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Life Cycle Assessment of (G+1) Office Building Using BIM and One-Click LCA

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ABSTRACT:

This study Combines the life cycle assessment (LCA) and building information modelling (BIM) to asess the environmental impacts of building materials used in the construction sector. For the architectural and structural drawings, Autodesk Revit software was utilised, and STAAD.pro was used for the building's design and analysis. In order to discuss the results produced by BIM and LCA technologies and to support the creation of design concepts, this research, on the subject of a (G+1) office building, is employed. using One Click LCA and Autodesk Revit as BIM platforms and tools respectively to achieve the objectives. This study demonstrates that BIM-LCA integration is the best way to achieve sustainable development and environmental protection, and that it also improves the decision-making process in the building industry. This work illustrates having various stages of building development by drawing the plans and modelling of walls ,placing the components, generating schedules, and finding out the carbon emission finally by studying the life cycle assessment of the building. The manufacturing and operating stages have an impact on the environment. In order to maintain the passive impact of carbon emission on the environment we can use reconsidering of different material.

Key Words: Life Cycle Assessment, BIM , Revit, STAAD.pro

Introduction:

Concern over the use of natural resources, the consumption of energy, and the effects on the environment is spreading around the world. Environmentally damaging emissions are being produced by environmentally intensive human activities such the combustion of fossil fuels, deforestation, and changes in land use. Construction is one of the key sectors that has a significant impact on the environment in terms of resource use, energy consumption, and other factors. As a result, more ideas and solutions are required to achieve sustainability standards in this business, especially in light of the difficult conditions that include rising competition, resource scarcity, and a lack of environmental protection standards. These factors have a fundamental impact on how the built environment and energy are impacted. construction, installation, use, until eventual destruction and recycling Consumption occurs throughout the whole Life Cycle Assessment (LCA) of building materials, including raw material extraction, manufacture, packaging, and site transportation. The distinctiveness of this work is to make note of incorporating BIM and LCA right from the start of the design process to evaluate environmental effects in the construction industry.

Building information modelling (BIM): It is a technique for fusing knowledge and technology to generate a digital, intelligent model of a project that incorporates numerous sources of information and evolves simultaneously with the actual project over its duration, including design, construction, and operational data in use, more affordably and with fewer detrimental environmental effects. By allowing the construction of a realistic digital representation of a building, BIM (Building Information Modelling) technology enables collaboration on all facets of building design between owners, architects, rcc consultants, and contractors. Building information modelling (BIM) is one of the most promising developments in the architectural, engineering, and construction (AEC) fields (BIM). In this, a (G+1) office building will be developed using BIM Revit software, and its life cycle assessment, or carbon emission, will be determined.. In order to develop (G+1) office building many processes are involved to create different components in the building. Because it is crucial for a civil engineer to save time, an effort is made to plan and assess an office building utilising the revit programme. Using STAAd.pro structural analysis and design software, a structure that can withstand all applied loads without failing for the duration of its planned life was created. Each structure's study and design should begin with gathering the essential load data in order to create the foundations, footings, and columns that will support the structure's loads. Once the relevant data and calculations have been gathered, structural work will be carried out to finish the building's architectural portion. To develop Architectural part of the office building plan should be clear. The main important thing is to understand the plan carefully and then execute that. In order to develop the architectural part according to the plan many stages are involved. The building's architectural components were developed using the Revit software, while its structural components were designed and analysed using STAAD.pro software, and its carbon emission were determined using one click life cycle analysis (LCA). As a result, the materials could be changed to maintain the building's passive impact on the environment.

OBJECTIVES

1. To create a G+1 office building using BIM REVIT.
2. To model all architectural, structural elements and placing all the doors ,windows etc components of the office building.
3. Life cycle assessment to find carbon emission of the modelled G+1 office building.
4. To decrease the carbon emission from the building to maintain the passive impact on the environment.
5. Suggesting and identified the alternative materials in order to decrease carbon emission to maintain passive impact.

LITERATURE REVIEW

1. Alexander Hollberg, Gianluca Genova, Guillaume Habert.“Evaluation of BIM-based LCA results for building design”

The fundamental idea is to assess, using a real-world case study, the potential of continually using BIM-based LCA throughout the design process. Here, the LCA is completed after the building's planning stage. BIM has the ability to improve the environmental performance of buildings during the design phase by reducing the work required to calculate the embodied environmental impacts of buildings.

