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COMPARATIVE ANALYSIS OF COST BUDGET PLAN CALCULATIONS USING BUILDING INFORMATION MODELING (BIM) AND CONVENTIONAL METHODS ON THE BRI BANK BUILDING CONSTRUCTION PROJECT IN MEDAN

Suranto[a], Nurmaidah[b], Arya Prio Pamungkas[b]
[a]Institut Modern Architecture dan Teknologi, Deli Serdang, Indonesia, email: suranto@imat.ac.id
[b]Civil Engineering Study Program, Faculty of Engineering, Universitas Medan Area, Indonesia,
email: nurmaidah@staff.uma.ac.id

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ABSTRACT

This research aims to analyze the comparison of work volume calculations and cost budget plans for the BRI Bank building construction project in Medan using the Building Information Modeling (BIM) method and conventional methods. The data used in this research is building volume data that was planned by redesign using Autodesk Revit. This data includes building technical data, such as building area, number of floors and volume of work. The research results show that using the BIM method with Autodesk Revit can produce more accurate work volume calculations compared to conventional methods. This has an impact on calculating the cost budget plan which is also more accurate. In addition, the BIM method has been proven to be able to increase efficiency and effectiveness in managing construction projects, especially in terms of coordination between disciplines, reducing design errors, as well as optimizing costs and time for project implementation. The results of the comparative analysis carried out turned out that the cost budget plan for implementing the BIM method was Rp. 2,976,607,161 while the total cost using the conventional method is Rp. 3,280,583,049. The cost budget plan calculation using the BIM method is 9.27% smaller than the conventional method.
***Key Words**: Cost budged plan, Building Information Modeling, construction efficiency*

ABSTRAK

Penelitian ini bertujuan untuk menganalisis perbandingan perhitungan volume pekerjaan dan rencana anggaran biaya pada proyek pembangunan gedung Bank BRI di Medan dengan menggunakan metode Building Information Modeling (BIM) dan metode konvensional. Data yang digunakan dalam penelitian ini adalah data volume bangunan yang direncanakan dengan mendesain ulang menggunakan Autodesk Revit. Data tersebut mencakup data teknis gedung, seperti luas bangunan, jumlah lantai, dan volume pekerjaan. Hasil penelitian menunjukkan bahwa penggunaan metode BIM dengan Autodesk Revit dapat menghasilkan perhitungan volume pekerjaan yang lebih akurat dibandingkan dengan metode konvensional. Hal ini berdampak pada perhitungan rencana anggaran biaya yang juga lebih akurat. Selain itu, metode BIM terbukti mampu meningkatkan efisiensi dan efektivitas dalam pengelolaan proyek konstruksi, khususnya dalam hal koordinasi antar disiplin ilmu, pengurangan kesalahan desain, serta optimasi biaya dan waktu pelaksanaan proyek. Hasil analisis perbandingan yang dilakukan ternyata rencana angagran biaya (RAB) penerapan metode BIM sebesar Rp. 2.976.607.161 sedangkan biaya total dengan metode konvensional sebesar Rp. 3.280.583.049. Perhitungan RAB dengan metode BIM lebih kecil 9,27% dibandingkan dengan metode konvensional.
***Kata Kunci:** Rencana Anggaran Biaya, Building Information Modeling, efisiensi konstruksi*

1. INTRODUCTION

Infrastructure development, including buildings and roads, is one of the main indicators of a region's economic development. In Indonesia, the construction sector continues to experience significant growth in line with the increasing public need for adequate infrastructure. However, this rapid development also brings new challenges, namely the increasing complexity of projects that must be managed more effectively and efficiently. One widely adopted solution to overcome this challenge is the use of Building Information Modeling (BIM).

BIM is an approach that integrates technology and communication in the design and construction process, enabling better and more efficient project management. With BIM, the planning, design and construction processes become more integrated, which in turn can improve the quality of the final result and reduce project duration and costs. According to Eastman et al. (2008), the use of BIM can provide various benefits such as increasing interdisciplinary coordination, reducing design errors, and optimizing costs and project implementation time.

Autodesk Revit is one software that implements BIM effectively. Revit allows the creation of comprehensive and detailed 3D models, covering various aspects of a construction project, from architecture, structure, to mechanical, electrical, and plumbing (MEP) systems. The use of Revit in construction projects has been proven to increase efficiency and accuracy in calculating work volumes and cost budgets.

In Indonesia, the application of BIM is still relatively new and has not been widely applied to building projects. This research aims to fill this gap by optimizing the calculation of work volume and cost budget for the BRI Bank building construction project on Jl. Sisingamangaraja, Medan, uses the BIM method with the help of the Autodesk Revit program. Through this research, it is hoped that a clearer picture can be obtained regarding the advantages and challenges of implementing BIM in Indonesia.

Eastman (2008) shows that BIM succeeded in reducing project costs by up to 9.27% on the Georgia State University building construction project in the United States compared to conventional methods. Apart from that, another study by Marizan (2019) in Malaysia showed that the use of BIM in the Sukajadi Community Health Center planning project in Prabumulih City could increase project efficiency by up to 15%.

Another study by Migilinskas et al. (2013) in Lithuania also found that applying BIM to the Vilnius Shopping Center shopping center construction project could reduce project completion time by 20% and project costs by up to 10% compared to traditional methods. In China, research by Li et al. (2014) showed that BIM helped in improving collaboration between project teams on the construction of office buildings in Shanghai, which ultimately reduced the risk of delays and improved construction quality.

With this background, this research is focused on analyzing the comparison of work volume calculations and cost budgets for the BRI Bank building construction project in Medan with the application of BIM using Autodesk Revit and conventional methods. It is hoped that the results of this research can become a reference and benchmark for construction practitioners in Indonesia in adopting BIM technology to increase the efficiency and effectiveness of their projects.

2. DATA AND METHODS

2.1. Research Data

The data used in this research is the planned building volume data obtained by redesigning withAutodesk Revit.This data is data related to building technical data and project structures obtained directly at the BRI Bank Building Construction project location on Jl. Sisingamangaraja No. 241 Gg. Indrajid Kel. Sudirejo-II District. Medan City.

Data collection was obtained from the BRI Bank building construction contractor, the data obtained was in the form of: Drawings and structural data as well as structural cost budgets.

