Evaluation of Environmental Impact on Green Building Materials

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Accepted for Publication: 2023
Published Date: November 2023

Abstract

This article presents an overview of the various building materials. Using green materials for building construction has become increasingly popular due to the environmental development concerns which have been covered by the UN 2030 Agenda. The aim of this article is to assess and evaluate the environmental impacts of the various sustainable building materials which includes bamboo flooring, earth, straw-bale, etc. It will explore different case studies of real life constructions used by these specific construction materials. Additionally, it includes the reason as to why sustainable materials are more effective and should be used. This study aspires to motivate further discussions and research to be made by experts on this topic. It also hopes to encourage more architects to use sustainable building materials.

Keywords: Sustainable Materials, Building Construction, Impact, Environmental

1. Why Do We Need to Build with Sustainable Materials?

Recently, environmental issues have been a wide topic of discussion. Many buildings are not believed to be sustainable due to the negative environmental consequences. Architects often prioritise the aesthetic and design concept of the building rather than the environment which leads to the use of excessive raw materials. It not only produces construction waste, but uses a lot of energy which leads to the production of carbon dioxide, a form of greenhouse gas. A component which accelerates the effects of global warming.

1.1 Production of Construction Waste

Construction and Demolition (C&D) waste often refers to the debris created by all the activities during the construction period of buildings. Due to the increase of human population growth in recent years, the use of raw materials has exponentially increased. The extraction of raw materials is now over 100 billion tons, annually according to the World Bank (2022). This means that the availability of raw materials has become more scarce and rare. Specifically, building construction is one of the biggest consumers of these natural resources, consuming more than 40% of the raw materials globally. However, it is estimated that 30% of the total amount of building materials delivered to a typical building site becomes construction waste. In the United Kingdom in 2023, the construction waste reached 62% of its total waste and 13% of all construction waste went directly to landfill. According to the Environmental Protection Agency (2018), C&D generated more than 600 million tons of debris each year in the United States. In 2021, more than 3600 metric tons of construction waste went directly to landfill daily. This proves that the construction industry creates huge amounts of waste each year. It is estimated that 75% of waste generated by the construction waste is currently neither reused or recycled. The waste created from C&D also accounts for 30% of the total waste produced globally alone, with at least 35% of all C&D waste disposed of in landfills each year. This impacts the environment hugely in a negative manner as considering the huge amounts of raw materials extracted each year, a lot of it becomes waste in landfills when it could have been preserved or used for other purposes. It contributes to significant global problems such as resource depletion and pollution. At the same time, many building materials contain hazardous components such as PVC, paints and components with toxic chemicals. This means that they cannot actually be recycled and reused as it would bring harm to human health. Even if buildings are deconstructed or demolished, materials that could originally

be reused would be lost due to the mix of materials, which salvages the products. Additionally, the transport of building materials produces another type of waste due to the carbon footprint, carbon dioxide. It is responsible for the greenhouse effect which leads to global warming, a significant challenge in the current world.

1.2 To Save Energy

Building materials require a lot of energy through transformation materials until it can be used. By reuse and recycling materials, less energy will be used as energy that is necessary to reuse some materials is very low. They usually do not require any extra transformation procedures, but can be directly reused on site. Compared to new materials, the energy needed to produce recycled materials is lower. This means that carbon dioxide emissions released would decrease, therefore greenhouse gas emissions would decrease too.

Considerably, metal uses the most energy during manufacturing. The total energy required to extract metal from its ore includes the process energy, chemical energy, thermal energy and energy that is lost to surroundings during the process. Then, energy is needed again to transform metal from the mineral ore to the metal. Although metal uses the most energy during processing, it has one of the highest recycling potentials as its carbon dioxide emissions are small when compared to a conventional manufacturing process. Other materials such as concrete and bricks are also often recycled as concrete contributes 4-8% of the world's carbon dioxide emission from all stages of its production. There are many other options that can be used to save energy and reduce carbon dioxide emissions which creates negative consequences to the environment.

1.3 Raw Materials Shortage

The construction sector is facing a material shortage globally due to the increase in demand of the already scarce materials. The increase in demand is due to the exponential increase in population and urbanisation. Moreover, the shortage of building materials is a consequence of the Covid-19 pandemic. It created a rapid demand for materials while also slowing down the production rates. There has been a sharp incline of shortages in timber, steel and cement. This shows the importance in reusing and recycling materials instead of using new ones as it could supply the consumers more quickly. This huge demand for the materials with low production rate means that it will have a higher price that people cannot often afford. Additionally, metals are beginning to be harder to extract due to the scarcity. The only ways to resolve this issue is to either find new mining sites which cause a huge environmental impact or reuse old materials.

2. Different Sustainable Construction Materials

There has been an increase in the variety and range of sustainable building materials as technology advances. There are now many more innovative solutions to the problem with resource depletion and ways to reuse and recycle the scarce natural materials. However, the methods of green construction materials do not limit to these only. As technology improves, there will be further improvements and an increase to these materials.