2. Alexander Vysotskiy, Sergei Makarov,Julia Zolotova, Eugenia Tuchkevich.“Features of BIM Implementation Using Autodesk Software”

Aim of this composition is to give specialists that a moving to BIM technologies with needed practical recommendations. BIM perpetration is a complicated process. If you want to avoid miscalculations and get great benefits from the integration authors advice you to consider recommendations listed in this composition

3. Kof A. B. Asare, Kirti D. Ruikar Mariangela Zanni Robby Soetanto.“BIM-based LCA and energy analysis for optimised sustainable building design in Ghana”

This exploration acknowledges that working towards an enhanced SBD governance is dependent on multiple factors and by extension multiple realities. This study sought to demonstrate that BIM- grounded LCA and Energy Analysis can grease SBD in Ghana

4. Dalia M.A. Morsi, Walaa S.E. Ismaeel, Ahmed Ehab, Ayman A.E. Othman .“BIM-based life cycle assessment for different structural system scenarios of a residential building”

This shows the selection of the three structural system scripts of a typical domestic structure and developing the BIM model for each. Presented an assessment of the environmental impacts for a typical middle- class domestic structure in Egypt regarding the material, construction element, life cycle stage and different impact orders

5. James Heaton,Ajith Kumar Parlikad, Jennifer Schooling.”Design and development of BIM models to support operations and maintenance”

This section proposes a methodology that allows for the birth of objects within a BIM model into a relational database to support the development of an AIM. This paper proposes a methodology that allows for the development of an AIM.

6. Mohammad K. Najjar, Karoline Figueiredo, Ana Catarina Jorge Evangelista, Ahmed W. A. Hammad, Vivian W. Y. Tam & Assed Haddad. “Life cycle assessment methodology integrated with BIM as a decision-making tool at early-stages of building design”

This study performs a practical operation of LCA methodology to estimate the damage impact orders of construction accoutrements . This study compared the LCA of structure accoutrements that are assembling the construction ofmulti-story office structures in Brazil considering two styles of construction in design, grounded on two assessment styles IMPACT2002þ and ILCD2011

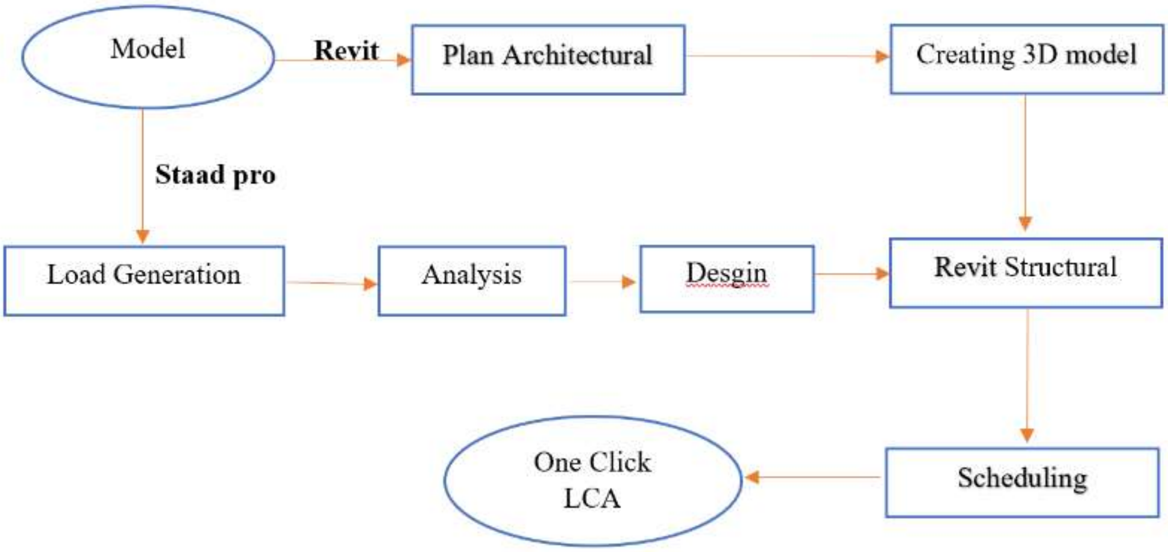
METHODOLOGY

To determine the carbon output from a building, the building's life cycle assessment can be completed in three steps :

