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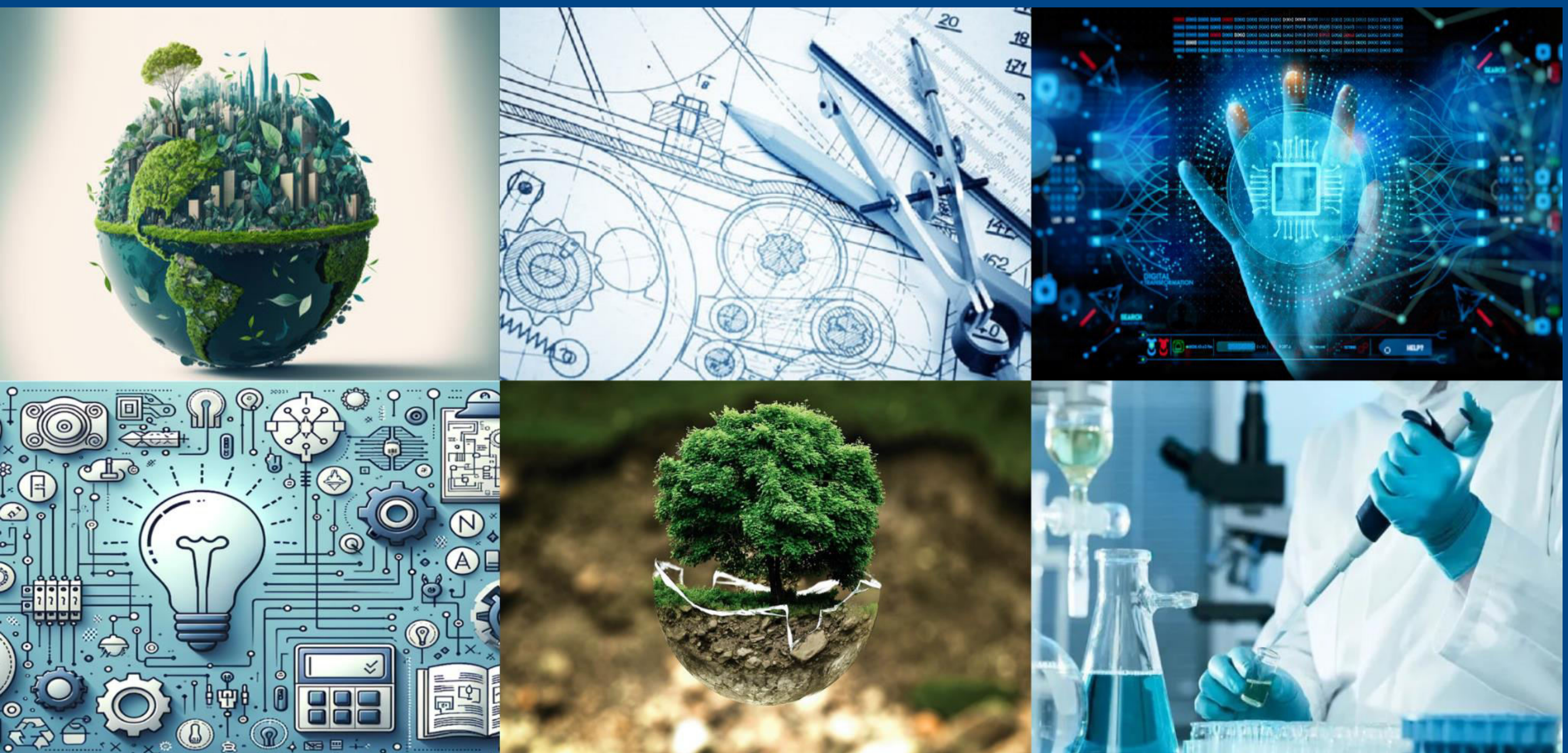

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Application of BIM Methodology in Revit for Automated Quantity Take-Off and Reinforcement Estimation

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ABSTRACT: This project focuses on automating quantity takeoff and reinforcement estimation for a g+2 residential building using BIM, specifically Revit software, by adopting structural analysis data and designs. Quantity takeoff and reinforcement estimation are more important in construction for calculating material requirement. By using BIM methodologies, we streamline the process, saving time and improving accuracy. In Revit, we create a 3D structural model of the building using pre-defined structural data such as beam, column, slab, and foundation sizes, as well as rebar diameters and spacings. Using this model, the software automatically calculates quantities for structural elements, along with reinforcement requirements, reducing manual work and minimizing errors. This approach supports effective project planning and resource management for building projects, making construction processes more efficient and easier. A significant advantage of this project is that it not only speeds up planning but also reduces resource waste and time delays in the construction industry, making processes more efficient and cost-effective.

