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Revolutionizing Single-Storey Residential Building Design and Construction with BIM Technology

[1]M. Anil Kumar, [2]M. Sai kumar, [3]V. Mouli, [4]M. Sai Kumar, [5]P. Syam Prasad, [6]S. Navya Sahithi

[1,2,3,4,5,6]Department of Civil Engineering, GMR Institute of Technology, Rajam, Andhra Pradesh, India

ABSTRACT –

This study focuses on the sustainable design of a single storey dwelling unit, considering the environmental impact caused by the construction industry. The study includes planning, interior and exterior design using Revit software, design of structural elements in Robot structural analysis, and structural analysis using Staad pro and Robot structural analysis. Additionally, the study evaluates the environmental impact of the building throughout its lifetime using LCA by One Click LCA. The aim of this study is to design a project that incorporates all the necessary structural properties of traditional construction, while promoting sustainability and minimizing environmental impact. Through this study, we hope to contribute to the development of sustainable construction practices and inspire other designers and builders to adopt environmentally conscious design principles.

Keywords – Revit, STAAD Pro, BIM, LCA using one click LCA, Robot structural analysis.

1. Introduction

1.1 About BIM:

BIM stands for Building Information Modeling. It is a digital process for designing, constructing, and managing buildings and other infrastructure. BIM involves creating a virtual 3D model of the building or structure, which includes information about its various components such as walls, floors, roofs, doors, windows, electrical systems, plumbing, and HVAC systems.

The BIM model allows architects, engineers, contractors, and other stakeholders to collaborate and share information throughout the building lifecycle, from design and construction to operation and maintenance. This can help to reduce errors and conflicts, improve efficiency and productivity, and ultimately lead to better buildings and infrastructure.

1.2 About Revit:

Revit is a software application developed by Autodesk that is used for Building Information Modeling (BIM). It is widely used by architects, engineers, contractors, and building professionals to create and manage detailed 3D models of buildings and other structures.

Revit allows users to create a digital representation of a building's physical and functional characteristics. This includes information about the building's structure, materials, lighting, heating, ventilation, and air conditioning systems, plumbing, and electrical systems.

Revit also includes tools for collaboration and coordination, such as clash detection, which allows users to identify and resolve conflicts between different building systems before construction begins.

With Revit, users can generate detailed drawings, schedules, and reports from the 3D model, which can be used for construction, cost estimating, and facility management.

1.3 About STAAD. Pro:

STAAD Pro is a structural analysis and design software developed by Bentley Systems. It is widely used by civil and structural engineers to design and analyze a variety of structures such as buildings, bridges, towers, industrial structures, and other types of infrastructure.

STAAD Pro allows engineers to analyze the behavior of a structure under various load conditions, including static, dynamic, and earthquake loads. The software provides a wide range of design tools and analysis capabilities, including finite element analysis (FEA), advanced analysis, and optimization. These tools can help engineers to design structures that are safe, efficient, and cost-effective.

With STAAD Pro, engineers can also design and model complex geometries, such as curved beams, trusses, and arches. The software provides a 3D modeling environment, allowing engineers to create detailed models of the structure, which can be analyzed and optimized for performance.

STAAD Pro also includes tools for foundation design, including options for shallow and deep foundation types. The software can also analyze and design retaining walls, soil-structure interaction, and underground structures.

Overall, STAAD Pro is a powerful tool for structural analysis and design, providing engineers with the tools and capabilities they need to design safe, efficient, and cost-effective structures.

1.4 About LCA:

LCA stands for Life Cycle Assessment. It is a methodology used to evaluate the environmental impact of a product, process, or service throughout its entire life cycle, from raw material extraction and manufacturing to use, end-of-life disposal, and potential recycling or reuse.

The purpose of LCA is to identify and quantify the environmental impacts associated with a product or service, including its carbon footprint, water use, energy consumption, and other potential impacts such as air pollution, land use, and toxic waste generation.

LCA typically involves four main steps:

1. Goal and Scope Definition - This involves defining the goal and scope of the LCA study, including the system boundaries, functional unit, and impact categories to be considered.
2. Life Cycle Inventory - This involves compiling a comprehensive inventory of all the inputs and outputs associated with the product or service being evaluated, including raw materials, energy use, and emissions.
3. Impact Assessment - This involves quantifying the potential environmental impacts associated with the inputs and outputs identified in the Life Cycle Inventory, using standardized impact categories such as global warming potential, water use, and acidification.
4. Interpretation - This involves interpreting the results of the LCA study, identifying opportunities for improvement, and communicating the findings to stakeholders.

LCA can be used to identify areas for improvement and to guide decision-making in product and process design, as well as in policy-making and strategic planning. By understanding the environmental impacts of a product or service throughout its entire life cycle, stakeholders can make more informed decisions and develop more sustainable solutions.

2. LITERATURE REVIEW

Ali Ghaffarianhosein, [2018], This literature review aims to provide a state-of-the-art review of the current levels of BIM implementation and associated benefits and challenges in the construction industry. The review emphasizes the substantial interconnectivity of BIM model design layers, resulting in automatic redrafting and redevelopment as the project develops. The degree of BIM comprehension and adoption is found to be closely related to the size of an AEC firm. The review also highlights the use of Life Cycle Environmental Assessment (LCEA) in the context of energy-efficient residential buildings, providing information on achieving a balance between embodied energy and operational energy, energy-related environmental impacts of demolishing, replacing, or refurbishing a building, and other design strategies to reduce energy-related environmental impacts. Overall, the review underscores the potential of BIM and LCEA to transform the construction industry and promote sustainability.**[1]**

