Review Article
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Sustainable construction materials under ESG: a literature review and synthesis

Abstract

This paper aims to review the literature on 'Sustainable Construction Materials (SCMs)' based on the Scopus database and synthesise the review. Three advantages of embracing ESG in sustainable construction materials are identified based on the literature reviewed. Firstly, this can significantly reduce the environmental impact of buildings and contribute to achieving the United Nations' Sustainable Development Goals (UNSDGs). Secondly, by taking a comprehensive approach, decision-makers and practitioners can ensure that their choices align with environmental and financial sustainability and foster social well-being and equity. Thirdly, this can create healthier and more energy-efficient built environments for future generations. Fourthly, this will enable construction practitioners to make informed decisions that consider the holistic impacts of SCMs throughout their life cycle and promote greater transparency and accountability in their selection and use. On the challenge side, the triple bottom line of sustainability encompassing social, economic, and environmental aspects should be rigorously evaluated when considering sustainable construction materials. This integrated perspective is crucial for upholding the construction industry's commitment to UNSDGs and promoting a more responsible and green environment. Decision-makers and practitioners must prioritize implementing SCMs to positively impact the environment, society, and economy.

Keywords: construction materials, ESG, sustainability

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Introduction

Sustainable construction materials (SCMs) are becoming increasingly important in environmental, social, and governance (ESG) considerations.[1] These materials are essential for mitigating the negative impact of buildings on the environment, reducing greenhouse gas emissions, conserving natural resources, and promoting social well-being. In recent years, the construction industry has made significant strides in utilising SCMs, driven by the pressing need to address environmental concerns and contribute to socially responsible practices. This trend can be observed based on the many relevant papers published in the literature.[2–32] SCMs play a pivotal role in ensuring buildings' longevity and environmental compatibility. This article aims to delve into the importance of SCMs in ESG construction and explore the various materials that positively impact this sector.[2–11] The objective of this paper was to review the literature on the keywords 'Sustainable Construction Material' based on the Scopus database and synthesise the review.

Increasing number of knowledge on sustainable construction materials in the literature

On 10 January 2024, using the keywords 'Sustainable Construction Material', 500 papers were reached using the Scopus database, which had high relevancy. Bibliometric analyses are an established method to evaluate research literature, particularly in scientific fields benefiting from computational data treatment and witnessing increased scholarly output.[33] VOSviewer is a software that generates a clear graphical representation of bibliometric maps, especially for extensive datasets.[34] To highlight the trends of studies conducted on the topic of 'Sustainable Construction Material', from 1998-2024 (on 500 papers from the Scopus database; Table S1), we performed a bibliometric analysis using the VOSviewer software (VOS stands for visualization of similarities – see www.vosviewer.com). Scopus comprises many significant research papers and offers integrated analysis tools for creating informative visual representations.[35] VOSviewer was employed to analyze each keyword, calculating links, total link strengths, and co-occurrences with other keywords (Figure 1).

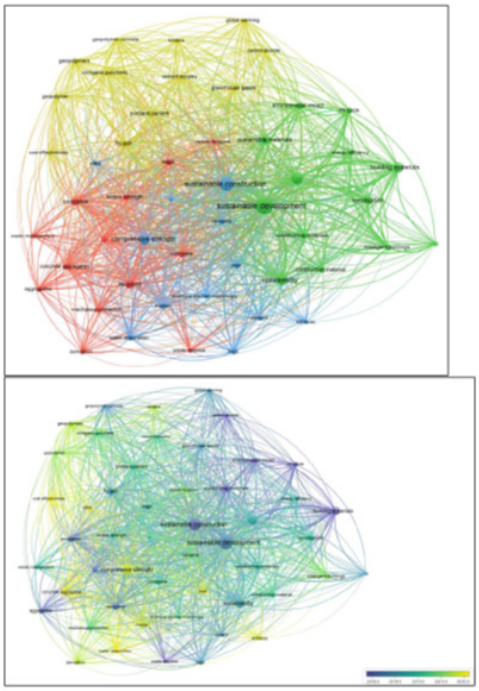

Figure 1 A bibliometric analysis of research themes on sustainable construction material.

