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Application of Building Information Modelling (BIM) Concept for Residential Building

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Abstract -
Building Information Modeling (BIM) has become increasingly adopted in large-scale construction projects; however, its application in residential construction and bungalows remains less explored. This paper investigates the potential benefits of BIM for residential building projects. It examines how BIM can enhance design accuracy, improve collaboration among stakeholders involved in residential construction, and optimize project delivery. The research explores the use of BIM for tasks such as creating 3D models with rich data on materials and specifications, which aids in generating construction documentation with enhanced clarity. Through a review of existing literature and potential case studies, this paper evaluates the cost-effectiveness of BIM for residential projects, considering the potential for reduced rework and improved project efficiency. The findings aim to contribute to a broader understanding of BIM's value in the field of residential building.

Key Words: BIM, Revit, Modelling, AutoCAD, Navisworks, Clash detection, Schedule of opening, Quantity Takeoff.

1. INTRODUCTION

1.1 General

A computerized, trustworthy, three-dimensional, virtual representation of the project to be created that can be used for design decision-making, construction planning and scheduling, maintenance, and cost estimation is known as building information modelling, or BIM. As more contractors realize the advantages of using this technology, the demand for BIM solutions has grown dramatically. The National BIM Standard defines a building information model as "a digital representation of physical and functional characteristics of a facility and a shared knowledge resource for information about facility forming a reliable basis for decisions during life-cycle; defined as existing from earliest conception to demolition." Throughout the course of a project, contractors, owners, engineers, and designers all employ building information models.

It became less common to make physical models. When design changes are needed, it takes longer to modify the physical models. The next step up from CAD and into the future is BIM. In the construction business, the BIM model is utilised for a variety of functions, including scheduling, quantity takeoff, and three-dimensional (3D) modelling. Various software programs are available for building information modelling. For instance. Graphisoft ArchiCAD, Bentley Architecture, and Autodesk Revit Architecture are a few examples of software used for engineering and architecture. Furthermore, the following tools are utilised for structural purposes: Autodesk Revit Structure, Structural Modeller, STAAD and ETABS, Navisworks, and MEP (mechanical, electrical, and plumbing) engineers can also use Autodesk Revit.

1.2 AutoCAD

One technology that can be used for design and drafting tasks is called CAD (Computer Aided Design). Compared to their hand drafted counterparts, CAD drawings are quicker, better, and more precise because they make use of a processor's processing capacity. Site plans and foundation plans for the proposed work are made using this program.

1.3 REVIT

The best software for the BIM process in the world is Autodesk Revit. Revit is a complete software program that facilitates every step of the building design and construction process, from project management and construction documentation to conceptual design. It enables users to produce intelligent 3D models that capture a building or structure's functional and physical attributes. Among the many uses for the models are construction documentation, analysis, and visualization. Among the many tasks this software completes is providing a 3D model with an architectural view. structural model that includes information on reinforcement, component scheduling to achieve quantity, and collision detection. The 3D model is the primary focus of this project.

1.4 Navisworks

The architectural, engineering, and construction (AEC) sectors are the main users of Autodesk Navisworks, a potent 3D project review tool. Through visualization, it enhances BIM cooperation. integrating and evaluating design data, spotting conflicts, and supporting project review and simulation. Below is a summary of important details:

1. Aggregation of Models: With Navisworks, users may create a single, integrated project model by combining 3D models from different design programs (such as AutoCAD, Revit, and others).
2. Identifying Clashes: Its ability to identify conflicts or confrontations between various building systems (such as structural, mechanical, electrical, and plumbing) is an essential aspect. This lessens the chance of expensive construction mistakes.
3. 3D Modelling: Navisworks connects project schedules to the 3D model to enable 4D simulations. This facilitates planning and coordination by allowing the construction sequence to be visualized across time.

2. LITERATURE REVIEW

1) Bhuskade Shrikant (2015): According to the study, there are three areas that could see future development: i) as BIM technology advances, higher levels of detail (LOD) in BIM models will become available; ii) time and cost parameters can be linked to BIM components in the building model simultaneously to provide a scheduled financial analysis; and iii) resource allocation on a 4D BIM model can be used to analyze and plan resource usage based on the most recent design and even simulate resource allocation. According to the study's findings, quantity takeoffs can be prepared to estimate building project costs once the Building Information Model is created.