Deosarkar.U, [2018], This literature review discusses the use of Life Cycle Environmental Assessment (LCEA) in the context of energy-efficient residential buildings. The aim is to demonstrate and discuss the use of LCEA to achieve a balance between embodied energy and operational energy over the anticipatelifetime of buildings. The review provides information on the energy-related environmental impacts of demolishing, replacing, or refurbishing a building at various stages in its life, as well as other design strategies to reduce energy-related environmental impacts. Overall, the review highlights the potential of LCEA to promote sustainability in the construction industry and support the design of energy-efficient buildings.**[2]**

Manoj U. Deosarkar, [2018], This literature review explores and tests the use of Revit in comparison to AutoCAD, with the goal of understanding the benefits and limitations of using BIM software for building design and management. The review emphasizes the innovative nature of BIM and highlights Revit's built-in tools for structural analysis and compliance checking. The review also discusses the process of planning, modeling, and scheduling for a commercial building, including the creation of families for doors. Overall, the review underscores the potential of BIM software like Revit to improve project outcomes and promote efficiency in the construction industry. **[3]**

Farzaneh Rezaei, [2018 This literature review examines the use of life cycle assessment (LCA) and building information modeling (BIM) in the early and detailed design stages of residential buildings. The review focuses on LCE analysis of different types of residential buildings in different climates, highlighting the need to achieve a balance between embodied energy and operational energy over the anticipated lifetime of the building. The review also discusses the energy-related environmental impacts of demolishing, replacing, or refurbishing a building at various stages in its life, and suggests various design strategies to reduce energy-related environmental impacts. Overall, the review emphasizes the potential of LCA and BIM to promote sustainability in the construction industry and support the design of energy-efficient buildings**.[4]**

Xining Yang, Mingming Hu,Jiangbo Wu ,Bin Zhao,[Received 26 July 2017, Received in revised form 5 February 2018, Accepted 7 February [2018], This study examines the combination of BIM and LCA tools to improve data flow and interoperability for low carbon building design. The study finds that the operation phase contributes the most to GHG emissions, while concrete is the most used material but contributes less to emissions than steel and aluminum. BIM-enabled LCA modeling can provide detailed assessments of a building's environmental performance and make LCA more accessible and credible for professionals. This approach can guide low carbon design and help reduce the environmental impact of buildings. [**5]**

Elke Meexa, Alexander Hollbergb,Elke Knapena,Linda Hildebrandc, Griet Verbeeck, [Received 27 October 2017; Received in revised form 18 January 2018; Accepted 10 February 2018],This paper highlights the need for integrating sustainability into building design processes and proposes a framework for doing so. The authors argue that early-stage design decisions have a significant impact on a building's overall environmental performance and that life cycle assessment (LCA) tools can help architects make more informed decisions. However, current LCA tools are not well-suited for early-stage design due to their complexity and lack of integration with design software. The authors call for the development of more user-friendly and integrated LCA tools that are tailored to architects' needs. Overall, the paper emphasizes the importance of incorporating sustainability into building design from the outset. **[6]**

Patrick Bynum, Svetlana Olbina,Raja R. A. Issa, [2013], Building Information Modeling (BIM) is a process that involves creating a digital model of a building, which can be used throughout the design and construction phases. The model can also be used to manage the building's operation and maintenance. BIM is increasingly being used to support sustainable design and construction practices. However, there are still challenges with interoperability and a lack of awareness of the potential benefits of BIM for sustainability. Design build and integrated project delivery (IPD) are seen as optimal project delivery methods to integrate BIM as a sustainability tool. As more professionals in the industry understand the potential benefits of BIM, it is likely to become a more widely used tool for sustainable design and construction. [**7]**

Alfonso Aranda Usón,Antonio Valero Capilla, [2017],This paper focuses on the use of life cycle assessment (LCA) to compare the energy and environmental impacts of different building materials and assess their potential for improvement. The study acknowledges the limitations of such assessments but provides useful guidelines for materials selection. The paper emphasizes the need for a broader sustainable building strategy that ensures a per capita decrease in the consumption and exploitation of natural resources, without creating rebound effects. The results highlight the importance of considering the entire life cycle of building materials to reduce their environmental impact. Overall, the paper adds to the growing body of literature on the importance of sustainable building practices. **[8]**

Dalia M.A. Morsi, Walaa S.E. Ismaeel, Ahmed Ehab, Ayman A.E. Othman, [2022], This paper focuses on the integration of BIM and LCA for the assessment of the environmental impact of different structural system scenarios in a typical middle-class residential building in Egypt. The study used the One-Click LCA plugin in the BIM platform to assess the time and cost constraints during the construction phase. Three scenarios were evaluated, including concrete, steel, and composite structural systems. The study demonstrates the feasibility of integrating LCA and BIM in LOD 400 through a complete LCA for all three scenarios. The results provide valuable insights for the selection of structural systems in terms of their environmental impact. **[9]**

Letizia D'Angelo, Magdalena Hajdukiewicz, Federico Seri, Marcus M. Keane, [2022], BIM-based building retrofit has been gaining attention in recent years due to its potential to improve the efficiency and sustainability of existing buildings. This paper proposes a novel workflow for building retrofit that combines BIM and BPM techniques to overcome the barriers preventing retrofitting of existing buildings. The workflow consists of 5 stages, including the analysis of retrofit workflow, identification of BIM goals and uses, planning of the overall BIM retrofit process, development of detailed process maps, and outlining of information exchange between BIM deliverables. The proposed methodology can provide a comprehensive and integrated approach to building retrofit and facilitate the decision-making process for building owners, designers, and contractors.**[10]**

Kanta Naga Rajesh, [2021], This study explores the use of used foundry sand and spent garnet sand as replacements for river sand in concrete production. The results show that a combination of UFS and SGS can be used to replace up to 60% of river sand while maintaining similar properties to conventional concrete. This has implications for the cost of concrete production and environmental sustainability. This study is original in that it is the first to investigate the use of these industrial by-products in combination as replacements for river sand in concrete.**[11]**

Ravindiran Gokulan, Kanta Naga Rajesh, [2022], This study investigates the optimization of river sand with spent garnet sand in concrete, using Response Surface Method (RSM) and R Programming's RStudio packages. The study proposes replacing river sand with spent garnet sand at various percentages and compares predicted and actual compressive and flexural strength at 28 days of curing. The results show that both software packages effectively predict and optimize the use of spent garnet sand in concrete, with a high correlation coefficient for both compressive and flexural strength. This has implications for the sustainable use of natural resources in concrete production.**[12]**

3. METHODOLOGY

Project Requirements: Understand the project requirements and scope, including the design objectives, timeline, budget, and client expectations.

