WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

A BIM Based Approach for Life-Cycle Analysis of Single Story Residential Building with Alternative Building Envelopes

Deepak, Praneeth, Vijay Durga,Sai Jagadeesh

GMR Institute of Technology, 3rd year civil, vizianagaram,532127, India

A B S T R A C T

Building Information Modelling(BIM) and Life Cycle Assessment (LCA) joined forces as a response to the desire for more eco-friendly construction practices. Designers started by using BIM for designing buildings, but then they realized they could also use it to check the environmental impact of buildings throughout their entire life. This helps designers and builders make eco-friendly choices from the very beginning until the end of a building's life, showing important how data-driven sustainability has become in construction. It grew rapidly due to increasing awareness and demand for sustainable building practices worldwide. In this study, we focus on employing a BIM-based approach to conduct a comprehensive life-cycle analysis of a single-story residential building. This paper suggest the methodology BIM+LCA conducting life cycle assessments to analyze their environmental impacts across different stages of their existence, from construction to demolition by taking design calculation period as sixty years. The main objective of this paper to develop a suitable building envelope which is environmental friendly. This paper focused on comparing the GWP, Acidification, Eutrophication, Depletion of non-renewable energy consumptions of each scenario. Finally ,It show that the model which is sustainable design and less impact to the environment from the envelope.

Keywords: BIM (Building Information Modelling); LCA (Life Cycle Assessment); Acidification; Eutrophication; Depletion of non-renewable energy

1. INTRODUCTION

Combining BIM with LCA is like uniting two powerful forces to transform eco-conscious construction: BIM enables precise digital building design, while LCA evaluates environmental impacts throughout a building's life cycle, resulting in smarter material choices and energy efficiency improvements. BIM empowers architects and engineers with digital design capabilities, facilitating precise building planning and visualization. Meanwhile, LCA assesses environmental impacts throughout a building's life cycle, aiding in informed decision-making for sustainable construction practices. Working together brings advantages like making better choices about materials, energy, and waste. But there are also challenges along the way that need to be overcome. Overall, it is about finding the balance between benefits and obstacles to achieve eco-friendly construction.

Sustainable design practices informed by BIM+LCA can result in long-term cost savings by reducing energy consumption, waste generation, and operational expenses over the lifespan of the building. Using BIM+LCA needs special skills and software that can be costly and take time to learn. But as people care more about the environment, it is becoming more important. The future seems optimistic because technology is getting better and more people want to build in greener ways. So, even though it is challenging, there is hope for a brighter, more sustainable future. As technology improves, and more people prioritize eco-friendly construction, BIM+LCA is likely to become a common practice in building design. This means that combining these two tools will be a regular part of how we plan and construct buildings, ultimately leading to a cleaner and healthier environment.

The exact percentage of emissions from the civil sector varies depending on factors such as the scale of construction activity, the types of materials and technologies used, and regional regulations and policies. However, studies suggest that the construction industry accounts for a significant portion of global greenhouse gas emissions, estimated to be around 39% of total carbon dioxide emissions, with a considerable portion attributed to the civil sector. Efforts to reduce emissions from the civil sector often focus on improving energy efficiency, utilizing sustainable materials, implementing green building practices, and incorporating life cycle thinking, such as LCA, into decision-making processes to minimize environmental impacts throughout the life cycle of construction projects.

LCA includes identifying areas where improvements can be made, such as optimizing resource usage and reducing environmental burdens. The results serve as valuable communication tools, enabling stakeholders to understand and compare the environmental performance of different options. It plays a crucial role in advancing sustainability goals and promoting a more environmentally responsible approach to decision-making. BIM+LCA enables a continuous improvement cycle, allowing designers and builders to learn from past projects and refine their practices to achieve increasingly sustainable outcomes in future projects.