KEY WORDS: Building Information Modeling (BIM), Revit, Quantity take-off, Reinforcement estimation.

I.INTRODUCTION

Building Information Modeling (BIM) is a digital process that creates and manages all the information about a building throughout its lifecycle. BIM involves creating a 3D model that not only represents the design of the building but also includes important data such as material quantities, cost estimates, and schedules. This shared digital model helps architects, engineers, contractors, and other stakeholders collaborate efficiently, leading to improved accuracy and fewer errors during construction.

The concept of BIM dates back to the 1960s when computer-aided design (CAD) systems began to replace manual drawing methods. However, the term "Building Information Modeling" was first coined in the 1990s by Charles Eastman, a professor at Georgia Tech, who envisioned a model that would combine 3D geometric data with relevant building information for a more comprehensive design and construction process. Over time, BIM evolved into a vital tool for managing the entire building lifecycle, from design and construction to operation and maintenance.

Revit, developed by Revit Technology Corporation, was first released in 2000. The software quickly gained popularity because of its ability to generate 3D models with integrated data. In 2002, Autodesk acquired Revit Technology Corporation, and Revit became one of the leading BIM tools in the architecture, engineering, and construction industries. Unlike traditional CAD software, Revit uses parametric modeling, meaning that every change in one part of the model (like changing the size of a column) automatically updates related components, such as beams and walls.

Charles Eastman, Autodesk, and experts like Randy Deutsch and Gregory P. Howell have contributed significantly to the development and popularization of BIM and Revit. These tools have transformed the way buildings are designed, constructed, and managed, providing a more efficient, accurate, and collaborative approach to the construction industry.

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II.LITERATURE REVIEW

Lam tatt soon, syuen wong et al., (2024)

The objective of this research is to compare and analyze the application of BIM-based Quantity Take-Off (QTO) in the Quantity Surveying (QS) profession. It focuses on examining the use of Building Information Modeling (BIM) software in the QTO process to address issues such as 3D modeling inaccuracies, quantities extraction challenges, and data loss. Additionally, the study aims to evaluate and compare the efficiency of two BIM software tools—Autodesk Revit and Cubic cost TAS—while ensuring compliance with the Malaysian Standard Method of Measurement of Building Works Second Edition (SMM2). The study concludes that the integration of BIM-based QTO provides significant benefits to the QS profession, including improved accuracy and time efficiency in the measurement of construction materials. However, challenges such as modeling errors, extraction inconsistencies, and data management need to be addressed to maximize its effectiveness. By comparing and analyzing the capabilities of Autodesk Revit and Cubic cost TAS, the research offers

valuable insights into the strengths and limitations of these tools, helping QS professionals better understand the potential of BIM in optimizing the QTO process.

Hang Thu Thi Le, Huyen Thi, et al.,(2023)

This study explores the use of Building Information Modeling (BIM) for quantity take- off in large-scale construction projects, specifically focusing on a class I project in Vietnam. With BIM being a mandatory process for certain public investment projects starting in 2023, the research investigates how BIM can improve the accuracy of volume take-offs compared to traditional methods. Revit is chosen as the BIM authoring tool for developing the 3D model and conducting semi-automatic quantity take-off, while Microsoft Excel is used for reporting the results. The study compares BIM and traditional methods to evaluate their effectiveness and applicability in large-scale projects. The study concludes that BIM, specifically through the use of Revit, offers a more accurate and efficient method for conducting quantity take-offs in large-scale construction projects. While traditional methods may still hold value, the integration of BIM technology significantly enhances accuracy and reduces human error, making it a compelling choice for future construction projects in Vietnam. The comparison highlights the advantages of BIM, including its ability to generate detailed 3D models and semi-automatically calculate quantities, which provides a more streamlined and reliable process for construction managers.