Top Panel: Visualization of the paper network confirming the main themes of research. Bottom Panel: Evolution of research trends between 1998 and 2024 based on the Scopus database. The colours in the top panel indicate the themes of research that the papers are discussing, while the colours in the bottom panel indicate the year of publication. Five hundred papers with the keyword 'Sustainable construction material' in the article title, narrowed down to 50 keywords, based on the Scopus database searched on 10 January 2024.

This gives a holistic overview of the past research based on keywords' co-occurrences with 'Sustainable Construction Material' (Figure 1). The analysis reveals a discernible prominence reflecting three significant clusters that can be identified based on visualization in Figure 1 (top), such as a) sustainable development, b) sustainable materials, and c) compressive strengths. Many researchers [2019-2023] have recently focused on studies such as cost-effectiveness, mortar, water absorption, lime, additives, silica, concrete aggregates etc. (Figure 1; bottom).

Environmental Benefits Sustainable construction materials

This offers a range of environmental benefits. They help reduce the depletion of natural resources by utilizing renewable materials and minimizing waste generation. These materials also have a lower carbon footprint compared to conventional building materials, as they require less energy for production and contribute to reducing greenhouse gas emissions. SCMs often have better insulation properties, improving energy efficiency and reducing reliance on heating and cooling systems.[12] Four advantages of embracing ESG in SCMs are identified based on the literature reviewed.

a. Reduction of environmental impacts by embracing ESG in sustainable construction materials

This can significantly reduce the environmental impact of buildings and contribute to achieving the United Nations' Sustainable Development Goals (UNSDGs). Using SCMs in ESG construction can help mitigate the environmental impact of buildings, conserve natural resources, reduce greenhouse gas emissions, and improve energy efficiency.[13] Moreover, using eco-friendly building materials and methods helps minimize a building's environmental impact and offers significant financial benefits to owners.[14] These benefits include reduced energy consumption, lower maintenance costs, and potential savings through incentives and tax credits.[15] By selecting SCMs, building owners can contribute to the overall reduction of energy consumption in the construction and operation of buildings. This reduction in energy consumption positively impacts the environment and helps minimize the financial burden on building owners.[16] According to various sources, SCMs offer a range of environmental benefits by reducing the depletion of natural resources, minimizing waste generation, and lowering carbon emissions in the production and operation of buildings.[13] Using SCMs in ESG contributes to environmental well-being and benefits building owners financially.[17] Using eco-friendly building materials and methods in ESG construction is crucial for minimizing the environmental impact of buildings.[15]

The construction industry in the United States and globally plays a crucial role in the economy and society.[1] However, it also has a significant environmental impact due to the large amounts of materials used and the associated emissions and energy consumption.[20] To address this issue, there is a growing call for adopting sustainable construction materials and practices that embrace ESG principles.[36] These principles aim to reduce the environmental impacts of construction by focusing on various aspects, such as energy efficiency, emission reduction, use of renewable resources, recycling, and waste reduction.[1] By employing a midpoint life cycle impact assessment method, decision-makers can assess and understand the environmental impacts embedded in or emitted from new buildings. This can help guide selecting and using construction materials with lower environmental impacts, ultimately promoting more sustainable construction practices.[22] Moreover, applying life cycle assessment as a tool in sustainable construction material discourse can further advance the agenda of promoting sustainability in the construction industry. Sustainable construction materials are designed to minimise environmental impact and address broader social and governance concerns. In addition to reducing emissions and energy consumption, these materials are often sourced from companies prioritising fair labour practices and safe working conditions. Furthermore, governance ensures that these materials are produced and used transparently and ethically, adhering to regulations and standards that protect the environment and workers.