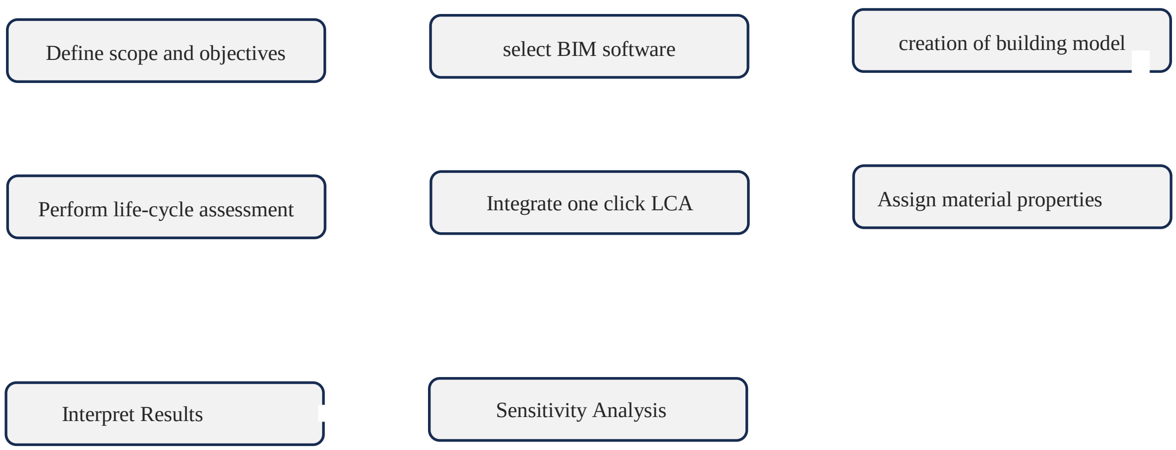
2. Literature Review

- Bernardette Soust-Verdaguer Et al (2018) Reports that, Earlier research didn't have tools that combined BIM and LCA for deciding how to design building envelopes to reduce environmental harm. There wasn't much focus on making LCA methods for studying buildings in Uruguay, which made it hard to measure their environmental impact. Even though studies in 2011 talked about the importance of checking how buildings affect the environment in Uruguay over time, they found there weren't tools specifically for this. So, this study tries to fix these problems by creating a way to use BIM and LCA together to look at how different house designs in Uruguay affect the environment right from the start, helping us make better choices all through the building's life. The authors of the study introduced a ratio to compare the environmental impacts of different building envelope alternatives, focusing on both embodied impacts and operational energy consumption. Despite the initial scenario showing the lowest impacts for Global Warming Potential (GWP), Human Toxicity (HT), and Ozone Depletion Potential (ODP), Alternative 1 was considered the best overall choice. This underscores the need for better tools in the literature, specifically those integrating BIM with LCA, to aid decision-making in building envelope design. The study examined various environmental impact categories, including Global Warming Potential (GWP), Freshwater Aquatic Ecotoxicity (FWE), Human Toxicity (HT), and Ozone Depletion Potential (ODP), to evaluate how different materials and design decisions affect the environmental footprint of a single-family house in Uruguay.
- Somayeh Asadi Et al (2017) Reports that, evaluate the current approaches to BIM-integrated Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) of buildings Previous studies like those by Seo et al (2007), Neuberg et al (2004), and Stadel et al (2011) have focused on real-time assessment, energy simulation, and life cycle energy analysis using various software modules. The authors states that there are problems with how different tools work together and how complex it is to use them, especially in the early stages of design. To tackle this, a new idea called the real-time BIM-integrated LCA/LCC framework is being suggested. This framework aims to give instant feedback on energy, carbon emissions, cost over a building's life, and how efficiently energy is used at important design points. This way, it helps designers make better decisions for sustainability right from the start.
- Madelyn Marrero Et al(2020) focused that, they used a method that combined Building Information Modeling (BIM) with Life Cycle Assessment (LCA) to see how urbanization projects affect the environment. They looked at three different ways to do this, finding that the third approach, even though it took the most time, was the best because it let them put LCA data directly into the BIM software. They then focused on a small urbanization project, including things like playgrounds, parking lots, roads, sidewalks, and bike paths, made of materials like concrete, asphalt, wood, and metal. They figured out how to classify these elements and calculate their environmental impacts in terms of embodied energy, carbon footprint, and water footprint. The results showed that things like parking areas, sidewalks, and driveways had big environmental impacts, especially materials like bitumen and aggregates. By using this method, they could see which elements were causing the most harm to the environment, helping them make decisions to reduce the project's overall environmental impact.
- Joaquín Díaz and Laura Álvarez Antón (2014) research that, This paper looks at how we can use Building Information Modeling (BIM) and Life Cycle Assessment (LCA) tools together to make construction more sustainable. It points out that while LCA is good for checking how a building affects the environment, it has some problems like being complicated and expensive. LCA focuses on the environment, but it needs to be combined with other tools for overall sustainability, and BIM is seen as a key tool for this. The study concludes that if we link BIM models with LCA information early on, we can figure out how a project will affect the environment and its cost, which helps make construction more sustainable. Overall, the idea is to use both LCA and BIM tools together to make construction projects better for the environment and more efficient.
- Sungwoo Lee Et al (2015) presented that, The study aimed to create a template to evaluate the environmental impact of building materials using BIM tools combined with life-cycle assessment (LCA) technology research and development. They determined the level of detail (LOD) in BIM needed to assess this impact and built a database of impact factors for major building materials. Libraries of building elements were also developed using existing databases, and a table was made to evaluate the environmental impact of these materials. The green template was then created as an evaluation tool and tested in a case study, showing a small average error rate of less than 5%.The study compared the results of evaluating the environmental impact using the green template with the actual quantity takeoff, finding an average error rate of about 5%. They also used Table 4 to compare the quantity takeoff with the results from the green template for different building elements, showing differences in measurements and error rates. The study made a green template to check the environmental impact of building materials using BIM tools, which improved research and development of LCA technology. They tested the green template and found it worked well, showing only a small difference between its results and traditional 2D takeoff, proving it is reliable

