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LIFE CYCLE ASSESSMENT FOR ALTERNATE BUILDING ENVELOPE

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Abstract: Reducing operational energy in residential structures requires careful consideration of the building envelope. By minimizing adverse effects on buildings and the environment, sustainable design is a strategy to design used to improve the environmental quality and the quality of the indoor environment in buildings. Additionally, a design philosophy aims to integrate the idea of sustainable development into the design of sustainable building envelopes in terms of initiatives and values. The integration of sustainable development concepts into projects and principles will improve building envelopment development's energy efficiency and lead to building sustainability.

A well-known scientific method for analyzing the environmental profile of products, processes, and services while accounting for energy use and environmental impacts is the life cycle assessment (LCA). Analyzing the sustainability of goods that have received Environmental Product Declaration certification is therefore more frequently used in the construction industry. (EPD). Concrete and aerogels for wall façades are the elements that are being looked at. The total energy performance of buildings is anticipated to be improved by the design of sustainable advanced materials and building envelope components.

Keywords - **Assessment, Building Envelope, Sustainability.**

I. INTRODUCTION

Life Cycle Assessment (LCA) is a tool for evaluating the environmental impact of a product or system over its entire life cycle. In the context of building envelopes, an LCA can be used to compare the environmental impacts of different building materials and systems, including alternative materials such as straw bales, rammed earth, and insulating concrete forms (ICFs). The life cycle of a building envelope typically includes the extraction of raw materials, the manufacture of the building materials, the transport of the materials to the construction site, the construction process itself, the use of the building and the eventual demolition and disposal of the building materials. A life cycle assessment takes all these phases into account and assesses the environmental impact of each phase as well as the overall impact of the building envelope. There are several key environmental impacts that an LCA can assess, including greenhouse gas emissions, energy use and water consumption, and waste generation. By assessing these impacts at each stage of the building envelope lifecycle, an LCA can provide valuable information on the environmental performance of alternative building materials and systems.

The life cycle assessment (LCA) of buildings can take many different shapes. Some investigations are restricted to specific building components. Others manage to convey the dynamic complexity of the complete structure, including the mechanical systems. To make modeling easier, the life cycle is frequently condensed. Standard presumptions are typically applied and only cursory consideration is oriented to the replacement, repair, and repair of machinery and systems.

Maintenance and repair of building components are often left out of Life Cycle Assessments (LCAs) that have defined cycles for replacing materials and systems. Because most trends are formed early in life, lengthier building life cycles lose significance over time, and results hold true for any length of study period, some researchers have chosen to employ extensive study periods of up to 30 years. These wide generalizations mask the unique characteristics of assemblies and components used in construction. Although the total impact of a building or material is mostly determined by its maintenance and repair effects, requirements vary, and their exclusion or wrong assumption in system modeling can distort the outcome. If the selection of materials is to be based on the results of an LCA, it is imperative that we determine the material's longevity, associated operational energy, maintenance, and repair effects, to the extent that this is practicable.

For example, straw bale construction is a popular alternative building material that has gained popularity in recent years. A life cycle assessment of straw bale construction would assess the environmental impact of the straw bale production process, the transportation of the straw bales to the construction site, the construction process itself, and the overall environmental impact of the finished building. Straw bale production typically involves growing crops, harvesting the straw, and baling the straw into rectangular bales. This process requires energy and water and can also result in greenhouse gas emissions if the crops are grown using synthetic fertilizers and pesticides. Transporting the bales of straw to the construction site can also lead to greenhouse gas emissions, depending on the distance traveled and the means of transport. The construction process for straw bale buildings typically involves stacking the bales and then applying a layer of plaster to a finished surface. This process requires minimal energy input and generates little waste, which can result in a lower environmental impact compared to traditional construction methods.

LCA can provide valuable information on the environmental impacts of alternative building envelopes, including straw bales, rammed earth and ICFs. By assessing the environmental impact of each stage in the lifecycle of these building materials and systems, an LCA can help designers and builders make informed decisions about the environmental performance of their projects.

Hospital or health care waste is generally named & popular as biomedical waste. The world health organization defines biomedical waste as, 'Waste generation by health care activities & includes blood, used needles, pharmaceuticals, radioactive materials etc." The biomedical waste is also known as infectious waste or medical waste or health care waste. According to biomedical waste management & handling rules 1998 of India. Biomedical waste means any waste which is generated during the diagnosis, treatment or immunization of human being or animals or in research activities. In simple words biomedical waste is the waste generated by the medical & health institute/agencies.

