

Implementation of Green Materials in Construction Management System in Malaysia

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ABSTRACT: The construction industry plays a pivotal role in social, economic, and environmental development. However, the industry's unsustainable development has caused various environmental issues, and one of the most significant problems is construction waste. In Malaysia, construction waste constitutes a substantial portion of solid waste each year, most of which ends up in landfills without proper treatment, leading to further environmental issues. Construction activities have also resulted in environmental problems such as water, air, and noise pollution in the country. Furthermore, the use of conventional construction materials in the country contributes to the industry's unsustainable development. Conventional concrete is the most commonly used construction material, generating the most construction waste in a construction project. The production of conventional concrete emits a massive amount of carbon dioxide (CO₂) due to the use of cement, accounting for 8% to 10% of global anthropogenic CO₂ emissions annually. Therefore, implementing environmental management practices and using green materials can be key factors in achieving sustainable development in the Malaysian construction industry.

KEYWORDS: Construction industry; environmental management; green materials; sustainable developmental; Malaysia

1. Introduction

The construction industry encompasses economic activities related to the manufacturing and trading of buildings, infrastructure repairs, renovation, and maintenance. It plays a significant role in a country's socio-economic development by producing essential public infrastructure and private physical structures for necessary and productive activities, such as housing, utilities, services, commerce, and more. Moreover, the industry creates job opportunities, making it a vital contributor to a country's economic growth [1]. However, the industry can also cause environmental issues, such as the generation of construction waste, soil erosion, air pollution, water pollution, and others. Therefore, to ensure sustainable development, environmental management practices must be implemented, and green materials should be

utilized in the industry. Environmental management refers to a management system that enables organizations to reduce their environmental impact. In the construction industry, environmental management can help minimize environmental impacts in four generic areas: resource consumption, emissions, solid waste, interface with the external environment, and intrinsic quality of the construction site [2, 3]. Green materials are construction materials related to resource and energy efficiency in the manufacturing process. These materials should pollute less to the environment and have no negative impact on human health. One potential green material in the market is green concrete, which can reduce 70% or more of the global warming potential of conventional concrete [4, 5]. The aim of this study is to provide an overview of the current status of environmental management practices and the utilization of green materials for construction in Malaysia. Additionally, it aims to discuss the prospects and challenges of environmental management practices and the utilization of green materials in the country.

2. Current Status of Construction Industry in Malaysia

The construction industry has played a significant role in the economy of Malaysia. From 1991 to 2010, it contributed an average of 4.09% to the country's GDP and an average of 8.56% to the total national workforce [6]. Some iconic constructions, such as the Petronas Twin Towers, the world's tallest building from 1998 to 2004, and the Kuala Lumpur International Airport, which was named one of the best airports in the Airport Service Quality (ASQ) survey for 2022, have not only brought economic benefits but also international recognition and fame to Malaysia. Furthermore, recent projections suggest that the Malaysian construction industry will grow by 16.5% in 2022 [7].

2.1. Environmental management practices for construction industry in Malaysia.

The construction industry in Malaysia has a significant impact on the environment through the generation of waste, soil erosion, air pollution, and water pollution. To ensure sustainable development, the industry must implement environmental management practices. Environmental management refers to an approach that enables an organization to reduce its environmental impacts. In the construction industry, environmental management can minimize environmental impacts in four generic areas: resource consumption, emissions and solid waste, interface with the external environment, and intrinsic quality of the construction site [3]. To implement environmental management in the construction industry, it is crucial to establish policies and procedures that ensure efficient resource use and waste reduction. This can be achieved through the use of green materials, such as green concrete, which has a lower global warming potential than conventional concrete. Additionally, adopting sustainable construction practices, such as energy-efficient design and construction techniques, can reduce energy consumption and minimize the environmental impacts of construction. In Malaysia, the government has implemented several initiatives to promote sustainable construction practices and environmental management in the construction industry. These initiatives include the Green Building Index (GBI) and the Low Carbon Cities Framework (LCCF), which encourage the use of green materials and sustainable construction practices in building design and construction [8, 9].

2.1.1. Construction waste management.

Construction waste is a significant issue in Malaysia, where it accounts for a large portion of solid waste generated each year (Figure 1). Most of the construction waste ends up in landfills without proper treatment, leading to environmental and health concerns. To address this issue, the Malaysian government has implemented policies and regulations that require construction projects to adhere to waste management guidelines. The Construction Industry Development Board (CIDB) has established a Construction Waste Management Plan (CWMP) to guide construction companies in implementing proper waste management practices. Construction companies are encouraged to practice the 3R concept (reduce, reuse, and recycle) to minimize the amount of waste generated. This includes using prefabricated materials, salvaging materials from demolition sites, and recycling materials such as concrete, wood, and steel. The average amount of construction waste generated from a construction project site is estimated to be around 27,000 tonnes, with concrete and aggregate waste being the highest among all the construction waste generated, accounting for about 65.8% of the total [10]. To reduce waste and environmental impact, the government has encouraged the use of green materials in construction projects. Green concrete, for example, is a potential alternative to conventional concrete that can reduce greenhouse gas emissions by more than 70%.