3.METHODOLOGY:

First, To create a digital model of the single-story residential building using BIM software. This model includes detailed information about the building's geometry, materials, components, and systems. Next, we'll select a suitable Building Information Modeling (BIM) software. This software will help us create a digital model of the building, capturing its design, materials, and systems in detail. After creating the model, To assign material properties to it. This means specifying the type of the materials used in the construction of the building, such as brick wall ,concrete wall, concrete roof, galvanized zinc solid metal roof etc.…

After completion of this to conduct a life-cycle assessment (LCA), integrate one click LCA software with our BIM model. This will enable us to analyze the environmental impacts of the building throughout its entire life cycle, from construction to demolition. With the integrated software, to perform the life-cycle assessment, evaluating factors like GWP, Acidification, Eutrophication and Depletion of non-renewable energy consumptionsat each stage of the building's life. During the LCA integration ,input the data such as Building materials, calculation period, building gross area. Check all the data before getting results. Once getting results, interpret them to understand the implications of different building envelopes on sustainability, performance, and cost-effectiveness.



By following this methodology, to gain valuable insights into how alternative building envelopes can influence the life cycle of single-story residential buildings, helping stakeholders make informed decisions about sustainable building practices.

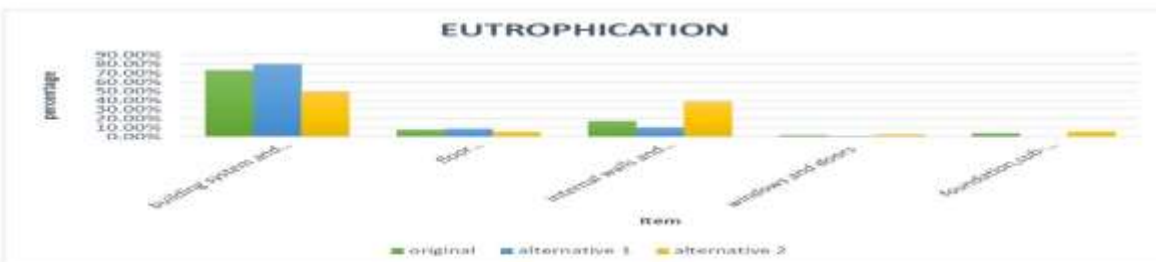
ENVELOPE TABLE:

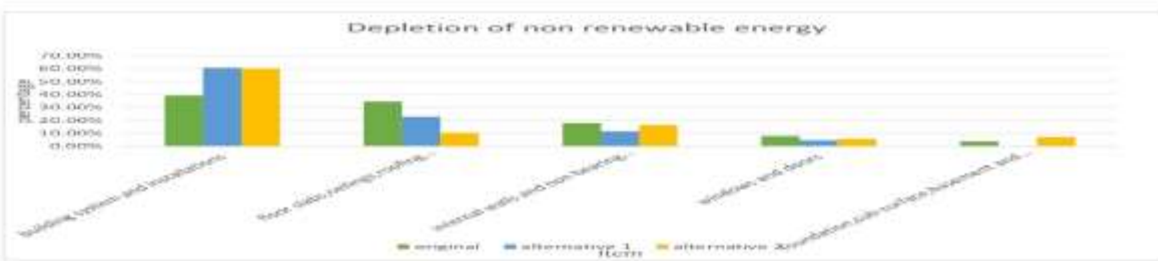
Sl.no	Description	Original building	Alternative 1	Alternative 2
1	External walls	Brick 120mm Mortar 15mm (cement mortar) Paint Interior	Aerated concrete block 200mm Mortar 10mm (cement mortar) Paint Interior	Aerated concrete block 200mm Paint Interior Paint Exterior Mortar 10mm (cement mortar)
2	External Roof	Concrete roof Air chamber 8cm Cement mortar1.5cm Paint interior	Sand wich panel(solid roof) Cement mortar 10mm Paint interior	Galvanized zinc metal sheet(solid roof) Cement mortar 10mm Paint interior