Stage 1: Building architectural design using Revit Software

Stage 2: Structural analysis and design and using STAAD.pro

Stage 3: Using One click LCA to find carbon emission



Methodology Flow Chart

Stage 1: Building architectural design using Revit Software

Building information modelling (REVIT) : Building Information Modelling (BIM) is a sophisticated 3D model-based technique that gives architects, engineers, and construction workers the knowledge and resources they need to design, develop, and maintain infrastructure and building more effectively. The steps below are used while using the Revit program for creating the architecture model of the building. There are various sorts of facilities on the ground floor and first floor of the office building, including managers' rooms, staff rooms, reception areas, printing rooms, and waiting areas. The building's total gross floor space is 199.77 sqm.

DEVELOPMENT OF (G+1) OFFICE BUILDING :

- Drawing of grids and levels
- Modelling of walls accordingly to the plan
- Placing Doors and windows
- Modelling of floors and roofs
- Staircase modelling
- Placing all the families of office building

Fig1. Ground Floor Plan

Fig 2. First floor plan

Fig 3. 3D view of the building

Stage 2: Structural analysis and design using STAAD.pro

Following the completion of the Revit plan, then in the STAAD.pro the size of a column can be determined by assuming the necessary information for the G+1 office building . In order to provide the input in STAAD.pro it should be manually calculated. This column size is entered into staad.pro as an input, and after the analysis is complete and it should be error-free to proceed further . Similar to how the loads being applied to the building, including the dead load, live load, wind load, and earthquake load, must be taken into account when determining the beam sizes. The STAAD.pro software determines whether a structure is failure or not simply applying all of the loads to a columns and beams. With the result in the STAAD.pro the structural design can be done in Revit software. The STAAD. Pro gives the design of the column , beams and foundation of the building with input that is given to it.