2) Sachin A. Ghadge (Sept 2020): The integrated 3D digital interface is progressively replacing the 2D-based design communication. The existing building, which has G+1 floors and a total built-up area of 158.07 square meters, is the subject of this project's research of BIM application. This building has two bedrooms on the ground floor, two bedrooms on the first floor and a bathroom linked to the terrace floor.

3) Thakkar Harshil S. (July 2021): The main goal of this study is to inform readers about the advantages of using BIM in residential projects prior to construction. As a result, the writers used a residential project in Gujarat, India, as their case study. Eight mistakes that may have been found prior to construction if BIM had been used were found in the 3D and 4D models of the project. To create a BIM model, Rs. 171,050 was required. However, it was found that Rs. 246.773 might have been saved if BIM had been used earlier. As a result, 1.44 was found to be the benefits to cost ratio for the two weeks of delay. It is one of the advantages of using BIM in construction.

4) June 2021, Manoj U. Deosarkar: This case study focusses on a residential block located in the Maharashtra state of India, specifically in the Pune region. By using BIM-based tools for design, analysis, planning, estimating, and clash detection, the study seeks to produce an intelligent model. This software manages the many needs and demands of designers and contractors while addressing the complexity of the project. This article presents a comprehensive 3D smart model, complete design report, full scheduling and estimating, and the identification of any conflicts that may arise during the project.

3. OBJECTIVE

3.1 Objective of this project

1. To research and comprehend how BIM is used in residential buildings.
2. To investigate the Building Information Modelling technique.

3. To improve building performance, create a better design solution, and effectively coordinate throughout the project.
4. To provide an enhanced and better workflow for the system.
5. To improve the consistency and accuracy of data.
6. To lessen mistakes and disputes.
7. Projects having a smaller environmental impact can be completed more quickly and affordably.
8. Put design concepts into visual form.
9. Boost output time and cost savings through better cooperation.

4. METHEDOLOGY

4.1 Making Plans:

This is a very fundamental step in the project's virtual construction; it displays every unit needed for the building's subsequent design. AutoCAD software is used to develop the plans, which include foundation plans, site plans, ground floor plans, first floor plans, and terrace floor plans.

4.1.1 AutoCAD plan

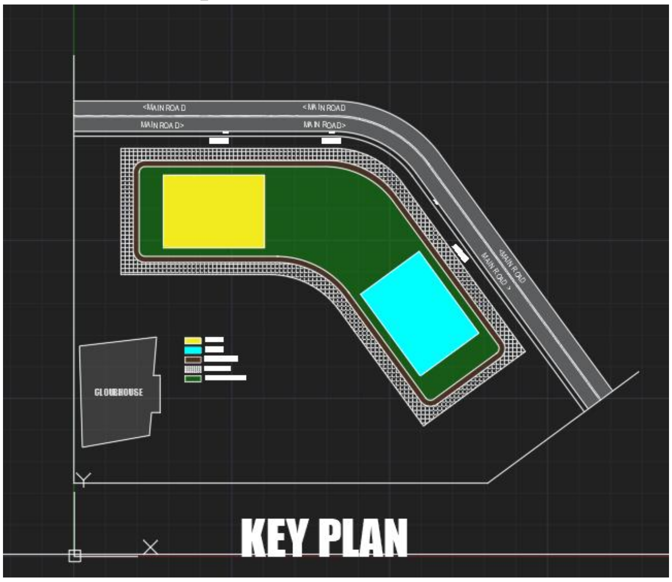

Fig -1: Key Plan

4.2 3D Modelling using Revit:

A highly detailed three-dimensional representation of the building design is produced by 3D modelling, which makes use of the architectural BIM concept. It guarantees a well-calculated and precise version of the plan that can be reproduced exactly as it is when it takes shape. To fully comprehend the construction, it is done in two ways. It displays the 3D model in both structural and architectural views.

Fig -2: Revit 3D Model

4.3 3D Modelling in Architectural view:

The technique of visualizing a design using digital tools to replicate the real built form for a three-dimensional user experience is known as 3D architectural modelling.

