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Evaluating Carbon Footprint in the Life Cycle Design of Residential Concrete Structures in Jordan

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Abstract

The construction industry is a significant source of greenhouse gas emissions, and there is a growing global interest in reducing the environmental impact of carbon dioxide emissions associated with building construction and operation. Concrete, the most commonly used material in construction, is known to release a substantial amount of environmentally harmful waste throughout its life cycle, including production, construction, operation, and demolition. The worldwide production and consumption of concrete contribute to approximately 5% of all human-related CO2 emissions each year. To assess the carbon footprint of concrete manufacturing and its application in construction projects, a comprehensive approach called life cycle assessment (LCA) is necessary. This paper presents a new process-based LCA approach to analyze carbon emissions and evaluate the carbon footprint of concrete from raw material extraction to the end-of-life stage. To address carbon emissions throughout the life cycle of concrete structures in the Middle East, the study adopts a case study approach, focusing on selected concrete structures in Jordan. The findings from these case studies highlight that the operational phase of concrete structures is the primary contributor to carbon emissions. By thoroughly examining the carbon cycle within structures and their interactions with the surrounding ecosystem, significant reductions in CO2 emissions, environmental deterioration, and its consequences can be achieved.

Keywords: Carbon Footprint; Life Cycle Assessment (LCA); Concrete, Residential Buildings; Jordan.

1. Introduction

In recent years, there has been a significant focus on the issue of environmental degradation, attracting attention and sparking discussions at local, regional, and international levels [1, 2]. It is widely recognized that the construction industry is a significant contributor to both high energy consumption and the emission of carbon dioxide [3, 4].

The 4th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) states that greenhouse gas (GHG) emissions from buildings amounted to 8.6 billion t-CO_2-e in 2004. It is projected that by 2030, these emissions could increase to 15.6 billion t-CO_2-e, representing a 26% increase and accounting for 30–40% of total GHG emissions [5]. To address this issue, it is crucial to implement policies aimed at reducing GHG emissions resulting from construction activities. These policies can be broadly categorized into two approaches: indirect pricing, such as regulations, and direct pricing, such as carbon taxes and emission trading schemes (ETS). To address the urgent need

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for sustainable development and low carbon footprint solutions, it is crucial to examine the impact of concrete on energy consumption and carbon emissions during its construction and production phases [6]. Previous research has extensively explored the use of concrete, its components, and alternative materials to reduce environmental impacts [7–9]. However, most of these studies have primarily focused on the environmental implications of residential concrete structures, with limited research conducted on concrete buildings in the Middle East, particularly in Jordan.

In Jordan, carbon emissions have risen significantly, surpassing an 188% increase between 1990 and 2018, which is more than double the initial level. Figure 1 illustrates this trend. Given the rapid growth and development in the region, it becomes even more crucial to investigate the carbon footprint associated with concrete use in construction practices in Jordan. By understanding the specific challenges and opportunities in this context, targeted measures can be implemented to mitigate carbon emissions and promote sustainable construction practices.

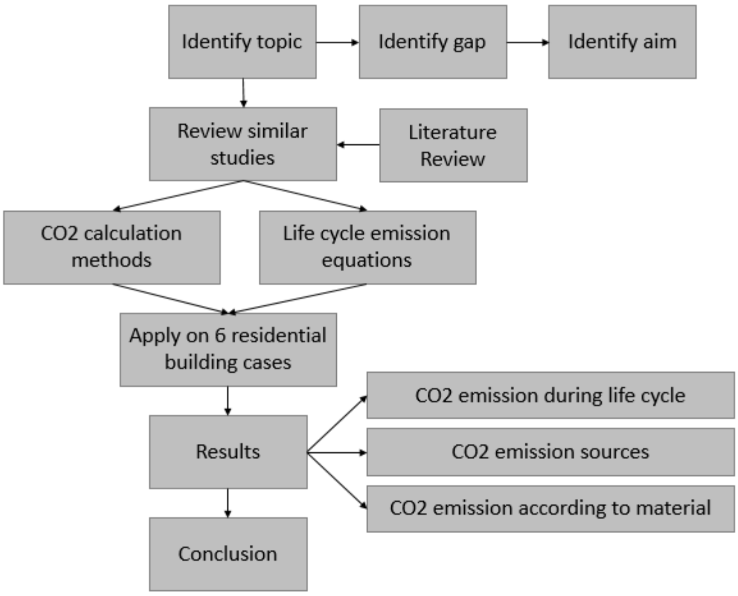


Figure 1. Work flow chart

The global concern regarding increased CO_2 emissions has made it crucial to assess the ecological impact of the building sector using Life Cycle Assessments (LCAs). To address the rising environmental impact caused by rapid urban development and construction demands, it is crucial to prioritize the control of CO_2 emissions. Achieving a balance in carbon emissions throughout the entire lifespan of concrete structures becomes imperative.

Several studies have identified various barriers to achieving a carbon-neutral construction industry. Factors such as lack of awareness, education, incentives, and high initial costs were found to hinder progress in Singapore and Hong Kong. Similarly, in a study focusing on commercial buildings in Beijing and Shanghai, barriers included the absence of regulations and financial incentives, ineffective monitoring, and a lack of awareness regarding energy-saving practices [10]. However, none of these studies have overlooked the integration of LCAs in Jordan. This research aims to address this gap by considering the end life cycle phase analysis of residential buildings.

Hence, it is necessary to conduct a thorough evaluation of the carbon footprint and environmental impact of concrete structures throughout their entire life cycle. This assessment should be carried out using a comprehensive framework. To achieve this, a life cycle assessment (LCA) framework has been utilized to analyze the carbon dioxide emissions associated with concrete residential structures and investigate ways to enhance their sustainability in Jordan. The goal of this research is to develop an improved LCA methodology that enhances our understanding of the environmental impact of concrete structures and provides recommendations for reducing their environmental burden, ultimately leading to the creation of more sustainable structures. Figure 1 illustrates the workflow chart for this study.