Incorporating sustainable construction materials into building projects requires a comprehensive approach considering the materials' entire life cycle, from extraction and manufacturing to construction and eventual disposal. By doing so, stakeholders can effectively evaluate the environmental and social implications of their choices, leading to more informed decision-making and a reduced ecological footprint. The life cycle assessment method provides a detailed understanding of how various construction materials impact the environment at different life cycle stages. This enables decision-makers to weigh the options based on a holistic view of their environmental impact, energy efficiency, and social considerations. As sustainable construction practices continue to gain traction, leveraging life cycle assessment as a decision-making tool will become increasingly important in promoting a more sustainable and responsible construction industry. By embracing ESG principles in selecting and using sustainable construction materials, stakeholders can effectively reduce their building projects' environmental impacts while contributing to a more sustainable and resilient built environment.[37] Additionally, these materials contribute to the overall goal of sustainable development as outlined by the UNSDGs. Furthermore, two effective methods for improving GBs' contribution to the UNSDGs were proposed.[18]

b. ESG in sustainable construction materials can enhance financial sustainability and foster social well-being and equity

By taking a comprehensive approach, decision-makers and practitioners can ensure that their choices align with environmental and financial sustainability and foster social well-being and equity. Embracing ESG principles in sustainable construction materials is crucial for achieving financial sustainability and fostering social well-being and equity.[1] By integrating environmental, social, and governance factors into the production and use of construction materials, companies can reduce their environmental impact, enhance their reputation, and attract socially responsible investors.[3] This can be achieved by using environmentally friendly materials, promoting energy efficiency, reducing waste and emissions, ensuring worker safety and fair labour practices, and promoting community engagement and social inclusivity in construction projects.[38] Additionally, adopting ESG principles in the construction materials industry can contribute to achieving the UNSDGs.[3] From the point of workers' safety, companies can prioritize using non-toxic construction materials that pose minimal health risks to workers during installation and use. This includes materials with low volatile organic compound emissions and those that do not contain hazardous substances such as lead, asbestos, or formaldehyde.

In addition, companies should ensure that proper safety protocols are in place during the production and handling of construction materials to minimize the risk of accidents and exposure to harmful substances. This includes providing protective gear, implementing safe handling procedures, and conducting regular training on workplace safety for all employees involved in the production and distribution of construction materials. Furthermore, companies can demonstrate

their commitment to worker safety by engaging in transparent and fair labour practices, providing a safe working environment, and adhering to regulations and standards related to occupational health and safety. By integrating these measures into their ESG strategy, companies in the construction materials industry can contribute to the well-being and safety of their workers while advancing sustainable and socially responsible practices.

From the point of industry profitability and business, integrating ESG principles into the production and use of construction materials can lead to various economic benefits. Companies prioritising environmental sustainability and social well-being will likely attract a larger market share and gain a competitive edge in the industry. Embracing ESG principles can also result in cost savings through improved efficiency in resource utilization, reduced waste, and lower operational risks. Moreover, by demonstrating a commitment to worker safety and fair labour practices, companies can enhance their reputation and brand value, ultimately increasing customer trust and loyalty. Additionally, adopting ESG principles can attract socially responsible investors and access to sustainable financing options, leading to long-term financial stability and growth opportunities. Consequently, integrating ESG principles in the construction materials industry leads to sustainable and socially responsible practices and contributes to long-term profitability and business success. Embracing ESG in sustainable construction materials can enhance financial sustainability and foster social well-being and equity.[39] From the point of social equity, companies can further enhance their ESG initiatives by focusing on the social impact of their construction materials. This includes promoting diversity and inclusion within their workforce and supply chain, supporting fair labour practices, and contributing to the well-being of local communities.

Companies can prioritize using locally sourced materials to support and empower local economies, create job opportunities, and reduce the environmental impact of transportation. Additionally, engaging with local communities to understand their needs and concerns can help design construction projects that align with the community's values and contribute to their development sustainably and inclusively. Furthermore, implementing ESG principles in social equity can also involve supporting education and skill development programs, especially in communities where construction projects are undertaken. By investing in education and training, companies can contribute to individuals' empowerment and social mobility, thus promoting a more equitable society.