Conceptual Design: Create initial design concepts for the and exterior of the building using Revit software.

Structural Design: Use STAAD PRO and ROBOT STRUCTURAL ANALYSIS software to evaluate the structural stability and safety of the building design. Design structural components in ROBOT STRUCTURAL ANALYSIS to ensure the building's durability and integrity.

Sustainability Assessment: Perform a life cycle assessment of the building design to evaluate its environmental impact throughout its entire life cycle. Identify opportunities to reduce the building's environmental impact through sustainable design strategies and materials.

Final Design: Finalize the design using Revit software, incorporating feedback from the client and other stakeholders. Ensure that the design meets all project requirements and is structurally sound, sustainable, and aesthetically pleasing.

Documentation: Create detailed drawings and specifications using Revit software, STAAD PRO, and ROBOT STRUCTURAL ANALYSIS software. Ensure that all documentation is accurate, complete, and compliant with relevant codes and standards.

Construction: Provide support during the construction phase to ensure that the design is implemented correctly and meets all project requirements.

Post-Construction: Conduct a post-construction review to evaluate the building's performance and identify opportunities for improvement in future projects.

4. INTERIOR AND EXTERIOR DESING USING REVIT

4.1 Interior design:

Revit software is a powerful tool for interior design, allowing designers to create and edit floor plans, elevations, and sections to define the layout and spatial relationships of interior spaces. By using Revit's parametric objects, designers can create accurate and detailed 3D models of the building's interior spaces, while furniture and other interior objects can be placed to add realism to the model. The software's material and lighting tools can be utilized to create visual interest and enhance the aesthetics of the design, and Revit's rendering capabilities allow designers to create high-quality visualizations of the interior design. Overall, Revit software is an essential tool for designers looking to create beautiful and functional interior spaces.

4.2 Exterior design:

Revit's parametric objects, coupled with its ability to create detailed 3D models, make it an ideal tool for exterior design. Designers can use Revit to create accurate floor plans, elevations, and sections, which define the layout and spatial relationships of the exterior spaces. The ability to place landscape elements such as trees, plants, and terrain adds an element of realism to the model. With the use of materials and lighting, designers can enhance the aesthetics of the design and create visual interest. Finally, Revit's rendering capabilities allow designers to create high-quality visualizations of the exterior design, making it easier to communicate design ideas with clients and stakeholders. Overall, the highlights of using Revit for exterior design include accuracy, detail, and visual appeal.