The following project data obtained is as follows:

- Structure Type: Multi-storey Building
- Contract Value: Rp. 18,000,000,000,-
- Building Area: 568 m^2

- Number of Floors: 4 Floors
- Building Height: 19.50 m
- Borepile and Pilecap Structure
- Column Structure
- Beam Structure
- Floor Plate Structure
- Stair Structure

2.2. Research Methods

RESEARCH FLOW DIAGRAM

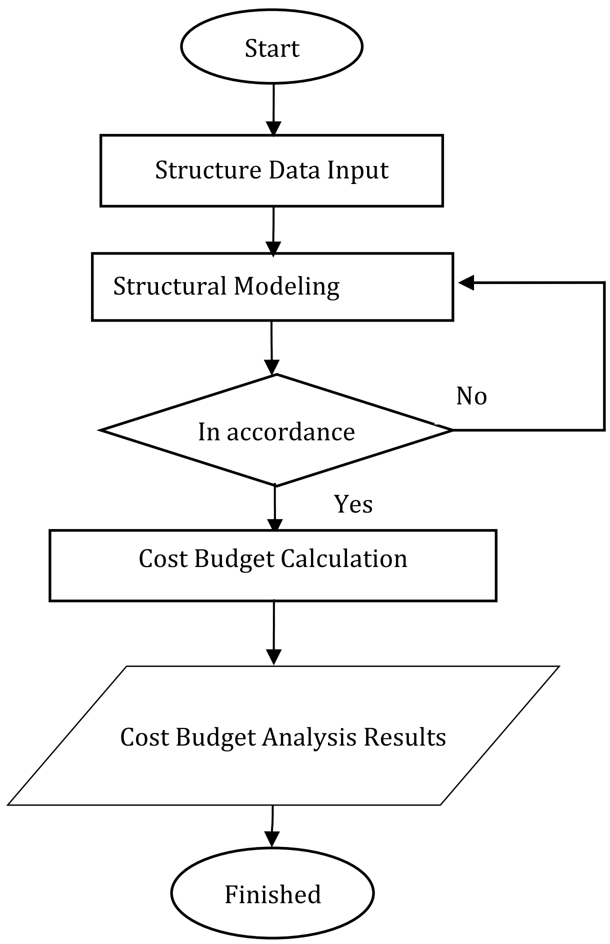


Figure 1. Research Flow Chart

3. RESULTS AND DISCUSSION

3.1. Foundation

1) Borepile and Pilecap Plans

*Autodesk Revit*will save all information in one place. For this matter, if changes are made to certain areas, it will change the entire model. For example, when you want to change an object in a 3D model, the plan appearance, cost budget plan, and so on will change.

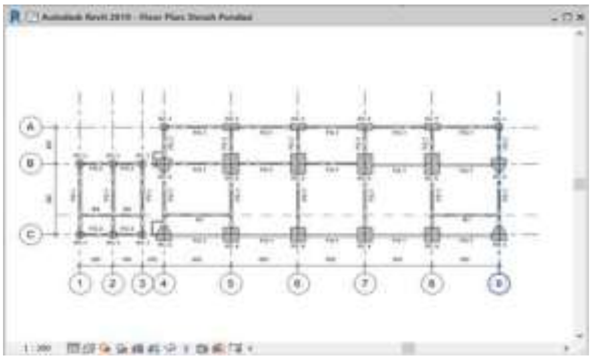


Figure 2. Foundation and Pilecap

Figure 2 shows the bore pile and pile cap floor plan modeling for the BRI Bank Building construction project using Autodesk Revit.

2) 3D Modeling of Foundations

After modeling the borepile and pilecap according to the points determined on the borepile and pilecap plan.

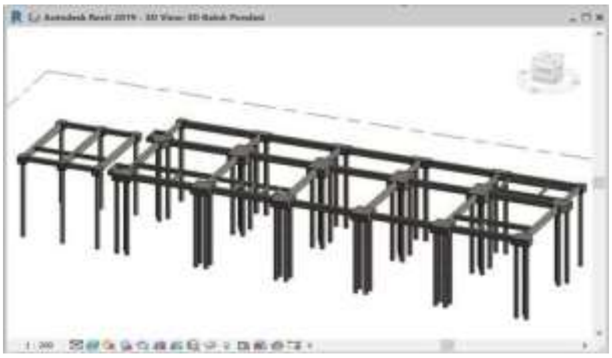


Figure 3. 3D Modeling of Foundations

Figure 3 shows the 3D modeling of the foundation, then the results of the 3D modeling are checked again so that the modeling really matches the results of the plans made by the consultant.

3) Details of Reinforcement and Foundation Pieces

Next, modeling is carried out for the reinforcement in the borepile and pilecap.

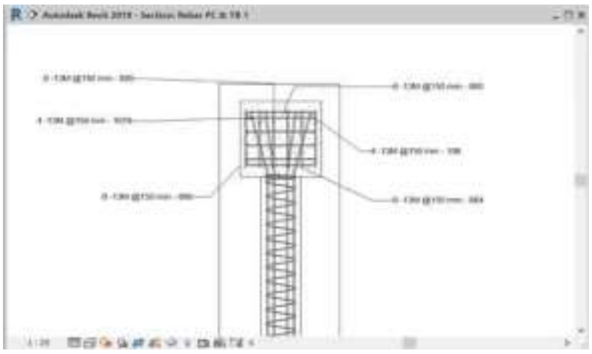


Figure 4. Foundation Reinforcement Details

Figure 4 shows the modeling of foundation reinforcement, then a picture of the foundation section is shown as shown in Figure 5.