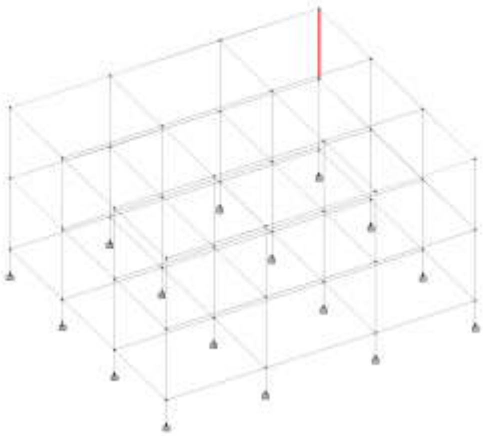


Fig 4. STAAD.pro frame

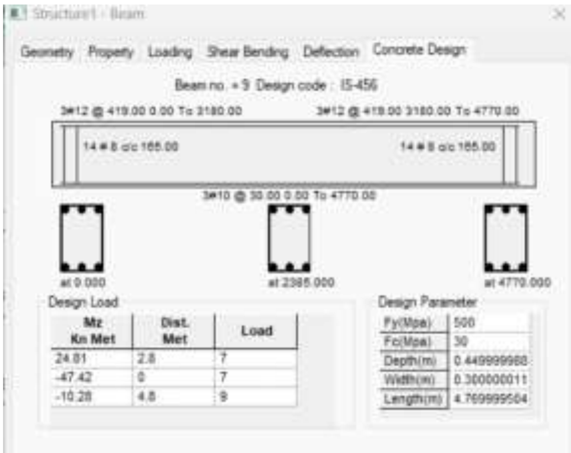


Fig 5. Concrete design of Beam

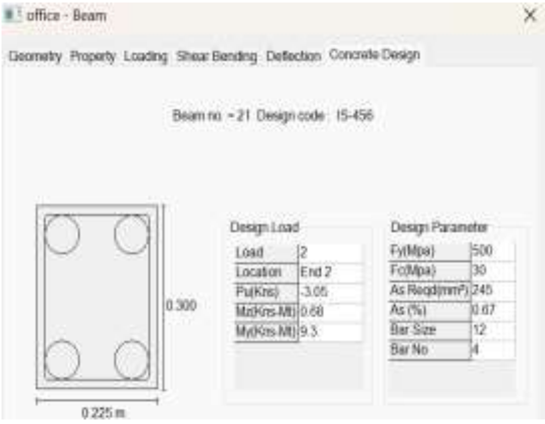


Fig6. Concrete Design of Column

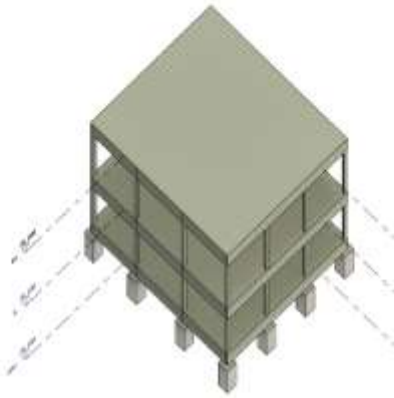


Fig7. Structural design of building

Stage 3 : Using One click LCA to find carbon emission

Life cycle assessment : Life cycle assessment, also known as LCA, is a method used to quantify the environmental effects of products by considering every stage of their life cycle, from the extraction of raw materials to construction, operation, and maintenance, recycling, and deconstruction at the end of their useful lives. This comprehensive methodology enhances and extends frameworks, impact analyses, and data quality. Since 1990, the LCA method has been widely applied in the building sector as a vital tool for evaluating the environmental consequences of building materials across the project's numerous life cycle stages. The LCA method analyses and investigates the numerous solutions that help reduce resource and energy consumption as well as the environmental impacts of building materialsThe three primary divisions of the Building LCA are Pre-Building Phase, Building Phase, and Post-Building Phase, as shown in Table 1. According to the makeup of each phase, which includes a range of activities, the pertinent contained energy has indeed been divided into several categories. Table 1 displays the five categories for building energy use during the course of respective lifetimes. The process of extracting and producing raw materials, which is referred to as embodied energy, is the first stage. Transporting building materials from the manufacturing facility to the construction site is considered the second stage, or grey energy. In stages three and four, actual energy use for the phases of construction and operation takes place. "Induced energy" and "operational energy" are the two ways that these two stages consume energy. The energy required for demolition and recycling at the final step represents the building's end-of-life phase. The right building materials can also lower embodied energy, according to study. However, employing an energy-efficient system that maintains pleasant indoor conditions while consuming less energy can help conserve operating energy, which is considered to make up the majority of the total energy consumed in buildings for cooling, heating, ventilation, lighting, heating water, and power.

Life Cycle Phase	**Activities**	**Relevant Contained Energy**
Pre-Building Phase	raw materials are extracted, then manufactured, packaged, and transported to the location.	The energy used in the extraction and production of building materials is known as embodiedenergy. Transporting building supplies from the factory to the construction site uses up "grey energy," which is a resource.
Building Phase	Construction, setup, running, and maintenance	Energy that is consumed during the procedure of constructing something is known as induced energy. Energy used to operate the structure is referred to as operation energy.
Post-Building Phase	Demolition and recycling	Disposal Energy :Is the energy used in the building's destruction and disposal

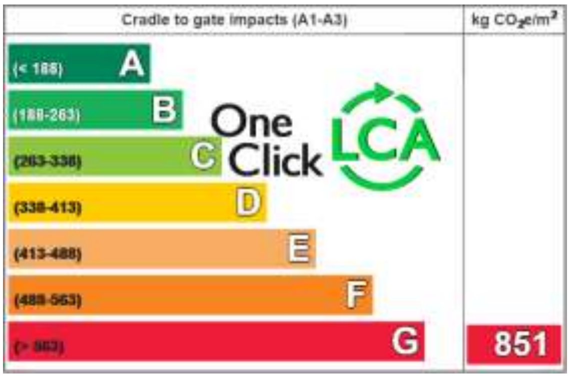
(Table 1. LCA phases and relevant energy consumption)

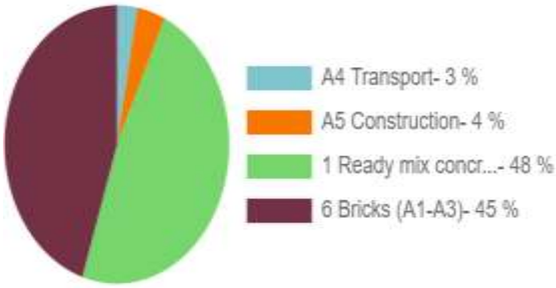
INTEGRATION OF BIM AND ONE CLICK LCA TO FIND CARBON EMISSION :