Fig -3: Architectural 3D Model

Fig -4: Interior Rendered View of a Flat

Fig -5: Interior View of Kitchen

Fig -6: Elevation View

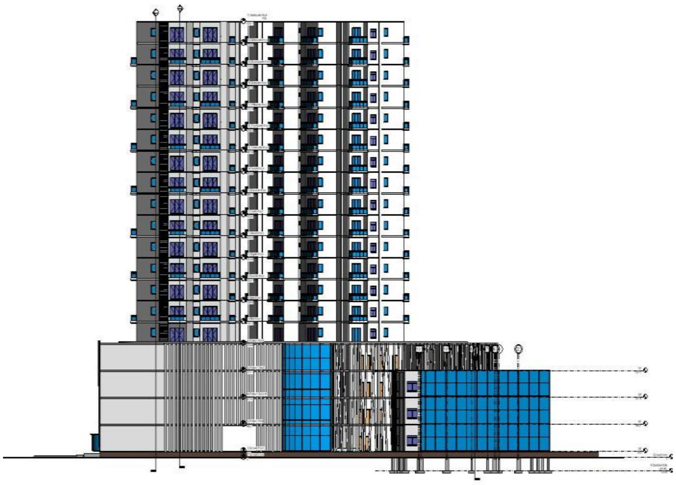

Fig -7: Elevation-West

Fig -8: Elevation-South

Fig -9: 3D View of Club House

4.4 Conflict Report:

Using HTML, XML, PDF, or another format, a conflict report is a document distributed to project stakeholders. It takes more effort to set up and monitor problem-solving over time, and it is the "traditional" method of communicating issues discovered with the clash detection program.

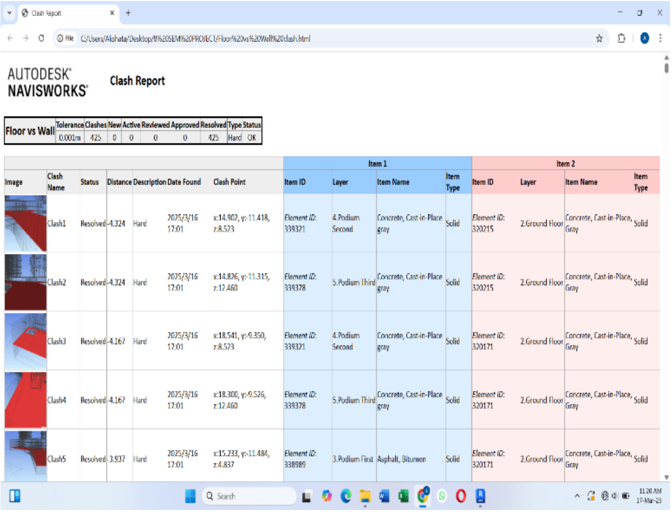

Fig -10: Clash Detection-HTML file

4.5 Identification and Settlement of Clashes:

When two components in your design occupy the same area, it creates a "clash." Clash detection is a technique used in Building Information Modelling (BIM) to determine whether, where, or how two building components such as walls, plumbing, etc. are interfering with one another.

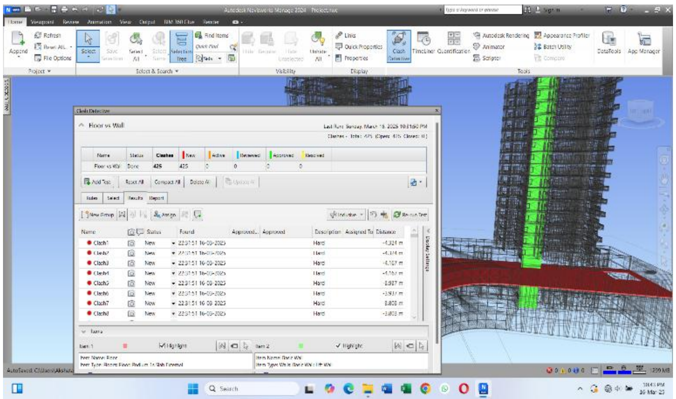

Fig -11: Clash Identification

5 RESULT AND CONCLUSION

5.1 Results:

Following results were acquired from our project through Revit.

