Tropical Environment, Biology, and Technology

Review
Volume 2(2), 2024, 80–92
https://doi.org/10.53623/tebt.v2i2.482

The Shift Towards Green Construction: A Review of Environmental Management Strategies and Sustainable Materials in Developed Countries

Brendan Sen[1], Nicholas Tam[2]*, Rabin Maharjan[3], Amit Kumar Maharjan[4], Gaurav Talukdar[5]

[1]ADV Environment, Jalan University, 46200 Petaling Jaya, Selangor, Malaysia
[2]Faculty of of Civil and Environmental Engineering, Warsaw University of Life Sciences, Nowoursynowska 166, 02-787, Warsaw, Poland.
[3]Department of Civil Engineering, Pulchowk Campus, Institute of Engineering, Tribhuvan University, Nepal
[4]Organization for Public Health and Environment Management, Lalitpur Metropolitan City – 10, Nepal
[5]Kansas Geological Survey, University of Kansas Lawrence, Kansas, 66045, USA

*Correspondence: tamnfy@gmail.com

SUBMITTED: 27 August 2024; REVISED: 3 October 2024; ACCEPTED: 7 October 2024

ABSTRACT: Green materials have proven to be highly effective in managing environmental impacts when implemented in construction activities. The aim of this review paper is to critically examine the shift towards green construction practices in developed countries, with a focus on the integration of environmental management strategies and the use of sustainable materials. Currently, developed countries such as Switzerland, Japan, and China have significantly benefited their local environments by implementing these practices in the construction industry. Authorities and governments in these nations have taken proactive steps to establish standards and policies for the construction sector, encouraging more industries to participate in environmental management and protection efforts. The enforcement of rules and regulations in these developed countries has led the construction industry to prioritize environmental management and protection. The use of green materials in construction projects, including autoclaved aerated concrete blocks and green roof technology, has shown positive trends in advancing environmental protection and management. Developing countries are encouraged to adopt similar initiatives and utilize green materials in their construction industries to help secure the importance of environmental sustainability.

KEYWORDS: Environment, green materials, management, developed countries

1. Introduction

Construction has been an ongoing activity for centuries across the globe, shaping the infrastructure of civilizations and enabling societal growth. In recent years, there has been a significant shift in how construction is approached, particularly in developed countries where environmental concerns have become a priority. These nations have increasingly adopted greener construction practices, integrating environmental management strategies and utilizing sustainable materials [1]. This movement toward green construction reflects not only technological advancements but also a response to the growing awareness of the environmental impact of traditional construction methods. The United States currently leads the global effort in implementing and constructing green buildings, with China and Canada following closely behind [2]. This leadership position underscores the United States' commitment to sustainable development, where the use of green materials and environmentally friendly construction techniques has become standard practice. The focus on green construction is part of a broader trend in developed countries to incorporate sustainability into all aspects of socio-economic development.

Developed countries are those that have reached a specific level of socio-economic advancement, often measured by their Gross Domestic Product (GDP) and the overall quality of life for their citizens. These nations typically exhibit high standards of living, advanced technology, and robust infrastructure. In addition to economic indicators, developed countries are characterized by their well-established education systems and high levels of industrialization. These factors contribute to the capacity of developed nations to invest in and implement green construction practices effectively. According to literature, several countries are recognized as developed, including South Korea, Australia, Canada, Japan, Italy, the United States, Germany, France, Spain, the United Kingdom, Switzerland, and Belgium. These countries share common traits such as advanced technological capabilities, high economic output, and a commitment to sustainable development. In the context of construction, these traits enable them to lead in the adoption of green building practices [3, 4].

In contrast, developing countries face numerous challenges in adopting green construction practices, which can hinder their progress toward sustainability. Key barriers include limited financial resources, inadequate infrastructure, and lack of access to advanced technologies [5]. Unlike developed nations, where investment in green technologies is often supported by strong financial markets and government incentives, many developing countries struggle to secure funding for sustainable construction projects. This financial limitation can restrict the ability to adopt innovative building materials and practices that are essential for green construction. Developing countries often grapple with regulatory frameworks that are not conducive to sustainability. In many cases, building codes and environmental regulations may be outdated or poorly enforced, making it difficult to promote green building standards. Furthermore, there is often a lack of awareness and education about green construction practices among stakeholders, including policymakers, builders, and the general public. This knowledge gap can hinder the effective implementation of sustainable practices and reduce the demand for green buildings [6].

Cultural factors and societal attitudes toward traditional construction methods also pose challenges. In many developing countries, conventional construction practices may be deeply ingrained, making it difficult to shift toward more sustainable approaches. There may be a perception that green construction is more expensive or less reliable, which can deter stakeholders from considering it as a viable option [7]. Infrastructure limitations in developing regions can complicate the adoption of green technologies. For instance, inadequate waste management systems may hinder recycling efforts, and limited energy access can restrict the use of energy-efficient solutions. In contrast, developed countries often have the infrastructure in place to support the widespread adoption of green technologies, such as efficient public transport systems and advanced waste management facilities [8, 9].