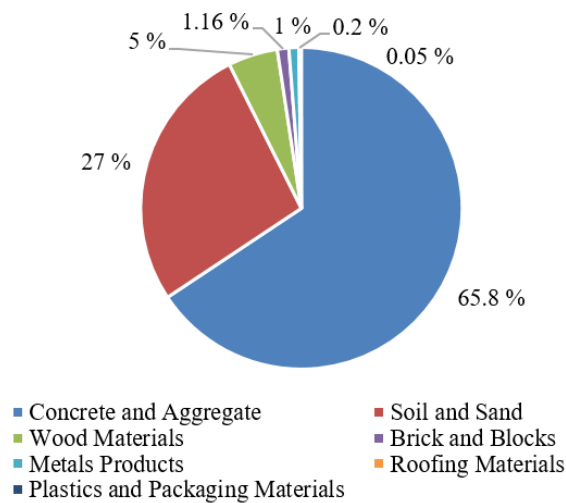


Figure 1. The composition of generated construction waste materials from a construction project site.

Regulations and legislation aimed at controlling and managing construction waste exist in Malaysia, as shown in Table 1. Landfill disposal and illegal dumping are currently the most common methods for managing construction waste in Malaysia. However, these methods are not environmentally friendly and can cause damage to the environment, unless it is a sanitary landfill. The 3R concept - Reduce, Reuse, and Recycle - is the only environmentally friendly management method. This concept aims to fully utilize resources before they are sent for disposal. Despite the Malaysian government's promotion of the 3R concept, its usage in the country is only 5% [10]. A case study conducted in Penang, Malaysia, on the current practices of the 3R concept among contractors found that weak implementation can be attributed to constraints in time and cost, lack of space, enforcement, awareness and knowledge, coordination, contractors' attitude, and low participation [11].

Table 1. The legislations and regulations of solid waste management, water quality control, and monitoring management in Malaysia.

No	Legislations and Regulations	References
1	General waste (industrial, commercial and domestic waste) is controlled under the Local Government Act 1976	[12]
2	Environmental Quality (Scheduled Waste) (Amendment) Regulations 2007	[13]
3	Environmental Quality (Compound of Offences) Rules 1978	[14]
4	Environmental Quality Act 1974 (Act 127) - Sec. 25: Restriction of pollution on inland water	[12]
5	Environmental Quality (Compound of Offences) Rules 1978	[14]
6	The effluent criteria for the parameters shall adhere to the Environmental Quality Act 1974 and the Environmental Quality (Sewage) Regulations 2009	[15]
7	Local Government Act 1976 - Sec. 69: Committing nuisance in streams	[16]
8	The National Water Quality Standards for Malaysia (NWQS)	[17]

The rapid development of the construction industry in Malaysia has resulted in a significant increase in the amount of construction waste being generated, as reported in a previous study [11]. In 2015 alone, Malaysia produced an average of 28.6 tons of construction waste per day. Unfortunately, the increase in construction waste has led to a rise in illegal dumping activities throughout the country. A study conducted in Johor found that 42% of the 46 illegal dump sites in the region were filled with construction waste [18]. One contributing factor to this situation is the rising waste disposal fees resulting from stricter waste treatment regulations aimed at better environmental conservation. A more recent survey by Johor Solid Waste Management and Public Cleansing Corporation (SWCorp) revealed that the number of illegal dump sites in the region has been increasing annually since 2017. Cairul Hisham Jalaluddin, the SWCorp director, mentioned that 90% of these sites were used by waste disposal contractors, construction, and recycling companies who do not want to pay the waste disposal fees [19]. Additionally, Umami Kalthum Shuib, the director of Federal Territories SWCorp, reported that illegal dumping activities also occur in Kuala Lumpur. Many building contractors who have projects in Selangor tend to dispose of their construction waste illegally in Kuala Lumpur in the early hours of the morning [20, 21]. Overall, the Malaysian construction industry needs to implement more effective environmental management practices for construction waste to avoid further damage to the environment.

2.1.2. Water quality management.

Water quality management is a critical issue in Malaysia due to rapid economic growth and urbanization that have put significant strain on water resources. The country has abundant water resources, but the quality of water is deteriorating due to various sources of pollution, such as domestic, industrial, and agricultural activities. The government of Malaysia has implemented various measures to manage and improve water quality in the country. The National Water Services Commission (SPAN) is the primary regulatory agency responsible for managing and ensuring the quality of water supply in Malaysia [22]. The commission sets standards and guidelines for water quality and monitors their implementation. The Water Services Industry Act 2006 provides the legal framework for regulating water quality in Malaysia. The act establishes the regulatory framework for water supply services, licensing of water supply services, and penalties for non-compliance with water quality standards [23].