Onnyxiforus Gondokusumo (2023)

This study examines the use of Building Information Modeling (BIM), specifically Revit, in calculating Quantity Take-Off (QTO) for concrete and rebar in construction projects. It analyzes the time efficiency, accuracy, and obstacles involved in using Revit compared to traditional methods. The analysis includes a comparison of QTO results, time requirements for the initial design and design changes, as well as the advantages and challenges of using Revit. Data was collected through interviews and calculations of QTO for concrete and rebar using both Revit and conventional methods.The study concludes that Revit is highly recommended for QTO calculations due to its ability to significantly speed up the process. Revit reduced calculation time for concrete QTO by up to 49% and rebar QTO by up to 20% during the initial design stage. For design changes, Revit proved even more efficient, reducing concrete QTO calculation time by 90% and rebar QTO by 67%, compared to conventional methods. Additionally, there were minimal differences in the QTO results for concrete, while rebar showed a slight variation of 0.6742%. Overall, respondents preferred using Revit over traditional methods, highlighting its efficiency and accuracy.

Nia Kartika, Muhamad yusuf Mahendra et al.,(2023)

This study explores the use of Building Information Modeling (BIM) for the estimation and quantity take-off of steel structures at the Kosmetika Global Health Indonesia site in Cikarang. The research involved creating a 3D model of the steel structures based on shop drawing documents and then calculating the quantity take-off for the estimated cost of the steel structure work using Autodesk Revit software. The aim was to assess how BIM can improve accuracy and efficiency in quantity take-off calculations and cost estimations. The study concludes that Autodesk Revit significantly optimizes the modeling process, transforming 2D designs into detailed 3D models that allow for more accurate and comprehensive quantity take-off calculations. The use of Revit also helps reduce material waste and supports BIM 5D, which aids in more precise cost estimations. The calculated estimated costs using Revit were 3.45% smaller than those from conventional manual methods, highlighting the advantages of using BIM in improving accuracy and reducing discrepancies that arise from the limitations of 2D-based manual calculations.

III.METHODOLOGY OF PROPOSED SURVEY

TEMPLATE SELECTION

The project began by selection of the US Imperial Structural Template in Revit. The template was chosen because it contained preloaded structural families like footings, columns, beams, and slabs, which were essential for the G+2 residential building. The selection ensured a standardized workflow and compatibility with the required project parameters.
Open Revit > New project > Browse > Templates > us imperial > structural analysis default.rte > Open

SETTING UNITS

After selecting the template, the default Imperial Units were retained for the project. Measurements such as feet, inches, and cubic feet were used throughout. The unit settings were verified to ensure accurate dimensions and calculations in the subsequent steps. This setup allowed for consistent and reliable modeling and quantity takeoff processes.

press UN to open unit setting box and adjust as needed
The grids and levels were developed to structure the building model. Horizontal and vertical grids were created and labeled systematically, such as Grid A, Grid B for columns and beams. Levels were defined for the ground floor, first floor, second floor, and roof slab, corresponding to the G+2 structure. This framework ensured precise placement of structural elements according to the architectural layout.
Structural tab> click grids and draw horizontal and vertical grids >label grids (A,B…1,2..)> Switch to elevation view >click levels >create levels >rename levels

ADDING STRUCTURAL ELEMENTS TO THE BUILDING MODEL

Structural elements were added step by step:
Footings: Three types of rectangular footings were placed at the foundation level, customized with varying dimensions according to the structural data.
Go to structure tab > in foundation panel, select Isolated > in the properties browser ,the desired footing type is selected > adding footing to the building model in the plan view at the appropriate grid locations.
Switch to elevation view > check the footing is positioned correctly > move or adjust in properties browser if needed.

Columns: Two types of columns were added at grid intersections, with their dimensions defined as per the design.
Go to structure tab > in structure panel, click column > in the property's browser, the desired column type will be selected > adding column to the building model
Switch to the elevation view > in the properties browser, defined the top level and bottom level as required > specify the structural material.

Beams: Five plinth beams and five regular beams were positioned, ensuring proper alignment with the columns.
Go to structure tab > in structure panel, click beam > in the properties browser, select desired beam type > add beams to the building model

Slab: A single slab was created for the top level, with varying thickness and dimensions as per the layout.
Go to structure tab > in foundation panel, click slab > structural foundation slab > select type of slab in properties browser > draw a rectangle(slab) at slab level

Slab opening for stair case: Go to structure tab > switch to the plan view > in openings panel, click shaft opening >select rectangle tool in draw option > draw an opening as per the layout > click finish edit model to finalize the opening.

