



Utilization of BIM And Life Cycle Metric Tools for Evaluating the Life Cycle of a Residential Building

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ABSTRACT—

The software that has been created and used the most in the building industry over the past few years is known as Building Information Modeling (BIM). BIM stands for building information modelling, which is a digital depiction of a building's planning and design (BIM). The key to completely modernizing the building phase is BIM. The usage of BIM encourages nations to develop their construction industries. BIM aids in strengthening ties among numerous parties. We can lessen the impact on society by utilizing BIM. Life cycle assessment (LCA) is the most efficient technique for evaluating the environmental pressure caused by construction components, building assemblies, and a building's entire life cycle (LCA). The construction sector, however, does not typically use this tactic.

Buildings have one of the highest operating demands when compared to other economic sectors, making building energy consumption an important issue. The switch to energy-efficient buildings is one of the most crucial steps towards sustainability. In order to improve the operating energy efficiency of the selected building designs and lessen the difficulties and associated construction costs, building information modelling and life cycle assessment have been developed. More than 40% of the world's CO₂ emissions and 40% of the use of natural resources are attributable to the building industry's energy use.

Keywords: Building Information Modeling (BIM), Life Cycle Assessment (LCA), CO₂ emissions, Sustainability, Construction.

Introduction

BIM stands for Building Information Modeling. It is a digital depiction of a structure's structural and functional details. A community's overall planning, construction, and maintenance are all included. Instead of dividing design and construction, control a structure using a single integrated system of 3D models and blueprints. Building information models (BIMs) are computer files that may be accessed, distributed, and networked to facilitate decision-making regarding a built asset (often but not always in proprietary format). The planning, design, construction, operation, and maintenance of buildings as well as a variety of physical infrastructures, such as ports, tunnels, highways, railroads, bridges, water, waste, power, and communication services, may all be done with the use of BIM software.

Construction is not an environmentally friendly activity by nature. The global cumulative environmental impacts of the construction processes have been increasing due to the large number of ongoing construction projects.

Life cycle assessment is a useful technique for evaluating how items or processes affect the environment throughout their entire life cycle (LCA). It is mostly quantitative and considers the flow of both material and energy [1].

According to two studies [2] and [3], the building industry is known for consuming a lot of energy and natural resources as well as having a negative impact on the environment.

The energy consumption of the building sector is responsible for more than 40% of global CO₂ emissions and 40% of the use of natural resources [4]. According to the United States Energy Information Administration, between 2012 and 2040, Brazil's residential sector will consume 1.6% more energy annually. Electricity is still anticipated to remain the most significant source of energy globally, with a growth from 61% in 2012 to 75% in 2040 [5]. In order to increase energy efficiency in construction, it is important to put innovative practices into practice, such as green building, the use of sustainable materials, and integrated renewable energy systems. With the help of Life Cycle Sustainability Assessment, the business owner may select a sustainable product that will save them money and reduce their overall environmental effect (LCSA). LCSA and BIM must be integrated into one system. The outcomes demonstrate the necessity of establishing a workflow between LCSA and BIM.

Energy use has both direct and indirect implications over the course of a building's existence. Enhancing energy efficiency in the building sector is a priority for energy policies and initiatives [6]. A building's energy use pattern can be influenced by the type of building, climate zone, economic

development level, and modern technologies that examine the many qualities and capacities of building materials [7]. The choice of the building envelope, which comprises the exterior walls, windows, roof, doors, and ground floor, can affect energy usage over a structure's lifetime [8].

Doing a Life Cycle Assessment required the usage of the following software:

1) AUTODESK REVIT:

The building information modelling programme Autodesk Revit was created for use by landscape architects, structural engineers, MEP engineers, designers, and contractors. Users can create buildings, structures, and their individual parts in 3D and provide general project file information. We use the design and documentation tool Revit to create the designs, drawings, and schedules needed for BIM (BIM). Details provided by BIM include the design, scope, quantity, or phases of a project. Every drawing page, 2D and 3D view, and timeline in the Revit model all display data from the same virtual building model. Revit records information about the project and synchronizes it with all other representations of it when you make changes to the building model. The Revit parametric change engine synchronizes changes to model views, drawing sheets, schedules, sections, and plans automatically.

2) STAAD PRO:

Modern visualization tools, a well-built analysis and design programme with advanced finite elements, and dynamic analysis capabilities are all features of STAAD PRO. from model creation, analysis, and design to visualization tools and result verification. STAAD PRO is frequently used for the design of multistory buildings, factories, tunnels, bridges, and other structures made of steel, concrete, aluminium, and cold-formed steel. A structural engineer must gather data on loads on the structure, geometry, support conditions, and material properties in order to conduct a thorough analysis. Such study often yields displacements, stresses, and support reaction data. Thereafter, this data is examined in light of the standards that point to the reasons for failure. The achievement of an acceptable probability that buildings produced will work satisfactorily during their design life is the goal of design. For the design goals to be met, there must be agreement with clearly stated standards for the construction, workmanship, materials, maintenance, and use of the building in service.

The minimum requirements determine the structure's design.

Standards recommended by the Indian standard codes.