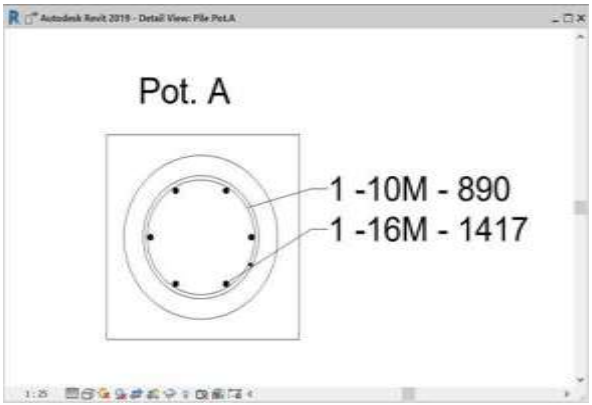
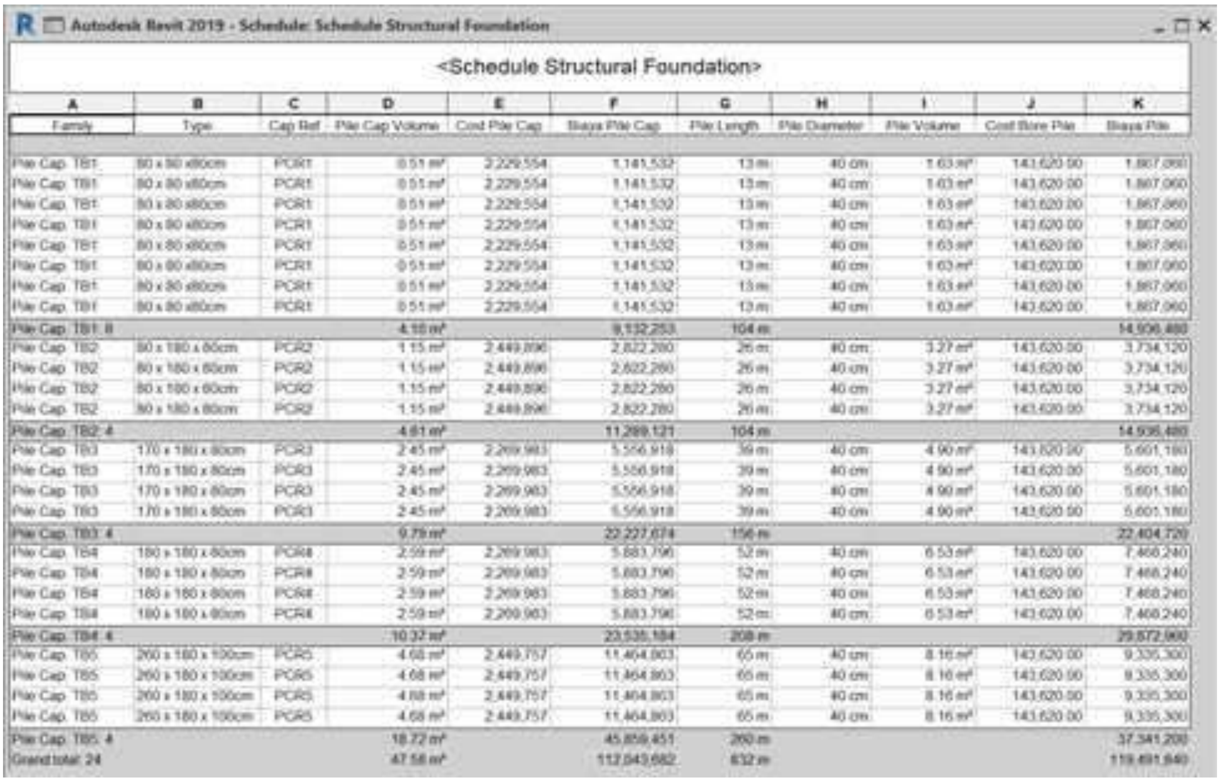


Figure 5. Foundation Cut

4) *Schedules* Foundation

Schedules is a feature on *Autodesk Revit* which works to find out the types of components used in building models, for example to find out foundations, columns and others. In the schedule table, we can arrange it according to our needs and can create formulas, filters and calculations.



Autodesk Revit 2019 - Schedule: Schedule Structural Foundation

<Schedule Structural Foundation>

A	B	C	D	E	F	G	H	I	J	K
Family	Type	Cap Ref	Pile Cap Volume	Cost Pile Cap	Biaya Pile Cap	Pile Length	Pile Diameter	Pile Volume	Cost Bore Pile	Biaya Pile
Pile Cap TB1	80 x 80 x80cm	PCR1	0.51 m³	2,229,554	1,141,532	13 m	40 cm	1.63 m³	143,620.00	1,867,060
Pile Cap TB1	80 x 80 x80cm	PCR1	0.51 m³	2,229,554	1,141,532	13 m	40 cm	1.63 m³	143,620.00	1,867,060
Pile Cap TB1	80 x 80 x80cm	PCR1	0.51 m³	2,229,554	1,141,532	13 m	40 cm	1.63 m³	143,620.00	1,867,060
Pile Cap TB1	80 x 80 x80cm	PCR1	0.51 m³	2,229,554	1,141,532	13 m	40 cm	1.63 m³	143,620.00	1,867,060
Pile Cap TB1	80 x 80 x80cm	PCR1	0.51 m³	2,229,554	1,141,532	13 m	40 cm	1.63 m³	143,620.00	1,867,060
Pile Cap TB1	80 x 80 x80cm	PCR1	0.51 m³	2,229,554	1,141,532	13 m	40 cm	1.63 m³	143,620.00	1,867,060
Pile Cap TB1	80 x 80 x80cm	PCR1	0.51 m³	2,229,554	1,141,532	13 m	40 cm	1.63 m³	143,620.00	1,867,060
Pile Cap TB1	80 x 80 x80cm	PCR1	0.51 m³	2,229,554	1,141,532	13 m	40 cm	1.63 m³	143,620.00	1,867,060
Pile Cap TB1: 8			4.10 m³		9,132,253	104 m				14,936,480
Pile Cap TB2	80 x 180 x 80cm	PCR2	1.15 m³	2,449,896	2,822,280	26 m	40 cm	3.27 m³	143,620.00	3,734,120
Pile Cap TB2	80 x 180 x 80cm	PCR2	1.15 m³	2,449,896	2,822,280	26 m	40 cm	3.27 m³	143,620.00	3,734,120
Pile Cap TB2	80 x 180 x 80cm	PCR2	1.15 m³	2,449,896	2,822,280	26 m	40 cm	3.27 m³	143,620.00	3,734,120
Pile Cap TB2	80 x 180 x 80cm	PCR2	1.15 m³	2,449,896	2,822,280	26 m	40 cm	3.27 m³	143,620.00	3,734,120
Pile Cap TB2: 4			4.61 m³		11,289,121	104 m				14,936,480
Pile Cap TB3	170 x 180 x 80cm	PCR3	2.45 m³	2,269,983	5,556,918	39 m	40 cm	4.90 m³	143,620.00	5,601,180
Pile Cap TB3	170 x 180 x 80cm	PCR3	2.45 m³	2,269,983	5,556,918	39 m	40 cm	4.90 m³	143,620.00	5,601,180
Pile Cap TB3	170 x 180 x 80cm	PCR3	2.45 m³	2,269,983	5,556,918	39 m	40 cm	4.90 m³	143,620.00	5,601,180
Pile Cap TB3	170 x 180 x 80cm	PCR3	2.45 m³	2,269,983	5,556,918	39 m	40 cm	4.90 m³	143,620.00	5,601,180
Pile Cap TB3: 4			9.79 m³		22,227,674	156 m				22,404,720
Pile Cap TB4	180 x 180 x 80cm	PCR4	2.59 m³	2,269,983	5,883,796	52 m	40 cm	6.53 m³	143,620.00	7,468,240
Pile Cap TB4	180 x 180 x 80cm	PCR4	2.59 m³	2,269,983	5,883,796	52 m	40 cm	6.53 m³	143,620.00	7,468,240
Pile Cap TB4	180 x 180 x 80cm	PCR4	2.59 m³	2,269,983	5,883,796	52 m	40 cm	6.53 m³	143,620.00	7,468,240
Pile Cap TB4	180 x 180 x 80cm	PCR4	2.59 m³	2,269,983	5,883,796	52 m	40 cm	6.53 m³	143,620.00	7,468,240
Pile Cap TB4: 4			10.37 m³		23,535,184	208 m				29,872,960
Pile Cap TB5	260 x 180 x 100cm	PCR5	4.68 m³	2,449,757	11,464,863	65 m	40 cm	8.16 m³	143,620.00	9,335,300
Pile Cap TB5	260 x 180 x 100cm	PCR5	4.68 m³	2,449,757	11,464,863	65 m	40 cm	8.16 m³	143,620.00	9,335,300
Pile Cap TB5	260 x 180 x 100cm	PCR5	4.68 m³	2,449,757	11,464,863	65 m	40 cm	8.16 m³	143,620.00	9,335,300
Pile Cap TB5	260 x 180 x 100cm	PCR5	4.68 m³	2,449,757	11,464,863	65 m	40 cm	8.16 m³	143,620.00	9,335,300
Pile Cap TB5: 4			18.72 m³		45,859,451	260 m				37,341,200
Grand total: 24			47.58 m³		112,043,682	632 m				119,491,840