The United States' leadership in green construction can be attributed to several factors. Firstly, there is a strong regulatory framework that encourages sustainable practices, including building codes and standards that mandate energy efficiency and the use of environmentally friendly materials. Additionally, there is significant market demand for green buildings, driven by the recognition of both public and private sectors regarding the long-term economic and environmental benefits of sustainable construction [9, 10]. In China, rapid urbanization and industrialization have prompted the government to adopt green building practices to mitigate the environmental impact of construction. The Chinese government has implemented policies that encourage the development of green buildings, such as subsidies for energy-efficient projects and stringent environmental regulations for new constructions [11]. Similarly, Canada has embraced green construction, focusing on reducing the carbon footprint of buildings and promoting the use of sustainable materials. Canadian construction practices often emphasize energy efficiency, waste reduction, and the use of locally sourced, renewable materials [12].

In these developed countries, the adoption of green construction practices is not just a trend but a necessity driven by the need to address climate change and environmental degradation. The construction industry is a significant contributor to global greenhouse gas emissions, and the shift toward sustainable building practices is crucial in reducing these emissions. Green buildings are designed to minimize energy use, reduce waste, and utilize materials that have a lower environmental impact compared to traditional construction materials. Moreover, the emphasis on green construction in developed countries reflects a broader societal shift toward sustainability. Consumers and businesses alike are increasingly prioritizing environmentally responsible practices, and this is reflected in the growing demand for green buildings. In turn, this demand drives innovation in the construction industry, leading to the development of new technologies and materials that further enhance the sustainability of buildings [7-10]. The aim of this review paper is to critically examine the shift toward green construction practices in developed countries, focusing on the integration of environmental management strategies and the use of sustainable materials.

2. Current Status and Government Policy on Environmental Management Practice

The current status of environmental management practices and government policies in some countries is shown in Figure 1. In Switzerland, industrial activities, including construction or infrastructure projects that may have a negative impact on the environment, require specific permits before operations can commence. An environmental impact assessment (EIA) must also be conducted for construction activities to determine whether the project complies with the provisions and regulations set by local authorities. To perform this assessment, the applicant or project proponent must investigate the potential adverse effects of the construction activity on the environment. The preparation of a report includes documenting the initial state of environmental conditions before construction, detailing the project and the construction activities planned, identifying possible adverse impacts at the construction site, and outlining mitigation measures to reduce negative effects. The relevant authorities responsible for assessing the environmental impact of the construction project will evaluate the EIA report, along with recommendations from other authorities, to ensure compliance with environmental regulations [13].

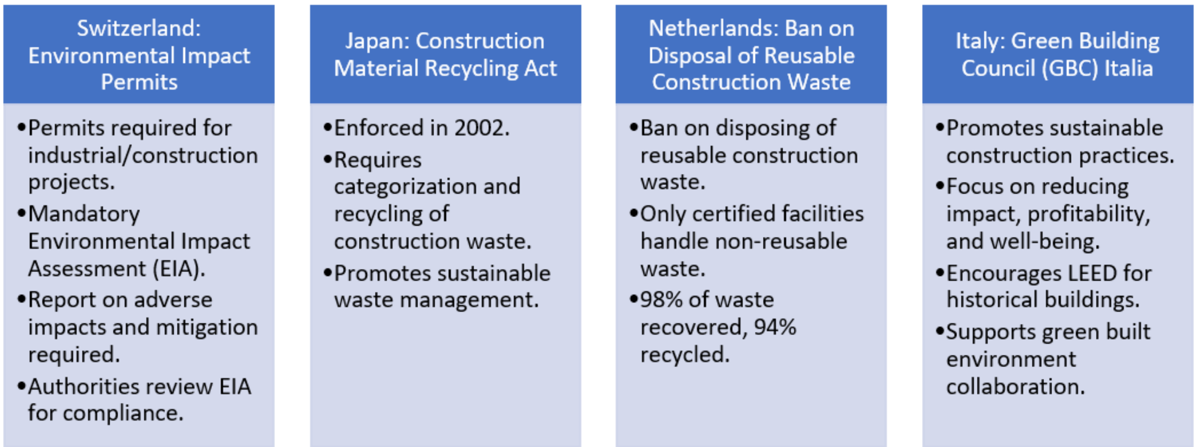

Figure 1. Current status and government policy on environmental management practice in some countries.