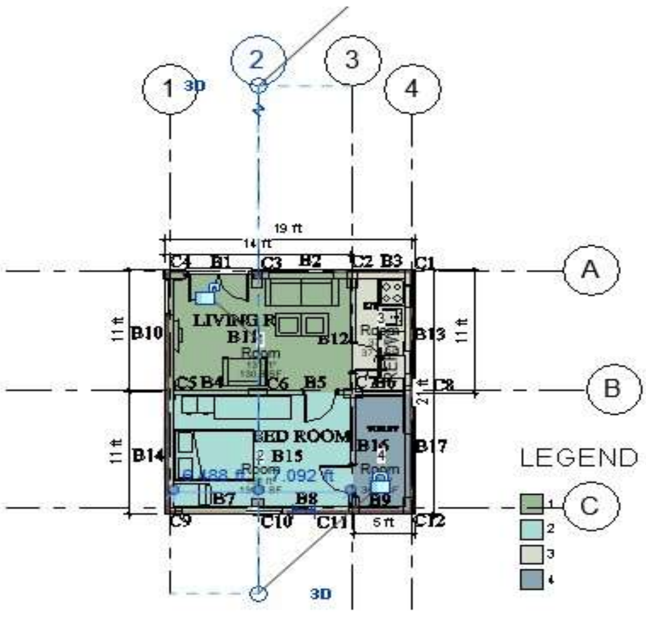


Figure 1: 2D Plan

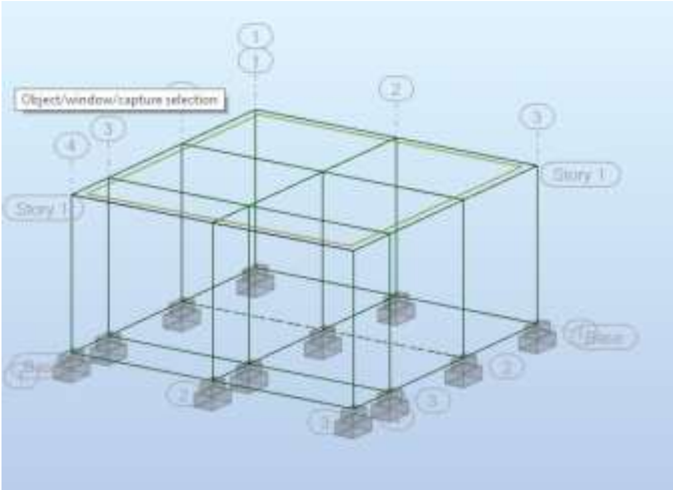


Figure 2: Revit Structural

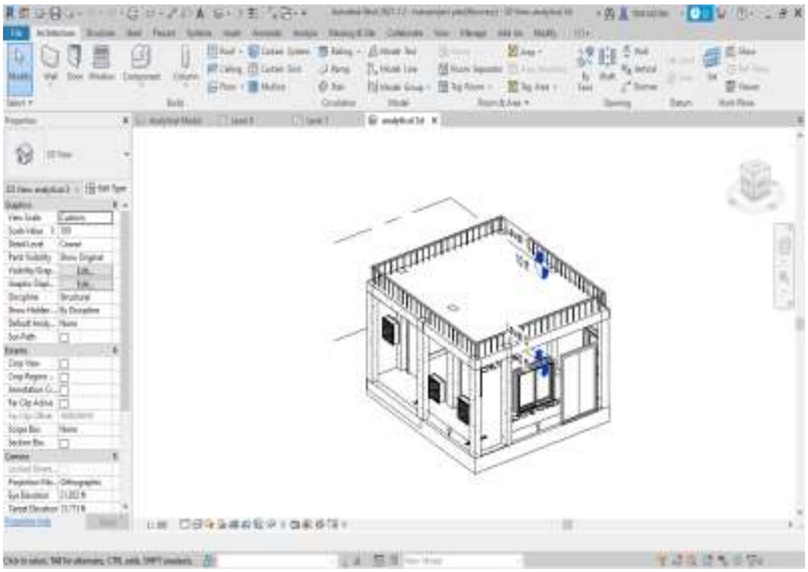


Figure 3: Analytical Model

5. MODELLING AND DESIGNING IN ROBOT STRUCTURAL ANALYSIS

Here is a general flowchart for modelling and designing in Robot Structural Analysis:

1. Determine the project scope and requirements.
2. Collect necessary data such as site information, structural drawings, and loads.
3. Create a 3D model of the structure in Robot Structural Analysis using the modelling tools.
4. Assign materials and sections to each element of the structure.
5. Apply loads such as dead loads, live loads, wind loads, and seismic loads to the structure.
6. Analyze the structure to determine its response to the applied loads.
7. Review the analysis results to identify areas of concern or potential failure.
8. Design the structural members for strength, stiffness, and stability according to the appropriate design codes and standards.
9. Review and optimize the design to achieve a balance between cost and performance.
10. Produce design drawings and reports to communicate the design to stakeholders.

This flowchart is a general guide, and the specific steps may vary depending on the project requirements and complexity. It's important to follow established design codes and standards and seek the guidance of experienced engineers in the process.

Case	1 - self weight					
Mode						
Sum of val.	-0.00	0.00	138.81	0.00	0.00	0.00
Sum of reac.	-0.00	0.00	138.81	423.22	-421.28	0.00
Sum of forc.	0.0	0.0	-138.81	-423.22	421.28	0.0
Check val.	-0.00	0.00	0.0	0.00	-0.00	0.00
Precision	1.51806e-15	1.31892e-16				
Case	3 - live load					
Mode						
Sum of val.	-0.00	0.00	111.04	-0.00	0.00	-0.00
Sum of reac.	-0.00	0.00	111.04	338.57	-337.02	0.00
Sum of forc.	0.0	0.0	-111.04	-338.57	337.02	0.0
Check val.	-0.00	0.00	-0.00	0.00	0.00	0.00
Precision	1.72507e-15	1.31892e-16				

Figure 4: Total Dead load and Live load

Node/Case/Mode	FX (kN)	FY (kN)	FZ (kN)	MX (kNm)	MY (kNm)	MZ (kNm)
Case	12 - Seismic - Indian IS:1893 Direction_X					
Mode CQC						
Sum of val.	44.67	11.53	85.51	0.00	0.00	0.00
Sum of reac.	29.57	0.00	0.02	0.05	97.74	238.00
Sum of forc.	29.57	0.00	0.02	0.05	97.74	238.00
Check val.	59.13	0.01	0.04	0.11	195.48	476.00
Precision	3.95916e-11	9.66048e-10				
Case	13 - Seismic - Indian IS:1893 Direction_Y					
Mode CQC						
Sum of val.	24.29	31.76	57.98	0.00	0.00	0.00
Sum of reac.	0.00	29.51	0.01	83.81	0.02	235.93
Sum of forc.	0.00	29.51	0.01	83.81	0.02	235.94
Check val.	0.01	59.02	0.02	167.62	0.05	471.87
Precision	3.96153e-11	9.66048e-10				
Case	14 - Seismic - Indian IS:1893 Direction_Z					
Mode CQC						
Sum of val.	0.35	0.40	10.24	0.00	0.00	0.00
Sum of reac.	0.02	0.01	9.57	29.48	26.74	0.16
Sum of forc.	0.02	0.01	9.57	29.48	26.74	0.16
Check val.	0.04	0.02	19.15	58.96	53.48	0.32