Figure 6. Foundation Schedules display

Figure 6 displays the foundation schedule resulting from Autodesk Revit modeling. This schedule contains the item name, volume, size, cost, and total cost.

3.2. Column Structure

1) Column Plan

The columns in the BRI Bank Building project are divided into several types, namely:

- Column K1 55x55 cm
- Column K2 55x55 cm
- Column K3 35x55 cm
- Column K4 40x40 cm

Figure 7 shows the floor plan modeling of the ground floor columns in the BRI Bank Building construction project using Autodesk Revit.

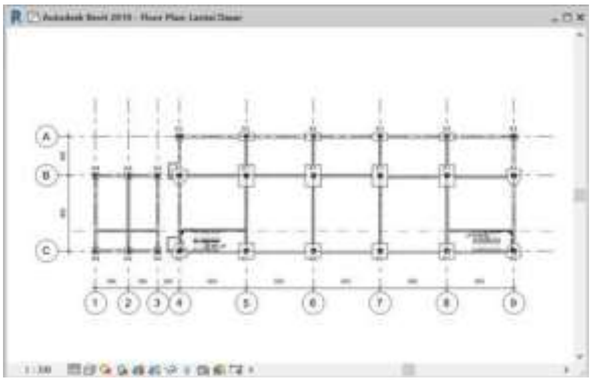


Figure 7. Ground Floor Columns

2) 3D Modeling of Column Structures

Next, 3D modeling of the column structure is carried out according to the points determined on the ground floor column plan.

Figure 8. 3D Modeling of Column Structures

Figure 8 shows the 3D modeling of the column, then the results of the 3D modeling are checked again so that the modeling really matches the planning results made by the consultant.

3) Details of Reinforcement and Column Structure Pieces

Then after the column structure modeling is complete and it is checked whether it complies with the specified dimensions. So, proceed with reinforcement modeling.

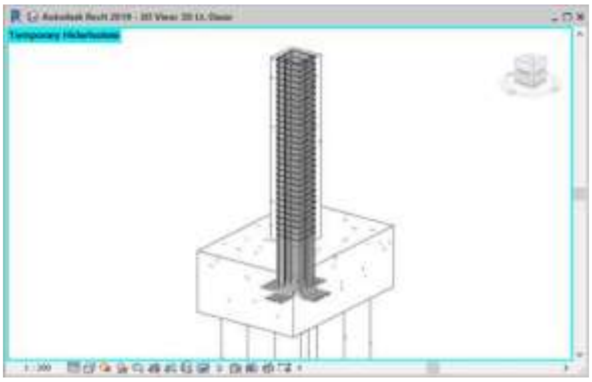


Figure 9. Column Structure Reinforcement Modeling

Figure 9 shows the 3D modeling of column structure reinforcement. Reinforcement must be done according to the planned column types, namely types K1, K2, K3 and K4.

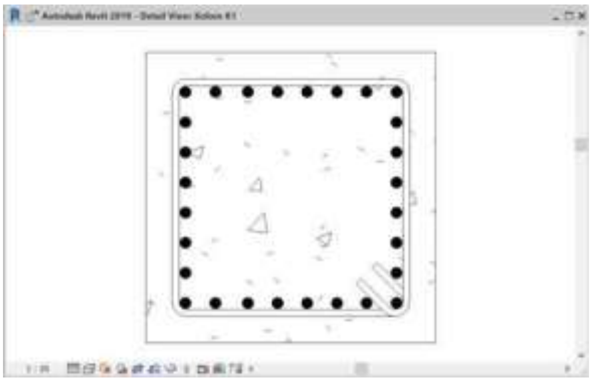
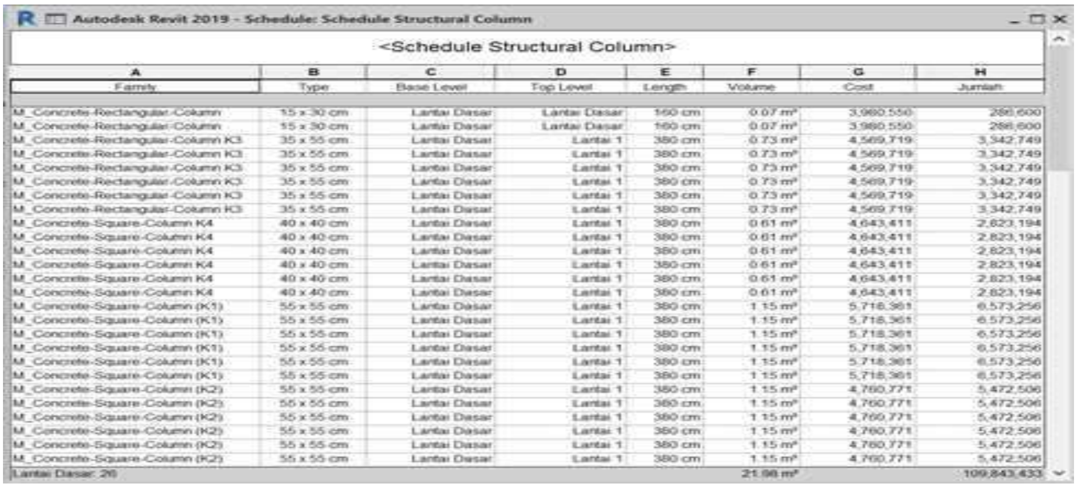


Figure 10. Column Structure Cut

Figure 10 shows the cuts and reinforcement in the column structure.