In Japan, the Construction Material Recycling Act, enforced in 2002, mandates that construction teams categorize specific construction materials or waste of defined sizes that have been demolished from a building or generated during construction. This regulation enables the recycling and reuse of construction materials or waste instead of merely disposing of them [14]. In the Netherlands, a national ban has been imposed on the disposal of reusable construction and demolition waste, permitting only certified crushers or sorters to dispose of non-reusable waste [15]. Waste classified as construction and demolition waste includes asbestos and asbestos-containing materials, dredging materials, aerated concrete, roofing waste, glass, gypsum, fiber optic cables, wood, paper or plastic-insulated cables and remnants, stone materials, grit, tar-containing asphalt, contaminated soil, and packaging for paint, adhesive, sealant, and resin. These materials must be recycled, reused, recovered, or backfilled to reduce the amount of waste sent to landfills. According to recorded statistics, over 98% of construction and demolition waste was recovered in 2012, with the highest portion—94%—being recycled [16].

Green Building Council (GBC) Italia is a non-profit organization founded to promote sustainable design and construction management practices. Its objective is to reduce adverse environmental impacts while improving the profitability of companies and enhancing the health and well-being of individuals in buildings. GBC Italia encourages the LEED certification system, which has developed a specific rating system for certifying historical architecture. This rating system addresses the restoration of historical buildings and the preservation of global cultural heritage. It is believed that this initiative fosters collaboration among various sectors of the property and construction industry and all stakeholders to develop a green built environment in Italian society that aligns with traditional architecture, culture, and the Italian landscape. This demonstrates the Italian community's commitment to promoting green building practices, especially for historical structures [7, 17].

Japan and China are both focusing on green building programs that incorporate sustainable design and construction while considering local economies, human needs, and environmental aspects. Both countries utilize wood-based building materials in their construction industries. A survey indicated that Japanese builders regard wooden materials as the most environmentally friendly structural building option compared to other materials evaluated in the study. Additionally, the results showed that Japanese green building programs create market value for various types of U.S. value-added wooden-based materials intended for constructing CASBEE-Sumai houses, which are built under the green building initiative. The Japanese government also provides subsidies to individuals who purchase houses, as well as to contractors who build using domestic woods. Consequently, this program encourages more buyers and contractors to purchase and construct homes with domestic wood, simultaneously enhancing environmental benefits [9, 18].

3. Overview of planning and propose of environmental management practice

Recycling construction and demolition waste has been practiced in Zurich, where these wastes have been calculated to account for 25–30% of the waste produced in the city. The materials that can be recycled include concrete, bricks, gypsum, wood, glass, metals, and other construction materials, which helps reduce the contribution of waste to landfills. This action is taken in line with the EU Circular Economy Action Plan, which states that recovering valuable resources from waste produced in the construction and demolition sectors is crucial. The materials that are recycled can replace some of the ingredients used in concrete production, known as aggregates. The city has been implementing the use of recycled concrete aggregates in public building construction projects for more than 15 years. Additionally, cement production contributes significantly to greenhouse gas emissions, as the production of clinker, which is the material needed to produce cement, generates more than 70% of concrete's greenhouse gas emissions. Therefore, in addition to recycling concrete, the city of Zurich also replaces standard cement with CEM III/B2, which substitutes about 80% of clinker with slag-sand, allowing for a reduction in greenhouse gas emissions of up to 30% during cement production [19, 20].

In Canada, the Construction Environmental Management Plan (CEMP) has been implemented for construction projects. Contractors following this CEMP must assume environmental responsibilities, including consistently meeting existing environmental laws, regulations, and other requirements, avoiding actions that could lead to negative environmental impacts or pollution, ensuring that all work complies with Standard Specifications and Special Provisions, and, most importantly, recovering or improving the condition of any habitat affected by negative environmental impacts. Environmental Monitoring (EM) is also included in the CEMP to ensure that environmental conditions are prioritized in all construction projects. The monitoring schedule encompasses oversight of the erosion and sediment control measures implemented at the construction site, evaluation of the performance of protective measures for drainage systems, monitoring machinery present at the construction site for possible leaks due to on-site operations and maintenance, and reporting any necessary clean-up of spills to the project representative [21, 22].

Additionally, the government has implemented policies related to green technology. These policies have been categorized into two groups: market-based instruments and non-market instruments. Market-based instruments target taxes related to environmental policies and establish systems for controlling and permitting pollution emissions. In contrast, non-market instruments focus on command-and-control regulations, policies that support the utilization of new and smart technologies, and voluntary actions. According to the article, the most effective single policy for reducing adverse environmental impacts is setting a price on the source of pollution or imposing taxes to decrease emission levels. The association of various policies allows different sources of environmental issues to be addressed, ensuring that a wider range of environmental challenges can be managed. This framework holds companies and individuals accountable for environmental damages, as the funds generated can be allocated for mitigation or remediation processes [23].