Wall : walls are created in properties browser interior , exterior and parapet wall with structural material (brick) was created and added to the building model.

Wall openings: select wall where you want to create opening > click edit profile > switch to the elevation view > draw an rectangle opening with the required dimensions > click finish edit model.

Stair case: since the staircase was not available in the family files, a custom structural element was created for the building model using component model in place method.
Create a temporary wall to serve as the working plane > component > model in place
>structural connections >set the work plane by selecting pick a plane and conform with set > in the draw option select line tool > choose extrusion and draw the stair case in working plane.
>complete the drawing for the staircase and click finish edit model > adjust stair case dimensions
> finish. Draw each flight separately to avoid overlapping

AUTOMATION OF QUANTITY TAKEOFF SCHEDULES

After completing the 3D model, quantity takeoff schedules were generated using Revit's tools. These schedules provide detailed quantity for various structural elements and reinforcement volume. Project browser > navigate to schedules /quantities and click new schedules/quantities> select desired category > okFor shortening and grouping : go to properties > shortening /grouping > click edit to modify the settings > sort by select desired criteria > enable grand totals and check itemize every instance for detailed or grouped results > click ok

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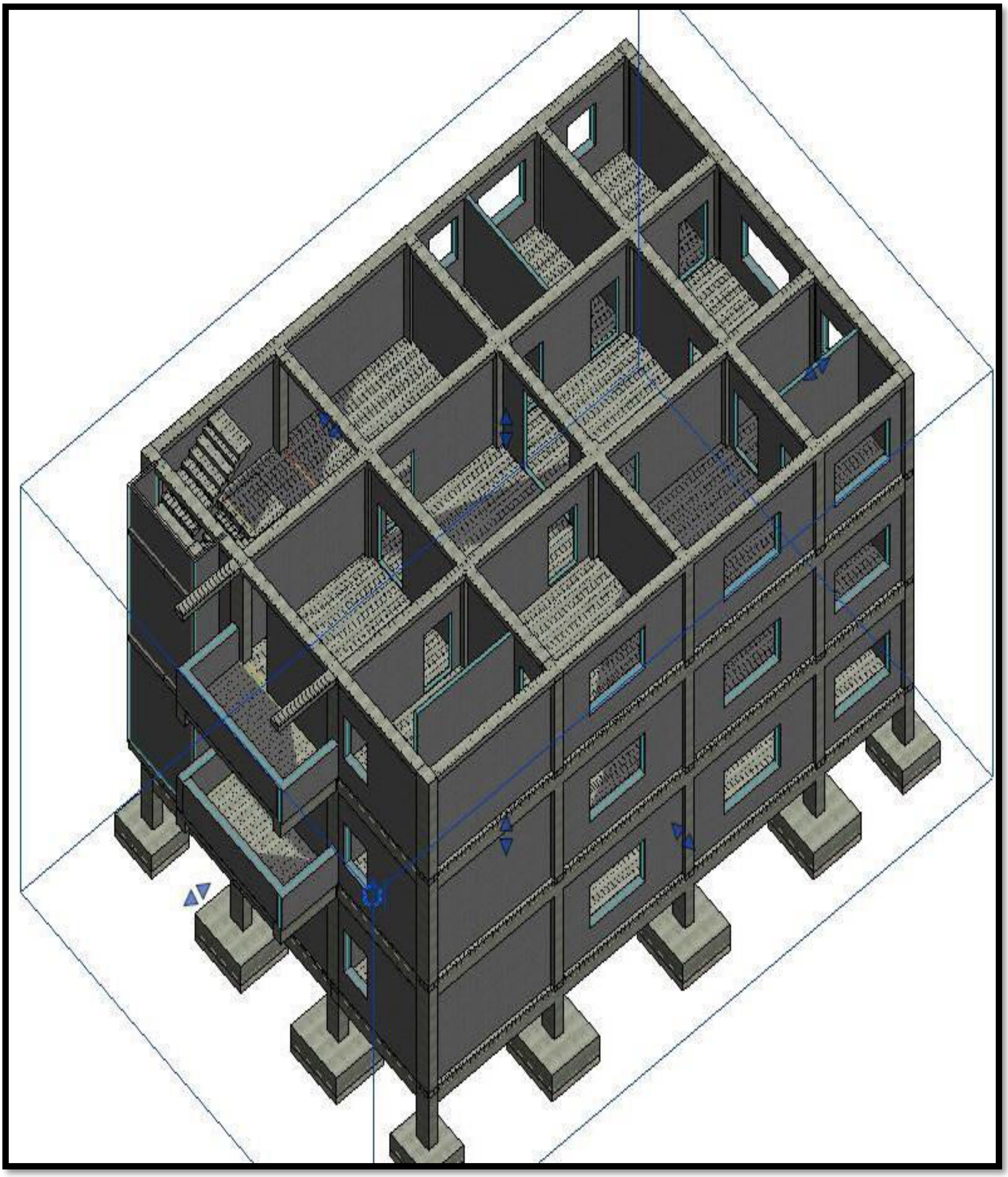