4) Schedules Column

Schedules on the completed column structure work.



Autodesk Revit 2019 - Schedule: Schedule Structural Column

<Schedule Structural Column>

A	B	C	D	E	F	G	H
Family	Type	Base Level	Top Level	Length	Volume	Cost	Jumlah
M_Concrete-Rectangular-Column	15 x 30 cm	Lantai Dasar	Lantai Dasar	160 cm	0.07 m³	3,980,550	286,600
M_Concrete-Rectangular-Column	15 x 30 cm	Lantai Dasar	Lantai Dasar	160 cm	0.07 m³	3,980,550	286,600
M_Concrete-Rectangular-Column K3	35 x 55 cm	Lantai Dasar	Lantai 1	380 cm	0.73 m³	4,569,719	3,342,749
M_Concrete-Rectangular-Column K3	35 x 55 cm	Lantai Dasar	Lantai 1	380 cm	0.73 m³	4,569,719	3,342,749
M_Concrete-Rectangular-Column K3	35 x 55 cm	Lantai Dasar	Lantai 1	380 cm	0.73 m³	4,569,719	3,342,749
M_Concrete-Rectangular-Column K3	35 x 55 cm	Lantai Dasar	Lantai 1	380 cm	0.73 m³	4,569,719	3,342,749
M_Concrete-Rectangular-Column K3	35 x 55 cm	Lantai Dasar	Lantai 1	380 cm	0.73 m³	4,569,719	3,342,749
M_Concrete-Rectangular-Column K3	35 x 55 cm	Lantai Dasar	Lantai 1	380 cm	0.73 m³	4,569,719	3,342,749
M_Concrete-Square-Column K4	40 x 40 cm	Lantai Dasar	Lantai 1	380 cm	0.61 m³	4,643,411	2,823,194
M_Concrete-Square-Column K4	40 x 40 cm	Lantai Dasar	Lantai 1	380 cm	0.61 m³	4,643,411	2,823,194
M_Concrete-Square-Column K4	40 x 40 cm	Lantai Dasar	Lantai 1	380 cm	0.61 m³	4,643,411	2,823,194
M_Concrete-Square-Column K4	40 x 40 cm	Lantai Dasar	Lantai 1	380 cm	0.61 m³	4,643,411	2,823,194
M_Concrete-Square-Column K4	40 x 40 cm	Lantai Dasar	Lantai 1	380 cm	0.61 m³	4,643,411	2,823,194
M_Concrete-Square-Column K4	40 x 40 cm	Lantai Dasar	Lantai 1	380 cm	0.61 m³	4,643,411	2,823,194
M_Concrete-Square-Column (K1)	55 x 55 cm	Lantai Dasar	Lantai 1	380 cm	1.15 m³	5,718,361	6,573,256
M_Concrete-Square-Column (K1)	55 x 55 cm	Lantai Dasar	Lantai 1	380 cm	1.15 m³	5,718,361	6,573,256
M_Concrete-Square-Column (K1)	55 x 55 cm	Lantai Dasar	Lantai 1	380 cm	1.15 m³	5,718,361	6,573,256
M_Concrete-Square-Column (K1)	55 x 55 cm	Lantai Dasar	Lantai 1	380 cm	1.15 m³	5,718,361	6,573,256
M_Concrete-Square-Column (K1)	55 x 55 cm	Lantai Dasar	Lantai 1	380 cm	1.15 m³	5,718,361	6,573,256
M_Concrete-Square-Column (K1)	55 x 55 cm	Lantai Dasar	Lantai 1	380 cm	1.15 m³	5,718,361	6,573,256
M_Concrete-Square-Column (K2)	55 x 55 cm	Lantai Dasar	Lantai 1	380 cm	1.15 m³	4,760,771	5,472,506
M_Concrete-Square-Column (K2)	55 x 55 cm	Lantai Dasar	Lantai 1	380 cm	1.15 m³	4,760,771	5,472,506
M_Concrete-Square-Column (K2)	55 x 55 cm	Lantai Dasar	Lantai 1	380 cm	1.15 m³	4,760,771	5,472,506
M_Concrete-Square-Column (K2)	55 x 55 cm	Lantai Dasar	Lantai 1	380 cm	1.15 m³	4,760,771	5,472,506
M_Concrete-Square-Column (K2)	55 x 55 cm	Lantai Dasar	Lantai 1	380 cm	1.15 m³	4,760,771	5,472,506
M_Concrete-Square-Column (K2)	55 x 55 cm	Lantai Dasar	Lantai 1	380 cm	1.15 m³	4,760,771	5,472,506
Lantai Dasar: 26					21.98 m³		109,843,433

Figure 11. Column Structure Schedules Display

Figure 11 displays the column structure schedule resulting from Autodesk Revit modeling. This schedule contains the item name, volume, size, cost, and total cost.

3.3. Beam Structure

1) Beam Plan

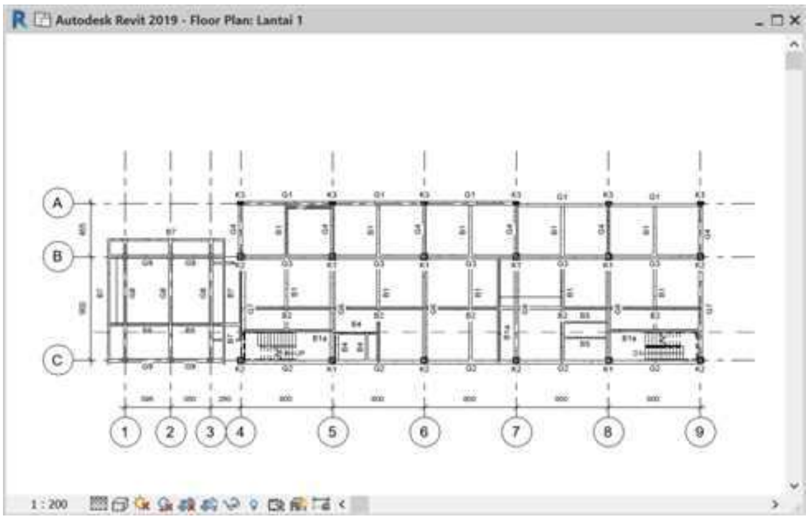


Figure 12. Beam Plan

Figure 12 shows the modeling of the beam structure plan for the BRI Bank Building construction project using Autodesk Revit.

