

A COMPARATIVE STUDY OF THE MOST ENVIRONMENT FRIENDLY HOUSING AROUND THE WORLD

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ABSTRACT

Green building materials are composed of recyclable materials and have nontoxic qualities. This indicates that compared to non-renewable resources, they are typically made from renewable resources. The purpose of this study is to strengthen the argument for green buildings and associated materials. The purpose of this is to ascertain whether these construction methods are valid. Using and comparing case studies globally, this study combines qualitative and quantitative methodologies. The case studies, which are based on newly constructed and renovated structures, are chosen from various geological sites and assessed using literature review and logical reasoning. Additionally, by defining a range of green construction materials that can be employed in place of non-green building materials, the research will address the issue. After closely examining the case studies around the world, the benefits and drawbacks of the green indicators and implementation will be assessed. The outcome of this comparison will help to enhance the existing instruction on green building and enhance the construction industry's general reaction to positive change. Green building efforts can be cost-effective even though they are easy to implement. These activities must be completely embraced in order to optimize their cost effectiveness. This includes modifying a particular building. Passive heating and cooling can be significantly enhanced by proper direction, design, and penetration sealing.

Key words: construction materials, green indicators, green building, buildings and associated materials.

1. INTRODUCTION

"The design, construction, and operation practices that significantly reduce or eliminate its negative impact on the environment and its occupants" is the definition of a "green building." (Green wall Australia, 2022). The effects of existing buildings on people and the environment materials result from the accumulation of garbage in landfills, excessive energy use, and the depletion of finite material sources (Ching and Ian, 2014). The massive generation of construction waste are the activities causing these problems (Ching and Ian, 2014). Therefore, since charges against the construction sector are at an all-time high, the green building itself is becoming an increasingly important emphasis throughout the process. These include high levels of pollution in the surrounding area and excessive use of global resources at every step of building construction (Ding, 2008). Although the industry's effects on the environment have already started, the body of knowledge on the subject is continuously growing. Most people believe that when they use green building materials, they are utilizing less-than-ideal, low-cost materials that perform worse than their counterparts (Spiegel and Meadows, 2012). Research on green construction and green building materials is therefore urgently needed in the business.

Sustainable Development and Sustainable Housing: Understanding the idea of sustainable development is necessary before the housing sector can be developed in a sustainable manner. The most popular and often utilized one can be found in the World Commission on Environment's development (WCED) report "Our Common Future." According to the statement, "sustainable development is development that satisfies present needs without jeopardizing the ability of future generations to satisfy their own needs." (WCED, 1987). Any dimension that is ignored will be seen as either not sustainable or only partially sustainable, which will have an adverse effect on the present and future generations. (John et. al., 2005). In order to be considered environmentally efficient, sustainable housing must first be of high quality, long-lasting, and adaptable. Furthermore, by making sensible and effective use of natural non-renewable resources, sustainable housing should be environmentally efficient resources (electricity, building supplies, space, etc.) during both the building and use phases (Novem, 2002)

A system of labels for sustainable housing and sustainable development has been devised. Most of them, like BREEAM in Britain and LEED in the US, are optional, though (Bartlett and Howard, 2008).

Zinkernagel (2001) What one person's definition of sustainability may be another's definition of exploitation, despoliation, and degradation (Dahl, 1997). Consequently, sustainability has a wide range of effects on every aspect of a civilization and on every continent. (Morse and Bell, 2003).

Comparative research scope: The goal of the study is to adopt a more comprehensive viewpoint to investigate the various approaches taken by various nations in their pursuit of sustainable housing development, considering their

unique circumstances. Examples of sustainable home building patterns for developed and developing nations are chosen from the case studies globally. To provide a detailed picture of each situation and identify the path toward sustainable housing development in each nation, a comparison of the nations' methods must be made.

2. METHODS AND DATA SOURCES

Case studies, a thorough literature evaluation have been selected for this study in order to explore the subject of green building and provide a solution to the research question. The goal of the case study approach was to gather information by analysing the documents of several case studies and to describe the advantages of green building design over traditional building design. The case studies, which addressed various geological situations, were chosen at random to guarantee impartial selection, are the basis for the distinctiveness of the building types chosen in the situations. In order to support the logical argument, the study will try to pinpoint the tenets of green building materials and ascertain how they relate to reducing resource depletion, environmental damage, and adverse health effects. This strategy has the advantage of allowing the presentation of the principles and the logical identification of the case for responding to the research question. This approach was chosen because it significantly relies on logical reasoning.