In addition to regulatory measures, the Malaysian government has implemented various water quality management programs, such as the River of Life Project, which aims to improve

the water quality of the Klang River in Kuala Lumpur. The project involves various stakeholders, including government agencies, local communities, and private companies, working together towards improving the river's water quality [24]. Despite these efforts, water quality remains a significant challenge in Malaysia. The country still faces issues such as river pollution, water scarcity, and inadequate sanitation facilities in rural areas. Therefore, it is crucial for the government and stakeholders to continue prioritizing and investing in water quality management to ensure the availability of clean and safe water for people and the environment [25]. Relevant standards, regulations, and guidelines are shown in Table 1.

Furthermore, the Malaysian Department of Environment (DOE) has proposed preparing a water quality monitoring plan for construction activities, including four steps: identifying sampling stations, identifying sampling frequency, describing water monitoring parameters, and assessing compliance with regulatory requirements [26]. A plan can be formulated to regulate river water quality through pollution control and mitigation measures on construction sites, based on the assessment results. Figure 2 illustrates the trend of river water quality in Malaysia from 2005 to 2012, indicating that 34 rivers were polluted in 2012. Construction activities were identified as the primary source of suspended solids (SS) in the rivers. Furthermore, the Johor Department of Environment (DOE) received 140 complaints regarding river pollution caused by anthropogenic activities, including construction activities, from January to October 2020. These findings indicate that the Malaysian construction industry needs to improve its environmental management practices to ensure water quality at construction sites [27, 28].

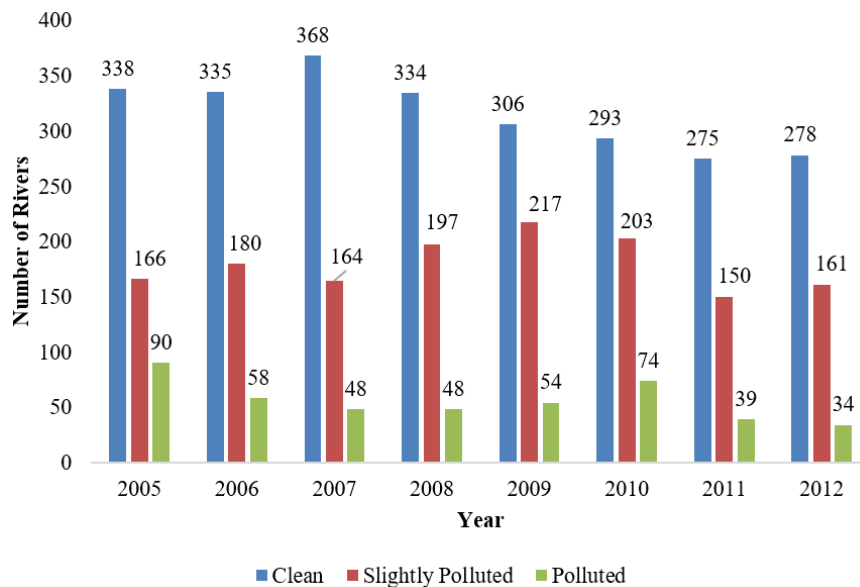


Figure 2. The river quality trend from 2005 to 2012 in Malaysia [27].

2.1.3. Air quality management.

The construction industry is widely recognized as a major contributor to air pollution, with heavy-duty construction vehicles being the primary source of emissions. These vehicles release gases such as carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO₂), and particulate matter (PM), which can negatively impact both the environment and human health. Furthermore, construction activities like piling, access road construction, and

transportation of equipment and materials on unpaved roads can generate dust, fly ash, and PM, exacerbating air quality issues [29].

In Malaysia, there are several legislations in place to regulate air quality, as summarized in Table 2. One commonly used method to control dust at construction sites is to use water, which is sprayed on unpaved roads to bind soil particles and prevent dust from spreading into the air during activities such as moving machinery, hacking, demolition, and tile cutting. However, it is recommended that the Malaysian construction industry should implement more effective methods to control dust pollution. Unfortunately, there is currently no standard regulation or guidance document in place to control, reduce, and monitor air pollutants, especially PM 2.5, at construction sites in Malaysia [29].

Table 2. The legislations and regulations of air quality control and monitoring management in Malaysia.