Base shear value = 274 KN

Figure 4: Total sesmic load

Case	Nature	Group	γ_f	N (kN)	Myu (kN*m)	Myl (kN*m)	Myi (kN*m)	Mzu (kN*m)	Mzl (kN*m)	Mzi (kN*m)
comb1	design	1	1.00	18.04	4.17	-6.37	-2.55	-5.46	7.11	2.84
COMB2	Design SLS	1	1.00	12.03	2.78	-4.25	-1.70	-3.64	4.74	1.90
comb 3	Design SLS	1	1.00	15.89	9.74	-7.00	3.88	-4.49	-1.46	-2.02
COMB4	Design SLS	1	1.00	11.82	2.12	0.40	1.27	-2.40	0.69	-1.35
COMB5	Design SLS	1	1.00	13.49	11.05	-8.98	4.18	-4.34	-2.23	-1.81
COMB6	Design SLS	1	1.00	8.40	1.52	0.26	0.91	-1.73	0.46	-0.97
COMB7	Design SLS	1	1.00	10.30	10.49	-9.09	3.85	-3.70	-2.43	-1.45
COMB8	Design SLS	1	1.00	5.22	0.96	0.15	0.57	-1.09	0.26	-0.61
COMB9	Design SLS	1	1.00	15.12	5.89	-3.29	2.55	-3.96	-0.83	-1.88
COMB10	Design SLS	1	1.00	-0.74	-8.80	9.44	-2.84	1.79	3.04	0.79
COMB11	Design SLS	1	1.00	4.35	0.73	0.20	0.43	-0.82	0.35	-0.46
COMB12	Design SLS	1	1.00	7.06	-5.69	7.83	-1.97	-0.10	2.91	-0.71
COMB13	Design SLS	1	1.00	11.13	1.93	0.43	1.16	-2.19	0.76	-1.23
COMB14	Design SLS	1	1.00	2.45	-8.24	9.55	-2.69	1.15	3.24	0.71
COMB15	Design SLS	1	1.00	7.53	1.29	0.31	0.77	-1.46	0.55	-0.82
COMB16	Design SLS	1	1.00	3.41	-3.43	4.91	-1.20	0.48	2.44	0.41
COMB17	Design SLS	1	1.00	7.97	1.40	-0.29	0.73	-1.59	0.50	-0.75

γ_f - load factor

Figure 5: column 1

Case	Nature	Group	γ_f	N	Myu	Myl	Myi	Mzu	Mzl	Mzi
				(kN)	(kN*m)	(kN*m)	(kN*m)	(kN*m)	(kN*m)	(kN*m)
comb1	design	4	1.00	102.55	0.14	0.07	0.11	0.04	-0.04	0.02
COMB2	Design SLS	4	1.00	68.37	0.09	0.05	0.07	0.03	-0.02	0.01
comb 3	Design SLS	4	1.00	73.78	5.98	-5.07	2.17	-0.85	-0.88	-0.29
COMB4	Design SLS	4	1.00	77.01	0.34	0.17	0.15	0.02	-0.02	0.01
COMB5	Design SLS	4	1.00	51.56	7.31	-6.44	2.64	-1.08	-1.09	-0.36
COMB6	Design SLS	4	1.00	55.60	0.26	0.11	0.12	0.01	-0.02	-0.00
COMB7	Design SLS	4	1.00	31.23	7.23	-6.49	2.60	-1.08	-1.08	-0.37
COMB8	Design SLS	4	1.00	35.27	0.18	0.06	0.08	0.00	-0.01	-0.00
COMB9	Design SLS	4	1.00	73.22	0.30	0.19	0.25	-4.66	-4.58	-1.59
COMB10	Design SLS	4	1.00	29.77	-6.99	6.65	-2.49	1.10	1.07	0.37
COMB11	Design SLS	4	1.00	25.73	0.07	0.10	0.02	0.02	-0.01	0.01
COMB12	Design SLS	4	1.00	72.61	-5.40	5.45	-1.91	0.90	0.84	0.31
COMB13	Design SLS	4	1.00	69.39	0.25	0.21	0.11	0.03	-0.02	0.01
COMB14	Design SLS	4	1.00	50.10	-6.91	6.70	-2.46	1.11	1.06	0.38
COMB15	Design SLS	4	1.00	46.07	0.15	0.15	0.06	0.02	-0.01	0.01
COMB16	Design SLS	4	1.00	50.81	0.20	0.13	0.09	5.87	5.69	2.01
COMB17	Design SLS	4	1.00	50.83	0.20	-0.13	0.08	0.02	-0.01	0.01

γ_f - load factor

Figure 6: column 4

Case	Nature	Group	γ_f	N	Myu	Myl	Myi	Mzu	Mzl	Mzi
				(kN)	(kN*m)	(kN*m)	(kN*m)	(kN*m)	(kN*m)	(kN*m)
comb1	design	2	1.00	43.93	6.51	-1.76	3.20	0.07	-0.05	0.03
COMB2	Design SLS	2	1.00	29.29	4.34	-1.17	2.13	0.05	-0.04	0.02
comb 3	Design SLS	2	1.00	34.89	8.35	-2.27	4.11	-3.21	-3.22	-1.09
COMB4	Design SLS	2	1.00	33.25	4.91	0.99	2.90	0.04	-0.04	0.01
COMB5	Design SLS	2	1.00	25.82	7.84	-3.41	3.61	-4.04	-4.01	-1.37
COMB6	Design SLS	2	1.00	23.76	3.54	0.66	2.09	0.02	-0.03	0.01
COMB7	Design SLS	2	1.00	16.92	6.54	-3.70	2.84	-4.05	-4.00	-1.38
COMB8	Design SLS	2	1.00	14.86	2.24	0.37	1.32	0.01	-0.02	-0.00
COMB9	Design SLS	2	1.00	32.03	4.68	1.05	3.23	-2.37	-2.44	-0.81
COMB10	Design SLS	2	1.00	9.77	-2.65	4.58	-0.87	4.09	3.97	1.39
COMB11	Design SLS	2	1.00	11.83	1.66	0.50	0.98	0.03	-0.01	0.02
COMB12	Design SLS	2	1.00	29.17	1.00	4.36	1.56	3.30	3.16	1.13
COMB13	Design SLS	2	1.00	30.82	4.44	1.10	2.63	0.06	-0.03	0.03
COMB14	Design SLS	2	1.00	18.67	-1.35	4.87	0.77	4.10	3.96	1.40
COMB15	Design SLS	2	1.00	20.73	2.96	0.79	1.75	0.05	-0.02	0.02
COMB16	Design SLS	2	1.00	22.24	3.24	0.73	1.92	3.06	2.99	1.03
COMB17	Design SLS	2	1.00	22.24	3.25	-0.73	1.66	0.03	-0.02	0.01