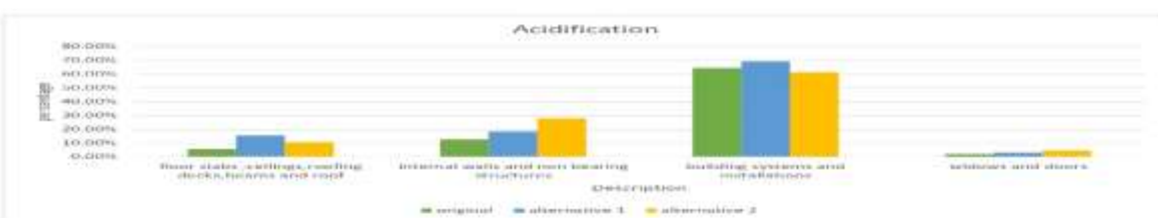
CONCLUSIONS:

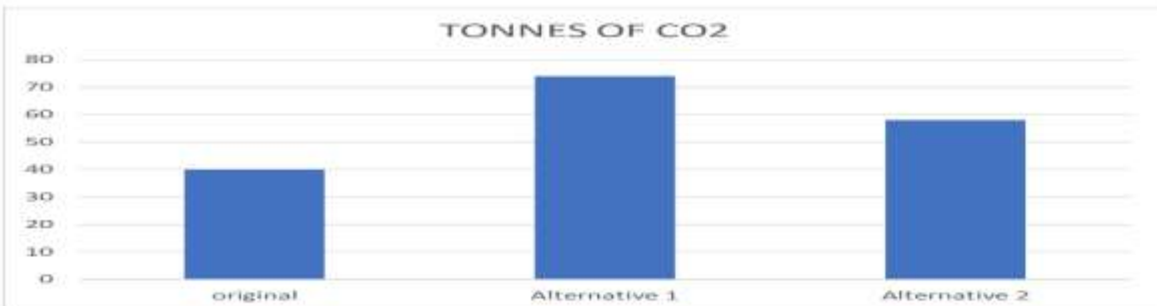
From the results, original model has less emission of co2 compare to alternative 1 and alternative 2.The embodied energy for alternative 1 and alternative 2 are more than the original model.so, original scenario has the lowest GWP impact. Alternative 2 has a lower GWP impact compared to Alternative 1.

Eutrophication has high percentage for alternative 1 compare with the original model and alternative 2 in the case of building System and installations. Eutrophication has Comparatively less for alternative 2 as compare with other models. Depletion of nonrenewable energy is almost similar values for alternative 1 and alternative 2 in the case of building System and installations .Acidification for alternative 1 and alternative2 shows higher impact comparing with original Scenario. the original product has less acidification compared to alternative1 and alternative2, and alternative1 and alternative 2 have non similar levels of acidification. It is important to note that the actual emissions can vary based on factors such as the specific production methods, energy sources used, and transportation distances. Additionally, advancements in technology and the adoption of more sustainable practices can impact the emissions associated with both steel and concrete production.









Acknowledgements

The authors wishes to acknowledge M/s GMR Institute of Technology for the moral support.

References

- Soust-Verdaguer, B., Llatas, C., García-Martínez, A., & Gómez de Cózar, J. C. (2018). BIM-based LCA method to analyze envelope alternatives of single-family houses: case study in Uruguay. Journal of Architectural Engineering, 24(3), 05018002, https://doi.org/10.1061/(ASCE)AE.1943-5568.0000303.
- Nwodo, M. N., Anumba, C. J., & Asadi, S. (2017). BIM-based life cycle assessment and costing of buildings: current trends and opportunities. In Computing in Civil Engineering 2017 (pp. 51-59), DOI: 10.1061/9780784480847.007.
- Marrero, M., Wojtasiewicz, M., Martínez-Rocamora, A., Solís-Guzmán, J., & Alba-Rodríguez, M. D. (2020). BIM-LCA integration for the environmental impact assessment of the urbanization process. Sustainability, 12(10), 4196, https://doi.org/10.3390/su12104196.
- Díaz, J., & Antön, L. Á. (2014). Sustainable construction approach through integration of LCA and BIM tools. In Computing in civil and building engineering (2014) (pp. 283-290), https://doi.org/10.1061/9780784413616.036.
- Lee, S., Tae, S., Roh, S., & Kim, T. (2015). Green template for life cycle assessment of buildings based on building information modeling: Focus on embodied environmental impact. Sustainability, 7(12), 16498-16512, https://doi.org/10.3390/su71215830.