The minimal design loads that must be used to construct a structure in order to meet the minimum requirements for structural safety included dead loads, living loads, and other external loads.

3) ONE CLICK WITH LCA:

The use of One Click LCA, an automated and user-friendly life cycle assessment tool, can be used to calculate and minimise the environmental impacts of building and infrastructure projects, products, and portfolios. As an automated LCA tool, One Click LCA was developed in 2011 by Bionova Ltd. in Helsinki, Finland. An automated LCA procedure offered through a web interface that can be coupled to the necessary software via open standards forms the basis of One Click LCA's business model. A tool called One Click LCA can be integrated into other applications. Moreover, One Click LCA includes more features than a typical LCA analysis. Climate resiliency, life cycle costing, site and material tracking, EPD development, and services for particular certification procedures like ISO 14001 certification are just a few examples.

Review of Literature

1) Life Cycle Assessment of a Residential building using BIM:

This article's main goal was to examine how building information modelling (BIM) can be used as a technology to alter project delivery and reevaluate construction business practices. BIM is a tool that enables us to do this by improving transparency throughout the process, which leads to increased efficiency and, as a result, decreases in both cost and delivery time.

2) Evaluation of BIM based LCA in design phase of Buildings:

Designing the building project in BIM in accordance with this framework will improve the GWP (Global Warming Potential), as interaction with BIM and LCA tools enables substitution of materials that contribute to the highest release of CO₂. Such automation in LCAs, and the ability for ongoing assessments will assist the decision-making processes to emphasize the environmental issues during design.

3) Life-cycle assessment of Residential Buildings:

The primary barriers to LCA application in the construction industry are highlighted in this research. Additionally, it offers a way to go through the hurdles found and encourage the usage of LCA techniques from the very beginning of the design process. The simplification of LCA for efficient use during the design process will also be covered in this study.

4) Integrated optimization with the building information modeling and life cycle assessment for generating energy efficient buildings:

The methodology suggested for this paper can be used for any type of architecture to determine which parts of the building provide the highest levels of operational energy consumption and environmental impacts.

5) Evaluation of BIM based LCA in early design phase (low LOD) of buildings:

In this research, Level of Development (LOD) is evaluated as a chance to improve the efficiency of calculating the environmental impacts at various early design stages using the Life Cycle Assessment approach (LCA). Early building material selection is aided by this.

6) Integration of Life Cycle Assessment in a BIM environment:

Two effective techniques, BIM and LCA, will be highlighted in this study. These techniques can be quite helpful in the context of sustainability. BIM helps integrated design on the one hand and enhances information management and collaboration between the various stakeholders throughout the various project lifecycle phases. LCA, on the other hand, is a long-term approach to evaluating environmental performance. Early on in the decision-making process, LCA and BIM should both be included in order to achieve a comprehensive perspective of the project that includes environmental requirements.

7) The BIM revolution: a literature review on rethinking the business of construction:

The major objective of this study was to investigate how building information modelling (BIM) may be used as a technology to modify project delivery and reconsider business procedures in the construction industry. By increasing transparency throughout the process, which leads to better efficiency and, as a result, lowers in both cost and delivery time, BIM is a technology that makes it possible for us to do this. This article gave a quick explanation of how the building information modelling (BIM) technology helps us achieve this goal by streamlining the process, increasing productivity, and, as a result, reducing the cost and length of the delivery process.

8) Computer aided analysis and design of multi storeyed buildings:

This paper states that the design entails manually calculating loads and using STAAD Pro to analyze the entire structure. Limit state design technique, with reference to the IS Code of Practice, is the design methodology utilized in STAAD Pro analysis. STAAD Pro features a user interface that is simple to use, visualization tools, and robust analysis and design engines with sophisticated finite elements and dynamic analysis capabilities. At first, they began by analyzing straightforward 2-D frames, and then personally tested the software's accuracy using the data. The outcomes turned out to be highly precise.

Methodology

A three-dimensional model of the building is created in Revit, and design of reinforcement for the created building model is done using STAAD Pro and life cycle analysis of the building is done using One Click LCA Software.

Steps for designing a model in Revit:

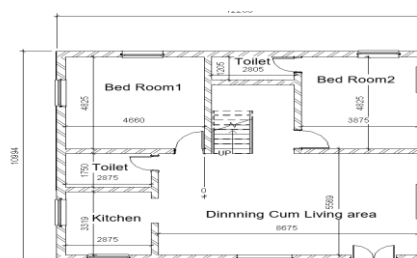
1) Preliminary Layout creation:

Choose a suitable template to use, then decide on the project's units. A finite plane can be enhanced using grids or levels to help define the project's surroundings. For each known storey or other architectural reference in the building, make a level. The building's column plan is created by including the grid lines.