2. Literature Review

2.1. Concrete and Carbon Footprint

Concrete is among the most widely utilized construction materials internationally While considering comparable, optimal steel, wood, and concrete structures, concrete structures produce the most greenhouse gas emissions Concrete has the most CO_2-equivalent emissions per unit of mass amongst these materials considered, yet it is just a few percent higher than steel where a dozen times greater than wood [8]. The excessive usage of concrete around the world has prompted academics to try to limit the so-called "*emission*" of concrete since concrete doesn't somehow release either carbon dioxide or any other gases, the phrase "*emission*" of concrete refers to greenhouse gas emissions. The term "emission" relates to the overall greenhouse emissions represented as CO_2-equivalent emissions during the product life cycle, however in the case of concrete, it mostly relates to the extraction of raw materials, components manufacturing, and build-up stages Significant-energy and chemical processes in the case of concrete, cement production—are the primary sources of high greenhouse gas emissions. The major component, clinker, and high-energy operations are accounting for around 45 percent of CO_2 emissions in the cement industry [8].

Concrete is one of the most commonly used construction materials worldwide [8, 11-14]. The term "sustainable concrete" refers to concrete optimization in terms of materials and technology, as well as economic, technical, and environmental factors [15]. Compared to steel and wood structures, concrete structures have the highest greenhouse gas emissions [8, 11]. Although concrete has slightly higher CO_2-equivalent emissions per unit of mass than steel, it is still much lower than wood [8]. The excessive use of concrete has led researchers to find ways to reduce its emissions. When we talk about the "emission" of concrete, we are referring to its greenhouse gas emissions. This includes the emissions generated during the entire life cycle of the product, mainly during the extraction of raw materials, manufacturing of components, and construction stages. The production of cement, which is a key component of concrete, involves energy-intensive and chemical processes that contribute significantly to greenhouse gas emissions [7, 11]. The primary culprit is the production of clinker and the energy-intensive operations, which account for around 45 percent of CO_2 emissions in the cement industry [8].

According to a study conducted by Kajaste & Hurme [16], the carbon emissions resulting from the combination of electricity and fossil fuels can vary from 304 to 490 kilograms of CO_2 per ton of cement. The study also highlighted the significance of the diversity of elements impacting the outcome, such as geographical area, manufacturing techniques, and quality of data. Individual analyses must bring these issues into consideration and work on data wisely [8, 11, 12].

2.2. Life-Cycle of Concrete in Residential Building: Definition

A life cycle assessment (LCA) is a methodology with a system-oriented approach for evaluating a product's or service's environmental impacts [4, 7, 11, 12]. It's being used to investigate energy and material fluxes, as well as their effects on the environment, in relation to the products or services, from extraction of raw materials to manufacture and consumption, to disposal [4, 7].

According to Jensen [17], life cycle assessment (LCA) entails evaluating specific components of a production process throughout its life cycle, most typically the environmental elements. It is also known as "life cycle analysis," "life cycle approach," "cradle to grave analysis," or "*Ecobalance*," and it refers to a rapidly growing range of tools and procedures for environmental management and, in the long run, sustainable development [4, 12, 17].

Throughout this article, a 50-year life span of concrete in residential buildings has been selected, in accordance with Jordan's prevailing design principles, regardless of the specific life cycle of a residential building. The analysis process of a building life cycle strategy covers the creation of natural resources used throughout structures to their final demolition, in which all types of waste are handled or repurposed. The production stage, construction and reformation stage, service life stage, and building End-of-Life stage are normally the four consecutive stages (EOL). All of these phases should be used to assess CO_2 and environmental pollutants, as well as the environmental impact of residential buildings over the lifespan [7, 11, 12, 18].

2.3. Similar Studies

Chen et al. [19] examine the annual energy usage and carbon emissions associated with the ten most commonly used building materials in China. Its goal is to identify opportunities for reducing CO_2 emissions in the construction industry on a large scale. The findings reveal that cement, steel, and brick account for over 70% of the total energy usage and carbon emissions of all building materials. The differences in energy usage and carbon emissions between steel-concrete buildings and brick-concrete buildings are not significant. However, there are substantial variations in energy usage and carbon emissions among different regions. The eastern and south-eastern regions have higher consumption of building materials and significantly greater energy usage and carbon emissions compared to other regions. The paper proposes several strategies for reducing energy usage and carbon emissions in China's building sector.

Alotaibi et al. [20] proposes and examines a method for assessing the life cycle of a building in terms of its embodied carbon across three stages: construction, operation, and demolition. Currently, the standardized method for this assessment is life cycle assessment (LCA), but it is time-consuming, costly, and requires expertise. The paper suggests an alternative approach and evaluates its effectiveness in analyzing the embodied carbon. Additionally, the study investigates various de-carbonization strategies identified in the literature for each stage of the building's life cycle to determine their potential for reducing embodied carbon. The analysis focuses on a high-rise residential building located in an urban area of India, utilizing building information modeling (BIM) to capture the existing conditions. The carbon emissions of the selected building are found to be 414 kg CO_2e/m^2/year, but by implementing different decarburization strategies, this value can be reduced to 135 kg CO_2e/m^2/year compared to the baseline assessment.

Evangelista et al. [21] aimed to evaluate and measure the environmental performance of four common residential buildings in Brazil with different designs. The assessment covers the entire life cycle of the buildings, considering various impact categories such as carbon emissions and energy consumption. The research also examines the significance of different life cycle stages, construction processes, and materials in terms of their contributions to environmental impacts. The findings indicate that the operational phase has the highest environmental significance, while the foundation, structure, masonry, and coating are the most influential construction elements. In relation to materials, concrete, ceramic tiles, and steel have the most substantial environmental impacts.