2.1 Earth

It has been proven to be impossible to only build with the basic building materials such as concrete and bricks as the demand for housing increases. However, using earth may be a solution to this problem. Earth is a mixture of clay, salt and sand, and occasionally gravel and stone. It is an alternative to industrial concrete. It is a ready building material which requires little industrial processing which decreases energy and carbon dioxide emissions. It is also reusable, affordable and non polluting. The modern earth construction is also often mixed with slaked lime or synthetic fibres to achieve a higher compressive strength and greater durability. Furthermore, earth has low thermal conductivity and an ability to absorb moisture from the air. There are many earth building techniques including rammed earth, earth blocks and cob constructions. However, earth should only be used where the area is not prone to water as it is sensitive to erosion. Despite that, this issue could be resolved by taking appropriate measures and having special design precautions.

2.1.1 Bayalpata Hospital

Photography by Elizabeth Felicella.

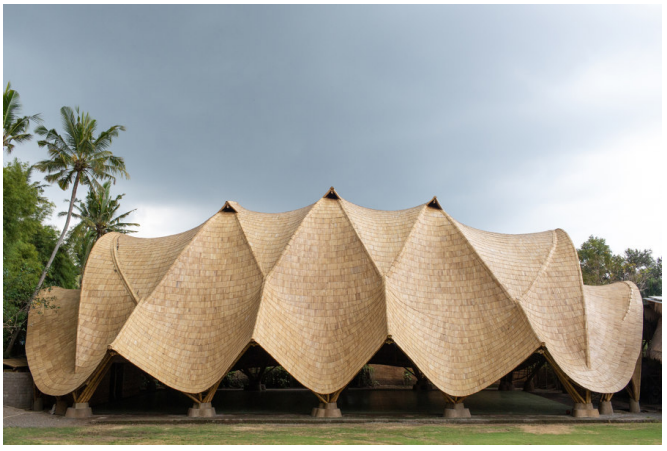
This rural hospital in Achham, Nepal is an example of building with earth. It is designed by Sharon Davis Design which introduced rammed earth as a construction material as it was a locally available material and affordable construction

method. It also minimises the carbon footprint as there is little transportation of this building material that is acquired from this region. With this new sustainable rural health hospital, Bayalpata is able to deliver care and support to the residents in this region.

2.2 Bamboo

Bamboo is an exceptional sustainable material as it requires little energy, produces a lot of oxygen and has a regenerative growth cycle. It is one of the most rapid growing plants and can reach approximately 30 m high in a few weeks. This means that it has a high production rate which may be able to solve the problem with the high demand of housing. It has solid fibre and a stronger compressive strength than concrete while its tensile strength is on par with steel. This ensures the ability to cope with natural disasters and prevents the structure from collapsing. Additionally, bamboo has a role in restraining erosion as it creates a barrier for water which can be used as a defensive component for villages. However, it has a poor durability in its natural state as it often attracts insects and fungus. It will cause decay and deterioration. It is also not fire resistant as it can be quickly ignited. Nevertheless, these can be prevented with the correct safety precautions such as applying chemicals that are fire retardant.

2.2.1 The Arc at Green School



Photography by Tommaso Riva

This structure designed by Ibuku is located in Bali, Indonesia. It is built from intersecting 14 metre tall bamboo arches spanning 19 metres, interconnected by anticlastic gridshells. It is a product of hard work from researching and engineering. It proves that a structure can be sustainable while retaining an element of aesthetic beauty.

2.3 Mycelium

Mycelium is the root structure of fungi which is a new innovative green construction material. It is biodegradable, consumes little energy and has a low carbon footprint. At the same time, it is an affordable material that has good fire, thermal and acoustic insulation. To create reliable construction materials with mycelium, it can be transformed to bricks and blocks by mixing with organic matter which makes it into a solid mass. However, the disadvantages of mycelium is that it cannot carry as much weight and has a decreasing water resistance overtime.

2.3.1 Hy-Fi Building New York

Photography by a+t research group

This innovative structure was designed by David Benjamin of New York architects The Living and was an installation in the MoMA PS1 courtyard for three months in 2014. It is an example of using mycelium for building construction. It used fungi bricks which were able to carry weight easily to the 40 ft height. When the structure was removed after, the bricks were composed and returned to the carbon cycle.

2.4 Straw-bale

Straw-bale is an option for environmentally sustainable construction as it is not only natural but locally available in different regions. It has a fast construction time and can be completely recycled after deconstruction. At the same time, it has optimal thermal insulation and high fire resistance. It can also be a benefit to earthquake prone areas as it is incredibly earthquake resistant. However, it can mostly be used in rural areas for the construction of low buildings. It also does not allow complex structures to be built. With technological advancements and more innovative minds, there is a possibility for this to be changed in the future.

2.5 Fly Ash Concrete

Fly ash is a coal combustion product. Fly ash concrete has a lot of environmental benefits. The amount of fly ash used in concrete annually, saves approximately 13 million tons of carbon dioxide being generated. By recycling fly ash, it reduces the carbon footprint as vehicles are not needed to transport them to landfills, and it also saves natural resources from being depleted by preventing new raw materials from being mined.

3. Conclusion

To resolve the urgency of the environmental issues in the current world, contributions should be done in any and every way possible. Architects have a role in designing a more beautiful and sustainable environment for people to live in. By designing new structures with more sustainable materials will allow them to be a part of building a better future for young generations. Sustainable materials are not only limited to earth, mycelium, bamboo and straw-bale, there are also other options to explore. This article hopes to motivate people to invent more solutions to the challenges of the construction industry.r

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