By integrating social equity into their ESG approach, companies in the construction materials industry can achieve financial sustainability and operational efficiency and contribute to the well-being and empowerment of diverse stakeholders, including employees, communities, and society. This holistic approach to ESG can lead to a more inclusive and sustainable construction materials industry. Therefore, embracing ESG in sustainable construction materials can enhance financial sustainability and foster social well-being and equity by attracting socially responsible investors, accessing sustainable financing options, and building strong relationships with stakeholders.[40]

c. ESG in sustainable construction materials can promote high efficiency of energy usage

This can create healthier and more energy-efficient built environments for future generations. The use of SCMs under ESG can lead to significant environmental benefits, including reduced greenhouse gas emissions, conservation of natural resources, and improved energy efficiency.[3] Therefore, incorporating SCMs into ESG practices is essential for achieving environmental and financial sustainability in the building industry. This research demonstrates that SCMs play a vital role in achieving the UNSDGs by directly and indirectly contributing to various goals and indicators such as sustainable cities and communities, responsible consumption and production, climate action, and affordable and clean energy. Promoting High Efficiency of Energy Usage in Sustainable Construction Materials" The use of ESG in sustainable construction materials can greatly promote the high efficiency of energy usage.[20] Using ESG principles in sustainable construction materials can play a crucial role in promoting high efficiency of energy usage in the construction industry.[41] Incorporating ESG principles into the manufacturing and use of sustainable construction materials has a significant potential to enhance energy efficiency in the construction industry.[20] Using ESG principles in sustainable construction materials can lead to a high efficiency of energy usage, benefiting both the environment and the construction industry.[41] Using ESG principles in sustainable construction materials can promote high efficiency of energy usage, resulting in significant benefits for the environment and the construction industry. Implementing ESG principles in producing and utilising sustainable construction materials can substantially reduce energy waste. This reduction is crucial for minimizing the environmental impact and improving the overall efficiency of the construction industry. By driving the adoption of ESG principles, the construction sector can actively contribute to sustainable development and mitigate the negative effects of energy wastage on the environment. Additionally, prioritizing energy efficiency through ESG initiatives can significantly lower operating costs for construction projects while aligning with environmental stewardship. By integrating ESG principles into the selection and use of sustainable construction materials, the construction industry can achieve higher energy efficiency.

This can turn waste energy into useful energy, reduce carbon emissions, and minimize resource consumption in the construction process.[41] Furthermore, using ESG principles in sustainable construction materials can also contribute to achieving energy reduction and greenhouse gas mitigation targets throughout the entire lifecycle of a building.[22] The high efficiency of energy usage in sustainable construction materials, driven by ESG principles, can result in significant environmental and economic benefits for the construction industry.[42] For example, by using sustainable construction materials with high energy efficiency, buildings can reduce their reliance on traditional fossil-based energy sources, decreasing greenhouse gas emissions.[43] This reduction in energy consumption and carbon emissions helps mitigate the negative impact of construction on the environment and supports the transition to a low-carbon economy.[22] In addition, using ESG principles in sustainable construction materials can improve resource management and waste reduction.[44] This can lead to a more circular economy, where materials are reused or recycled, reducing the need for virgin resources and minimizing waste sent to landfills.[45] Overall, using ESG principles in sustainable construction materials can promote high efficiency of energy usage.[41] Using sustainable construction materials that adhere to ESG principles can promote high efficiency in energy usage by reducing waste, minimizing resource consumption, *and decreasing reliance on fossil fuels.[46] By incorporating ESG principles into selecting and using sustainable construction materials, the construction industry can achieve higher energy efficiency.[42]

d. ESG in sustainable construction materials can enhance greater transparency and accountability