2) Add Fundamental Building Components:

- i. Create Walls: Go to the architecture tab, choose a wall, then select the properties toolbar, click on edit type, duplicate, and then ok. Next click on edit, specify the wall's thickness and unconnected height, and then click apply.
- ii. Include doors, windows and necessary components: The element of doors is adaptable to any kind of wall. Plan, section, elevation, and 3D views all have the option to insert doors. You can import many kinds of doors from the Autodesk Revit family. With the edit type menu, the door's attributes can be changed. To add skylights to a roof or windows to a wall, use the Windows tool. Choose the window type from the Type Picker. Modify a window's construction style, materials, dimensions, and other features. Components are typically supplied and installed on-site building items including furniture and plumbing equipment. First go to the necessary level, then choose the component for doors, windows, and other architectural features using the panel bar, select the load family option to one level, click choose the India folder twice. Decide which elements are necessary. Place on the necessary area after clicking "open."
- iii. Design roof: Build a roof using an extrusion or the building's footprint. With Revit, there are numerous ways to design roofs. Choose the strategy that best complies with the demands of your project design.

Create floors: Choose Architecture. Choose the floor from the built panel, choose your floor level, choose the line from the draw panel, provide a value for the plinth offset, draw the line at the outer boundaries of the wall and then choose Finish Edit Mode. Choose floor, then choose properties tool bar, now click on edit type, now choose duplicate, provide duplicate name, click on edit, then choose second row floor thickness and finally click on ok and again on ok.



Ground Floor Plan

Fig 1: Plan

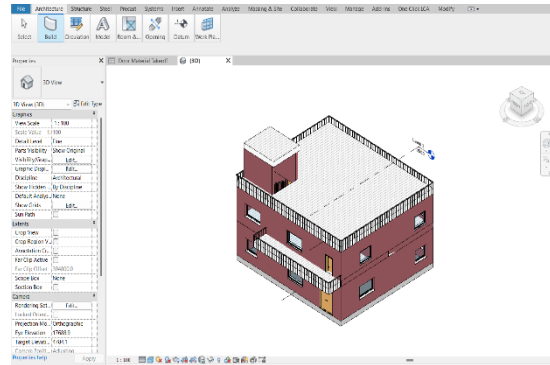


Fig 1: Architectural view

3) Design of reinforcement for a residential building using STAAD Pro:

- i. Design of the structural framework
- ii. Creating a structure model in STAAD Pro
- iii. Applying of various load combinations to the member
- iv. Analysing the Structure
- v. Designing of the Structure

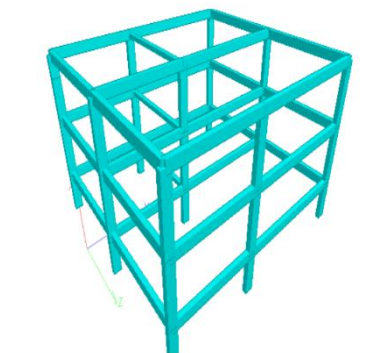


Fig 3: Staad analysis

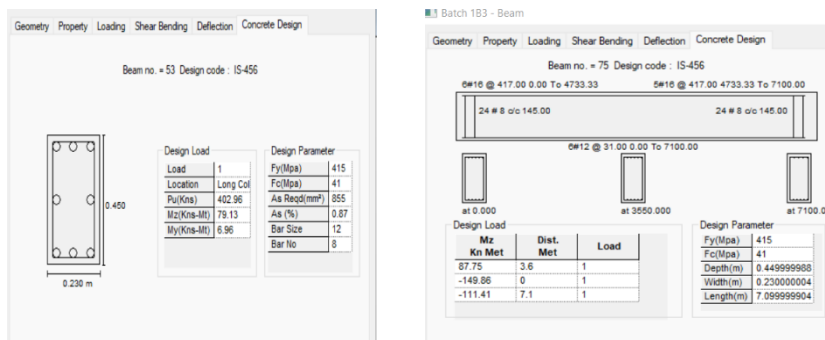


Fig 4: Details of beam and column

4) One-Click LCA Analysis:

Choose the project in the LCA for the carbon emission calculation as the net carbon emission for residential structures. The required details should be provided, including the annual energy consumption of the structure and specifics like the property's size and number of stories. To input residential building data into the one-click LCA, use a.gbxml file. Cross-check the imported data, localise the net carbon emission design circumstances, and present the net carbon emission findings. The results, which display the building's net carbon emissions from the start of construction to the end of destruction, will be displayed as bar charts and pie charts.

Conclusion

The average temperature of the earth is raising day by day at an alarming rate. Carbon dioxide gas is responsible and contributes the highest to the global warming. Construction industry is responsible for higher carbon emissions.

The solar heat gain coefficient calculates how much solar energy enters a building through a window, door, or other opening. This solar energy can enter the building in one of two ways: directly into the home or by being absorbed and subsequently released as heat inside the home. The building industry accounts for almost 28–30% of total carbon emissions on a global basis. So, in order to achieve decarbonization and long-term structural development and prevent negative environmental repercussions on a global scale, all business kinds will need to work together. Hence, only one click is required. The LCA method is a tool for lowering carbon emissions in the building industry.

This tool can be used to identify the precise area or kind of material that contributes to a building's greenhouse gas emissions as well as the building's overall carbon emissions. According to the study's conclusions, the building elements floors, beams, columns, and slabs are those that produce the most amount of carbon emissions, and the majority of these emissions take place when a structure is being rebuilt. Materials like plastic and glass are also responsible for the emission of carbon.

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