iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 Issue: IX Month of publication: September 2024

DOI: https://doi.org/10.22214/ijraset.2024.64272

Lifecycle Evaluation of Environmentally Friendly Construction Materials: A Review

Reena P[1], Mohanapriya V[2]
[1, 2]Assistant Professor/Civil, JKKMCT, T.N Palayam

Abstract: This approach presumes that practices like using locally sourced materials or products containing recycled content are environmentally beneficial, irrespective of the product's manufacturing process or disposal methods. The choice and application of sustainable building materials are crucial in the design and construction of green buildings. This chapter aims to provide an overview of sustainable materials and their environmental impacts. Additionally, it explores life cycle assessment (LCA) as a methodological framework for evaluating these materials and examines the limitations of LCA in analyzing the sustainability of building materials. the Life Cycle Assessment (LCA) method was utilized to evaluate the environmental impacts of building materials in different construction systems. The study compared three types of construction systems: reinforced concrete, hot-rolled steel, and light steel. Among these, the light steel system had the lowest embodied energy and global warming potential, followed by reinforced concrete and hot-rolled steel. Additionally, the constructions were assessed using the LEED certification system.
Keywords: Green Building Materials, LCA, Sustainable Construction, Sustainable Development.

I. INTRODUCTION

Environmental economics and sustainable development have increasingly become key concerns globally, affecting professionals across various fields (Cole, 1999). Since the major oil crisis of the 1970s, discussions on sustainability have largely focused on the concept of ecologically sustainable development (ESD) (Balder stone, 2004). In the context of building development, ESD involves the efficient utilization of resources to fulfill the needs of both current and future generations while minimizing negative impacts on the natural environment. Enhancing the durability of materials to extend the lifespan of constructions is a crucial aspect of sustainability in the building industry. Briatka et al. (Contribution 1) investigated how internal curing of cement-based composites influences changes in volume and strength parameters, aiming to reduce cracking and thereby extend the concrete's service life. Their study found that replacing a portion of natural aggregate with lightweight aggregate significantly improved these parameters, particularly in the early stages of concrete setting. The findings demonstrate the effectiveness of lightweight aggregate as an internal curing agent, especially in sealed systems, in terms of enhancing compressive strength. Buildings have a substantial impact on the environment. Construction activities account for 40% of the global annual consumption of raw stone, gravel, and sand, as well as 25% of raw timber. Additionally, buildings use 40% of the world's energy and 16% of its water each year. In the United States, construction and demolition waste equals the amount of municipal solid waste produced. Furthermore, around 30% of new and renovated buildings worldwide suffer from poor indoor air quality [1], leading to various negative environmental impacts.

Raw material extraction can deplete resources and reduce biodiversity, while the manufacturing and transportation of building products consume energy and produce emissions that contribute to global warming, acid rain, and smog. Waste generation can create landfill issues, and poor indoor air quality can diminish worker productivity and negatively impact health.

Life Cycle Assessment (LCA) is a method used to analyze and evaluate the potential environmental impacts throughout the lifecycle of a product or service. It can be applied to products, processes, or organizations to document environmental performance, identify opportunities for improvement, compare alternatives, and support eco-labeling criteria. Often, LCA results influence changes in product or process design and supplier choices. However, static system models used for descriptive purposes, such as environmental reporting, may also be employed for planning and development. These models often rely on average technology mixes (e.g., annual electricity consumption patterns), which can result in discrepancies between the LCA's goals and its practical application, potentially leading to misleading conclusions or suboptimal decisions.

II. TYPES OF LIFECYCLE EVALUATIONS

1) Evaluates impacts related to resource extraction, production, transportation, usage, and disposal or recycling.(eg- bamboo flooring from cultivation to installation).