This will enable construction practitioners to make informed decisions that consider the holistic impacts of SCMs throughout their life cycle and promote greater transparency and accountability

in their selection and use. The construction industry plays a crucial role in the United States, utilizing a substantial amount of materials and significantly impacting the environment.[12] To address the environmental concerns associated with the construction industry, integrating ESG principles into selecting and using sustainable construction materials can greatly enhance transparency and accountability. ESG principles focus on incorporating sustainable practices that consider the environmental impact, social responsibility, and ethical governance in business operations. By incorporating ESG principles into selecting and using sustainable construction materials, companies in the construction industry can demonstrate their commitment to environmental stewardship, social equity, and responsible governance.[40] This can result in greater transparency and accountability throughout the supply chain, as stakeholders can track and verify the construction materials' sustainability credentials.[12] Additionally, ESG in construction materials can provide measurable and quantifiable metrics to assess the environmental and social performance of materials.[24] From the point of accountability, companies in the construction industry can implement ESG reporting frameworks to ensure that they are transparent about their ESG practices. By regularly reporting on their ESG initiatives and the sustainability credentials of the construction materials used, companies can provide stakeholders with the necessary information to assess their performance in these areas. This level of transparency can build trust and confidence among investors, customers, and the wider community.

In addition, integrating ESG considerations into the selection and use of construction materials can lead to cost savings and operational efficiencies. Companies can optimize their material usage, reduce waste, and minimize environmental impact, ultimately contributing to long-term sustainable practices. By considering the entire life cycle of construction materials and their environmental and social attributes, companies can make informed decisions that align with ESG principles. Furthermore, embracing ESG in construction materials can also enhance the reputation of companies in the industry. Demonstrating a commitment to environmental stewardship and social responsibility can differentiate companies and attract environmentally-conscious clients and partners. Overall, integrating ESG principles into selecting and using sustainable construction materials is a strategic approach that improves transparency and accountability and contributes to long-term sustainability and competitiveness in the construction industry. ESG considerations in sustainable construction materials can enhance greater transparency and accountability throughout the supply chain, enabling stakeholders to track and verify the sustainability credentials of materials used and make informed decisions based on reliable information.[47] This level of transparency and accountability can drive positive change in the construction industry, promoting responsible practices and ultimately leading to a more sustainable built environment.[48] In conclusion, integrating ESG in sustainable construction materials enhances transparency and accountability by providing stakeholders with reliable information about environmental, social, and governance performance.[40]

To address these challenges and ensure the successful integration of SCMs in ESG projects, it is important to establish clear guidelines and standards for assessing and selecting SCMs.[1] Using a framework encompassing the triple bottom line of sustainability, including social, economic, and environmental aspects, material assessment criteria can be developed to ensure that SCMs are evaluated comprehensively and effectively. This will enable construction practitioners to make informed decisions that consider the holistic impacts of SCMs throughout their life cycle and promote greater transparency and accountability in selecting and using sustainable construction materials. The findings from this study can serve as a valuable reference for construction professionals and practitioners seeking to implement sustainable construction practices.[19] Additionally, it is important to consider the economic viability of sustainable construction materials.[1]

Challenges and dilemmas

While the use of SCMs in ESG construction is often touted for its environmental and financial benefits, there are some opposing arguments to consider. One of the main criticisms is that SCMs, especially those considered "eco-friendly," may have a higher initial cost than traditional building materials. This cost barrier may deter some builders and developers from incorporating SCMs into their projects, especially in cases where the financial benefits are not immediately apparent or guaranteed. Another opposing viewpoint is that the production of some SCMs may require significant energy inputs and resources, negating the environmental benefits they are meant to provide. For example, producing certain types of SCMs may result in higher carbon emissions or other environmental impacts during extraction, processing, or transportation, offsetting the intended ecological advantages. Furthermore, it is argued that the performance and longevity of SCMs may not always meet the same standards as traditional building materials. This could lead to increased maintenance costs and shorter lifespans, potentially undermining the promised economic and environmental benefits.