The use of bar-coding system technology has been implemented through an incentive reward program (IRP) among construction workers. This bar-coding system aims to reduce the generation of construction waste by tracking real-time data on new materials, unused materials, packing debris, materials used for construction, and transferring this data to project management systems and headquarters through an online platform. With the bar-code labeling shown in the figure above, this system facilitates the reduction of wasted materials, as any transfer of materials—such as withdrawals or restocking—is recorded when bar-code labels on the materials are scanned, allowing for constant monitoring of material movements. Immediate actions can be taken to resolve any problems, such as incorrect material withdrawals, ensuring that workers on-site understand any mistakes made, allowing for prompt adjustments [24].

Based on a review of Australia's green building evaluation, Life Cycle Assessment (LCA) has been adopted. LCA is a method that assesses the potential impacts of certain processes or materials on environmental aspects over the product's lifetime. It is a valuable method for compiling information and data on the energy and materials required for any construction project while evaluating potential negative environmental impacts that may arise during or after construction. As noted, LCA provides significant benefits in terms of sustainability assessment at multiple stages [25, 26].

The use of recycled materials in the production of ceramic tiles is also a common environmental management practice among certain companies. It is known that 80% of the recycled materials have been reincorporated into the manufacturing of ceramic tiles. Furthermore, waste generated during the manufacturing process is also recycled to become part of the raw materials for tile production. According to the article, researchers are currently exploring the use of waste materials from both ceramic and non-ceramic industries to be incorporated into ceramic compositions as a method to reduce or replace traditional raw materials or to produce new products with different applications [27].

4. Current Situation of Green Materials for Construction

4.1. Co-incineration of waste material for cement kilns process.

Cement, as the main component required in construction projects, produces a significant amount of carbon dioxide, one of the most common greenhouse gases, during its production processes. Operating kilns requires the burning of fossil fuels, which contributes approximately 40% of carbon dioxide emissions [28]. Therefore, an alternative method for operating the kilns is co-incineration of waste materials to generate the necessary energy for cement production. Waste materials can include various types of waste, such as wood and plastics from demolition activities, as well as industrial and municipal sewage sludge. This practice has been implemented in Germany, where replacing fossil fuels with waste materials has reduced reliance on conventional energy sources and minimized the disposal of waste in landfills. When the co-incineration process is executed properly and at standardized locations, the release of carbon dioxide and sulfur dioxide from hazardous materials, along with other hazardous gases, can be effectively managed. Additionally, burning biomass, including animal and agricultural waste, for kiln operation can positively impact carbon dioxide emission reduction. Reports indicate that European countries have achieved a 70% substitution rate using this alternative energy generation method, with the UK showing a 40% substitution rate [29]. This illustrates the beneficial use of waste materials rather than their mere disposal in landfills.

4.2.New ceramic tiles.

In the Spanish Ceramic Tile Industry (SCTI), the development of green ceramic tiles has emerged as a significant innovation in the construction sector. Thinner ceramic tiles are currently under development, making the manufacturing process more environmentally friendly. The production of these thinner tiles requires a reduced amount of raw materials, potentially decreasing usage by up to 50%, which includes energy and water consumption during manufacturing, transportation, and storage of the final ceramic tiles. It has been reported that ceramic tiles can effectively remove nitrous oxide compounds from the air. Furthermore, they require less water and fewer cleaning products for maintenance, thereby reducing their adverse environmental impact. Ceramic tiles can also create a ventilated facade that enhances building thermal insulation and can act as photovoltaic plates resistant to ultraviolet radiation [27]. These tiles are typically installed in public areas, such as road pavements, where they are constantly exposed to weathering. Importantly, when exposed to high temperatures, these ceramic tiles do not release volatile organic compounds (VOCs) into the atmosphere. VOCs can cause negative health impacts, including irritation of the eyes, nose, and throat, headaches, and some compounds are known to be carcinogenic [30]. Thus, the development and implementation of ceramic tiles in constructed buildings can provide significant positive environmental effects.

4.3.Utilization of carbon dioxide.

In Germany, research into the capture and utilization (CCU) of carbon dioxide has received funding from the Federal Ministry of Education and Research (BMBF). Technologies for utilizing carbon dioxide in the construction industry have been developed, and local governments have supported projects related to carbon dioxide capture and utilization. According to the article, utilizing carbon dioxide in the synthesis of basic chemicals can expand the raw material base for the chemical industry. Carbon dioxide can also serve as energy storage for chemical compounds and act as a catalyst for necessary chemical reactions and activation. Researchers have found that utilizing carbon dioxide to produce new materials, such as carbon dioxide-based mattresses, can reduce carbon dioxide emissions by approximately 20% compared to the production of conventional mattresses or foam products [31, 32].

4.4.Eco-labels.