2) Includes impacts related to production and transportation up to the delivery of the product.(eg- recycled steel from the recycling plant to the construction site)
3) Evaluates the environmental benefits or drawbacks during the product's use, including energy efficiency and maintenance.(eg- green roof system during its installation and maintenance phase.).
4) Provides insights into the cost-effectiveness of environmentally friendly materials compared to conventional options.(eg- Comparing the lifecycle costs of using recycled versus virgin materials in a construction project.)
5) Helps in making informed choices between alternative materials or construction methods based on their lifecycle impacts(e.g- Comparing the environmental impacts of concrete vs. timber in a construction project).

III. BUILDING MATERIALS HAVE VARIOUS ENVIRONMENTAL IMPACTS THROUGHOUT THEIR LIFECYCLE

A. *Resource Depletion*

1) Raw Material Extraction: Extracting raw materials such as sand, gravel, and timber can lead to the depletion of natural resources. Excessive extraction may result in habitat destruction and a decline in biodiversity.
2) Finite Resources: Certain materials, including specific metals and minerals, are non-renewable. Overuse of these materials can lead to their eventual scarcity.

B. *Energy Consumption*

1) Manufacturing Energy: The production of materials like cement and steel consumes significant amounts of energy, which contributes to high energy use and greenhouse gas emissions.
2) Operational Energy: The choice of materials affects a building's energy efficiency, impacting the energy required for heating, cooling, and lighting throughout its use.

C. *Greenhouse Gas Emissions*

1) Carbon Footprint : Many building materials have a large carbon footprint due to CO2 emissions generated during their production, transportation, and usage. For example, cement production is a notable source of CO2 emissions.
2) Lifecycle Emissions: Emissions related to materials can extend beyond their production to include their use and maintenance, affecting their overall contribution to global warming.

D. *Water Use*

1) Water Consumption: The production of certain materials, such as concrete and ceramics, requires substantial amounts of water, which can deplete local water resources.
2) Water Pollution: Manufacturing processes may generate wastewater that, if not properly treated, can pollute local water bodies.

E. *Waste Generation*

1) Construction Waste: Construction activities produce waste, including off-cuts, damaged materials, and packaging, much of which ends up in landfills.
2) End-of-Life Waste: At the end of their useful life, some materials pose challenges for disposal, leading to landfill accumulation or environmental contamination.

F. *Air Pollution*

1) Emissions During Production: The manufacturing of building materials can release pollutants into the air, including particulate matter, nitrogen oxides (NOx), and sulfur dioxide (SO2).
2) Indoor Air Quality: Certain materials, such as specific paints and finishes, may emit volatile organic compounds (VOCs) that can deteriorate indoor air quality.

G. *Impact on Human Health*

1) Toxicity: Some building materials contain harmful substances that can pose health risks, such as lead in older paints or formaldehyde in certain engineered wood products.

2) Indoor Environment: Poor air quality or exposure to toxic materials can negatively impact occupants' health, leading to respiratory issues and other health concerns.

H. *Ecological Impacts*
1) Habitat Disruption: The processes involved in extracting and processing materials can disrupt local ecosystems and wildlife habitats.
2) Biodiversity Loss: Activities related to construction and material extraction can lead to a loss of biodiversity and alter ecological balances.

I. *Transportation Impacts*
1) Transportation Energy: Transporting materials from production sites to construction sites involves energy use and emissions, contributing to the overall environmental impact.
2) Infrastructure Impact: The infrastructure needed for transportation, such as roads and shipping routes, can also have additional environmental effects.

J. *Durability and Longevity*
1) Service Life: Materials with longer lifespans can reduce the frequency of replacements and renovations, thereby lowering their overall environmental impact.
2) Maintenance: Materials that require frequent maintenance or replacement contribute to greater resource use and waste generation over time.

K. *Recycling and Reuse*
1) Recycling Potential: The capacity to recycle or reuse materials at the end of their lifecycle can lessen their environmental impact compared to materials that are not recyclable.
2) Circular Economy: Embracing circular economy principles, such as reusing and recycling materials, helps minimize waste and reduces the demand for new resources.