Fig 1 Developed 3D Building Model in REVIT

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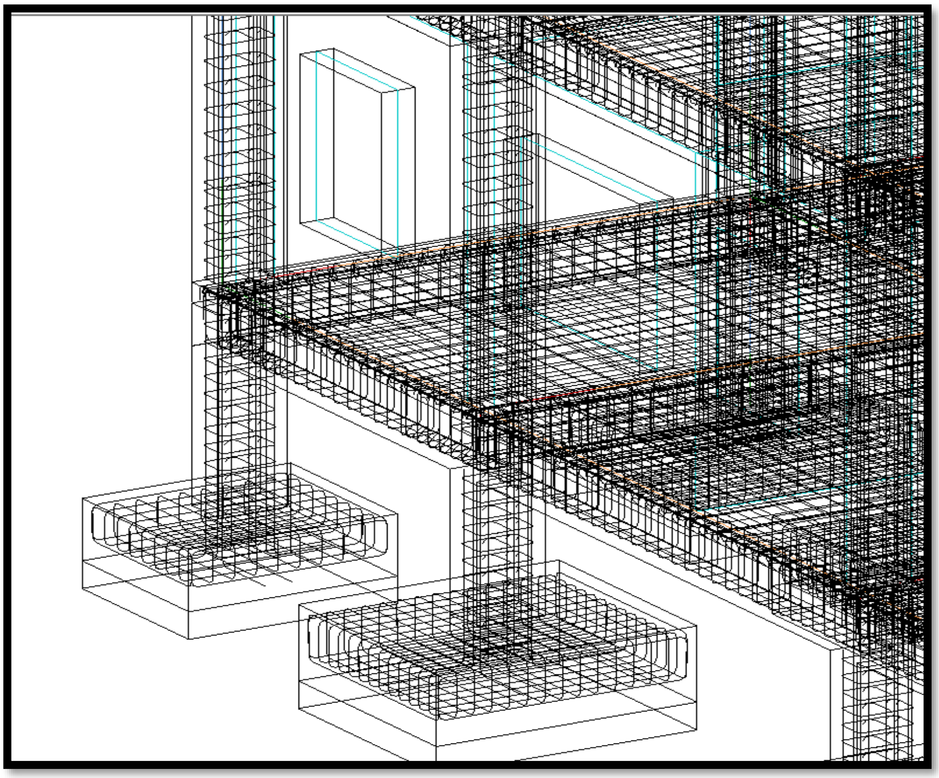

Fig 2 Reinforcement Distribution in the G+2 Residential building Model

Rebar Schedule				
Family and Type	Material	Reinforcement Volume	Total Bar Length	Number of lengths (12m each)
Rebar Bar: 8 mm	Rebar, ASTM A615, Grade 60	0.264 m³	5248	437
Rebar Bar: 10 mm	Rebar, ASTM A615, Grade 60	2.218 m³	28240	2353
Rebar Bar: 12 mm	Rebar, ASTM A615, Grade 60	0.384 m³	3391	283
Rebar Bar: 16 mm	Rebar, ASTM A615, Grade 60	0.588 m³	2926	244
Rebar Bar: 20mm	Rebar, ASTM A615, Grade 60	0.028 m³	89	7
Grand totals		3.482 m³	39895	3325