No	Legislations and Regulations	Ref.
1	Environmental Quality Act 1974 (Act 127) - Sec. 22: Restriction of pollution at the atmosphere - Prohibition of open burning	[14]
2	Environmental Quality (Licensing) Regulations 1977	[29]
3	Environmental Quality (Compound of Offences) Rules 1978	[30]
4	Environmental Quality (Clean Air) Regulations 1978	[31]
5	Environmental Quality (Control of Emission from Diesel Engines) Regulations 1996	[32]
6	Environmental Quality (Control of Emission from Petrol Engines) Regulations 1996	[32]
7	Environmental Quality (Compounding of Offences) (Open Burning) Rules 2000	[33]
8	Factories and Machinery (Noise Exposure) Regulations 1989 (DOSH)	[15]
9	Environmental Quality Act 1974 (Act 127) - Sec. 23: Restriction of noise pollution	[34]

2.1.4. Noise control management.

Construction activities have the potential to contribute to noise pollution, as heavy machinery and equipment used on construction sites such as bulldozers, air compressors, pneumatic hammers, loaders, pavement breakers, and dump trucks can generate high levels of noise. Prolonged exposure to noise pollution can result in various health risks such as hearing impairment, stress, cardiovascular disease, hypertension, and sleep disturbance [35]. In Malaysia, there are legislations and regulations in place to control noise pollution, as presented in Table 2. The Department of Environment (DOE) Malaysia has also published guidelines for environmental noise limits and control, including ambient noise standards to reduce disturbance in the environment, noise limits for new development and projects to protect the public from excessive noise, and procedures for environmental noise measurements, assessment, and mitigation [36].

Despite these measures, noise disturbance from construction activities remains a concern in Malaysia. For instance, it was reported that around 90 residents of Taman Desa in Kuala Lumpur protested against the loud noise from a new condominium construction site, and a construction site near the Jalan Tun Fuad Stephens-Jalan Istiadat junction in Kota Kinabalu caused noise nuisance to nearby residents for months [37]. Therefore, it is imperative for the Malaysian construction industry to prioritize environmental management practices for noise control at construction sites.

2.2. Utilization of green materials for construction industry in Malaysia.

The use of traditional building materials in construction has resulted in deforestation, increased carbon emissions, and waste disposal issues. Therefore, there is a pressing need for the utilization of green materials in the construction industry in Malaysia. Green materials are environmentally friendly building materials that have a low carbon footprint, can be sustainably sourced, and have minimal impact on the environment. These materials include, but are not limited to, recycled materials, sustainable wood, bamboo, hempcrete, and other natural materials. The use of green materials in the construction industry not only reduces the carbon footprint of the industry but also provides a more sustainable and long-term solution for the environment [38]. In Malaysia, there is a growing trend towards the use of green materials in construction. The Malaysian Green Building Confederation (MGBC) promotes the adoption of sustainable practices in the construction industry and encourages the use of green materials. Furthermore, the Malaysian government has launched the Green Technology Financing Scheme (GTFS) to provide funding for green technology projects, including those in the construction industry. Several green building projects have been successfully implemented in Malaysia, including the Green School in Selangor, which utilizes sustainable materials such as bamboo and recycled materials to create a zero-waste campus. The project has received international recognition for its innovation and sustainability [39].

2.2.1 Autoclaved aerated concrete.

Concrete is one of the most important construction materials globally and has the second-highest consumption rate after water among all construction materials. However, the production of concrete's main raw material, cement, requires high energy consumption, contributing significantly to environmental pollution and greenhouse gas emissions [5]. Globally, cement production accounts for 8% to 10% of anthropogenic CO₂ emissions, with about 4.1 billion tonnes of cement manufactured every year, and this figure is expected to grow constantly in the future [4]. In Malaysia, the rapid development of the construction industry has led to substantial growth in cement (2% to 6% annually) and concrete production (13% annually) from 2011 to 2016 [42]. As the Malaysian construction industry is expected to expand further, it is likely that cement production will also increase. To address these environmental concerns, Autoclaved Aerated Concrete (AAC) is a lightweight, precast, foam concrete building material that is widely used in the construction industry. It is made by combining sand, cement, lime, gypsum, water, and a small amount of aluminum powder, which reacts with the other ingredients to create tiny bubbles of hydrogen gas. The mixture is poured into molds and then cured in an autoclave, which is a high-pressure steam chamber. This process causes the mixture to expand and solidify, resulting in a lightweight, porous concrete that has good thermal insulation and soundproofing properties. AAC blocks are easy to handle and can be cut, sawn, and drilled with conventional tools, making them a popular alternative to traditional concrete blocks. They are also fire-resistant and do not emit any toxic gases when exposed to fire. AAC is considered an eco-friendly building material because it uses a small amount of raw materials and produces less waste and carbon emissions than traditional concrete [9]. The utilization of Autoclaved Aerated Concrete (AAC) in Malaysia is gradually increasing. AAC is a potential green material to replace traditional concrete due

to its eco-friendly properties. AAC is produced from natural materials such as sand, lime, water, and cement, which are mixed with an expanding agent and cured in an autoclave. The resulting material is lightweight, highly insulating, and has a low environmental impact [43]. AAC has been used in various construction projects in Malaysia, including residential, commercial, and industrial buildings. For instance, the Taman Desa Medical Centre in Kuala Lumpur was constructed using AAC blocks for its exterior walls to reduce the building's weight and improve its thermal insulation properties. AAC has also been used in the construction of low-cost housing projects, such as the MyHome scheme, to reduce the overall construction cost and improve the building's energy efficiency [44]. The Malaysian government has recognized the potential of AAC and has provided support for the development and adoption of the material in the construction industry. The Malaysian Industrial Development Authority (MIDA) has identified AAC as a strategic material for the country's sustainable development and has encouraged the establishment of AAC production facilities in the country [45, 46]. The advantages and disadvantages of ACC is shown in Table 3.