2) 3D Modeling of Beam Structures

Next, 3D modeling of the beam structure is carried out according to the points determined on the structural plan.

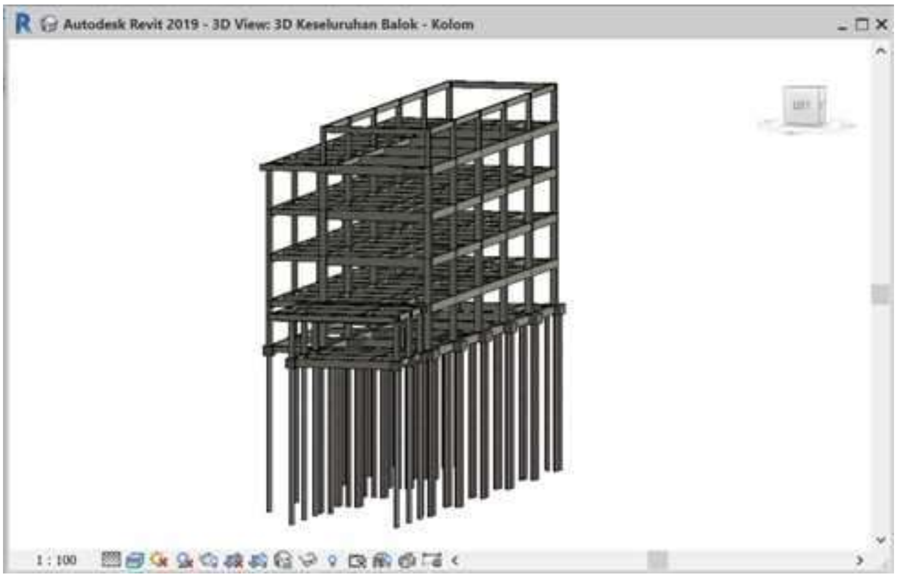


Figure 13. 3D Modeling of Beam Structures

Figure 13 shows the overall beam structure starting from the ground floor to the roof floor.

3) Details of Reinforcement and Cutting of Beam Structures

The following is a detailed view of the reinforcement and cuts in one type of beam.

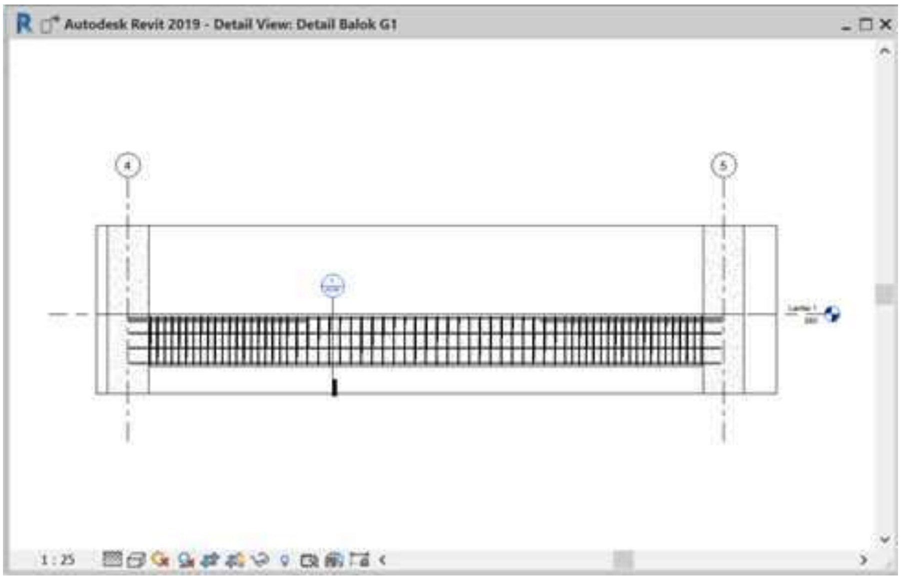
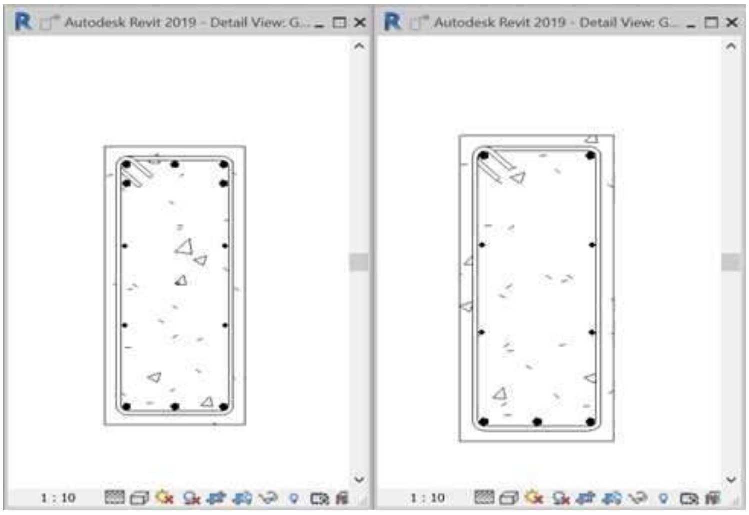


Figure 14. Reinforcement of G1 Beam Structure

Figure 14 modeling of G1 beam structural reinforcement. In the process of modeling reinforcement in beam structures, field reinforcement and support reinforcement must be taken into account. So that there are no mistakes in reinforcing the beam structure.