IV. FRAMEWORK FOR LIFE-CYCLE ASSESSMENT (LCA)

A. *Goal and Scope Definition*
1) Objective Setting: Establish the primary purpose of the LCA study. This includes specifying the questions the study seeks to answer and the decisions it is intended to inform.
2) Scope: Define the boundaries of the assessment. This involves determining which stages of the lifecycle will be included (e.g., production, use, disposal), specifying the functional unit for comparison (such as per unit of product), and identifying the impact categories to be evaluated.

B. *Inventory Analysis*
1) Data Collection: Collect data on all relevant inputs and outputs associated with each stage of the lifecycle. This includes gathering information on resource use (such as raw materials and energy) and environmental emissions (including waste and pollutants).
2) Life-Cycle Inventory (LCI): Develop a comprehensive inventory that records all resource consumption and environmental emissions. This inventory should account for both direct and indirect impacts throughout the lifecycle of the product or service.

V. LIMITATION

LCA offers a structured and uniform method for evaluating the environmental impacts of building materials. Its adoption is increasing as a way to improve performance from a lifecycle standpoint. This method involves a thorough analysis of the materials and energy used, as well as the emissions produced, across different spatial scales and scenarios (Finnveden et al., 2009). Despite its benefits, LCA has limitations in the environmental evaluation of building materials (IEA, 2004; Keeler & Burke, 2009). The process can be complex and time-consuming. Cole (2010) points out that, despite the range of LCA tools available, limitations in data and the variety of construction methods can hinder these tools' ability to accurately model and assess the environmental impacts across all stages of a building's lifecycle.

VI. CONCULATION

The growing interest in integrating Life-Cycle Assessment (LCA) into construction decision-making is reflected in the substantial ongoing research in this field. As environmental concerns continue to escalate within society, the focus on sustainability in construction is expected to persist. LCA offers a valuable framework for incorporating sustainability considerations into construction practices and has the potential to enhance existing green building assessment methods. Numerous new construction materials are being developed that match or exceed the performance of traditional materials. By utilizing the LCA framework and tools like BEES software, engineers can identify building materials that are both eco-friendly and cost-effective, leading to more sustainable and economical green building solutions.

REFERENCES

[1] P. S. S. Vamsi1, Nandamuri SivaRaja and B. Sarath Chandra kumar , Assistant Professor K. L. University, Guntur, A.P, India *Life Cycle Assessment of a Green Building Material – A Review.* Issue 4, Vol.3 (May 2014) .