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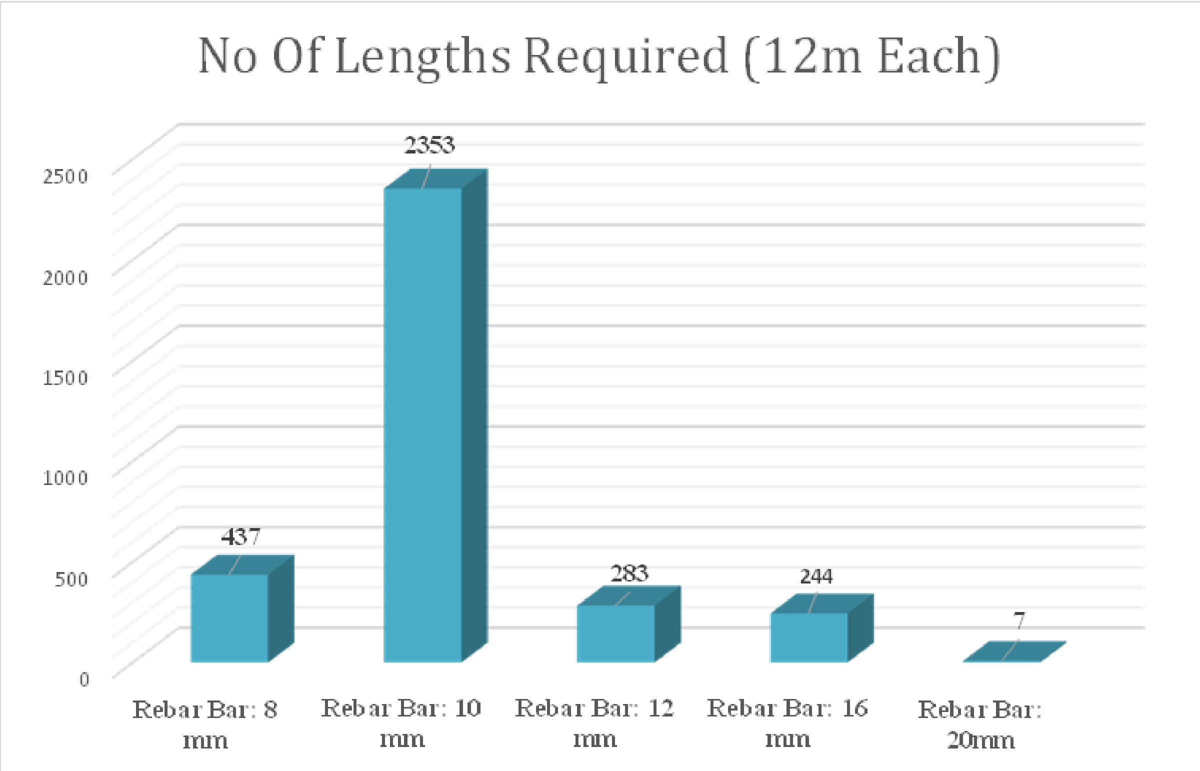
OVERALL REINFORCEMENT PERCENTAGE DISTRIBUTION IN THE BUILDING

Total Reinforcement percentage with respect to reinforced structural elements (Excluding walls)

$$= \frac{\text{Total Reinforcement Volume}}{\text{Sum Of Volumes Of Reinforced Structural Elements}} \times 100$$

$$= \frac{3.482}{223.61} \times 100 = 1.557\%$$



Graph 1 No of Lengths required for 12 m Rebars

IV.CONCLUSION AND FUTURE WORK

From the above project, it can be concluded that:

1. Visualization of a clear and detailed BIM based 3D structural model in Revit.
2. By using BIM methodology, the generation of quantity takeoff schedules was done for a g+2 residential building.
3. The total reinforcement percentage in the g+2 residential building excluding walls was 1.557%
4. Graphs comparing total volume and reinforcement volume for different structural elements helped to understand reinforcement distribution
5. By using BIM, the entire estimation process becomes easier, more systematic and reducing manual effort.
6. The BIM based generation of quantity takeoff schedules and reinforcement estimation is time saving process when compared to traditional methods
7. The BIM based process helps to reduce manual errors in estimation, makes the project most accurate.

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