The introduction of eco-labels in the construction industry secures both economic and environmental benefits. Eco-labels enable owners or operators to make informed decisions by providing information regarding economic value and efficiency in environmental preservation. They serve as a form of sustainability reporting, indicating whether a product meets predefined criteria. Wood-based products are commonly used in the construction industry, and the Forest Stewardship Council (FSC) certifies wood products sourced from sustainably managed forests. This organization also certifies final products made from wood harvested from these certified forests. By labeling wood-based building products with eco-labels, personnel involved in managing construction projects can select these certified materials to ensure they are environmentally friendly [33].

5. Green Materials Technologies

5.1. Autoclaved aerated concrete (AAC).

In many developed countries, autoclaved aerated concrete (AAC) blocks have gained widespread use in the construction industry. AAC is considered a green concrete, produced from materials such as industrial fly ash, rice husk ash, sunflower shell ash, pumpkin ash, and ground-granulated blast furnace ash. The use of AAC blocks is environmentally sustainable, as it incorporates a significant amount of industrial waste. These aggregates account for 65% to 75% of the total volume of the concrete [34]. The advantages of AAC blocks include their lightweight nature, ability to withstand high loads, excellent insulation properties, and increased durability, as they weigh three times less than traditional red bricks. The incorporation of industrial waste, such as fly ash, is eco-friendly and sustainable, as this material is non-toxic, does not release harmful gases, and requires less energy during the manufacturing process. AAC blocks reduce the dead load of constructed buildings, facilitating the construction of taller structures. The presence of air pores and thermal mass in AAC blocks enhances thermal insulation, which helps lower electricity costs for buildings by reducing heat transfer between walls and ceilings made with AAC blocks. Additionally, AAC blocks possess excellent fire-resistant properties, being non-combustible and able to withstand direct fire exposure for up to six hours [35].

However, there are some disadvantages associated with AAC blocks. Construction during rainy weather can cause the blocks to crack after installation. This issue can be mitigated by using lower mortar strength and ensuring the AAC blocks are dry during and after installation. AAC blocks also require careful handling, as they are more brittle than clay bricks, to prevent breakage prior to installation. After construction, only longer and thinner screws should be used, along with wood-suitable drill bits or hammering methods, to install cabinets or wall hangings on AAC walls due to their brittleness [35, 36]. Additionally, building insulation requires supplementary insulating materials to comply with the National Construction Code (NCC) in Australia. Typically, texture coating and plasterboard internal linings are used in conjunction with AAC blocks after they have been completely installed. These additional materials are essential for ensuring compliance with NCC provisions, especially for AAC walls with a thickness of 200 mm [37].

5.2. Green roofing.

A green roofing system is a surface designed to support vegetation, which can also be referred to as roof gardens. The vegetation in a green roof system can range from a few centimeters to over a meter in depth, depending on the management of the roof garden. The structure of a green roof can be seen in the image below, located on top of a building. The concept of green roofs was initially researched in Germany, Switzerland, and Scandinavia, leading to the development of guidelines and standards, with the most recognized being the FLL Guidelines by the German Landscape Research, Development and Construction Society. Green roof systems are widely implemented in Europe, as they effectively manage stormwater, reduce energy usage for building cooling, mitigate the urban heat island effect, and provide habitats for wildlife species [38]. In China, many buildings traditionally feature concrete roofing, which traps heat inside. Moreover, concrete-paved roads contribute to increased surface rainwater runoff, elevating the risk of flooding. In response, Chinese authorities have begun implementing green roof systems to allow buildings to cool internally, reducing reliance on air conditioning. Additionally, green spaces and surfaces integrated into city roads help absorb surface rainwater, decreasing runoff and the potential for flooding [39].

The advantages of implementing green roof technology are significant. Green roofs can lead to substantial electricity cost savings by providing a natural cooling effect for buildings. The plants or vegetation on the roof absorb heat, reducing roof temperatures. In winter, green roofs provide thermal insulation, preventing heat loss from the building. Consequently, green roofs reduce the need for air conditioning and heating systems, thereby lowering electricity consumption. Moreover, green roofs improve surface rainwater management, as plants can absorb and store rainwater, decreasing the volume released into the environment and minimizing flooding risks. Additionally, green roofs can extend the lifespan of the building's roof. The vegetation acts as a protective barrier for the waterproof membrane beneath, safeguarding it from damage caused by rain and corrosion. Most importantly, green roofs contribute to reducing carbon dioxide emissions from buildings. By lowering the need for heating and cooling systems, carbon dioxide emissions decrease, while plants absorb surrounding carbon dioxide. Green roofs can also provide habitats for wildlife; a survey conducted in Switzerland found 172 separate species on 11 green roofs. Furthermore, green roofs can enhance air quality by reducing levels of sulfur dioxide by 37%, nitrous acid by 21%, and dust particles in the atmosphere by 0.2 kg [40, 41]. However, implementing green roofs can increase installation costs compared to traditional roofs, as additional structural support may be needed to accommodate the extra weight. Furthermore, ongoing maintenance is essential to ensure the longevity of the green roof system. Given that a green roof functions as a garden, knowledgeable individuals must oversee watering, fertilizing, and weeding to sustain the vegetation over time [41].