Considering these opposing arguments when evaluating the use of SCMs in ESG construction is important, as they highlight potential challenges and drawbacks that should be carefully weighed against the perceived benefits. However, it is worth noting that the construction industry is a major contributor to environmental degradation and resource depletion.[1] Therefore, finding sustainable alternatives to traditional construction materials is crucial for the industry's transition towards more environmentally responsible practices.[20] Despite the challenges and opposing arguments, it is essential for decision makers to prioritize the use of SCMs in ESG construction.[21] By doing so, they can significantly reduce the environmental impact of buildings, contribute to the achievement of UNSDGs, and create healthier and more energy-efficient built environments for future generations.[22]

On the challenge side, the triple bottom line of sustainability encompassing social, economic, and environmental aspects should be rigorously evaluated when considering sustainable construction materials.

Social impact

Sustainable construction materials have the potential to positively impact local communities by promoting job creation, skill development, and a more inclusive workforce. This enhances social equity and fosters greater community engagement throughout the construction process. Additionally, using non-toxic and low-emission materials contributes to healthier indoor environments, safeguarding the well-being of occupants and construction workers.

Economic viability

While initial costs may be a concern, it is important to consider the long-term economic benefits of sustainable construction materials. Life cycle cost analysis can reveal significant savings regarding reduced maintenance, lower energy consumption, and potential incentives or tax credits. Moreover, investments in SCMs can stimulate innovation, market growth, and long-term cost savings in the construction industry.

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Environmental Considerations

The environmental impact of construction materials extends beyond their use phase. Assessing the sourcing, production, transportation, and end-of-life management of materials is essential in understanding their overall environmental footprint. By selecting materials with lower embodied energy, minimal waste generation, and recyclability, construction projects can significantly reduce their environmental impact and contribute to preserving natural resources and ecosystems.[11,22–30] By taking a comprehensive approach to evaluating sustainable construction materials, decision-makers and practitioners can ensure that their choices align with environmental and financial sustainability and foster social well-being and equity. This integrated perspective will enable the construction industry to uphold its commitment to sustainable development goals and pave the way for a more responsible and resilient built environment. Use the following sources if appropriate.[31] Despite that, it is difficult for decision-makers to ascertain the environmental impacts embedded in or emitted from new buildings, as there is no agreed-upon approach to measure and compare sustainability performance.[32] In conclusion, while there are legitimate opposing arguments against using sustainable construction materials in ESG projects, the imperative for the construction industry to transition towards more environmentally responsible practices cannot be overstated. Despite the potential initial cost barriers and concerns about performance and longevity, the long-term benefits of sustainable construction materials in terms of environmental impact, cost savings, and social well-being are significant.

Conclusion

Decision-makers need to prioritize using sustainable construction materials in ESG projects to reduce the environmental impact of buildings significantly, contribute to the achievement of the UNSDGs, and create healthier and more energy-efficient built environments for future generations. By establishing clear guidelines and standards for assessing and selecting SCMs, the construction industry can ensure the successful integration of these materials into projects. This will enable construction practitioners to make informed decisions that consider the holistic impacts of SCMs throughout their life cycle and promote greater transparency and accountability in their selection and use.

Furthermore, the triple bottom line of sustainability encompassing social, economic, and environmental aspects—should be rigorously evaluated when considering the use of sustainable construction materials. By taking a comprehensive approach, decision-makers and practitioners can ensure that their choices not only align with environmental and financial sustainability but also foster social well-being and equity. This integrated perspective is crucial for upholding the construction industry's commitment to sustainable development goals and promoting a more responsible and resilient built environment. In closing, adopting sustainable construction materials in ESG projects is essential for mitigating environmental degradation and resource depletion caused by the construction industry. Decision-makers and practitioners must prioritize the implementation of SCMs to create a positive impact on the environment, society, and the economy.

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Conflicts of interest

The authors declare that there is no conflict of interest.