Robayo-Salazar et al. [22] assesses the environmental impact of alkali-activated binary concrete (AABC) made from natural volcanic pozzolan from Colombia (NP) and granulated blast furnace slag (GBFS). The study uses a life cycle assessment (LCA) to evaluate the Global Warming Potential (GWP) and Global Temperature Change Potential (GTP) of the AABC compared to ordinary Portland cement (OPC) concrete. The findings indicate that the AABC can be produced with comparable or higher compressive strength than OPC concrete, while having a significantly lower carbon footprint (GWP). The AABC's GWP is 44.7% lower, with 210.90 kg CO_2 eq/m^3, compared to 381.17 kg CO_2 eq/m^3 for OPC concrete. These results are considered significant for promoting and establishing the production of low carbon footprint alkali-activated concrete on an industrial scale in countries like Colombia, where volcanic ash soils are prevalent.

Ahmed & Tsavdaridis [23] address the need to redesign critical structural elements and systems in order to conserve material and energy resources and minimise the impact on the built environment's economy. Among non-load bearing construction elements, flooring systems have a significant impact, second only to partition walls. The focus of this study is to highlight the benefits of lightweight flooring systems and contribute to the development of a new prefabricated, ultra-shallow, and lightweight flooring system. The methodology used involves conducting an environmental life cycle analysis (LCA) using the TRACI method and an economic LCA. The study compares the environmental and economic impacts of three types of flooring systems: a prefabricated floor called Cofradal260 commonly used in residential buildings in France, a hollow core precast floor with an in-situ concrete finishing layer, and the proposed system. The assessment reveals that the proposed flooring system has 28.89% lower embodied energy and 37.67% lower embodied greenhouse gas (GHG) emissions compared to the Cofradal floor. Furthermore, it has 20.18% lower embodied energy and 35.09% lower embodied GHG emissions compared to the hollow core precast floor units. The LCA also demonstrates that the proposed flooring system reduces construction costs by 13.08% and end-of-life costs by 41.83% compared to the Cofradal260 slab. Similarly, it reduces construction costs by 1.87% and end-of-life costs by 18.95% compared to the hollow composite precast slab.

3. Research Methodology

3.1. Overview of the CO_2 Calculation Methods

Different quantitative methodologies have been used to analyze the environmental impacts of building construction [11]. These include procedure-based analysis and economic input-output analysis. Procedure-based analysis, also known as Life Cycle Assessment (LCA), examines data related to the production and disposal of a product to assess energy consumption and CO_2 emissions [24]. It is a bottom-up approach that aligns with ISO standards for evaluating the environmental consequences of products based on their manufacturing processes. By considering the materials used and energy consumed during manufacturing, this approach calculates the environmental impacts and CO_2 emissions [5]. However, the assessment of CO_2 emissions in the procedure-based approach can vary depending on how well the evaluator defines the system boundary of the products and services being evaluated [8, 11].

Alternatively, the economic input-output approach is utilized to evaluate the carbon dioxide (CO_2) emissions associated with services and products [8, 11]. This approach takes a top-down perspective, considering not only the direct environmental consequences of the targeted services and products but also their indirect effects [11]. Typically, this assessment relies on data acquired from census or statistical reports concerning the production or delivery of a service or product [8, 11]. While the application of the input-output assessment has been extensively observed in the building sector, particularly in the United States and Japan, due to the availability of data from over 400 relevant sectors, this study faced limitations in terms of statistical data availability. Consequently, the methodology employed for concrete structures in this study adopted a procedure-based or bottom-up approach, specifically utilizing life cycle assessment (LCA) with relevant international standards and methodologies. Recently, researchers and practitioners worldwide have acknowledged the effectiveness of the LCA approach in quantifying CO_2 emissions and assessing their economic and environmental impacts [7, 11].

3.2. Life-cycle CO_2 Emissions of Residential Structures Calculations Equations

In this study, carbon footprint in residential buildings considered from three main sources; transportation, industrial and chemical activity, and energy consumption. The land footprint CO_2 emissions were not incorporated in this research caused by a lack of data in the current case studies. The overall life cycle Carbon dioxide emissions of residential constructions computed using Equations 1 to 3 depending on the data provided as follows:

$$TE = \sum (ICp + ECP + T)\ 4\ p{=}1 \quad (1)$$

$$ICp = \sum (2\ m{=}1\ Mpm \times CFm) \quad (2)$$

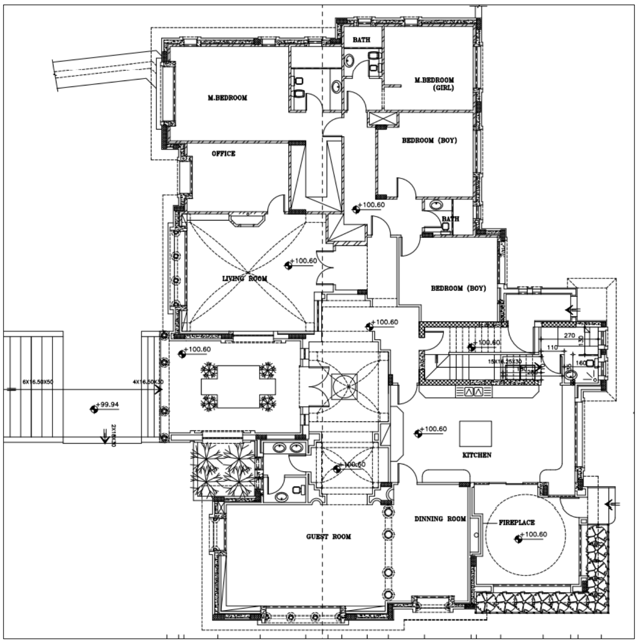
$$ECp = \sum (n\ k{=}1\ Mpk \times CFk) \quad (3)$$

where, TE is the overall emission during the building's life cycle, p is the different phases of a building life cycle, IC is referring to the are industrial and chemical factors, while, EC is pointed to the energy consumption factor. And, T is representing transportation. Equation 2 shows the calculation of the exact amount of industrial and chemical activities (IC). Where, m is the types of materials utilized in the building which contribute to carbon dioxide emission, in the case of this study, only cement and steel reinforcement were calculated. Here, M is the intended material and CF is the conversion factor, where it is 0.396t/t for cement and 0.319t/t for steel [7].