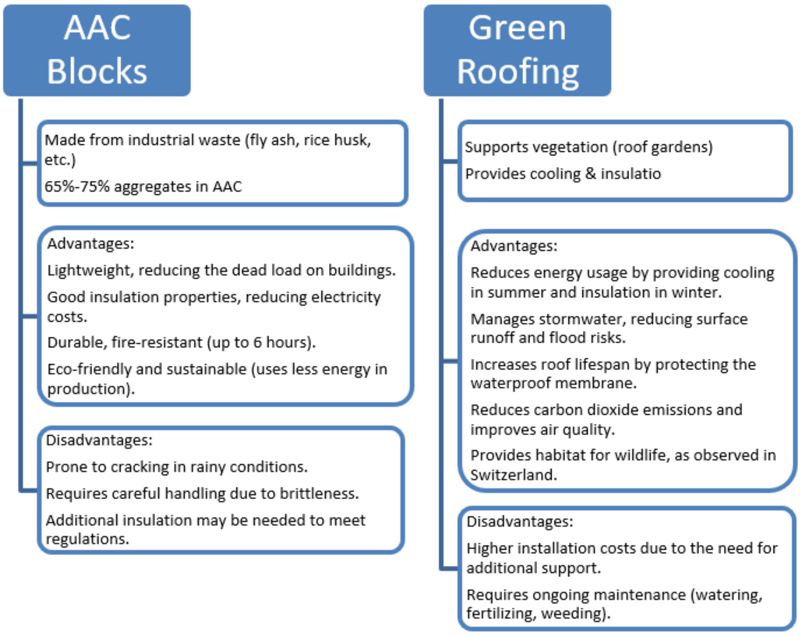

Figure 2. Some example of green materials in construction.

6. Conclusion

In many developed countries, the construction industry increasingly adopts green materials and environmental management practices to secure ecological benefits. Governments are actively establishing regulations aimed at promoting environmental protection within this sector. Similarly, developing countries are beginning to embrace the use of sustainable materials in their construction processes. Contractors in these regions are also employing environmental management practices to ensure compliance with local laws and regulations. By adhering to these practices, the construction industry can effectively prioritize environmental protection and sustainability. The growing trend highlights the recognition of the importance of integrating eco-friendly approaches into construction activities, ultimately contributing to a more sustainable future.

Acknowledgements

The authors would like to express their sincere gratitude to ADV Environment Malaysia, Warsaw University of Life Sciences, Tribhuvan University Nepal, Organization for Public Health and Environment Management Nepal, and the University of Kansas, Lawrence, USA, for their invaluable support and collaboration in this research. Their contributions have significantly enhanced the quality and impact of this study.

Author Contribution

Brendan Sen: writing, data analysis; Nicholas Tam: project coordination, writing; Rabin Maharjan: data collection, result interpretation; Amit Kumar Maharjan: methodology design, synthesis of findings; Gaurav Talukdar: literature review, manuscript revision.

Conflicts of Interest

The authors declare that they have no conflicts of interest to disclose.

References

[1] Vagtholm, R.; Matteo, A.; Vand, B.; Tupenaite, L. (2023). Evolution and Current State of Building Materials, Construction Methods, and Building Regulations in the U.K.: Implications for Sustainable Building Practices. *Buildings*, *13*, 1480. https://doi.org/10.3390/buildings13061480.

[2] The countries with the most green buildings. BDC network. (accessed on 1 June 2024) Available online: https://www.bdcnetwork.com/countries-most-green-buildings.

[3] Gryshova, I.; Kyzym, M.; Khaustova, V.; Korneev, V.; Kramarev, H. (2020). Assessment of the Industrial Structure and its Influence on Sustainable Economic Development and Quality of Life of the Population of Different World Countries. *Sustainability*, *12*, 2072. https://doi.org/10.3390/su12052072.

[4] Attahiru, Y.B.; Aziz, M.M.A.; Kassim, K.A.; Shahid, S.; Bakar, W.A.W.A.; NSashruddin, T.F.; Rahman, F.A.; Ahamed, M.I. (2019). A review on green economy and development of green roads and highways using carbon neutral materials. *Renewable and Sustainable Energy Reviews*, *101*, 600–613. https://doi.org/10.1016/j.rser.2018.11.036.

[5] Akcay, E.C. (2023). Barriers to Undertaking Green Building Projects in Developing Countries: A Turkish Perspective. *Buildings*, *13*, 841. https://doi.org/10.3390/buildings13040841.

