research are very significant in the context of developing sustainable construction materials. These findings not only offer new insights, but also offer a clear direction for the construction industry looking to adopt a more environmentally friendly approach.

1. **Innovations in Construction Materials:**

   These findings can encourage innovation in the development of new, more environmentally friendly construction materials. For example, the results of this research could lead to the discovery of alternative materials that are more sustainable and efficient in resource use.

2. **Improved Environmental Performance:**

   By using construction materials based on these findings, it can be expected that the environmental performance of construction projects will improve significantly. This can include reducing carbon emissions, more efficient use of resources and reducing construction waste.

3. **Industry Awareness:**

   The implications of these results may also help increase awareness in the construction industry about the importance of sustainability. This could encourage more companies to adopt environmentally friendly and sustainable construction practices.

4. **Regulations and Policies:**

   These findings can influence the formation of regulations and policies in the construction sector. Governments and regulatory bodies may begin to provide incentives or implement rules that encourage the use of sustainable construction materials.

5. **Advanced Research Development:**

   The results of this research can also be a basis for further research in the field of sustainable construction materials. This could open the door to new discoveries and the development of more advanced technologies.

Thus, it can be concluded that the results of this research have great potential to change the paradigm in the construction industry towards more sustainable and environmentally friendly practices.

By describing the methodological steps used in this study, this section provides a clear understanding of how the research was conducted and how the data was analyzed. Next, the Results and Discussion section presents the main findings and implications of the study.

**Conclusions**

In this research, we have carried out a systematic evaluation of the literature on innovations in sustainable construction materials, with a focus on materials and production methods. Based on the analysis carried out, several important findings can be concluded:

Firstly, much progress has been made in the development of sustainable construction materials. Materials such as bamboo, eco-friendly concrete and recycled materials have shown significant potential in reducing carbon footprints and other environmental impacts.

Second, production methods have also undergone significant developments, with the use of advanced technology and more efficient construction practices. Green technology and the use of renewable energy are an important focus in efforts to increase production sustainability.

However, this research also identifies several challenges that need to be overcome in adopting sustainable construction material innovations, including high production costs, infrastructure limitations, and regulatory uncertainty.

In conclusion, innovations in sustainable construction materials promise great potential in reducing the environmental impact of the construction industry. However, greater efforts are needed to overcome existing challenges and accelerate the adoption of these innovations. This research provides valuable insights for stakeholders in the construction industry to guide future steps towards more sustainable development.

Thus, this conclusion summarizes the main findings of this research and highlights the importance of adopting sustainable construction materials innovation to achieve overall sustainable development.

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