Energy consumption is calculated through Equation 3, here, k is the kind of energy used in different stages of the building's life cycle. Also, M represents the intended energy, in this case is electricity, and as mentioned, CF is the conversation factor for k.

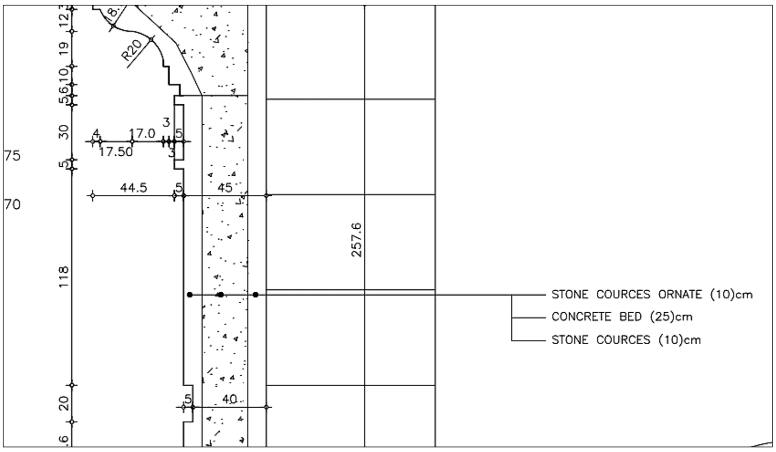
3.3. Case Study of Residential Buildings in Jordan

Six case studies of residential buildings in Jordan were conducted to investigate carbon footprint of residential structures in the middle east/Jordan. The first case study is detached house designed by architect Sameer Amarin and located in Amman-Jordan. The project built up area is 650 m^2 (Figure 2). The main construction materials used in this case study were brick and concrete.



(a)

(b)

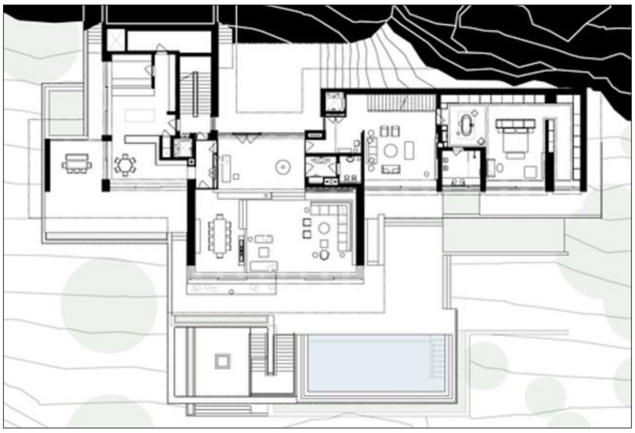


(c)

(d)

Figure 2. (a) Layout, (b) 3D Model, (c) Wall construction detail, (d) The location of Sameer Amareen Residential building

The second case study is also a detached house designed by the architect Sahel Al Hiyari located in Amman-Jordan. The main construction material used in this case study was masonry concrete blocks, including cement, steel, sand, gravel, and water. Figure 3 shows design layout of the second case study.



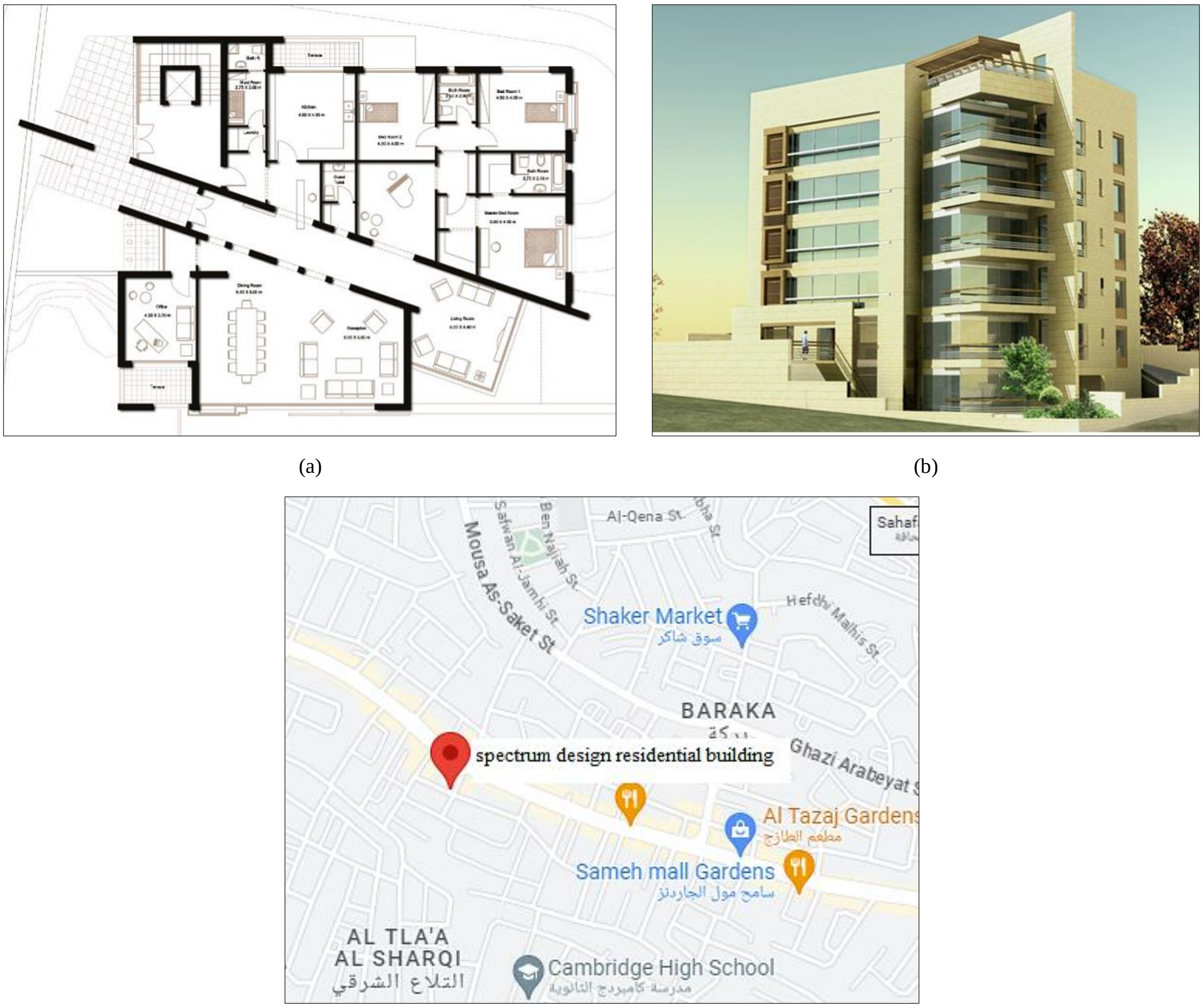
(a)