Biomedical waste management defines waste management as the practices & procedures or the administration of activities that provide for the collection, source separation, storage, transportation, transfer, processing, treatment & disposal of waste. Biomedical waste management is a routine procedure of hospital administration as prescribed by law. Hospital waste, hospital acquired infection, transfusion transmitted diseases, rising incidence of hepatitis B, HIV & Other diseases, create potential threat of infection, contamination & serious health hazards to doctors, nurses, ward boys, support staff, sanitation workers, rag pickers & other health care workers. Who are regularly exposed to biomedical waste as an occupation hazard as well as general public in the surrounding area.

II. LITERATURE REVIEW

1. Abdulrahman Fnais et al., 2022[6]

This paper reviews the introduction of LCA and its significance in determining the environmental effect of products and processes. The technique employed in the authors' literature review is then thoroughly described by the authors, including the databases searched and the inclusion criteria for choosing pertinent articles. The study discusses several LCA-related issues, including as methodological advancements, application domains, and case studies. The development of novel impact assessment techniques is one of the themes the authors detect in contemporary LCA research, along with a focus on the circular economy and the use of big data and machine learning.

Results and discussions: The main issues facing LCA researchers and practitioners are discussed in the paper's conclusion, including the need for more standardized methodology and data, the difficulty of understanding LCA findings, and the necessity of more stakeholder cooperation. Overall, this article gives a thorough summary of the existing research in LCA and identifies the main topics that will be the focus of further study in this area. For anybody interested in LCA and its uses, it is a helpful resource.

2. Aashish Sharma et al., 2010[5]

This paper reviews measurement and comparison of the environmental effects of human activity on diverse goods are necessary for sustainable development. Providing products and services to society has a variety of negative effects on the environment. Emissions into the environment are a factor in environmental impact. The environmental effect of a building during its whole service life must be understood in order to design an ecologically responsible structure. The purpose of the study is to examine numerous buildings located in various locations whose LCA has been completed in order to determine their current stage of life cycle.

Result and discussions: The efficient utilization of all available energy is significantly influenced by building. Either the residential or commercial real estate sector. The high rate of energy consumption contributes significantly to the use of fossil fuels and the release of several harmful gases, both of which have negative effects on the environment such as the ODP and the greenhouse effect. There are several options available for the constructing phase of a project.

3. Randa Ghattas et al., 2013[4]

This paper reviews on an increasing trend in life cycle assessments (LCA) demonstrates that while energy consumption is reduced with increased energy efficiency, this might result in an increase in embodied energy due to added material load for some energy efficiency solutions. The idea is important for a variety of reasons. Most efficiency criteria only take into account a building's usage phase, neglecting its embodied phase. This is owing to the fact that 90% of the energy needed in buildings will still be for operational purposes. But regulations are tightening, people are becoming more conscious of the environment, and people are demanding more energy-efficient structures. As a result, including embodied phase into architectural rules and standards is becoming more important. Furthermore, if constructing energy-efficiently results in an increase in carbon emissions compared to building conventionally.

Result& discussions: LCA discloses ambiguity, allowing comparison and informing data gathering activities. It also helps to understand the confidence in the results reported. Additionally, there is little study on retrofitting existing homes using energy-saving techniques.