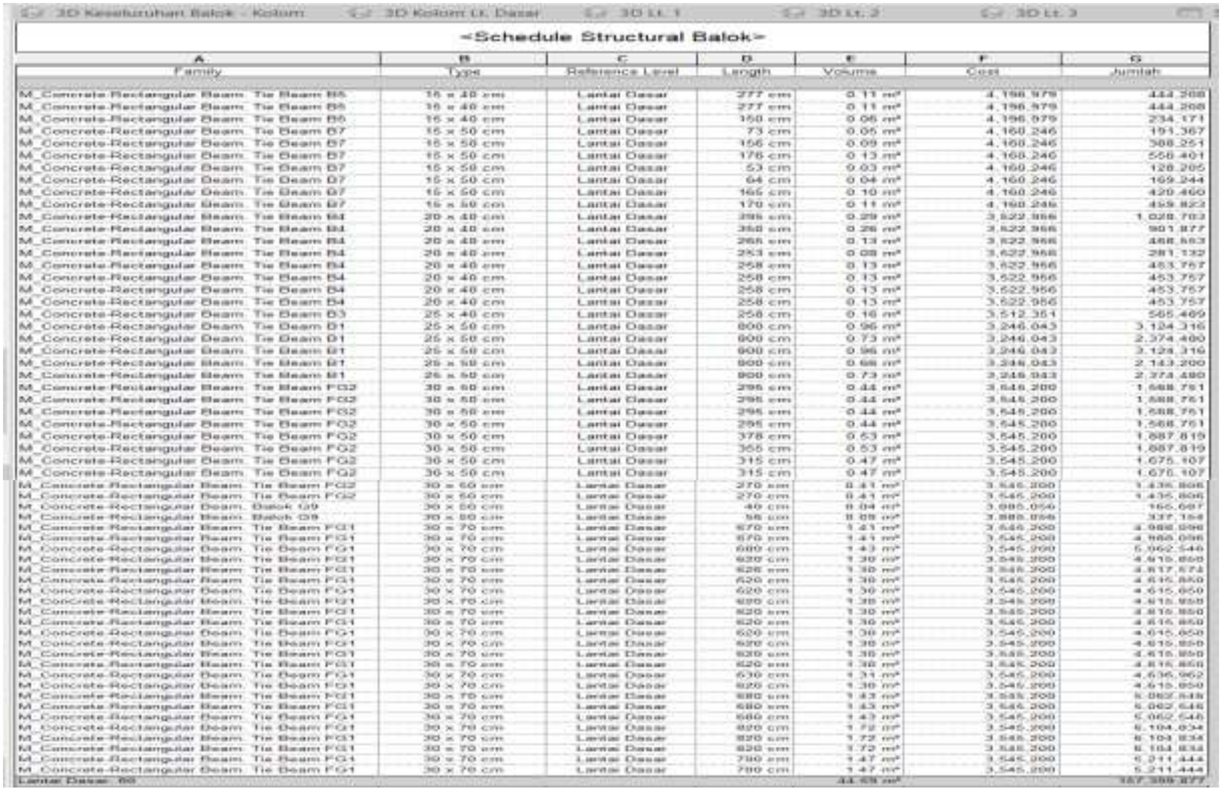
(a) (b)

Figure 15. G1 Beam Structure Section (a) Support Reinforcement (b) Field Reinforcement

Figure 15 shows a section of beam G1 and the reinforcement in the beam.

4) Schedules Beam Structures

Display schedules on the completed beam structure.