5.1.1 Scheduling of Windows Through Autodesk Revit

Window Schedule					
Count	Family and Type	Width	Height	Sill Height	Family and Type
1	W4- 1200 X 1300	1200	1300	700	2 Vantaux - Imposte haute: 1200 X 1300
1	W4- 1200 X 1300	1200	1300	700	2 Vantaux - Imposte haute: 1200 X 1300
1	W1 -2500 X 2100	2500	2100	100	3 Vantaux - Droits: 1800 x 1250
1	W4- 1200 X 1300	1200	1300	100	2 Vantaux - Imposte haute: 1200 X 1300
1	W1 -2500 X 2100	2500	2100	100	3 Vantaux - Droits: 1800 x 1250
1	W1 -2500 X 2100	2500	2100	100	3 Vantaux - Droits: 1800 x 1250
1	W1 -2500 X 2100	2500	2100	100	3 Vantaux - Droits: 1800 x 1250
1	W2-1900x2100	1900	2100	100	ALUMINIUM 6X4.5 - Copy.0001: ALUMINIUM 1900x2100
1	W4- 1200 X 1300	1200	1300	700	2 Vantaux - Imposte haute: 1200 X 1300
1	W2-1900x2100	1900	2100	100	ALUMINIUM 6X4.5 - Copy.0001: ALUMINIUM 1900x2100
1	W2-1900x2100	1900	2100	100	ALUMINIUM 6X4.5 - Copy.0001: ALUMINIUM 1900x2100
1	W2-1900x2100	1900	2100	100	ALUMINIUM 6X4.5 - Copy.0001: ALUMINIUM 1900x2100
1	W2-1900x2100	1900	2100	100	ALUMINIUM 6X4.5 - Copy.0001: ALUMINIUM 1900x2100
1	W2-1900x2100	1900	2100	100	ALUMINIUM 6X4.5 - Copy.0001: ALUMINIUM 1900x2100
1	W2-1900x2100	1900	2100	100	ALUMINIUM 6X4.5 - Copy.0001: ALUMINIUM 1900x2100
1	Wa- 8'x10'	2438	3048	200	Windows_Sgl_Plain: Podium Window 8'x10'
1	Wa- 8'x10'	2438	3048	200	Windows_Sgl_Plain: Podium Window 8'x10'
1	Wa- 8'x10'	2438	3048	200	Windows_Sgl_Plain: Podium Window 8'x10'
1	Wa- 8'x10'	2438	3048	200	Windows_Sgl_Plain: Podium Window 8'x10'
1	Wa- 8'x10'	2438	3048	200	Windows_Sgl_Plain: Podium Window 8'x10'
1	Wa- 8'x10'	2438	3048	200	Windows_Sgl_Plain: Podium Window 8'x10'
1	Wa- 8'x10'	2438	3048	200	Windows_Sgl_Plain: Podium Window 8'x10'
1	Wa- 8'x10'	2438	3048	200	Windows_Sgl_Plain: Podium Window 8'x10'
1	Wa- 8'x10'	2438	3048	200	Windows_Sgl_Plain: Podium Window 8'x10'
1	Wa- 8'x10'	2438	3048	200	Windows_Sgl_Plain: Podium Window 8'x10'
1	Wa- 8'x10'	2438	3048	200	Windows_Sgl_Plain: Podium Window 8'x10'
1	Wa- 8'x10'	2438	3048	200	Windows_Sgl_Plain: Podium Window 8'x10'
1	Wa- 8'x10'	2438	3048	200	Windows_Sgl_Plain: Podium Window 8'x10'
1	Wa- 8'x10'	2438	3048	200	Windows_Sgl_Plain: Podium Window 8'x10'
1	Wa- 8'x10'	2438	3048	200	Windows_Sgl_Plain: Podium Window 8'x10'
1	Wa- 8'x10'	2438	3048	200	Windows_Sgl_Plain: Podium Window 8'x10'
1	Wa- 8'x10'	2438	3048	200	Windows_Sgl_Plain: Podium Window 8'x10'
1	Wa- 8'x10'	2438	3048	200	Windows_Sgl_Plain: Podium Window 8'x10'
1	Wa- 8'x10'	2438	3048	200	Windows_Sgl_Plain: Podium Window 8'x10'
1	Wa- 8'x10'	2438	3048	200	Windows_Sgl_Plain: Podium Window 8'x10'
1	Wa- 8'x10'	2438	3048	200	Windows_Sgl_Plain: Podium Window 8'x10'
1	Wa- 8'x10'	2438	3048	200	Windows_Sgl_Plain: Podium Window 8'x10'
1	Wa- 8'x10'	2438	3048	200	Windows_Sgl_Plain: Podium Window 8'x10'
1	Wa- 8'x10'	2438	3048	250	Windows_Sgl_Plain: Podium Window 8'x10'