[6] Falcone, P.M. (2023). Sustainable Energy Policies in Developing Countries: A Review of Challenges and Opportunities. *Energies*, *16*, 6682. https://doi.org/10.3390/en16186682.

[7] Ferriz-Papi, J.A.; Lee, A.; Alhawamdeh, M. (2024). Examining the Challenges for Circular Economy Implementation in Construction and Demolition Waste Management: A Comprehensive Review Using Systematic Methods. *Buildings*, *14*, 1237. https://doi.org/10.3390/buildings14051237.
[8] Nepal, R.; Phoumin, H.; Khatri, A. (2021). Green Technological Development and Deployment in the Association of Southeast Asian Economies (ASEAN)—At Crossroads or Roundabout? *Sustainability*, *13*, 758. https://doi.org/10.3390/su13020758.
[9] Jaiswal, S.V.; Hunt, D.V.L.; Davies, R.J. (2024). Construction 4.0: A Systematic Review of Its Application in Developing Countries. *Applied Sciences*, *14*, 6197. https://doi.org/10.3390/app14146197.
[10] Wang, C.; Che, Y.; Xia, M.; Lin, C.; Chen, Y.; Li, X.; Chen, H.; Luo, J.; Fan, G. (2024). The Evolution and Future Directions of Green Buildings Research: A Scientometric Analysis. *Buildings*, *14*, 345. https://doi.org/10.3390/buildings14020345.
[11] Zhang, Y.; Kang, J.; Jin, H. (2018). A Review of Green Building Development in China from the Perspective of Energy Saving. *Energies*, *11*, 334. https://doi.org/10.3390/en11020334.
[12] Ensign, P.C.; Roy, S.; Brzustowski, T. (2021). Decisions by Key Office Building Stakeholders to Build or Retrofit Green in Toronto's Urban Core. *Sustainability*, *13*, 6969. https://doi.org/10.3390/su13126969.
[13] Leyder, C.; Klippel, M.; Bartlomé, O.; Heeren, N.; Kissling, S.; Goto, Y.; Frangi, A. (2021). Investigations on the Sustainable Resource Use of Swiss Timber. *Sustainability*, *13*, 1237. https://doi.org/10.3390/su13031237.
[14] Environmental policies and firm-level management practices in Japan. Working paper, Organisation for Economic Cooperation and Development. (accessed on 1 June 2024) Available online: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.447.8152&rep=rep1&type=pdf.
[15] Bains, M.; Hongyi, Y.; Jialong, C. (2019). International policy perspectives on construction waste minimisation and recycling. *Proceedings of the Institution of Civil Engineers-Waste and Resource Management*, *172*(3), 76–85.
[16] Screening Template for Construction and Demolition Waste Management in The Netherlands. (accessed on 1 June 2024) Available online: https://ec.europa.eu/environment/pdf/waste/studies/deliverables/CDW_The%20Netherlands_Factsheet_Final.pdf.
[17] Green Building Council Italia. (accessed on 1 June 2024) Available online:https://www.worldgbc.org/member-directory/green-building-council-italia.
[18] Ren, W.; Kim, K. (2023). A Study on the Green Building Trend in China—From 2001 to 2022, Focusing on Research Topic Words. *Sustainability*, *15*, 13505. https://doi.org/10.3390/su151813505.
[19] A low carbon, circular economy approach to concrete procurement. (accessed on 1 June 2024) Available online: https://ec.europa.eu/environment/gpp/pdf/news_alert/Issue_88_Case_Study_168_Zurich.pdf.
[20] Gherman, I.-E.; Lakatos, E.-S.; Clinci, S.D.; Lungu, F.; Constandoiu, V.V.; Cioca, L.I.; Rada, E.C. (2023). Circularity outlines in the construction and demolition waste management: A literature review. *Recycling*, *8*, 69. https://doi.org/10.3390/recycling8050069.
[21] Construction Environmental Management Plan: Fraser Surrey Port Lands – Transportation Improvements. (accessed on 1 June 2024) Available online: https://www.portvancouver.com/wp-content/uploads/2021/05/Appendix-J-Construction-Environmental-Management-Plan.pdf.
[22] Jorat, M.E.; Minto, A.; Tierney, I.; Gilmour, D. (2024). Future carbon-neutral societies: Minimising construction impact on groundwater-dependent wetlands and peatlands. *Sustainability*, *16*, 7713. https://doi.org/10.3390/su16177713.