Table 3. The advantages and disadvantages of ACC.

Advantages	Disadvantages	References
<ul style="list-style-type: none"> • High thermal insulation: AAC has excellent thermal insulation properties due to its high porosity, which can help reduce energy consumption for heating and cooling buildings. • Lightweight: AAC is a lightweight material, which makes it easier to handle and transport during construction. • Fire-resistant: AAC is fire-resistant due to its inorganic composition and does not emit toxic gases in case of fire. • Eco-friendly: AAC is made from natural materials, such as sand, cement, lime, and water, and does not require high-temperature firing, which reduces its environmental impact. • Good sound insulation: AAC has excellent sound insulation properties due to its high porosity, which can help reduce noise pollution. 	<ul style="list-style-type: none"> • High initial cost: AAC can have a higher initial cost compared to traditional building materials, such as concrete or bricks. • Requires specialized installation: AAC requires specialized installation techniques and equipment due to its lightweight and porous nature, which can increase the cost of installation. • Limited availability: AAC may not be readily available in all regions, which can limit its adoption in certain areas. • Susceptible to moisture: AAC can be susceptible to moisture absorption if not properly sealed or protected, which can lead to reduced durability and potential for mold growth. • Brittle: AAC can be brittle and susceptible to damage from impacts or extreme weather conditions. 	<p>[47-50]</p>

2.2.2. Bamboo.

Bamboo is a promising green material for construction in Malaysia due to its abundance, renewability, and eco-friendliness. Bamboo is a type of grass that grows rapidly and can be harvested within three to five years, making it a highly sustainable and renewable resource for construction. In addition, bamboo has a higher strength-to-weight ratio than traditional building materials such as wood and concrete, making it an ideal material for building lightweight structures [51]. Bamboo has been used in various construction projects in Malaysia, such as the Bamboo Playhouse in Kuala Lumpur, which was built using bamboo as the primary construction material. Bamboo has also been used in the construction of low-cost housing projects, such as the Rumah Aspirasi Rakyat (RAR) in Sabah, which used bamboo as a substitute for traditional building materials [52]. A previous study compared the estimated construction cost, projected maintenance cost, and overall life cycle cost of an eco-budget chalet built with two types of Malaysian bamboo (*Dendrocalamus asper* and *Bambusa vulgaris*) as the main construction material with the same chalet design built with reinforced

concrete as the main construction material [51, 53]. Despite the advantages of bamboo as a green material, there are also some potential drawbacks to consider. One of the main concerns is the susceptibility of bamboo to pest infestations, which can lead to the degradation of the material over time [5]. In addition, bamboo requires careful treatment and processing to ensure its durability and longevity in construction applications [52]. Table 4 shows the advantages and disadvantages of using bamboo as a construction material.

Table 4. The advantages and disadvantages of using bamboo as construction materials.

Advantages	Disadvantages	Reference
<ul style="list-style-type: none"> • Sustainability: Bamboo is a renewable resource, and it can be harvested every 3-5 years without harming the plant or the environment. This makes it a more sustainable alternative to traditional wood. • Strength: Bamboo is strong and durable, with a tensile strength that is higher than that of steel. This makes it an excellent material for construction, particularly for structures that need to withstand high winds or seismic activity. • Flexibility: Bamboo is also flexible and can bend without breaking, which makes it an ideal material for building in areas prone to earthquakes or strong winds. • Low cost: Bamboo is relatively inexpensive compared to other building materials such as concrete or steel, which makes it an attractive option for those on a tight budget. • Aesthetic appeal: Bamboo has a natural and elegant appearance that can enhance the beauty of any structure, making it a popular choice for architects and designers. 	<ul style="list-style-type: none"> • Limited availability: Although bamboo is widely available in many parts of the world, it may not be easily accessible in some regions, making it difficult to source. • Vulnerability to pests: Bamboo is susceptible to insect and fungal infestations, which can weaken its structural integrity over time. • Limited structural capabilities: While bamboo is strong and flexible, it has limitations in terms of the structural load it can bear compared to some other construction materials like steel or concrete. • Susceptibility to moisture: Bamboo is a natural material that is prone to rotting and decay when exposed to moisture, which can lead to structural instability and a shorter lifespan. • Fire hazard: Bamboo is a flammable material and may not be suitable for areas prone to wildfires or where strict fire safety regulations are in place. 	[51, 52]