(b)

(c)

Figure 3. (a) Layout, (b) 3D shot, (c) The location of Sahel Al Hiyari Residential building

While the third case study is 6-story brick-concrete apartment designed by spectrum design office. And located in Amman-Jordan. The main construction materials used in this case study were brick and concrete [25]. Figure 4 shows the layout for the third case study.



(a) (b)

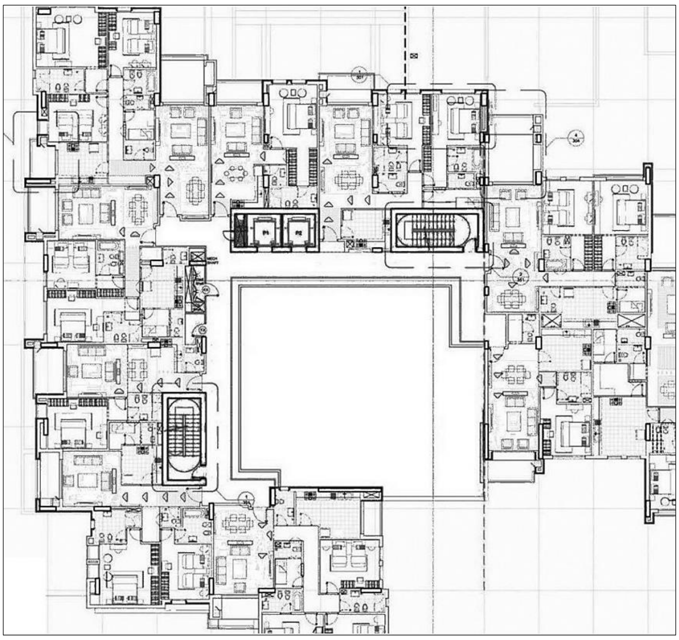
(c)

Figure 4. (a) Layout, (b) 3D Model, (c) Spectrum design residential building

The fourth case study is Marsa Zayed in Aqaba which is the largest real estate and development project in the history of Jordan [26]. It is a mixed-use development including residential, commercial, recreational and entertainment facilities covering 3.2 million sqm. Marsa Zayed will offer more than 30,000 residences ranging from apartments to elegant townhouses and luxurious villas [26]. This project will consist of 151 townhouses and 263 village flats that will be serviced by a neighborhood retail and community center and Sheikh Zayed's Grand Masjid which will accommodate around 2,000 worshipers [26]. In the case of this study, we only examine one apartment tower which was constructed from concreate material. Figure 5 shows the exterior shots and the layout of the project.

(a) (b)

(c)



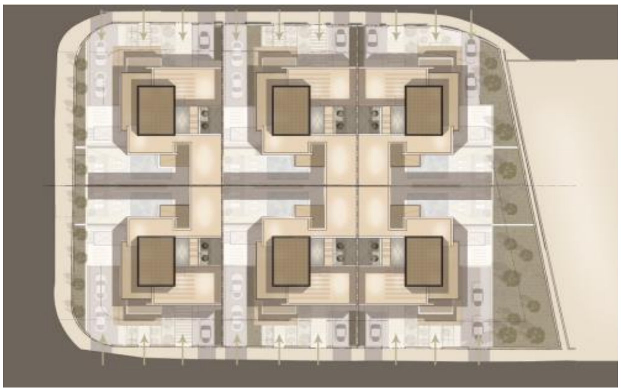
(d)

(e)

Figure 5. (a) Exterior shots, (b) Exterior shots, (c) Exterior shots, (d): layout, (e) The location of Marsa Zayed building

The fifth case study the Kuwait Diplomatic Residence in Amman/ Jordan, the project was especially designed to form a blend between the Kuwaiti and Jordanian cultures in a modern and aesthetic sense. The Diwaniyeh constitutes an essential space in the building; it grows upwards in a poetic sense creating other livable spaces such as a living room in the first floor, and a sitting area on the roof to celebrate the wonderful views of Amman. The ground floor contains functions such as a reception area for guests, living room, kitchen, and the private guest bedroom. The first floor contains a group of Master Bedrooms dedicated for the relaxation of its users along with a family room which views the Swimming Pool. The basement is fully dedicated for the activities and leisure of the family which opens up to the pool, with a large living space to accommodate the needs of everyone. In addition to that, it houses the building services and the main kitchen, all secluded in private place in the basement. The villas are all replicas of each other situated in conventional ways in order to give each villa its own privacy and the best views. Figure 6 shows exterior and the site plan for the residence.