Overall Analysis of Green Buildings and sustainable housing:

Analysing the data that demonstrates the advantages of using green building materials in terms of cost, waste, energy, air pollution, environmental impact, and effects on human health is crucial after reading the literature that lists the different kinds of green building materials and compares them to conventional building materials. The examination began with (Jayanetti and Follett, 2008) asserting that there is a widespread misperception that the construction of green buildings is 5% to 15% more expensive than that of conventional buildings. They concluded that this number must be contested because it has not been substantiated by any current studies. Such a conclusion was substantiated by (Ambrosio et.al.,2023), which went on to imply that cost consultants in the building industry significantly underestimate the potential cost savings and grossly exaggerate the central costs of green building. The research in (Gharehbaghi et.al., 2020; Ambrosio et.al., 2023) supports this, claiming that green building design makes considerably better use of resources including materials, energy, water, and land than conventional building design. According to these assertions, green building design and the use of green building materials outperform conventional building design in terms of resource utilization, energy consumption, and human health effects. The energy consumption of green buildings is another advantageous topic that comes up in the literature. According to the authors of (Pritchard and Pitts, 2006), their tests revealed that green buildings use roughly 30% less energy than conventional ones. This is corroborated by those in (Kats, 2003), who claimed that depending on the certification level, green buildings save anywhere from 30% to 55% on energy costs when compared to conventional structures. According to the researchers' assertions, green buildings save at least 30% on energy costs when compared to conventional structures, and the percentage can increase based on the kind of green building. The study is sound, but it's important to find out which kinds of green and conventional buildings were used to calculate the figures. It's also important to find out if any materials contributed to that 30%.

3. THE FIRST CASE STUDY

Design response: Prior to the restoration, the house had a hallway that connected the kitchen and living room. A bathroom was built in lieu of the kitchen area because the owners didn't like the setup. Furthermore, the emphasis on green building options made it possible to implement a variety of amenities. Among these are solar power, LED lighting, double-glazed windows and doors, and newly installed insulation. To maintain the building's original heritage features, the rest of the house was left mostly unaltered.

Table 1. Building's overall GREEN infrastructure representations.

S.NO.	BUILDING FEATURES	INFERENCE
1.	Building size	125m ²
2.	Size of the land	190m ²
3.	Green building features	<ul style="list-style-type: none"> ➤ 2000 L steel rainwater tank ➤ Concrete slab with cement replacement and recycled aggregates ➤ Energy-efficient appliances Evacuated tube solar hot water system ➤ Natural rubber floor tiles and low volatile organic compound (VOC) adhesive

The green building or housing improvements were carried out as per below:

Energy-efficient lighting: All of the lighting in the house was replaced with light-emitting diodes during the refurbishment, while the previous one had just normal globes. With an average of 12 watts, the watt range varied according to the room that needed to be lit. This allowed for below-average energy use while providing adequate and effective active illumination where needed.

Insulation: Enough glass wool batts, mostly composed of recyclable materials, were used to update the home's walls and roofs throughout the renovation. Wall insulation had a grade of 3.5, and roof insulation received a rating of 4. As the ability to keep the house warm during the colder months grew, so did the overall quality of the house.

Use of sustainable materials: A wide variety of sustainable building materials were used in the remodelling rather than brand-new ones. The shelving was built using salvaged wood, and the benchtop and cabinets were mostly composed of leftover components from another demolition. The porch was constructed from Green Element's extra inventory, and the bathroom sink was also fixed and renovated. The slab's development was the most significant use of sustainable materials. Its components consisted of 30% cement substitute and 60% recyclable resources. More than a ton of CO₂ was saved by using the alternative.

Water conservation: The ancient house lacked any tools or procedures to conserve water and lower active water use. A brand-new 2000 L rainwater storage tank was installed outside as part of the restoration. The toilet, laundry, and garden (for plants) are all connected to the plumbing. A 4-star water-efficient toilet and 3-star faucets were installed in the restroom and kitchen, respectively, in addition to the rainwater tank. Compared to the old formation, this alteration has allowed the owners to conserve more than 100 L of water every day. Prior to refurbishment, the owners wanted a fresh experience and listed certain improvements they wanted to see, with a primary emphasis on environmental and energy efficiency. The rubber floor tiling was a significant improvement. Its environmental sustainability and temperature control capabilities outperformed those of conventional floor tiling by a significant margin. Along with the makeover, all the home's appliances were updated to meet eco-friendly standards.

The SECOND CASE STUDY:

A two-story home in inner suburbs serves as the second case study that is presented. The house had renovations that totally changed its before empty status and made it a residence that is ecologically friendly, energy-efficient, and sustainable.

Design response: The property had a central staircase prior to the renovations, which was incredibly ineffective in controlling the passage of heat. Instead of keeping the house warm, the staircase allowed heat to move upward, leaving the bottom. The main goal of the entire makeover was to make sure the house was rebuilt as a small, sealed structure with no unnecessary ceiling insertions or holes throughout the house to better control the passage of heat. By utilizing green construction initiatives, the goal made it possible to achieve the most effective passive heating and cooling.

Table:2: Building's overall green infrastructure representation:

S.NO.	BUILDING FEATURES	INFERENCE
1.	Building size	228m ²
2.	Size of the land	825m ²
3.	Green building features	<ul style="list-style-type: none"> ➤ Bamboo flooring ➤ Effectively sealed building with minimal gaps ➤ Solar hot water system ➤ Light-emitting diode (LED) lighting ➤ Low-VOC paint ➤ North-facing design ➤ Rainwater tank

The following were the green building improvements:

Active heating and cooling: The original house had a reverse split system on the second level and a very inefficient heater on the bottom floor. During the remodelling, a highly efficient hydronic heating system that uses a gas boiler and radiator was installed. The builder used ceiling fans to boost the flow of cool air throughout the house for active cooling.