3. Challenges & Prospects of Construction Industry in Malaysia

3.1. Challenges environmental management practices.

Environmental management practices in Malaysia face numerous challenges that threaten the country's natural resources and sustainability. The rapidly growing economy in Malaysia has led to industrialization and urbanization, causing an increase in pollution levels, deforestation, and loss of biodiversity. Although the Malaysian government has implemented policies and regulations to mitigate these environmental issues, there are still several challenges to effective environmental management practices in the country [53]. One of the main challenges in Malaysia is the lack of enforcement of existing environmental laws and regulations. Although several environmental laws and regulations are in place, there is often a lack of monitoring and enforcement, which allows businesses to violate regulations without consequence. In addition, there is a lack of transparency and public participation in environmental decision-making, which can lead to conflicting interests and inadequate protection of the environment [54]. Another challenge is the rapid pace of development and urbanization, leading to the destruction of forests, wetlands, and other natural habitats. Malaysia has one of the highest deforestation rates globally, posing a threat to biodiversity and exacerbating climate change. Additionally, the country is facing a water crisis due to overexploitation of its water resources and pollution, leading to a decline in water quality and availability [55].

Furthermore, Malaysia is facing challenges in waste management, particularly with regards to plastic waste. The country is one of the largest producers of plastic waste in the world, and improper waste management practices have led to the accumulation of plastic waste in the environment, including marine ecosystems. The government has implemented policies to address this issue, such as a plastic bag charge and a ban on certain types of plastic, but there is still a lack of awareness and understanding among the public on the importance of waste reduction and proper waste disposal [56]. To address these challenges, Malaysia needs to strengthen its environmental governance and enforce regulations more effectively. This includes increasing transparency and public participation in decision-making processes and implementing measures to hold businesses accountable for environmental violations. The government should also prioritize sustainable development and conservation of natural resources, including the protection of forests, wetlands, and water resources. Additionally, there needs to be a shift towards more sustainable waste management practices, such as increased recycling and reduction of single-use plastics [57]. Table 5 summarizes the challenges and opportunities of practicing environmental management in the Malaysian construction industry.

Table 5. The challenges of practising environmental management in the Malaysian construction industry.

Challenges	Opportunities:	Reference
<ul style="list-style-type: none"> • Lack of Awareness and Education: One of the primary challenges facing the construction industry in Malaysia is a lack of awareness and education regarding environmental issues. Many industry players are not familiar with environmental regulations and best practices, which can lead to non-compliance with regulations and inefficient use of resources. • Limited Access to Resources: The construction industry requires significant amounts of natural resources, such as timber, water, and energy, which are becoming increasingly scarce. As a result, the industry needs to find ways to reduce its reliance on these resources and find more sustainable alternatives. • High Waste Generation: The construction industry generates a significant amount of waste, including hazardous waste, which can cause environmental damage if not managed correctly. The management of construction waste in Malaysia is still in its early stages, and there is a need for more effective and efficient waste management systems. • Fragmented Industry: The Malaysian construction industry is fragmented, with many small and medium-sized enterprises (SMEs) operating independently. This fragmentation can make it challenging to implement standardized environmental management practices across the industry. 	<ul style="list-style-type: none"> • Green Building Standards: The Malaysian government has introduced several green building standards, including the Green Building Index (GBI) and the Malaysian Carbon Reduction and Environmental Sustainability Tool (MyCREST). These standards incentivize the adoption of environmentally responsible building practices. • Sustainable Construction Materials: There are opportunities to adopt sustainable construction materials, such as recycled concrete, bamboo, and other renewable materials. The use of these materials can help reduce the industry's reliance on natural resources. • Innovation and Technology: Technology can help the industry adopt more sustainable practices. For example, building information modeling (BIM) can optimize building design and reduce material waste. Additionally, renewable energy technologies, such as solar panels and wind turbines, can help reduce the industry's carbon footprint. • Collaboration: The industry can collaborate with government agencies, NGOs, and other stakeholders to develop more effective environmental management practices. Collaboration can help promote knowledge-sharing, capacity building, and the adoption of best practices. 	[25, 29, 54]