Fig -12: Window Schedule

5.1.2 Scheduling of Door Through Autodesk Revit

Door Schedule						
Count	Family and Type	Height	Width	Thickness	Sill Height	Description
1	M_Door-Exterior-Revolving-Full Glass-Metal: 3500 x 2500	2500	3500		0	
1	Storefront_Entry_w_Sidelights_10928: D	2100	2010	51	0	
1	Storefront_Entry_w_Sidelights_10928: D	2100	2010	51	0	
1	Storefront_Entry_w_Sidelights_10928: D	2100	2010	51	0	
1	Storefront_Entry_w_Sidelights_10928: D	2100	2010	51	0	
1	Storefront_Entry_w_Sidelights_10928: D	2100	2010	51	0	
1	Storefront_Entry_w_Sidelights_10928: D	2100	2010	51	0	
1	Door D5- 762x2110mm	2110	762	38	0	Internal Single Door
1	Door D5- 762x2110mm	2110	762	38	0	Internal Single Door
1	Door D5- 762x2110mm	2110	762	38	0	Internal Single Door
1	Door D5- 762x2110mm	2110	762	38	0	Internal Single Door
1	Door D1- 1500x2110mm	2110	1500	44	0	
1	Door D2-1200x2110mm	2110	1200	44	0	
1	Door D6- 600x2110mm	2110	600	38	0	Internal Single Door
1	Door D6- 600x2110mm	2110	600	38	0	Internal Single Door
1	Door D5- 762x2110mm	2110	762	38	0	Internal Single Door
1	Door D5- 762x2110mm	2110	762	38	0	Internal Single Door
1	Door D5- 762x2110mm	2110	762	38	0	Internal Single Door
1	Door D5- 762x2110mm	2110	762	38	0	Internal Single Door
1	Door D5- 762x2110mm	2110	762	38	0	Internal Single Door
1	Door D5- 762x2110mm	2110	762	38	0	Internal Single Door
1	Door D2-1200x2110mm	2110	1200	44	0	
1	Door D1- 1500x2110mm	2110	1500	44	0	
1	Door D1- 1500x2110mm	2110	1500	44	0	
1	Door D -1800x2110mm	2110	1800	44	0	
1	Door D5- 762x2110mm	2110	762	38	0	Internal Single Door
1	Door D5- 762x2110mm	2110	762	38	0	Internal Single Door
1	Door D5- 762x2110mm	2110	762	38	0	Internal Single Door
1	Door D5- 762x2110mm	2110	762	38	0	Internal Single Door
1	Door D5- 762x2110mm	2110	762	38	0	Internal Single Door
1	Door D5- 762x2110mm	2110	762	38	0	Internal Single Door
1	Door D2-1200x2110mm	2110	1200	44	0	
1	Door D1- 1500x2110mm	2110	1500	44	0	
1	Door D5- 762x2110mm	2110	762	38	0	Internal Single Door
1	Door D5- 762x2110mm	2110	762	38	0	Internal Single Door
1	Door D1- 1500x2110mm	2110	1500	44	0	