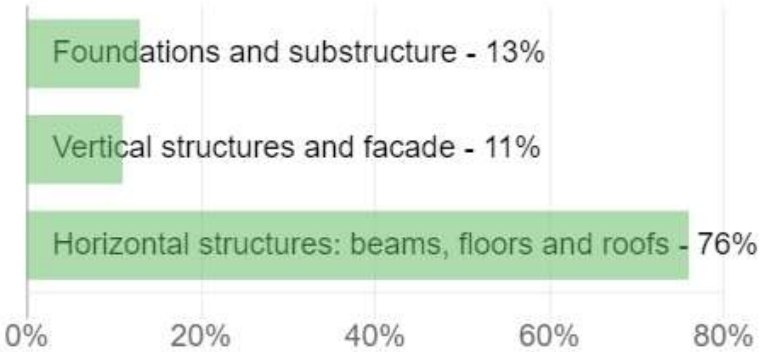
The first method for assessing LCA performance was direct access to the BIM model data. According to this approach, BIM models created during the early design phase serve as the primary means of gathering data needed to conduct a comprehensive life cycle evaluation of buildings. Also, the evaluation, environment performance measurement, and decision-making processes are used by reducing manual data entry and enhancing the LCA technique. The second technique involved the incorporation of environmental attributes into BIM objects. This approach will intimately link the environmental life cycle assessment database with BIM tools. It motivates decision-makers to take environmental factors into account, such as designers, architects, and engineers. This strategy is currently regarded as an inadequate way to assess LCA studies in the construction sector.

There by importing the BIM data base of office building the carbon emission of the office building was evaluated given in the following results and diagrams such has bar charts and pie charts etc.

Trail 1:







Product Stage			Construction Process Stage		Use Stage							End-of-Life Stage				Benefits and loads beyond the system boundary		
Raw material supply	Transport	Manufacturing	Transport to building site	Installation into building	Use/application	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction/demolition	Transport	Waste processing	Disposal	Reuse	Recovery	Recycling
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D	D	D

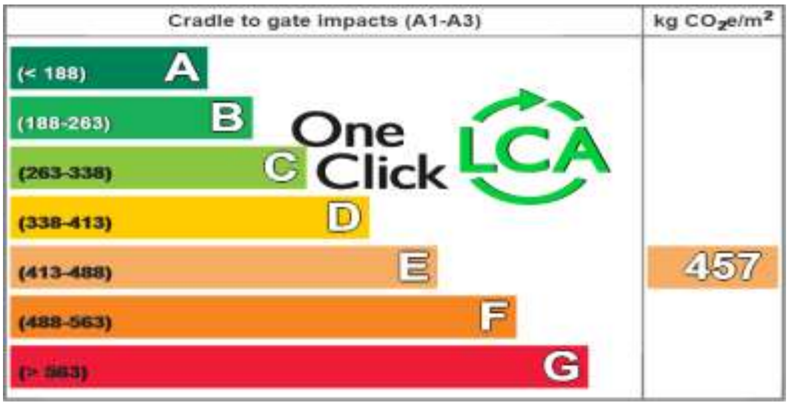
In the trail 1 the total carbon emission from the office building is 170 tonnes i.e 851 kg CO_2/m^2 which is at G grade i.e . The range of results at two standard deviations from the mean for the building type is included in the performance metric. Seven (seven) evenly spaced bands make up the range. The results' median falls into band "D," whereas the results' lowest and highest values fall into bands "A" and "G," respectively.

The building's total percentage of carbon emissions is 13% from the substructure and foundations, 11% from the vertical structures and facades, and 76% from the horizontal structures like beams, floors, and roofs.

The majority of carbon emissions in this are caused by clay bricks.

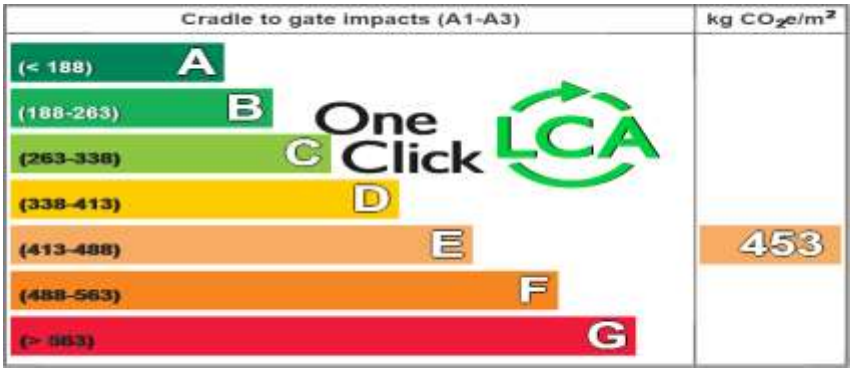
The trail 2 can be completed manually to decrease the building's carbon emissions.

Trail 2 :



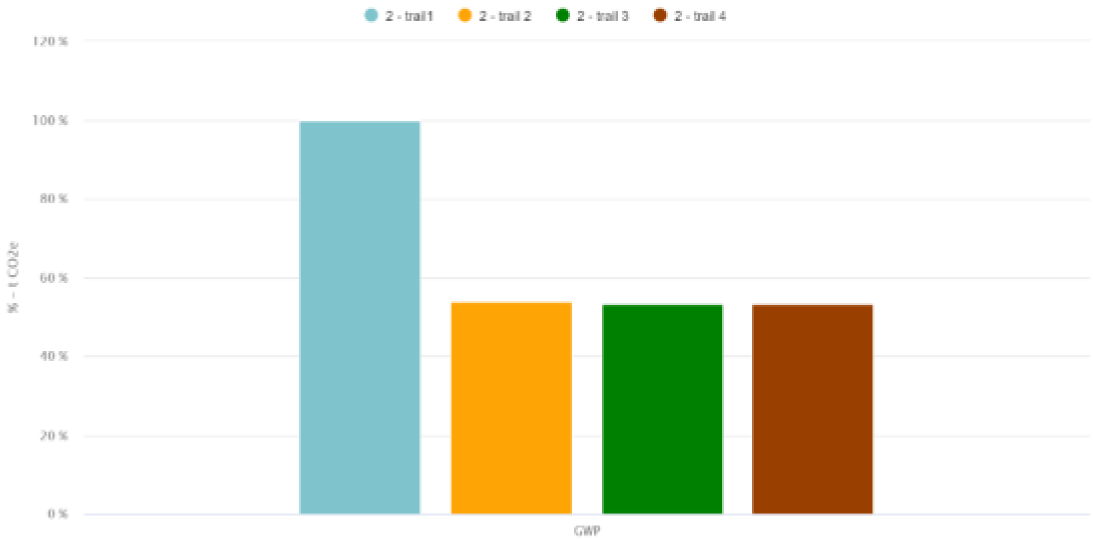
The use of reclaimed bricks in place of the clay ones reduces the carbon emissions in this construction. Hence, the building's carbon footprint shrunk by 91 tonnes, or 457 kg of CO2 per square metre.

Trail 3 :



By reducing the distance that the goods must be transported, or logistics, there is a minor reduction in carbon emissions in Trail 3.

RESULTS AND DISCUSSIONS



According to all the research and findings, Ready Mix Concrete was primarily responsible for the majority of the horizontal structures' carbon emissions. By switching from clay to reclaimed bricks, we were able to reduce carbon emissions by 91 tonnes and maintain the environment's passive influence. This proves that using reclaimed bricks is a more sustainable option.

Trail 1 which gives the result of 170 tonnes of carbon emission

Trail 2 gives the result of 91 tonnes of carbon emission with the replacement of reclaimed bricks i.e 457 kg of co2 per sqm.

Trail 3 gives the result of 91 tonnes of carbon emission i.e 453 kg of co2 per sqm.

CONCLUSION

This study concludes that a common BIM (Building Information Modelling) programme called Revit enables users to generate a digital model of a construction or infrastructure project. Popular structural analysis and design software is STAAD.pro that civil and structural engineers use for all kinds of structural engineering projects. Complete Structural Analysis, Customized Design, Time-Saving Functions, Integrated Workflow, User-Friendly UI, Cost-Effective, and others are some benefits of utilising STAAD.pro. STAAD.pro is an effective and flexible software solution for structural analysis and design that provides engineers working on a variety of projects with a number of features and advantages. The environmental impact of structures, infrastructure, and other items throughout the course of their life cycles can be calculated and reported using the One Click LCA (Life Cycle Assessment) software programme. With the usage of different software like Autodesk Revit and STAAD.pro software considering all the data regarding finding the carbon emission of an office building One Click LCA software is used. After importing all the database of an office building from the BIM into One Click LCA it analyses all the data and gives us a result of the carbon emission i.e 851 kg of co2 per sqm.

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