III. LCA OF BUILDINGS

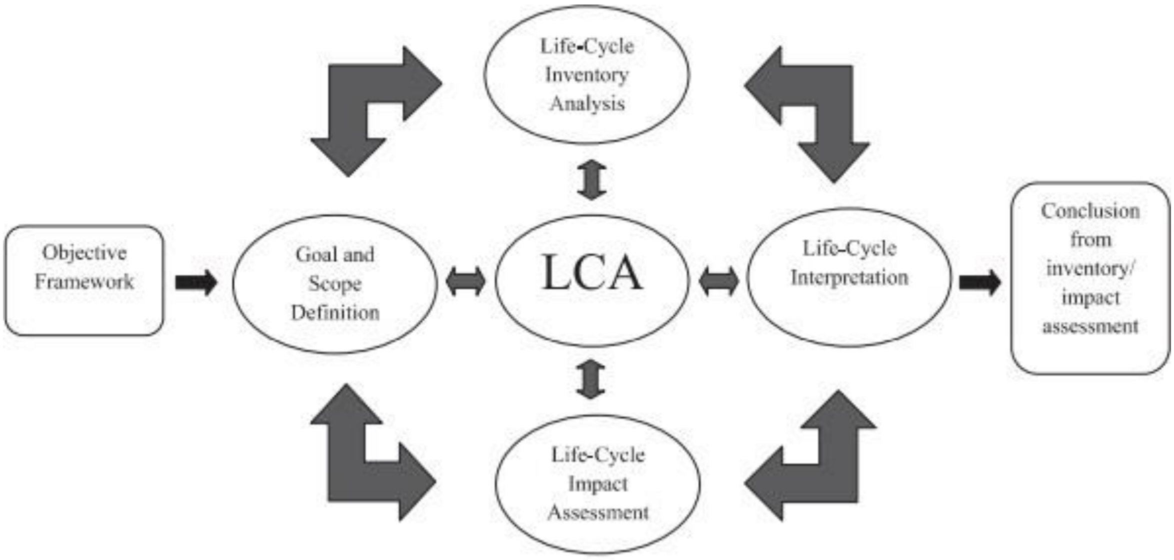

Figure 1 stages of LCA

Building LCA is described as a comparative analysis tool used to assess environmental risks and resource consumption related to the product. Procedure or activity that lasts the duration of the product. There has been discussion of the various Energy requirements for many types of buildings, including those utilized for residential, commercial, or other uses. These results offer comparisons between several iterations of the used components and speak to how a product function. This tool is multidisciplinary because it also has an effect on how people interact with the environment and other people. Modeling is possible. LCA is marketed as a method for managing environmentally friendly products. The following applications of LCA are listed in the international standard for LCA (i.e., ISO 14040 1997): decision-making, discovery of improvement opportunities, etc.
LCA may be categorized into following three types: **I.** Input-Output LCA, **ii.** Hybrid LCA

LCA of Residential Buildings

Adalbert et al. carried out LCA on four multi-family structures constructed in Sweden in 1996. Usable floor space (m2) was used as the functional unit, and a 50-year building lifespan was envisioned. The primary objective was to examine the various life cycle stages of all four buildings in order to determine which stage has the greatest environmental effect and whether there were any differences in environmental impact because of the building's construction and structural framework. With the aid of an LCA tool created at the Danish Building Research Institute, the environmental effect was assessed. This study examined the potential for eutrophication, acidification, global warming, and human toxicity as well as other environmental effects. We took into account the phases of a structure's production, transportation, erection, occupancy, repair, destruction, and removal. 6400 was the expected amount of power consumed. A building's overall environmental effect is mostly caused by its occupation, which accounts for between 70 and 90 percent of all construction and installation costs.

The study was carried out at Houghton, Boulder, and Colombia. Newark, Iowa, and Ames in Michigan. State of the US is New Jersey. The LCA and LCC-compatible Building for Environment and Economic Sustainability (BEES) tool, version 3.0, was used in this study. In four separate multi-occupant buildings, a 25-year operational life cycle for plumbing fixtures and water-consuming equipment was studied utilizing this instrument, an apartment. A college apartment. Both a building for offices and a hotel. It is recommended to utilize natural gas for water heating rather of electricity because doing so would result in an $80,000 savings. Traditional fixtures and appliances should be replaced with more ones that are efficient.
In order to evaluate the energy use and GHG emissions of high and low populated buildings, Norman et al. It demonstrates how important it is to select the right functional unit in order to fully comprehend the impacts of urban density, and it does this by selecting two functional units: living area (on a monthly basis) and the number of occupants per house. (Per capita basis). For Toronto, both criteria were chosen. (Canada). The life cycle assessment (LCA) method known as economic input-output (EIO) LCA was used to determine the environmental impacts of generating the resources required for infrastructure construction. An instrument called EIO-LCA was created by academics at Carnegie Mellon.

LCA of Commercial Building

Junnila and Horvath investigated the important environmental features of a brand-new, high-end office structure with a lifespan of more than 50 years. The functional unit used in this study is I kW h/m2/year, and Southern Finland (Northern Europe) served as the study's site.
Emissions and waste were quantified using inventory analysis, potential environmental consequences from the emissions and waste were evaluated using impact assessment, and the most significant elements were determined using interpretation. The five key stages of a building's life cycle were analyzed in this study: the manufacturing of building materials, construction, building usage, maintenance, and destruction. The results show that the fabrication of construction materials and energy use have the worst consequences. Particularly. Electricity-powered illumination. HVAC units. The most important factors were found to be heat

conduction through the structures, manufacturing maintenance of steel, concrete, paint, and workplace waste management. 48,000 tones C02 equivalent/m2. The projected CHG emissions were for 50 years.