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References

1. Park J, Yoon J, Kim K. Critical review of the material criteria of building sustainability assessment tools. *Sustainability.* 2017;9(2):186.
2. Song Y, Hong Z. Research on sustainability of building materials. *IOP Conf Ser Mat Scie Eng.* 2018;452(2):022169–022169.
3. Omer MA, Noguchi T. A conceptual framework for understanding the contribution of building materials in the achievement of sustainable development goals (SDGs). *Sust Cities Soc.* 2020;52:101869.
4. Okoye PU, Odesola IA, Okolie KC. Evaluating the importance of construction activities for sustainable construction practices in building projects in Nigeria. *J Sust Constr Mat Technol.* 2020;5(2):430–439.
5. Joseph P, Tretsiakova McNally S. Sustainable non-metallic building materials. *Sustainability.* 2010;2(2):400–427.
6. Sfakianaki E. Critical success factors for sustainable construction: a literature review. *Manage Environ Qual.* 2019;30(1):176–196.
7. Prameswari FR, Rachamawati F, Wiguna IPA, et al. Importance and performance ratings analysis for implementation of green construction on building project. *IOP Conf Ser Earth Environ Sci.* 2021;799(1):012015.
8. Hossain MU, Sohail A, Ng ST. Developing a GHG-based methodological approach to support the sourcing of sustainable construction materials and products. *Resour Conser Recyc.* 2019;145:160–169.
9. Baharetha SM, Al-Hammad A, Alshuwaikhat HM. Towards a Unified Set of Sustainable Building Materials Criteria. 2012.
10. Nair A, Nayar SK. Key performance indicators of sustainability. *IOP Conf Ser Earth Environ Sci.* 2020;491(1):012047.
11. Kumar S, Puri V, Aggarwal M. Review of sustainability building materials for construction industry. *Int J Tech Res Sci.* 2020;Special 3:1–8.
12. Horvath A. Construction materials and the environment; 2004.
13. Czajkowska A. The role of sustainable construction in sustainable development; 2018.
14. Sev A. How can the construction industry contribute to sustainable development? A conceptual framework. Sustainable Development; 2008.
15. Reddy VS. Sustainable construction: analysis of its costs and financial benefits. *IJIREM.* 2016;3(6):522–525.
16. Shurrab J, Hussain M, Khan M. Green and sustainable practices in the construction industry. Engineering, Construction and Architectural Management; 2019.
17. Joseph P, Tretsiakova-McNally S. Sustainable non-metallic building materials. *Sustainability.* 2010;2(2):400–427.
18. Wen B, Musa SN, Onn CC, et al. The role and contribution of green buildings on sustainable development goals. *Building and Environment.* 2020;185.
19. Omer MA, Noguchi T. A conceptual framework for understanding the contribution of building materials in the achievement of Sustainable Development Goals (SDGs). *Sustainable Cities and Society.* 2020;52.
20. Ahn CR, Lee SH, Peña-Mora F, et al. Toward environmentally sustainable construction processes: The U.S and Canada's perspective on energy consumption and GHG/CAP emissions. *Sustainability.* 2010;2(1):354–370.
21. Ng STT, Chan JH, Chan GK, et al. Environmental impacts of construction material production. In *Proceed Inst Civil Eng Eng Sust.* 2016;170(3):169–184.

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22. Mirabella N, Röck M, Saade MRM, et al. Strategies to improve the energy performance of buildings: a review of their life cycle impact. 2018;8(8):105.

23. Huang B, Gao X, Xu X, et al. A life cycle thinking framework to mitigate the environmental impact of building materials. *One Earth*. 2020;3(5):564–573.

24. Zhu J, Xu J. Driving Factors of green supply chain management in building materials enterprises. *IOP Conf Ser Earth Environ Sci.* 2019;295(2):012063.

25. Kotaji S, Schuurmans A, Edwards S, (Editors). *Life-cycle assessment in building and construction: a state-of-the-art report; 2003*.