(a)



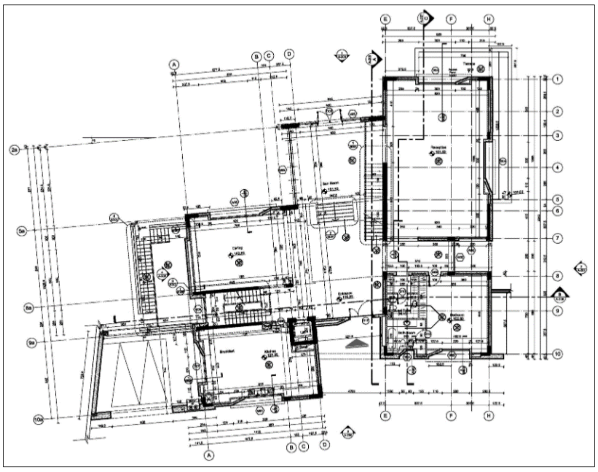
(b)

(c)

Figure 6. (a) Exterior shots, (b) Site plan, (c) The location of Kuwait Diplomatic Residence

The final case study is Villa Zabaneh Located within one of Amman’s most prominent residential districts, Mrs. Hania & Ramzi Zabaneh house provides the family with a perfect home experience close to the rest of the Zabaneh family that inhabits the area. From day one, the value of creating a gallery house was imprinted in the concept of such cotemporary yet local house. Its exterior massing state a dialogue between its edges and facades, while its interiors marvel with sculptural elements and natural lighting. Figure 7 shows exterior and the layout of the Zabaneh Villa.

(a)



(b)

(c)

Figure 7. (a) 3D Model, (b) Layout, (c) The location of Villa Zabaneh buildings

The data analysis of those case studies was conducted based on information about details of quantitative characteristics and utility bills for the mentioned case studies.

4. Results and Discussion

The results show that the residential buildings designed by Sahel Al Hiyari has the highest carbon emission of around 431.5 t/100m^2 followed by Kuwait Diplomatic Residence with 335.34 t/100m^2 followed by Residential building by Spectrum Design with 332.14 t/100m^2 then Residential building by Sameer Amarin with 280.39 332.14 t/100m^2. The least one has an emission if 258.41 for Villa Zabaneh (Figure 8).

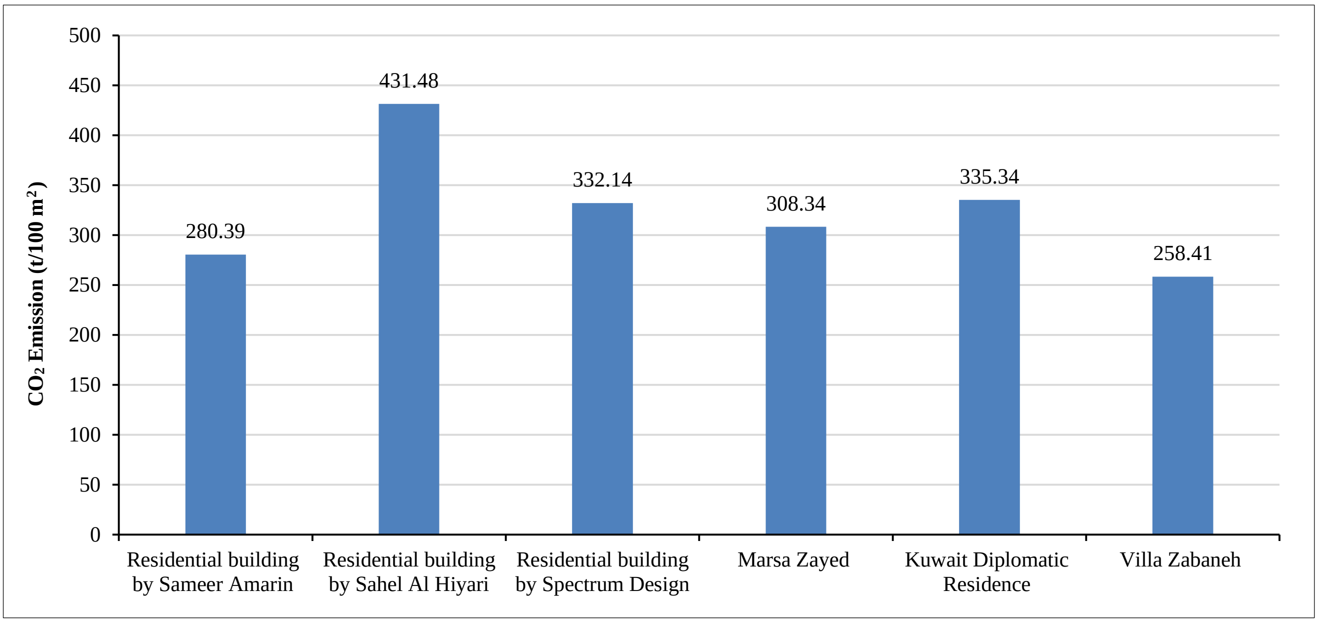


Figure 8. Case studies CO_2 emissions (t/100 m^2)

4.1. Analyzing CO_2 Emissions During the Case Studies Life Cycle

The results show that the residential buildings designed by Sahel Al Hiyari has the highest carbon emission of around 431.5 t/100m^2 followed by Kuwait Diplomatic Residence with 335.34 t/100m^2 followed by Residential building by Spectrum Design with 332.14 t/100m^2 then Residential building by Sameer Amarin with 280.39 332.14 t/100m^2. The least one has an emission if 258.41 for Villa Zabaneh.

Throughout the life cycle of the selected case studies, the findings show that house's operation stage assigned to almost 83% of carbon dioxide emission that has the greatest influence on the ecosystem and the environment through the life cycle of the residential structures. Production stage of life cycle contributed to almost 8-10% of carbon dioxide emission. While, construction and end of life stages of life cycle concrete structures contributed the least impact on the environment and ecosystem with less than 10% as described in Figure 9 and Table 1. These findings corresponded with the findings of Kim et al. [4], Jahandideh et al. [7], and Purnell [13].