IV. CASE STUDIES

i. LCA of Residential building from Nanganallur, Chennai, TN

Prabhu Residential building situated in Nanganallur, Chennai of G+2 Storage, which was constructed in 2021, was chosen for case study. The building is having area of 225 Sq.m and built-up area of 560 Sq.m. An inventory of the building's materials, including bricks, glass, PVC, electrical components, etc., is the first step in evaluating the life cycle of a structure. You may calculate the overall mass balance of the building's materials using that list. The activities that took place, from the extraction of raw materials to the point of building, in order to assess the environmental effect of those resources.

Next, we consider how the structure will affect the environment both during construction and for the first 50 years after it is finished. This encompasses all the energy used during the building's lifetime as well as all the energy used in its construction. Returning to the building's mass balance, we can determine the building materials' End of Life (EoL), standardizing it based on the building's position. Therefore, steel and copper would be recycled, glass and concrete could be land-filled, timber could be burned, etc. The logistics-related emissions, as well as the energy and material use for recycling and disposal, are added to this step.

ii. LCA of Building envelope in Barcelona, Spain

The case study evaluating the life cycle evaluation of an alternative building envelope is Castell and Roca's (2013) investigation of three building envelopes in Barcelona, Spain. The study aimed to compare the environmental impacts of three different building envelope solutions through a life cycle assessment. The three building envelope solutions considered in the study were a traditional brick wall, a lightweight steel frame wall, and a wood frame wall with cellulosic insulation.

With regard to four effect categories—global warming potential (GWP), acidification potential (AP), eutrophication potential (EP), and photochemical oxidizing potential (POFP)—each solution's environmental impact was evaluated using the Eco Indicator 99 methodology. The results of the study showed that the timber frame wall with cellulose insulation had the lowest environmental impact in all four-impact categories.

The GWP of the wood frame wall was 30% lower than that of the brick wall and 20% lower than that of the steel frame wall. The AP and EP of the timber frame wall were also significantly lower than the other two solutions. The study also found that the wood-frame wall with cellulosic insulation had the lowest POFP, indicating its potential to reduce the formation of photochemical oxidants. The study concludes that the wooden frame wall with cellulose insulation is a more environmentally friendly alternative to conventional building materials in relation to the four impact categories considered. However, the study also emphasized the importance of considering other impact categories, such as B. resource depletion and human toxicity, in future assessments. Overall, this case study provides further evidence of the environmental benefits of using alternative building materials and demonstrates the importance of life cycle assessments to assess the environmental impact of building envelopes.

IV. RESULTS AND DISCUSSION

The use of building life cycle analysis (LCA) is increasing at all stages of a building's life cycle, including material production, design, construction, use era, and end-of-life. The dynamic nature of buildings, shifting operational and climatic conditions, the lengthy lifespan of buildings, as well as the particular difficulties associated with each stage of the life cycle, must all be considered. Due to the computationally expensive nature of assessing design alternatives, the uncertainty surrounding the design and a lack of specific information, conducting LCA during the early stages of design is challenging.

The promotion of circular economy principles and alternative construction techniques is also essential to lessen the environmental effects of building processes and construction waste. Promoting circular economy principles and alternative construction techniques is also essential to lessen the environmental effects caused by waste and the building process, which only makes matters worse.

REFERENCES

[1] Abdulrahman Fnais, Yacine Rezgui, loan Petri, Thomas Beach, Jonathan Yeung, Ali Ghoroghi& Sylvain Kubicki; "*The International Journal Of Life Cycle Assessment",* Volume 27, Page 627-657 (2022), Published: 04 May 2022.

[2] Aashish Sharma, Abhishek Saxena, Munish Sethi, Venu Shree, Varun. *"Life cycle assessment of buildings: A review* "Renewable and sustainable Energy reviews 15(2011) 871-875. Published on: 2 Sep, 2010. Doi: 10.1016/j.rser.2010.09.008.

[3] Randa Ghattas, Germy Gregory, Elsa Olivetti, Suzzane Greene. *"Life cycle assessment for Residential Buildings: Literature review and gap analysis"* Published on: March 12, 2013. Link: Microsoft Word - BuildingLCAReview_v15.docx (mit.edu).

[4] Hoxha, E., Sharma, A., & Zmeureanu, R. (2017). Life cycle assessment of a passive house in Montreal: comparison with conventional and high-performance houses. Energy and Buildings, 148, 92-104.

[5] Castell, A., & Roca, X. (2013). Life cycle assessment of three building envelopes in Barcelona. Building and Environment, 70, 1-12.