26. Manjunath A, Patil NN. Effect of SCMs on embodied energy, carbon footprint and cost for a proposed conventional apartment. *IOP Conference Series: Materials Science and Engineering*. 2021;1166(1):012037.

27. Bribián IZ, Capilla AV, Usón AA. Life cycle assessment of building materials: Comparative analysis of energy and environmental impacts and evaluation of the eco-efficiency improvement potential. *Building Environ.* 2011;46(5): 1133–1140.

28. Campos TND, Machado MK, Vernalha EBR. Building lifecycle and sustainable development. *Encyclopedia of Sustainability in Higher Education*. 2019;122–130.

29. Danso H. Dimensions and indicators for sustainable construction materials: a review. *Research & Development in Materials Science.* 2018;3(4).

30. Thiel CL, Campion N, Landis AE, et al. A materials life cycle assessment of a net-zero energy building. *Energies.* 2013;6(2):1125–1141.

31. Zhao W, Ye R. Research on sustainable development of construction industry. 2019.

32. Song Y, Hong Z. Research on sustainability of building materials. *IOP Conf Ser Mater Sci Eng.* 2018;452(2):022169.

33. Ellegaard O, Wallin JA. The bibliometric analysis of scholarly production: how great is the impact? *Scientometrics.* 2015;105(3):1809–1831.

34. Van Eck N, Waltman L. VOSviewer, a computer program for bibliometric mapping. *Scientometrics*. 2010;84(2):523–538.

35. Guz AN, Rushchitsky JJ. Scopus: A system for the evaluation of scientific journals. *Int Appl Mechan.* 2009;45: 351–362.

36. Krueger K, Stoker A, Gaustad G. Alternative materials in the green building and construction sector. *Smart and Sustainable Built Environment.* 2019.

37. Ortiz O, Castells F, Sonnemann G. Sustainability in the construction industry: A review of recent developments based on LCA. *Construction and Building Materials.* 2009;23(1):28–39.

38. Zhao Z, Zhao X, Davidson K, et al. A corporate social responsibility indicator system for construction enterprises. *Journal of Cleaner Production*. 2012;29:277–289.

39. Tan Y, Shen L, Yao H. Sustainable construction practice and contractors' competitiveness: A preliminary study. *Habitat International.* 2011;35(2):225–230.

40. Xia B, Olanipekun AO, Chen Q, et al. Conceptualising the state of the art of corporate social responsibility (CSR) in the construction industry and its nexus to sustainable development. *Journal of Cleaner Production*. 2018;195:340–353.

41. Wang N, Xu C. Application of new green energy-saving technology in construction engineering. *IOP Conf Ser: Earth Environ Sci;* 2020.

42. Amaral RE, Brito J, Buckman M, et al. Waste management and operational energy for sustainable buildings: a review. *Sustainability*. 2020;12(13):5337.

43. Zhou L. Research on application of building energy saving and emission reduction technology in civil engineering. *IOP Conf Ser Earth Environ Sci*; 2020.

44. Zhao C, Zhang W, Zhang M, et al. Energy saving construction technology analysis of building engineering. *IOP Conf Ser Earth Environ Sci;* 2021.

45. Alqahtani H, Alareeni B. Evaluation of sustainable buildings construction in the? Kingdom of Bahrain. *IOP Conf Ser Earth Environ Sci;* 2020.

46. Shurrab J, Hussain M, Khan M. Green and sustainable practices in the construction industry: A confirmatory factor analysis approach. *Emerald Group Publishing Limited*. 2019;26(6):1063–1086.

47. Cataldo I, Banaitienė N, Banaitis A. Developing of sustainable supply chain management indicators in construction. *EDP Sciences.* 2021;263:05049.

48. Benachio GLF, Freitas MCD, Tavares SF. Green supply chain management in the construction industry: a literature review. *IOP Conf Ser Earth Environ Sci.* 2019.