3.2. Challenges of utilization of green materials.

The utilization of green materials has become increasingly important in Malaysia, as the country seeks to promote sustainable development and reduce its carbon footprint. The construction industry, being one of the largest consumers of energy and materials, is a

significant contributor to environmental degradation. Hence, the use of green materials in construction can help to reduce the environmental impact of buildings, while also providing numerous benefits, including energy savings, improved indoor air quality, and reduced waste. One example of the successful utilization of green materials in Malaysia is the Ken Rimba residential development in Shah Alam. The project, developed by Ken Holdings Berhad, incorporated several sustainable features, including green materials, to minimize its environmental impact. The buildings were constructed using fly ash bricks, an eco-friendly brick made from waste material generated from coal-fired power plants. Additionally, sustainable timber, such as bamboo and acacia, was utilized for window frames and doors, and concrete with a high percentage of recycled content was also used. Furthermore, rainwater harvesting systems, solar panels for water heating, and low-flow water fixtures were incorporated into the design [59]. Another example of the utilization of green materials in Malaysia is the Permodalan Nasional Berhad (PNB) 118 Tower in Kuala Lumpur. The tower, set to be the tallest building in Malaysia, incorporates numerous sustainable features, including the use of green materials. The tower's facade is made of low-emissivity glass, which helps to reduce solar heat gain and improve energy efficiency. The tower's construction also utilized high-strength concrete with a high percentage of recycled content, reducing the environmental impact of the building's construction [60, 61]. Table 6 summarizes the barriers to implementing green building materials in Malaysia.

Table 6. The barriers of implementing green building materials in Malaysia.

Barriers	Benefit	Reference
<ul style="list-style-type: none"> • Cost: One of the main barriers to implementing green building materials in Malaysia is the higher cost compared to traditional materials. Developers may be hesitant to invest in green building materials due to the higher upfront costs, despite the long-term benefits. • Limited availability: Another challenge is the limited availability of green building materials in Malaysia. Many of the materials need to be imported, and this can make them more expensive and difficult to obtain. • Lack of knowledge and expertise: There is a shortage of skilled workers in Malaysia with knowledge of green building techniques, and this can make it difficult to incorporate green building materials into construction projects. • Regulatory barriers: There are also regulatory barriers to implementing green building materials in Malaysia. The country's building codes and regulations may not be designed to accommodate these materials, and this can make it difficult to obtain the necessary approvals for projects. 	<ul style="list-style-type: none"> • Energy savings: Green building materials are designed to be more energy-efficient, which can result in significant savings on energy costs over the lifetime of a building. • Improved indoor air quality: Many green building materials are designed to improve indoor air quality by reducing the amount of volatile organic compounds (VOCs) that are released into the air. • Reduced environmental impact: The use of green building materials can help to reduce the environmental impact of construction by reducing the amount of waste generated and conserving natural resources. • Marketing advantage: Green building materials can be used as a marketing advantage to attract environmentally conscious customers who value sustainable living. 	[60, 61]

3.3. Prospects of environmental management practices & utilization of green materials.

The prospects for environmental management practices are promising due to the increasing global awareness of the negative impacts of human activities on the environment. The public is becoming more conscious of these impacts, leading to a shift towards more sustainable practices in industries such as agriculture, manufacturing, and construction. Governments worldwide have implemented policies and regulations to encourage companies to adopt sustainable practices, including tax incentives and grants. Moreover, investing in research and development of sustainable technologies offers opportunities to create innovative solutions

for environmental problems [62]. The prospects for green materials are also promising as they can reduce the environmental impact of construction and other industries. The use of green materials can lower carbon emissions, reduce energy consumption, and minimize waste production. Additionally, green materials can improve indoor air quality, reduce exposure to toxins, and promote occupant health and well-being. Investing in green materials can promote innovation and growth in industries such as construction and manufacturing [63].

4. Recommendations

4.1. Enhancement of law enforcement, punishments and penalties.

In Malaysia, the Construction Industry Development Board (CIDB) has introduced the Green Construction Index (GCI) to encourage the use of green materials and sustainable practices in the construction industry. The GCI provides a comprehensive rating system that measures the environmental performance of buildings and construction projects. The rating system evaluates various aspects, including energy efficiency, water conservation, waste management, and indoor environmental quality. Although there are existing environmental legislations in Malaysia, their weak enforcement renders them ineffective. Many people do not comply with environmental legislation, as evidenced by illegal dumping of construction waste, water pollution due to construction activities, and other problems [20–22]. Therefore, the enforcement of environmental legislation needs to be strengthened. Additionally, penalties and punishments for environmental offences should be increased to encourage the public to take the laws seriously. Moreover, a new approach to punishment could be introduced, such as requiring environmental offenders to participate in environmental conservation activities. This approach could contribute to environmental awareness among society.

4.2 Environmental awareness campaigns.

Environmental awareness campaigns can have a significant impact on encouraging the adoption of green materials in Malaysia's construction management system. These campaigns can educate the public on the advantages of using green materials and sustainable practices, while also raising awareness about the detrimental impacts of traditional construction methods. By increasing public awareness of environmental issues, environmental awareness campaigns can promote environmental consciousness and facilitate sustainable development in Malaysia. Therefore, it is important to organize frequent environmental awareness campaigns, particularly targeting young people, to educate them about the significance of safeguarding the environment [64]. Effective environmental awareness campaigns could involve initiatives such as promoting proper waste disposal, increasing the use of renewable energy sources, animal conservation, and more. Education and training programs aimed at construction professionals, architects, engineers, and other stakeholders in the construction industry can also be effective in promoting the use of sustainable practices and green materials, while also emphasizing the environmental consequences of construction activities [65].