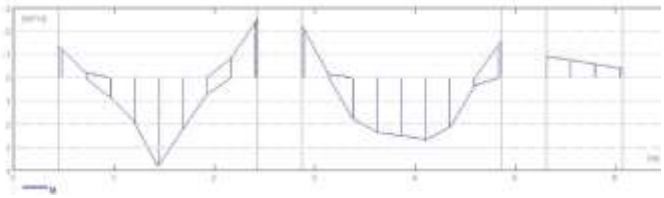
γ_f - load factor

Figure 7: column 2

Case	Nature	Group	γ_f	N	Myu	Myl	Myi	Mzu	Mzl	Mzi
				(kN)	(kN*m)	(kN*m)	(kN*m)	(kN*m)	(kN*m)	(kN*m)
comb1	design	11	1.00	40.19	-0.39	0.73	0.29	7.68	-7.96	-3.18
COMB2	Design SLS	11	1.00	26.80	-0.26	0.49	0.19	5.12	-5.31	-2.12
comb 3	Design SLS	11	1.00	28.31	1.22	-1.27	0.38	3.15	-1.89	1.86
COMB4	Design SLS	11	1.00	29.07	-0.06	0.01	-0.05	3.54	-1.38	1.95
COMB5	Design SLS	11	1.00	19.91	1.57	-1.59	0.51	1.84	-1.64	1.17
COMB6	Design SLS	11	1.00	20.85	-0.03	0.00	-0.03	2.33	-1.00	1.29
COMB7	Design SLS	11	1.00	12.16	1.59	-1.60	0.53	0.79	-1.28	0.59
COMB8	Design SLS	11	1.00	13.11	-0.01	-0.00	-0.01	1.28	-0.64	0.71
COMB9	Design SLS	11	1.00	29.19	5.86	-5.69	2.00	0.50	-4.37	1.06
COMB10	Design SLS	11	1.00	11.07	-1.66	1.61	-0.58	2.35	0.19	1.14
COMB11	Design SLS	11	1.00	10.12	-0.06	0.02	-0.04	1.86	-0.44	1.03
COMB12	Design SLS	11	1.00	27.44	-1.38	1.30	-0.50	4.40	-0.71	2.30
COMB13	Design SLS	11	1.00	26.68	-0.10	0.02	-0.07	4.00	-1.22	2.21
COMB14	Design SLS	11	1.00	18.81	-1.69	1.61	-0.59	3.40	-0.17	1.72
COMB15	Design SLS	11	1.00	17.86	-0.08	0.02	-0.06	2.91	-0.80	1.60
COMB16	Design SLS	11	1.00	17.71	-7.49	7.14	-2.62	6.71	2.93	2.90
COMB17	Design SLS	11	1.00	19.36	-0.06	-0.01	-0.04	2.62	-0.90	1.21

γ_f - load factor

Figure 8: column 11

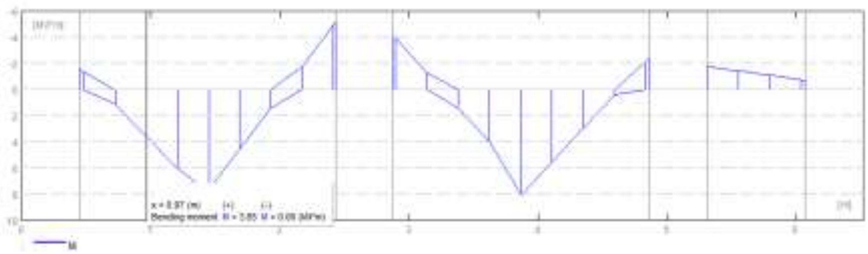


Span	Mtmax. (kN*m)
P1	3.84
P2	2.67
P3	0.00

2.4.3 Required reinforcement area

Span	Span (mm2)		Left support (mm2)		Right support (mm2)	
	bottom	top	bottom	top	bottom	top
P1	48	0	48	51	35	51
P2	32	0	32	47	32	39
P3	53	0	37	45	53	54

Figure 9: Beam A1 to A4

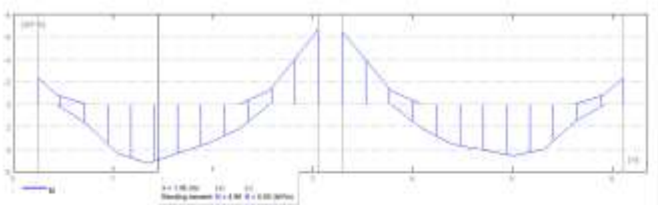


Span	Mtmax. (kN*m)
P1	7.83
P2	8.05
P3	0.00

2.4.3 Required reinforcement area

Span	Span (mm2)		Left support (mm2)		Right support (mm2)	
	bottom	top	bottom	top	bottom	top
P1	62	0	16	26	0	42
P2	63	0	6	35	9	24
P3	20	0	12	23	20	23

Figure 10: Beam B1 to B4

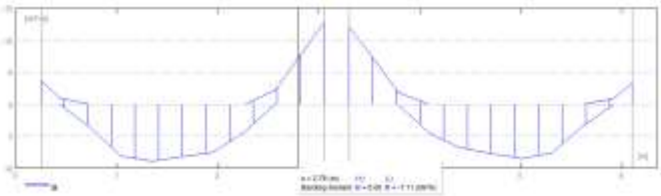


Span	Mtmax. (kN*m)
P1	5.26
P2	4.57

2.4.3 Required reinforcement area

Span	Span (mm2)		Left support (mm2)		Right support (mm2)	
	bottom	top	bottom	top	bottom	top
P1	41	0	14	18	0	52
P2	36	0	0	50	15	18