[23] Nikzad, R.; Sedigh, G. (2017). Greenhouse gas emissions and green technologies in Canada. *Environmental Development*, *24*, 99–108. https://doi.org/10.1016/j.envdev.2017.01.001.
[24] Kubáňová, J.; Kubasáková, I.; Čulík, K.; Štítik, L. (2022). Implementation of barcode technology to logistics processes of a company. *Sustainability*, *14*, 790. https://doi.org/10.3390/su14020790.
[25] Jolly, R.; Fairweather, H.; Rayburg, S.; Rodwell, J. (2024). Life cycle assessment and cost analysis of mid-rise mass timber vs. concrete buildings in Australia. *Sustainability*, *16*, 6465. https://doi.org/10.3390/su16156465.
[26] Zuo, J.; Pullen, S.; Rameezdeen, R.; Bennetts, H.; Wang, Y.; Mao, G.; Zhou, Z.; Du, H.; Duan, H. (2017). Green building evaluation from a life-cycle perspective in Australia: A critical review. *Renewable and Sustainable Energy Reviews*, *70*, 358–368. https://doi.org/10.1016/j.rser.2016.11.251.
[27] Gabaldón-Estevan, D.; Criado, E.; Monfort, E. (2014). The green factor in European manufacturing: A case study of the Spanish ceramic tile industry. *Journal of Cleaner Production*, *70*, 242–250. https://doi.org/10.1016/j.jclepro.2014.02.018.
[28] Khaiyum, M.Z.; Sarker, S.; Kabir, G. (2023). Evaluation of carbon emission factors in the cement industry: An emerging economy context. *Sustainability*, *15*, 15407. https://doi.org/10.3390/su152115407.
[29] Imbabi, M.S.; Carrigan, C.; McKenna, S. (2012). Trends and developments in green cement and concrete technology. *International Journal of Sustainable Built Environment*, *1*(2), 194–216. https://doi.org/10.1016/j.ijsbe.2013.05.001.
[30] Volatile organic compounds (VOCs). (accessed on 1 June 2024) Available online: https://www.pca.state.mn.us/air/volatile-organic-compounds-vocs#:~:text=Exposure%20to%20VOCs%20themselves%20can,are%20suspected%20or%20proven%20carcinogens.
[31] Mennicken, L.; Janz, A.; Roth, S. (2016). The German R&D program for CO2 utilization—innovations for a green economy. *Environmental Science and Pollution Research*, *23*(11), 11386–11392. https://doi.org/10.1007/s11356-016-6641-1.
[32] Li, X.; Qin, Q.; Yang, Y. (2023). The impact of green innovation on carbon emissions: Evidence from the construction sector in China. *Energies*, *16*, 4529. https://doi.org/10.3390/en16114529.
[33] Studer, W.P.; De Brito Mello, L.C.B. (2021). Core Elements Underlying Supply Chain Management in the Construction Industry: A Systematic Literature Review. *Buildings*, *11*, 569. https://doi.org/10.3390/buildings11120569.
[34] Murthi, P.; Sri, N.V.; Baig, M.M.; Sajid, M.A.; Kaveri, S. (2022). Development of green concrete using effective utilization of autoclaved aerated concrete brick trash as lightweight aggregate. *Materials Today: Proceedings*. https://doi.org/10.1016/j.matpr.2022.07.316.
[35] Autoclaved aerated cement blocks (AAC blocks)—properties and advantages. (accessed on 1 June 2024) Available online: https://theconstructor.org/building/autoclaved-aerated-cement-blocks-aac-properties-advantages/37211/.
[36] Rafiza, A.R.; Fazlizan, A.; Thongtha, A.; Asim, N.; Noorashikin, M.S. (2022). The physical and mechanical properties of autoclaved aerated concrete (AAC) with recycled AAC as a partial replacement for sand. *Buildings*, *12*, 60. https://doi.org/10.3390/buildings12010060.
[37] Autoclaved aerated concrete. (accessed on 1 June 2024) Available online: https://www.yourhome.gov.au/materials/autoclaved-aerated-concrete#:~:text=Increasingly%2C%20AAC%20is%20being%20used,panels%20available%20from%20the%20manufacturer.
[38] Dvorak, B.; Volder, A. (2010). Green roof vegetation for North American ecoregions: A literature review. *Landscape and Urban Planning*, *96*(4), 197–213. https://doi.org/10.1016/j.landurbplan.2010.04.009.

[39] Han, Y.; Wang, Z. (2023). Transplantation and adaptation: Research on reinforced concrete structures in modern Nanjing (1909–1949). *Buildings*, *13*, 1468. https://doi.org/10.3390/buildings13061468.

[40] Hamid, H.N.A.; Romali, N.S.; Rahman, R.A. (2023). Key barriers and feasibility of implementing green roofs on buildings in Malaysia. *Buildings*, *13*, 2233. https://doi.org/10.3390/buildings13092233.

[41] Azkorra-Larrinaga, Z.; Romero-Antón, N.; Martin-Escudero, K.; Lopez-Ruiz, G. (2023). Environmentally sustainable green roof design for energy demand reduction. *Buildings*, *13*, 1846. https://doi.org/10.3390/buildings13071846.