Table 1. CO_2 emissions of different life-cycle phases of the selected case studies

	CO_2 Emission (t/100m^2)				
Building	**Production**	**Construction**	**Operation**	**End of life**	**Total**
Residential building by Sameer Amarin	27.5	52.5	250	20	350
Residential building by Sahel Al Hiyari	35	62.5	330	30	457.5
Residential building by Spectrum Design	37.5	49.5	350	26	463
Marsa Zayed	40	70	380	48	538
Kuwait Diplomatic Residence	36.5	51.5	320	25	433
Villa Zabaneh	27.5	53.5	280	32	393
Total	204	339.5	1910	181	

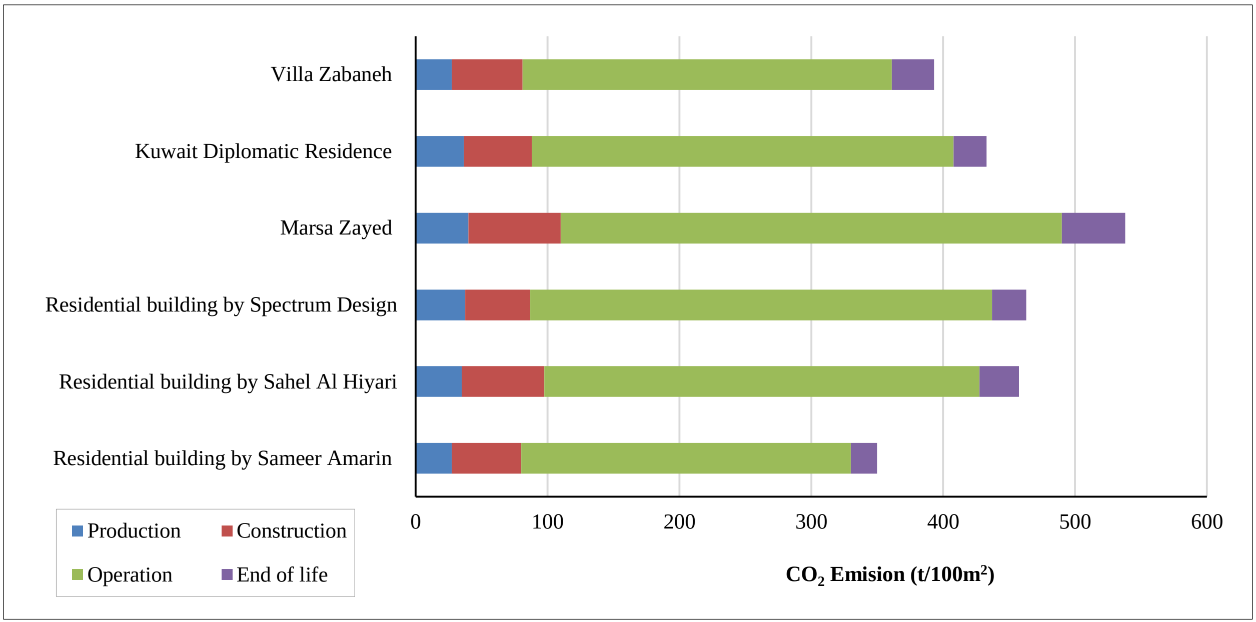


Figure 9. CO_2 emissions of different life-cycle phases of the selected case studies

4.2. Analyzing CO_2 Emissions Sources

In the all sector, Marsa Zayed Building has the highest carbon emission o and the lowest is for Residential building by Sameer Amarin. The carbon emission is analyzed according to transportation, energy consumption and industrial and chemical sectors as shown in Table 2 and Figure 10. The energy consumption sector release around 68% of the carbon emission followed by 22% for the industrial and chemical sector and finally transportation sector of 11%. Those findings were in corresponded with the findings of Jahandideh et al. [7] and Paik and Na [11]. This high percentage indicate that we need a serious action toward sustainable design solutions to reduce energy consumption during building operation phase of the residential building.

Table 2. Sources of CO_2 emissions in the selected case studies

	CO_2 Emission (t/100m^2)		
Building	**Transportation**	**Energy Consumption**	**Industrial and Chemical**
Residential building by Sameer Amarin	35	221	65
Residential building by Sahel Al Hiyari	42	230	67
Residential building by Spectrum Design	38	250	70
Marsa Zayed	50	330	120
Kuwait Diplomatic Residence	45	270	88
Villa Zabaneh	40	290	95
Total	250	1591	505