Figure 11: Beam 1A to 1C



Span	Mtmax. (kN*m)
P1	8.87
P2	8.48

2.4.3 Required reinforcement area

Span	Span (mm2)		Left support (mm2)		Right support (mm2)	
	bottom	top	bottom	top	bottom	top
P1	70	0	12	28	0	101
P2	67	0	0	96	13	26

Figure 12: Beam 2A to 2C

Table 1: Seismic Direction_x

	F_x (KN)	F_y (KN)	F_z (KN)	M_x (KNm)	M_y (KNm)	M_z (KNm)
SUM OF VALUE	44.67	11.38	85.57	0.00	0.0	0.0
SUM OF FORCE	29.57	0.00	0.02	0.05	97.74	238

Table 2: Seismic Direction_y

	F_x (KN)	F_y (KN)	F_z (KN)	M_x (KNm)	M_y (KNm)	M_z (KNm)
SUM OF VALUE	24.29	31.76	57.98	0.00	0.00	0.0
SUM OF FORCE	0.00	29.51	0.01	83.81	0.02	235.94

Table 3: Seismic Direction_z

	F_x (KN)	F_y (KN)	F_z (KN)	M_x (KNm)	M_y (KNm)	M_z (KNm)
SUM OF VALUE	0.35	0.40	10.24	0.0	0.0	0.0
SUM OF FORCE	0.02	0.01	9.57	29.48	26.74	0.16

Table 4: Total Dead Load

	F_x (KN)	F_y (KN)	F_z (KN)	M_x (KNm)	M_y (KNm)	M_z (KNm)
SUM OF VALUE	-0.0	0.0	138.81	0.0	0.0	0.0
SUM OF FORCE	0.0	0.0	-138.81	-423.22	421.8	0.0

Table 5: Total Live Load

	F_x (KN)	F_y (KN)	F_z (KN)	M_x (KNm)	M_y (KNm)	M_z (KNm)
SUM OF VALUE	-0.0	0.0	111.04	-0.0	0.0	0.0
SUM OF FORCE	0.0	0.0	-111.04	-338.57	337	0.0

6. RESULTS AND DISCUSSION

6.1 STAAD.pro

Here is a general methodology for using STAAD Pro software for structural analysis and design:

1. Start by defining the structure geometry by creating nodes and connecting them with elements such as beams, columns, and plates.
2. Assign appropriate material properties to the elements, such as elastic modulus, density, and yield strength.
3. Apply loads to the structure, including dead loads, live loads, wind loads, seismic loads, and temperature loads.
4. Define support conditions for the structure, such as fixed supports, pinned supports, and rollers.
5. Use the analysis tools in STAAD Pro to analyze the structure and determine its response to the applied loads.
6. Review the analysis results to identify areas of concern or potential failure.
7. Design the structural members for strength, stiffness, and stability according to the appropriate design codes and standards.
8. Use STAAD Pro's design tools to check the design against the code requirements and optimize the design if necessary.
9. Produce design drawings and reports to communicate the design to stakeholders.

It's important to follow established design codes and standards and seek the guidance of experienced engineers in the process. STAAD Pro offers a wide range of features and tools that can help make the process more efficient and accurate.

S.NO	TYPE OF DATA	VALUE
1	Column A1 Maximum Pu Maximum moment Mz	-0.48 KN 0.93 KN-M
2	Column A2 Maximum Pu Maximum moment MZ	-0.05 KN 1 K KN-M
3	Column A3 Maximum Pu Maximum moment Mz	-0.49 KN 1.01 KN-M
4	Column A4 Maximum Pu Maximum moment Mz	-0.92 KN 0.96 KN-M
5	Column B1 Maximum Pu Maximum moment Mz	-0.72 KN 1.28 KN-M
6	Column B2 Maximum Pu Maximum moment Mz	-0.14 KN 1.47 KN-M
7	Column B3 Maximum Pu Maximum moment MZ	-0.82 KN 1.48 KN-M
8	Column B4 Maximum Pu Maximum moment Mz	-1.4 KN 1.33 KN-M
9	Column C1 Maximum Pu Maximum moment Mz	-0.48 KN 0.93 KN-M

10	Column C2 Maximum Pu Maximum moment Mz	-0.05 KN 1 KN-M
11	Column C3 Maximum Pu Maximum moment Mz	-0.49 KN 1.01 KN-M
12	Column C4 Maximum Pu Maximum moment MZ	-0.92 KN 0.96 KN-M
13	AST required AST provided	900 mm^2 905.143 mm^2

Table 6: Staad pro values

6.2 One Click LCA

One Click LCA is a cloud-based software platform for life cycle assessment (LCA) and sustainability analysis of buildings and infrastructure projects. It provides tools and resources for architects, engineers, and building professionals to evaluate the environmental performance of their projects and identify opportunities for improvement.

The platform offers a range of features, including:

1. Life Cycle Assessment: One Click LCA allows users to perform life cycle assessments of buildings and infrastructure projects according to various international standards, including EN 15978, ISO 21930, and ISO 14040/44. Users can input data on materials, energy consumption, water use, and other factors to calculate the environmental impact of the project over its entire life cycle.
2. Carbon Footprinting: One Click LCA offers carbon footprinting tools that enable users to calculate the carbon emissions associated with their projects. This includes embodied carbon, operational carbon, and carbon sequestration from materials and vegetation.
3. Environmental Product Declarations (EPDs): One Click LCA allows users to create and manage EPDs for building materials and products. This helps users to evaluate the environmental impact of individual materials and products and make informed decisions about material selection.
4. Building Certification: One Click LCA offers tools to support building certification schemes such as LEED, BREEAM, and DGNB. Users can input data on energy consumption, water use, materials, and other factors to demonstrate compliance with certification requirements.
5. Reporting and Analytics: One Click LCA provides reporting and analytics tools to help users visualize and communicate the results of their sustainability analyses. Users can create interactive dashboards and reports to share with stakeholders and track progress over time.