Insulation and building materials: The original house had a brick facade, but it wasn't totally energy inefficient. However, some parts needed to be changed. Bricks were removed from several areas of the building during the refurbishment which were swapped out for cladding made of restored timber weatherboards.

Energy-saving lighting: The lighting within the home was upgraded to efficient light-emitting diodes. This allows for active lighting throughout the home where required, while committing to just 10 watts.

Solar PV system with solar hot water: A brand-new solar hot water system was included as part of the restoration, raising the overall efficiency of water utilization and decreased booster usage.

Use of sustainable resources: The extra materials from the previously refurbished house were donated to those in need; the remainder were used to renovate the new house.

Water conservation: There were no water-saving features of any kind in the original house. Consequently, two 5000 L rainwater tanks were added as part of the refurbishment, both of which were directly connected to the restroom and laundry room. As a result, less water was used actively, and water recycling is now possible. The owners wanted to enhance the house by increasing the amount of natural light and improving the winter temperature control. Passively heating the house would be a fundamental accomplishment required by the requirement for a sustainable housing. As discussed above, the house went through a variety of green building changes that ultimately increased its efficiency and effectiveness as a green building structure.

The Third Case Study: The case study presented is a two-bedroom, single-story house. It was a subpar insulated stone building prior to the remodelling, and it was quite difficult to control the temperature within the house. The proposed makeover will totally alter the old building and build a new, energy-efficient residence.

Table 3. Building's overall GREEN infrastructure representations.

S.NO.	BUILDING FEATURES	INFERENCE
1.	Building size	125m ²
2.	Size of the land	330m ²
3.	Green building features	Ceiling fans with no other mechanical heating or cooling ➤ Heat pump hot water system Insulation, ➤ LED lighting ➤ Solar PV panels ➤ Structural insulated panels (SIPs) ➤ Zero-VOC paint and floor treatments

Design response: Because the house was originally intended to accommodate two people, there was not much room for renovations. Furthermore, there were several challenges associated with the refurbishment. The primary concern that emerged was the two off-street parking spots—one of which must be sheltered—are being proposed by the council. The owners aimed to accomplish the goal of creating ecologically friendly and energy-efficient structures. The green building improvements were:

Energy-efficient lighting: LEDs were used to update the home's lighting throughout. Furthermore, the home's design allowed for more than adequate natural lighting, thus there was little need for active lighting and minimal energy consumption.

Solar PV system with solar hot water: The old house had no solar heating or power of any kind. A 3.5-kilowatt solar PV system was put on the roof in order to address the owner's goal of ensuring enough energy supply through natural means.

Wall construction: New walls had to be added as part of the refurbishment, and the owners insisted on utilizing environmentally friendly building materials. The adoption of structural insulated panels, or SIPs, was the answer. These panels are composed of foam sandwiched between external sheathing and offer excellent performance. The ultimate product is long-lasting, economical, and ecologically benign.

Water conservation: The old house routinely consumed excessive amounts of water and neglected to conserve it. The builder constructed two 5000 and 2000 L rainwater tanks, for a total of 7000 L, to counteract this. Every water source was connected to these tanks within the house. As a result, the owner's water expenses were reduced by more than 60% and water usage was significantly reduced. Several upgrades to the green building were included in the refurbishment. Since the new house uses very little active heating and cooling, the emphasis on enabling effective passive heating and cooling worked well. The main outcome of the project was the structural insulated panels, which significantly improved the home's environmental friendliness.

4. DISCUSSION

The different case studies, involving two different kinds of dwellings were explored in this research. The first were houses that were constructed using a conventional building design and subsequently given a green building makeover. The second group consisted of newly constructed dwellings that were intended to illustrate how well green building design works. In the first instance, The second case building was a refurbished two-story residence that prioritized better temperature control during colder months and expanding the amount of natural illumination. The modifications included solar photovoltaic systems, insulation, and passive heating and cooling. The overall goal for the third building was to create an energy-efficient construction with a constrained budget and space.

5. CONCLUSION

The following are the study's conclusion:

- (a) Implementing green building projects is simple. A home's energy efficiency and environmental friendliness can be significantly improved by installing rainwater tanks to reduce active water consumption.
- (b) Green building projects can save money. Most of the cost effectiveness.
- (c) A home's use of active lighting is greatly influenced by natural illumination. The orientation and types of windows in a home provide effective natural lighting.
- (d) Passive heating and cooling are significantly enhanced by penetration orientation, design, and sealing. This helped in lowering the need for active heating and cooling and ultimately resulting in lower energy and greenhouse gas emissions.
- (e) When linked to essential areas of the house (garden, laundry, and toilet), rainwater tanks lower the quantity of mains water utilized.

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