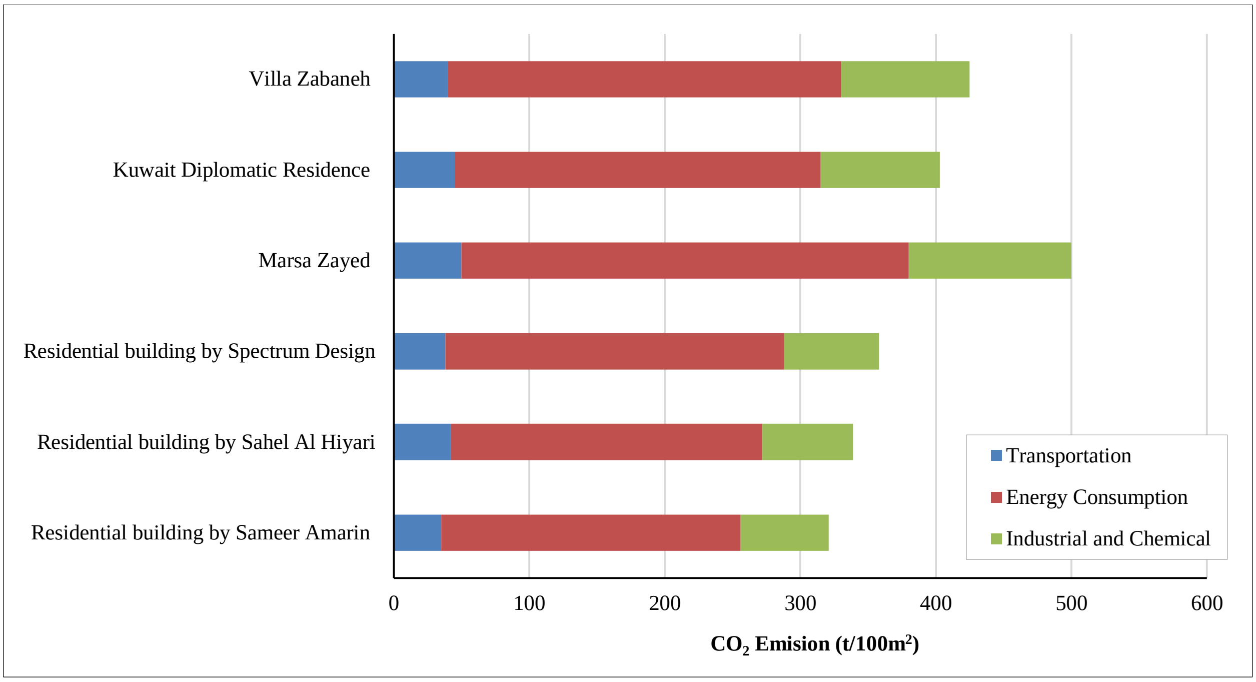


Figure 10. Sources of CO_2 emissions in the selected case studies

4.3. Analyzing CO_2 Emissions According Material Type Characteristics

In comparing the CO_2 emission for different building materials of the selected case studies, Figure 11 shows that cement is responsible of carbon dioxide emission with 85% in the residential building. Brick has the lowest CO_2 emission which indicate that using local construction materials is essential to reduce carbon footprint of the residential buildings in Jordan.

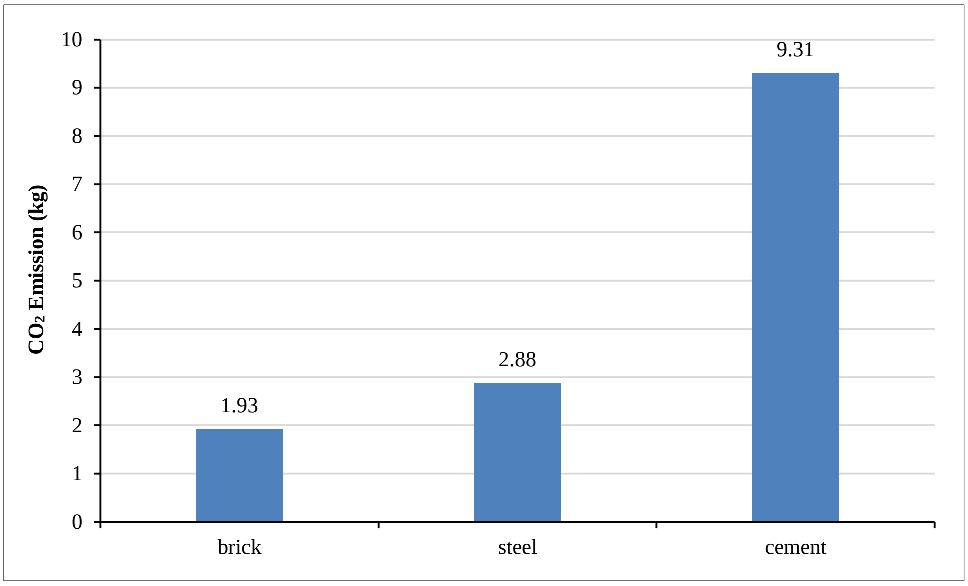


Figure 11. CO_2 emissions by different building construction material

5. Conclusion

A comprehensive study conducted in Jordan analyzed the ecological impact and carbon dioxide emissions associated with concrete residential buildings using the Life Cycle Assessment (LCA) Framework. The research revealed that energy consumption during the operational phase and the land footprint were the main sources of CO_2 emissions in residential structures. The study emphasized the importance of incorporating sustainable design solutions, such as natural ventilation and renewable energy, to reduce greenhouse gas emissions. Additionally, minimizing the use of cement in concrete production by utilizing local materials like brick was found to have lower carbon dioxide emissions. This research represents the first in-depth examination of the carbon footprint of residential buildings in Jordan and provides insights for future studies in the Middle East. The construction industry is a significant contributor to global greenhouse gas emissions, and there is a growing interest in mitigating the environmental impact of concrete through the entire life cycle of structures. The worldwide production and consumption of concrete account for around 5% of human-related CO_2 emissions annually. To assess the carbon footprint of concrete, a process-based LCA approach is necessary. This paper introduces a new LCA approach that analyzes carbon emissions and evaluates the carbon footprint of concrete from extraction to end-of-life. The study focuses on selected concrete structures in Jordan as case studies to address carbon emissions in the Middle East. The findings highlight that the operational phase of concrete structures is the primary source of carbon emissions. By considering the carbon cycle within structures and their interactions with the environment, significant reductions in CO_2 emissions and environmental degradation can be achieved.

6. Declarations

6.1. Author Contributions

Conceptualization, M.R.A. and O.O.; methodology, M.R.A.; software, S.A.; validation, S.A., M.R.A., and O.O.; formal analysis, O.O.; investigation, O.O.; resources, M.R.A.; data curation, A.A; writing—original draft preparation, A.A.; writing—review and editing, M.R.A.; visualization, A.A.; supervision, O.O.; project administration, S.A.; funding acquisition, O.O. All authors have read and agreed to the published version of the manuscript.

6.2. Data Availability Statement

The data presented in this study are available in the article.

6.3. Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

6.4. Conflicts of Interest

The authors declare no conflict of interest.

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