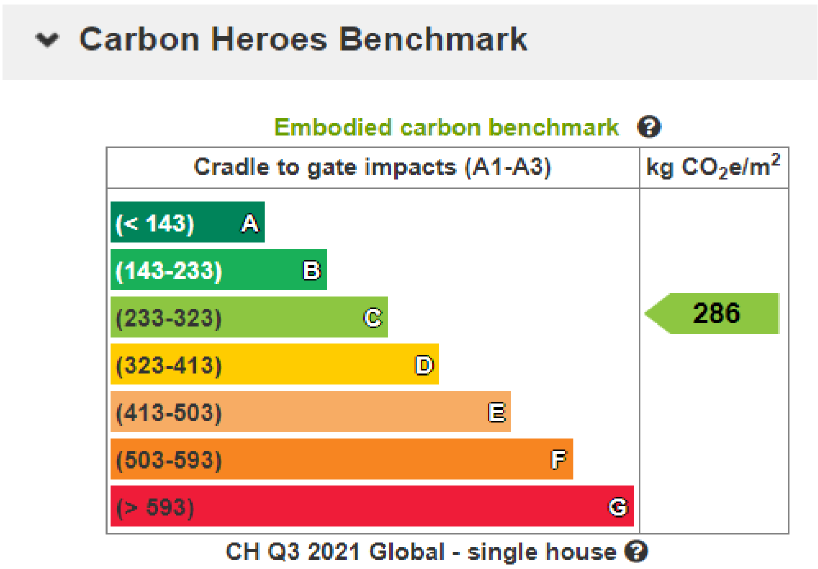


Figure 13: Carbon Benchmark

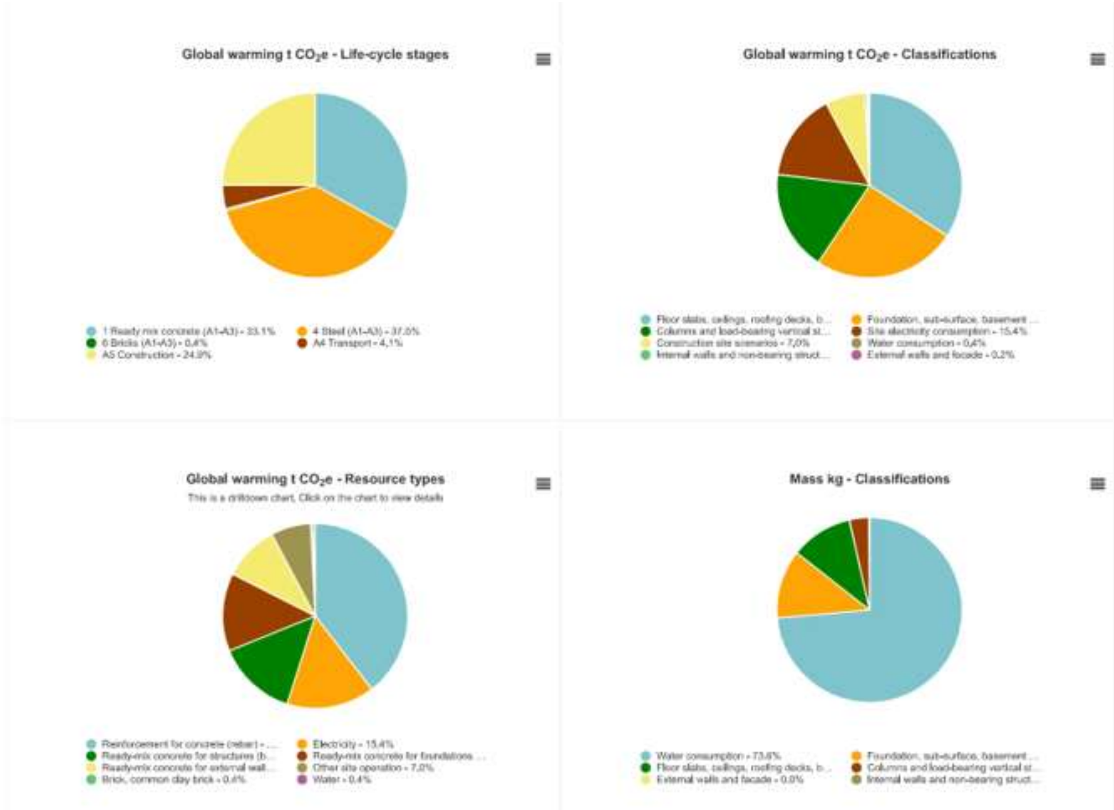


Figure 14: Co2 emission pie charts

7. CONCLUSION:

In conclusion, this study provides a comprehensive approach to designing a sustainable single storey dwelling unit. By incorporating sustainable design principles and evaluating the environmental impact of the building throughout its lifetime, this study promotes the importance of sustainable construction practices. The use of Revit software, Robot structural analysis, and Staad pro in the design and analysis of the building's structural elements ensures the project is built with sound engineering principles. The findings of this study can serve as a valuable resource for architects, engineers, and construction professionals looking to incorporate sustainable design principles into their projects. Ultimately, this study serves as a reminder of the critical role the construction industry plays in promoting sustainability and reducing environmental impact, and highlights the importance of designing buildings with long-term sustainability in mind.

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