4.3. Utilization of plastic waste.

Table 7 summarizes the advantages and limitations of using plastic waste as construction materials. The use of plastic waste for construction purposes in Malaysia has garnered considerable attention in recent years. Improper disposal of plastic waste poses a significant environmental concern, as it leads to pollution and threatens human health and the environment. Hence, utilizing plastic waste for construction not only provides a sustainable solution for plastic waste management but also promotes sustainable construction practices [66]. Plastic waste can be transformed into lightweight and durable building materials such as roofing tiles, pavement blocks, and wall panels, serving as an alternative to traditional construction materials like bricks, concrete, and wood. Compared to traditional materials, these building materials have a lower carbon footprint and are more environmentally friendly. Moreover, utilizing plastic waste in construction reduces the demand for virgin materials, conserving natural resources and reducing energy consumption [67, 68]. In Malaysia, several initiatives have been introduced to encourage the use of plastic waste in construction. The Malaysian government has implemented policies and regulations to promote sustainable construction practices, including the use of recycled materials. The Construction Industry Development Board (CIDB) has established guidelines and standards for the use of recycled materials in construction [69]. For instance, the Eco Block project, initiated by the Malaysian government, aims to transform plastic waste into interlocking blocks that can be used for construction purposes. The blocks are composed of a mixture of plastic waste and cement, and have been tested for their strength and durability. The project has provided a solution for plastic waste management, while also offering a cost-effective and environmentally friendly alternative to traditional construction materials [70].

Table 7. The advantages and limitations of using plastic waste as construction materials.

Advantages	Limitations	References
<ul style="list-style-type: none"> • Environmentally friendly: Plastic waste is a readily available resource that can be used as a sustainable construction material. The use of plastic waste in construction reduces the need for traditional construction materials and promotes sustainable practices. • Cost-effective: Using plastic waste in construction can be cost-effective compared to traditional materials. Recycled plastic is often cheaper than virgin materials, and the manufacturing process can also be less expensive. • Lightweight: Plastic waste can be transformed into lightweight construction materials, which can be useful in applications where weight is a concern, such as roofing. • Durable: Plastic waste can be transformed into durable construction materials that can withstand harsh environmental conditions. • Versatile: Plastic waste can be transformed into various construction materials, such as paving blocks, roofing tiles, and wall panels. 	<ul style="list-style-type: none"> • Limited availability: The availability of plastic waste as a resource can be limited, as it depends on the amount of plastic waste that is produced and recycled in a given area. • Quality control: The quality of plastic waste can be inconsistent, which can affect the quality of the final product. It is important to have proper quality control measures in place to ensure the consistency and durability of the recycled plastic construction materials. • Safety concerns: The use of plastic waste in construction may raise concerns about the safety of the materials, as some plastic types may contain harmful chemicals or additives. • Aesthetic limitations: Recycled plastic construction materials may not have the same aesthetic appeal as traditional materials, which may limit their use in certain applications. • Durability concerns: Recycled plastic materials may not be as durable as traditional construction materials, which may limit their use in high-stress applications. 	[72–75]

Another example is the Menara Paragon building in Johor Bahru, which incorporated over 140 tons of recycled plastic into its concrete mixture, resulting in a reduction of over 200 tons of carbon dioxide emissions [71]. It is important to note that the use of plastic waste in construction also poses some limitations and challenges, such as technical limitations,

durability concerns, and possible health risks associated with the use of certain types of plastic waste. Nonetheless, with proper regulations, guidelines, and testing, the utilization of plastic waste in construction can provide a sustainable solution for plastic waste management, reduce environmental impacts, and promote sustainable construction practices in Malaysia.

5. Conclusion

The Malaysian construction industry is currently undergoing rapid and unsustainable development, resulting in environmental issues. To achieve sustainable development in the industry, it is essential to promote environmental management practices and the use of green materials. However, the current state of environmental management practices and the utilization of green materials in the Malaysian construction industry is not ideal, and several challenges must be addressed. Challenges related to environmental management practices include weak law enforcement, high disposal costs, insufficient environmental awareness, inadequate incentives, and lack of commitment. Challenges related to the utilization of green materials include insufficient environmental awareness, high costs of green materials, limited supply of green materials, inadequate technical understanding and confidence in green materials, lack of rules and regulations, and clients' preference for conventional materials. Relevant departments must take steps to address these issues to ensure sustainable development in the industry. Despite these challenges, the prospects for environmental management practices and the utilization of green materials in the Malaysian construction industry are promising, as the industry is gradually moving towards sustainable development.

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Conflicts of Interest

The authors declare no conflict of interest.

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