Fig -12: Door Schedule

5.1.3 Scheduling of Walls Through Autodesk Revit

Family and Type	Length	Width	Volume	Base Constraint
Basic Wall: Lift Wall	5715	229	20.57 m^3	2.Ground Floor
Basic Wall: Lift Wall	3581	229	12.89 m^3	2.Ground Floor
Basic Wall: Lift Wall	5753	229	19.75 m^3	2.Ground Floor
Basic Wall: Lift Wall	2248	229	7.96 m^3	2.Ground Floor
Basic Wall: Lift Wall	3962	229	13.44 m^3	2.Ground Floor
Basic Wall: Lift Wall	2210	229	7.13 m^3	2.Ground Floor
Basic Wall: Lift Wall	2217	229	31.90 m^3	2.Ground Floor
Basic Wall: Lift Wall	4912	229	67.93 m^3	2.Ground Floor
Basic Wall: Lift Wall	2177	229	28.62 m^3	2.Ground Floor
Basic Wall: Lift Wall	2061	229	28.61 m^3	2.Ground Floor
Basic Wall: Lift Wall	6934	229	24.96 m^3	2.Ground Floor
Basic Wall: Lift Wall	6934	229	24.96 m^3	2.Ground Floor
Basic Wall: Lift Wall	6681	229	23.04 m^3	2.Ground Floor
Basic Wall: Lift Wall	2149	229	32.31 m^3	2.Ground Floor
Basic Wall: Lift Wall	4784	229	67.63 m^3	2.Ground Floor
Basic Wall: Lift Wall	2149	229	29.05 m^3	2.Ground Floor
Basic Wall: Lift Wall	6934	229	24.96 m^3	2.Ground Floor
Basic Wall: Lift Wall	6934	229	24.96 m^3	2.Ground Floor
Basic Wall: Lift Wall	6681	229	23.04 m^3	2.Ground Floor
Basic Wall: Lift Wall	3309	229	50.50 m^3	2.Ground Floor
Basic Wall: Lift Wall	5280	229	73.21 m^3	2.Ground Floor
Basic Wall: Lift Wall	5280	229	73.21 m^3	2.Ground Floor
Basic Wall: Lift Wall	5086	229	71.14 m^3	2.Ground Floor
Basic Wall: Lift Wall	3309	229	47.35 m^3	2.Ground Floor
Basic Wall: Lift Wall	5098	229	70.17 m^3	2.Ground Floor
Basic Wall: Lift Wall	2008	229	7.87 m^3	2.Ground Floor
Basic Wall: Lift Wall	2438	229	8.78 m^3	2.Ground Floor
Basic Wall: Lift Wall	2008	229	6.59 m^3	2.Ground Floor
Basic Wall: Lift Wall	2008	229	7.41 m^3	2.Ground Floor
Basic Wall: Lift Wall	2438	229	8.78 m^3	2.Ground Floor
Basic Wall: Lift Wall	2008	229	6.59 m^3	2.Ground Floor
Basic Wall: Lift Wall	2149	229	29.05 m^3	2.Ground Floor
Basic Wall: Lift Wall	4166	229	11.25 m^3	2.Ground Floor
Basic Wall: Lift Wall	419	229	1.44 m^3	2.Ground Floor
Basic Wall: Lift Wall	2210	229	5.97 m^3	2.Ground Floor
Basic Wall: Lift Wall	2705	229	6.58 m^3	2.Ground Floor
Basic Wall: Lift Wall	419	229	1.44 m^3	2.Ground Floor
Basic Wall: Lift Wall	4204	229	11.86 m^3	2.Ground Floor

Table -1: Walls Schedule

5.1.4 Quantity Takeoff for Columns, Beams and Footings

Row Labels	Length	Width	Thickness	Height	Perimeter	Area	Volume	Count
Club House Frame structurre.nwc								
<No level>								
Levels								
Level								
1/4" Head	0	0	0	0	0	0	0	6
FF								
CH Stru plan FF.dwg								
Import Symbol								
CH Stru plan FF.dwg	0	0	0	0	0	0	0	1
Structural Framing								
Concrete-Rectangular Beam								
150 X 150	189.8263302	0	0	0	0	0	3.987424416	26
230 X 300	106.0187456	0	0	0	0	0	6.539970622	10
300 X 500	8.861291698	0	0	0	0	0	1.46211313	1
FOUNDATION LEVEL								
Structural Columns								
Concrete-Rectangular-Column								
230 X 600	350.664	0	0	0	0	0	48.391632	24
230 X450	73.055	0	0	0	0	0	7.5611925	5
300 x 600	131.499	0	0	0	0	0	23.66982	9
Structural Foundations								
Footing-Rectangular								
1200x1200x350	0	0	0	0	0	0	17.136	34
GF								
Structural Foundations								
Footing-Rectangular								
1200x1200x350	0	0	0	0	0	0	2.016	4
Structural Framing								
Concrete-Rectangular Beam								
150 X 150	197.7656347	0	0	0	0	0	4.165283935	30
230 X 300	106.0187456	0	0	0	0	0	6.539970622	10
300 X 500	8.861291698	0	0	0	0	0	1.46211313	1
Ground level								
CH Structural Plan GF.dwg								
Import Symbol								
CH Structural Plan GF.	0	0	0	0	0	0	0	1
Walls								
Basic Wall								
230 mm lift shaft	8.377891269	0	0	63.055	0	105.6535868	24.30032496	5
SF								
CH Stru Plan SF.dwg								
Import Symbol								
CH Stru Plan SF.dwg	0	0	0	0	0	0	0	1

Fig -14: Quantity Takeoff

5.2 Conclusion:

- The planning and 3D modelling of a G+18 residential building was successfully completed using Autodesk Revit software.
- Revit enabled the seamless conversion of 2D plans into detailed 3D models, enhancing visualization and presentation.
- The project demonstrated how Building Information Modeling (BIM) improves:
  - Visualization for clients before actual construction.
  - Schedule adherence by linking time with design.
  - Cost savings through better coordination.
  - Clash detection and resolution, minimizing rework and errors.
- Deliverables included:
  - Coordinated 3D models.
  - Clash detection reports.
  - As-built documentation.

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