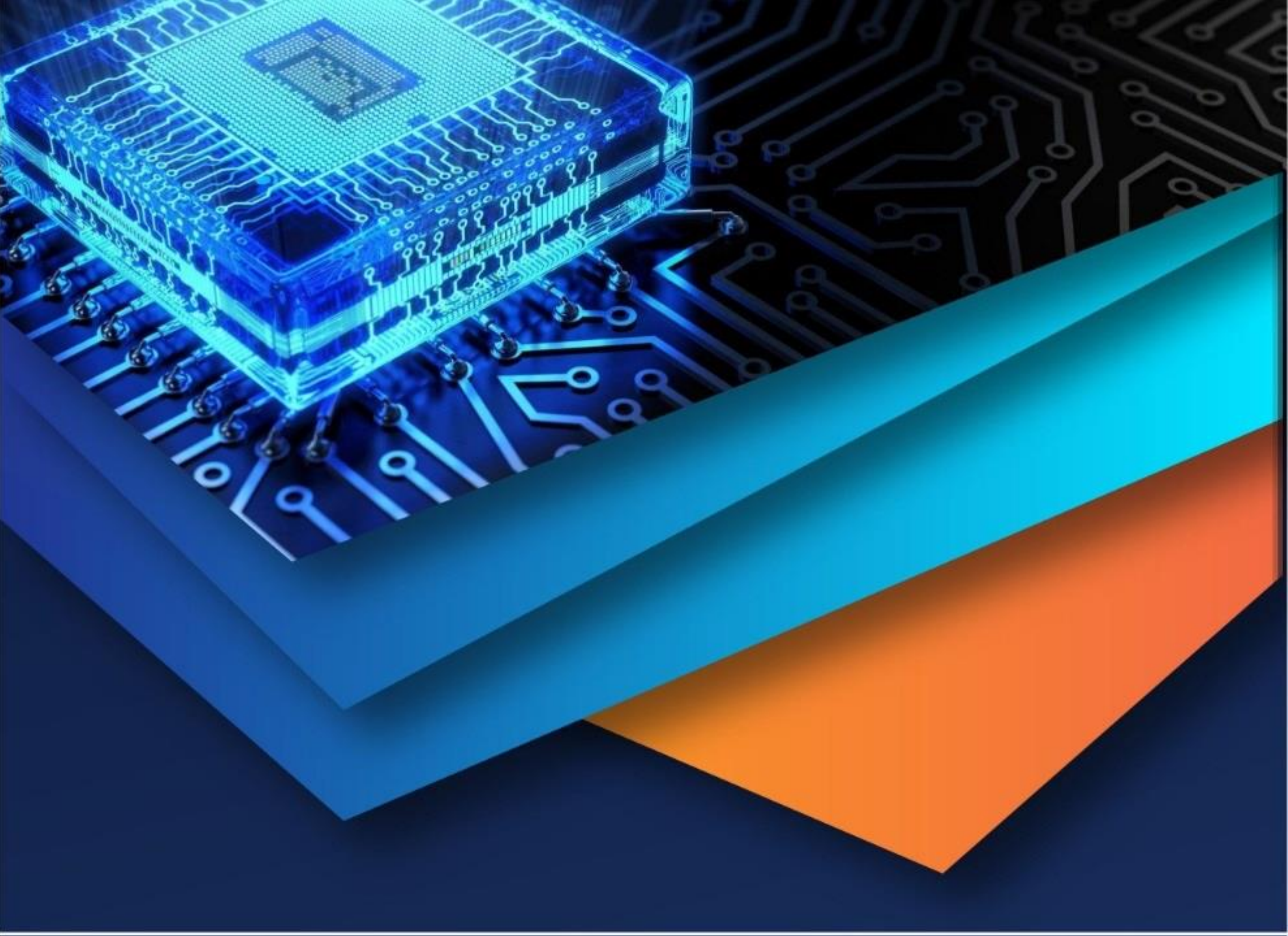
[2] Adriana Estokova ,Dagmar Samesova Institute of Environmental Engineering, Faculty of Civil Engineering, Technical University of Kosice, Vysokoskolska 4, 042 00 Kosice, Slovakia. *Sustainable Building Materials and Life Cycle Assessment* Sustainability 2021, 13, 2012.

[3] Grace K. C. Ding, University of Technology Sydney, Australia, *Life cycle assessment (LCA) of sustainable building materials: an overview.*

[4] Abeysundara, Y., Babel, S. & Gheewala, S. (2009), A matrix in life cycle perspective for selecting sustainable materials for buildings in Sri Lanka, Building and Environment, 44,99.

[5] Amanjeet Singh, George Berghorn, Satish Joshi, and Matt Syal, (March 2011). ―Review of Life-Cycle Assessment Applications in Building Construction‖ Journal of Architectural Engineering, ASCE 7-1004

[6] Humbert, S., Abeck, H., Bali, N., and Horvath, A. (2007). ―Leadership in energy and environmental design (LEED)-A critical evaluation by LCA and commendations for improvement.‖ Int. J. Life Cycle Assess., 12 (Special Issue 1), 46–57.



10.22214/IJRASET

INDEX COPERNICUS 45.98

ISRA JIF IMPACT FACTOR: 7.129

SJIFactor TOGETHER WE REACH THE GOAL IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY