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CASE STUDY : ENERGY ANALYSIS AND LCA OF A HOSTEL BUILDING

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ABSTRACT :

Building information modelling (BIM) is a modern data information platform and management tool that promotes the development of green buildings. Buildings demand energy in their life cycle right from its construction phase to demolition phase. High energy consumptions may lead to serious environmental impacts like increase in the rate of global warming. Therefore, it is important to study the energy consumption of building at the conceptual stage. Studies show that 40% of global CO2 emissions each year are caused by the built environment and Cement is a widely utilized building ingredient in the construction industry, an essential part of the concrete mix. This study presents a comprehensive analysis of a building's energy performance and environmental impact using a combination of energy analysis and life cycle assessment (LCA).The building's energy consumption patterns were analyzed using Building Information Modeling (BIM) and energy simulation software such as Autodesk GBS & Autodesk Insight360, revealing key insights into its energy use intensity (EUI) and major energy consumers. Concurrently, the LCA assessed the environmental impacts of the building's life cycle stages, highlighting the contributions of construction materials, operation, and end-of-life processes to global warming potential (GWP) and other environmental indicators using ONE Click LCA.

Keywords : BIM (Building Information Modelling), Energy Analysis, LCA (Life Cycle Assessment), Autodesk Revit Software, Green Building Studio, Autodesk Insight 360, ONE Click LCA .

INTRODUCTION:

Building Information Modelling is referred to as BIM. It is a computerized representation of the physical and functional characteristics of a structure. BIM is a 3D-based model technique that provides information and tools to architects, engineers, and builders so they can plan, design, and manage their projects more effectively. Planning, building, and upkeep of a community are all included . Use a single integrated system of 3D models and drawings to operate a structure rather than separating design and construction. 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). A range of physical infrastructures, including buildings, roads, railroads, bridges, ports, and tunnels, are planned for, designed, built, operated, and maintained using BIM software by private citizens, companies, and governmental organizations. BIM is used as the framework for modelling the building, where the choice of material and climatic databases is made.

ENERGY ANALYSIS:

Building Information Modeling (BIM) tools can be invaluable for energy analysis in the design, construction, and operation phases of a building. BIM is a digital representation of the physical and functional characteristics of a building, and it can be used to simulate and analyze various aspects of a building's energy performance.

LCA (LIFE CYCLE ASSESSMENT):

Life Cycle Assessment (LCA) is a systematic approach to evaluate the environmental impacts of a product, process, or service throughout its entire life cycle. In the context of buildings, LCA is used to assess the environmental performance of a building from the extraction of raw materials, through construction, use, and eventual demolition or disposal. Buildings have a significant impact on the environment, accounting for a large share of global energy use, greenhouse gas emissions, and resource consumption. LCA provides a comprehensive framework for quantifying these impacts and identifying opportunities for improvement .By conducting an LCA of a building, stakeholders can make informed decisions to reduce environmental impacts, optimize resource use, and enhance sustainability. This project aims to apply LCA methodology to analyze the environmental performance of a building and explore strategies for reducing its environmental footprint.

SOFTWARES USED:

Revit , Green Building Studio , Insight360 and Oneclick LCA.

METHODOLOGY:

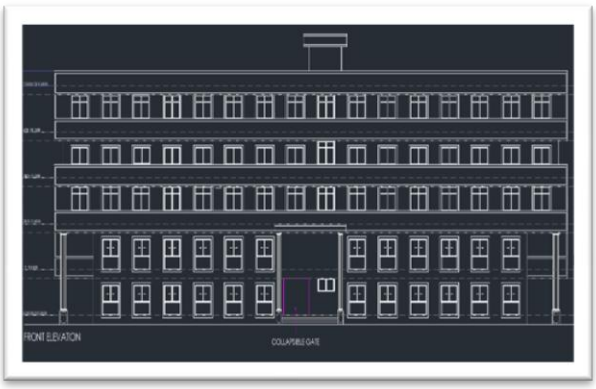
Developing 2D design of a building

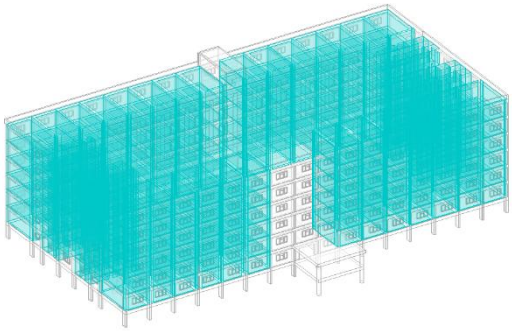
Design and analyzing the building using STAAD pro

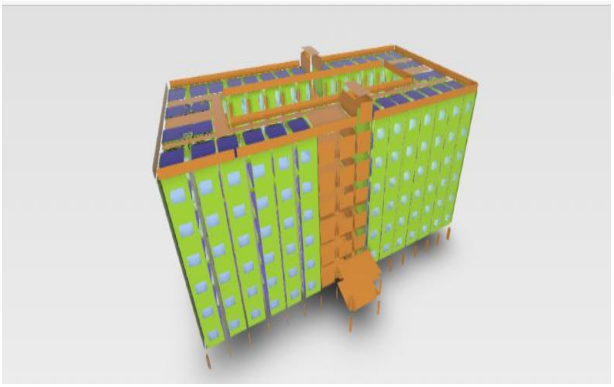
Developing 3D model of the building using Revit

Energy Analysis of Building using GBS and INSIGHT 360

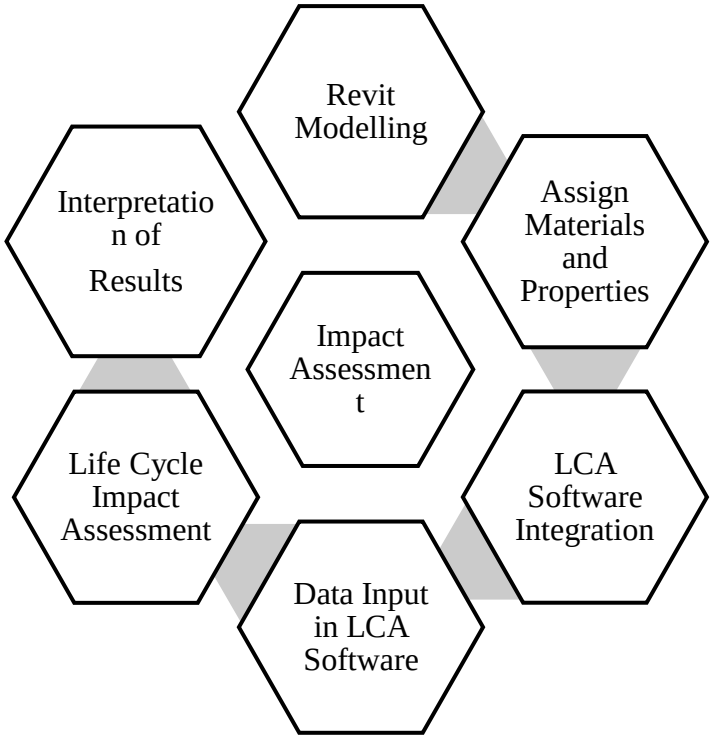
LCA OF Building using One click LCA Plugin







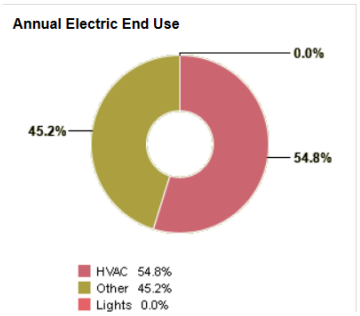
LCA using ONE click LCA plugin:

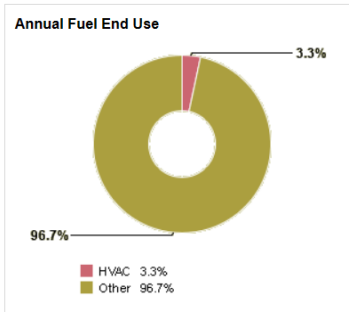


RESULTS AND DISCUSSIONS:

Results and Analysis using GBS :

The current orientation of the Building is Himalaya block of Boys Hostel GMR Institute of Technology, Rajam , Srikakulam , AndhraPradesh, INDIA is 10 degree with the north, with current orientation the average energy usage at this orientation is 969.9MJ/m²/year.





1 Base Run		2 Design Alternative	
Energy, Carbon and Cost Summary		**Estimated Energy & Cost Summary**	
Annual Energy Cost	₹4,864,205	Annual Energy Cost	₹3,084,705
Lifecycle Cost	₹66,250,477	Lifecycle Cost	₹42,013,682
Annual CO_2 Emissions		Annual CO_2 Emissions	
Electric	0.0 Mg	Electric	0.0 Mg
Onsite Fuel	39.5 Mg	Onsite Fuel	40.1 Mg
Large SUV Equivalent	4.0 SUVs / Year	Large SUV Equivalent	4.0 SUVs / Year
Annual Energy		Annual Energy	
Energy Use Intensity (EUI)	729 MJ / m² / year	Energy Use Intensity (EUI)	729 MJ / m² / year
Electric	482,670 kWh	Electric	304,655 kWh
Fuel	791,295 MJ	Fuel	804,999 MJ
Annual Peak Demand	138.4 kW	Annual Peak Demand	94.4 kW
Lifecycle Energy		Lifecycle Energy	
Electric	14,480,094 kW	Electric	9,139,644 kW
Fuel	23,738,853 MJ	Fuel	24,149,979 MJ

Energy optimization parameters:

After altering different design parameters in the Green Building Studio ,the parameters which gives the minimum EUI value is being chosen and again run the model with optimized parameters which will results in the building's EUI value has decreased from 969.6 MJ/m2/year to 729.1 MJ/m2/year. The comparison between default and optimized values is given in the Table given below.

Default Setting VS Optimized Settings using Green Building Studio

Parameters	Default Settings	Optimized Settings
Orientation	0^0	0^0
WWR - Southern Walls	None	0%
WWR - Northern Walls		0%
WWR - Western Walls		0%
WWR - Eastern Walls		0%
Window Shades – South	No shades	2/3 Window Height
Window Shades – North		2/3 Window Height
Window Shades – West		2/3 Window Height
Window Shades - East		2/3 Window Height
Daylighting & Occupancy Controls	None	Ocupancy day light sensors and controls
Mean Energy Cost	969.6 MJ/m2/year	729.1 MJ/m2/year

Results and Analysis using Insight 360 :

The current orientation of the Building is 10 degree with the north, with current orientation, which is 10 degree with north the average energy usage at this orientation is 329 kWh/m2 /yr.

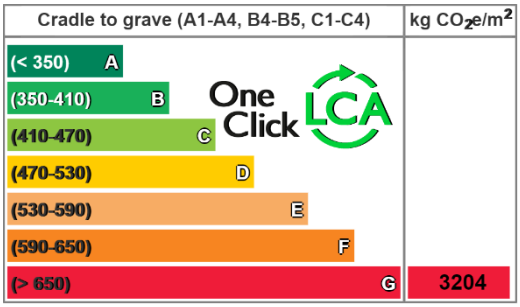
Default Settings VS Optimized Settings using Insight 360

Parameters	Default Settings	Optimized Settings
Orientation	10^0	135^0
WWR - Southern Walls	None	30%
WWR - Northern Walls		0%
WWR - Western Walls		0%
WWR - Eastern Walls		0%
Window Shades – South	No shades	2/3 Window Height
Window Shades – North		2/3 Window Height
Window Shades – West		2/3 Window Height
Window Shades - East		2/3 Window Height
Wall Construction	Uninsulated	R-38
Daylighting & Occupancy Controls	None	Occupancy day light sensors and controls

Operating Schedule	24/7-12/7	BIM-12/7
Mean Energy Cost	329 kWh/m2 /year	181 kWh/m2 /year

Results and Analysis for LCS using ONE CLICK LCA:

Embodied energy – The total amount of energy consumed by a building during its complete life cycle stages is called as embodied energy.

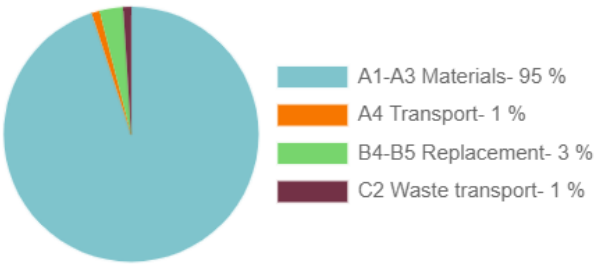


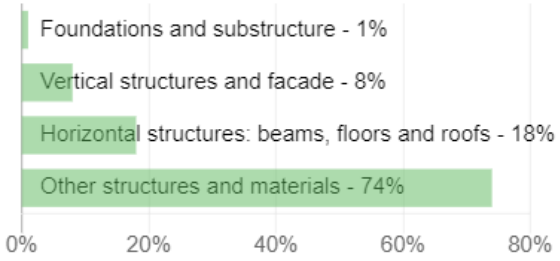
Embodied carbon benchmark

From the above figure it is shown that the developed model comes under 'category G' , as it is having greater than 650 $kgCO_2e/m^2$.

Embodied carbon by life-cycle stage: Global warming potential (GWP) is a metric used to compare the ability of different greenhouse gases to trap heat in the atmosphere. It is a relative measure, with carbon dioxide (CO2) being assigned a GWP of 1. This means that any other greenhouse gas with a GWP of 2 will trap twice as much heat as CO2 over a given period, typically 100 years.

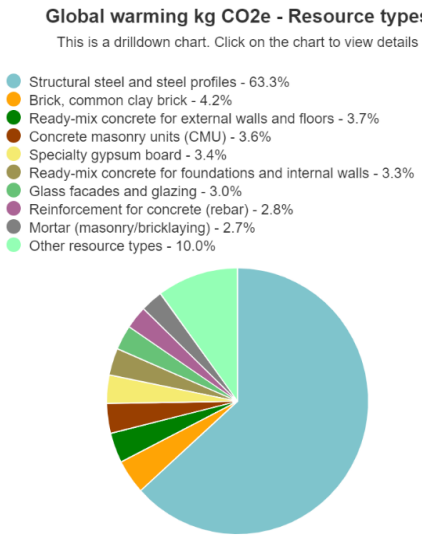
Global Warming Potential





Embodied carbon by structure

Here is the interpretation of data of carbon emissions that contribute to the environment by means of different resource types.



CONCLUSIONS:

(1) Orientation of a building plays a key role in Energy optimization of a building. If we see the table of Orientation with EUI in Results and discussions, the orientation of building with 180 degrees is almost the optimized condition.

(2) Using Sensors for daylighting controls decreases the significant amount of EUI .

(3) Providing better WWR for building results in low consumption of Energy .

(4) In the similar way , Energy saving per year is achieved by ***148 kwh/m2/year*** by optimizing the parameters like Orientation, WWR, Shade, Lighting and Materials of the Building by the Insight platform and ***240.5 MJ/m2/year*** by Green Building Studio. The analysis identified that HVAC has the largest energy consumers of Annual electric and fuel energy, accounting for ***59%*** of total energy use.

(5) [illegible] than 650 $kgCO_2e/m^2$ i.e. 3204 $kgCO_2e/m^2$.

(6) 4,581 Tonnes CO_2e is releasing from the developed project. And the most contributed materials are Steel sheets , generic 15% recycled content , S235 , S275 and S355(2852 tonnes) and the less contributed materials are Recycled mesh fabric (3.3 tonnes).

(7) The A1-A3 materials a building are the most contributors of CO_2.

(8)In this study , there is no optimization of building using ONE Click LCA .Optimization of building can be done by using alternatives for building materials.

(8) By combining these findings, you can see that improving the building's insulation and HVAC systems not only reduces its energy consumption but also lowers its environmental impact by reducing GWP. Similarly, choosing construction materials with lower environmental impacts can further enhance its sustainability.

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