<Schedule Structural Balok>

A	B	C	D	E	F	G
Family	Type	Reference Level	Length	Volume	Cost	Jumlah
M_Concrete-Rectangular Beam: Tie Beam B5	15 x 40 cm	Lantai Dasar	277 cm	0.11 m³	4,196,979	444,268
M_Concrete-Rectangular Beam: Tie Beam B5	15 x 40 cm	Lantai Dasar	277 cm	0.11 m³	4,196,979	444,268
M_Concrete-Rectangular Beam: Tie Beam B5	15 x 40 cm	Lantai Dasar	150 cm	0.06 m³	4,196,979	234,171
M_Concrete-Rectangular Beam: Tie Beam B7	15 x 50 cm	Lantai Dasar	73 cm	0.05 m³	4,160,246	191,367
M_Concrete-Rectangular Beam: Tie Beam B7	15 x 50 cm	Lantai Dasar	156 cm	0.09 m³	4,160,246	308,251
M_Concrete-Rectangular Beam: Tie Beam B7	15 x 50 cm	Lantai Dasar	176 cm	0.13 m³	4,160,246	556,401
M_Concrete-Rectangular Beam: Tie Beam B7	15 x 50 cm	Lantai Dasar	53 cm	0.03 m³	4,160,246	128,205
M_Concrete-Rectangular Beam: Tie Beam B7	15 x 50 cm	Lantai Dasar	64 cm	0.04 m³	4,160,246	169,244
M_Concrete-Rectangular Beam: Tie Beam B7	15 x 50 cm	Lantai Dasar	165 cm	0.10 m³	4,160,246	420,460
M_Concrete-Rectangular Beam: Tie Beam B7	15 x 50 cm	Lantai Dasar	170 cm	0.11 m³	4,160,246	459,822
M_Concrete-Rectangular Beam: Tie Beam B4	20 x 40 cm	Lantai Dasar	295 cm	0.29 m³	3,522,956	1,028,703
M_Concrete-Rectangular Beam: Tie Beam B4	20 x 40 cm	Lantai Dasar	350 cm	0.26 m³	3,522,956	901,877
M_Concrete-Rectangular Beam: Tie Beam B4	20 x 40 cm	Lantai Dasar	265 cm	0.13 m³	3,522,956	468,563
M_Concrete-Rectangular Beam: Tie Beam B4	20 x 40 cm	Lantai Dasar	253 cm	0.08 m³	3,522,956	281,132
M_Concrete-Rectangular Beam: Tie Beam B4	20 x 40 cm	Lantai Dasar	258 cm	0.13 m³	3,522,956	453,757
M_Concrete-Rectangular Beam: Tie Beam B4	20 x 40 cm	Lantai Dasar	258 cm	0.13 m³	3,522,956	453,757
M_Concrete-Rectangular Beam: Tie Beam B4	20 x 40 cm	Lantai Dasar	258 cm	0.13 m³	3,522,956	453,757
M_Concrete-Rectangular Beam: Tie Beam B4	20 x 40 cm	Lantai Dasar	258 cm	0.13 m³	3,522,956	453,757
M_Concrete-Rectangular Beam: Tie Beam B3	25 x 40 cm	Lantai Dasar	258 cm	0.16 m³	3,512,351	565,469
M_Concrete-Rectangular Beam: Tie Beam B1	25 x 50 cm	Lantai Dasar	800 cm	0.96 m³	3,246,043	3,124,316
M_Concrete-Rectangular Beam: Tie Beam B1	25 x 50 cm	Lantai Dasar	800 cm	0.73 m³	3,246,043	2,374,480
M_Concrete-Rectangular Beam: Tie Beam B1	25 x 50 cm	Lantai Dasar	800 cm	0.96 m³	3,246,043	3,124,316
M_Concrete-Rectangular Beam: Tie Beam B1	25 x 50 cm	Lantai Dasar	800 cm	0.66 m³	3,246,043	2,143,200
M_Concrete-Rectangular Beam: Tie Beam B1	25 x 50 cm	Lantai Dasar	800 cm	0.73 m³	3,246,043	2,374,480
M_Concrete-Rectangular Beam: Tie Beam FG2	30 x 50 cm	Lantai Dasar	295 cm	0.44 m³	3,545,200	1,568,761
M_Concrete-Rectangular Beam: Tie Beam FG2	30 x 50 cm	Lantai Dasar	295 cm	0.44 m³	3,545,200	1,568,761
M_Concrete-Rectangular Beam: Tie Beam FG2	30 x 50 cm	Lantai Dasar	295 cm	0.44 m³	3,545,200	1,568,761
M_Concrete-Rectangular Beam: Tie Beam FG2	30 x 50 cm	Lantai Dasar	295 cm	0.44 m³	3,545,200	1,568,761
M_Concrete-Rectangular Beam: Tie Beam FG2	30 x 50 cm	Lantai Dasar	378 cm	0.53 m³	3,545,200	1,887,819
M_Concrete-Rectangular Beam: Tie Beam FG2	30 x 50 cm	Lantai Dasar	355 cm	0.53 m³	3,545,200	1,887,819
M_Concrete-Rectangular Beam: Tie Beam FG2	30 x 50 cm	Lantai Dasar	315 cm	0.47 m³	3,545,200	1,675,107
M_Concrete-Rectangular Beam: Tie Beam FG2	30 x 50 cm	Lantai Dasar	315 cm	0.47 m³	3,545,200	1,675,107
M_Concrete-Rectangular Beam: Tie Beam FG2	30 x 50 cm	Lantai Dasar	270 cm	0.41 m³	3,545,200	1,435,806
M_Concrete-Rectangular Beam: Tie Beam FG2	30 x 50 cm	Lantai Dasar	270 cm	0.41 m³	3,545,200	1,435,806
M_Concrete-Rectangular Beam: Balok G9	30 x 50 cm	Lantai Dasar	40 cm	0.04 m³	3,885,056	165,687
M_Concrete-Rectangular Beam: Balok G9	30 x 50 cm	Lantai Dasar	56 cm	0.09 m³	3,885,056	337,164
M_Concrete-Rectangular Beam: Tie Beam FG1	30 x 70 cm	Lantai Dasar	670 cm	1.41 m³	3,545,200	4,988,096
M_Concrete-Rectangular Beam: Tie Beam FG1	30 x 70 cm	Lantai Dasar	670 cm	1.41 m³	3,545,200	4,988,096
M_Concrete-Rectangular Beam: Tie Beam FG1	30 x 70 cm	Lantai Dasar	680 cm	1.43 m³	3,545,200	5,062,546
M_Concrete-Rectangular Beam: Tie Beam FG1	30 x 70 cm	Lantai Dasar	620 cm	1.30 m³	3,545,200	4,615,650
M_Concrete-Rectangular Beam: Tie Beam FG1	30 x 70 cm	Lantai Dasar	626 cm	1.30 m³	3,545,200	4,617,574
M_Concrete-Rectangular Beam: Tie Beam FG1	30 x 70 cm	Lantai Dasar	620 cm	1.30 m³	3,545,200	4,615,650
M_Concrete-Rectangular Beam: Tie Beam FG1	30 x 70 cm	Lantai Dasar	620 cm	1.30 m³	3,545,200	4,615,650
M_Concrete-Rectangular Beam: Tie Beam FG1	30 x 70 cm	Lantai Dasar	620 cm	1.30 m³	3,545,200	4,615,650
M_Concrete-Rectangular Beam: Tie Beam FG1	30 x 70 cm	Lantai Dasar	620 cm	1.30 m³	3,545,200	4,615,650
M_Concrete-Rectangular Beam: Tie Beam FG1	30 x 70 cm	Lantai Dasar	620 cm	1.30 m³	3,545,200	4,615,650
M_Concrete-Rectangular Beam: Tie Beam FG1	30 x 70 cm	Lantai Dasar	620 cm	1.30 m³	3,545,200	4,615,650
M_Concrete-Rectangular Beam: Tie Beam FG1	30 x 70 cm	Lantai Dasar	620 cm	1.30 m³	3,545,200	4,615,650
M_Concrete-Rectangular Beam: Tie Beam FG1	30 x 70 cm	Lantai Dasar	620 cm	1.30 m³	3,545,200	4,615,650
M_Concrete-Rectangular Beam: Tie Beam FG1	30 x 70 cm	Lantai Dasar	630 cm	1.31 m³	3,545,200	4,636,962
M_Concrete-Rectangular Beam: Tie Beam FG1	30 x 70 cm	Lantai Dasar	620 cm	1.30 m³	3,545,200	4,615,650
M_Concrete-Rectangular Beam: Tie Beam FG1	30 x 70 cm	Lantai Dasar	680 cm	1.43 m³	3,545,200	5,062,546
M_Concrete-Rectangular Beam: Tie Beam FG1	30 x 70 cm	Lantai Dasar	680 cm	1.43 m³	3,545,200	5,062,546
M_Concrete-Rectangular Beam: Tie Beam FG1	30 x 70 cm	Lantai Dasar	680 cm	1.43 m³	3,545,200	5,062,546
M_Concrete-Rectangular Beam: Tie Beam FG1	30 x 70 cm	Lantai Dasar	820 cm	1.72 m³	3,545,200	6,104,834
M_Concrete-Rectangular Beam: Tie Beam FG1	30 x 70 cm	Lantai Dasar	820 cm	1.72 m³	3,545,200	6,104,834
M_Concrete-Rectangular Beam: Tie Beam FG1	30 x 70 cm	Lantai Dasar	820 cm	1.72 m³	3,545,200	6,104,834
M_Concrete-Rectangular Beam: Tie Beam FG1	30 x 70 cm	Lantai Dasar	780 cm	1.47 m³	3,545,200	5,211,444
M_Concrete-Rectangular Beam: Tie Beam FG1	30 x 70 cm	Lantai Dasar	780 cm	1.47 m³	3,545,200	5,211,444
Lantai Dasar: 60				44.69 m³		157,399,877

Figure 16. Beam Structure Schedules Display

Figure 16 displays the beam structure schedule resulting from Autodesk Revit modeling. This schedule contains the item name, volume, size, cost, and total cost.

3.4. Floor Plate Structure

1) Floor Plate Plan

The floor plate structure itself has a thickness of 12 cm.

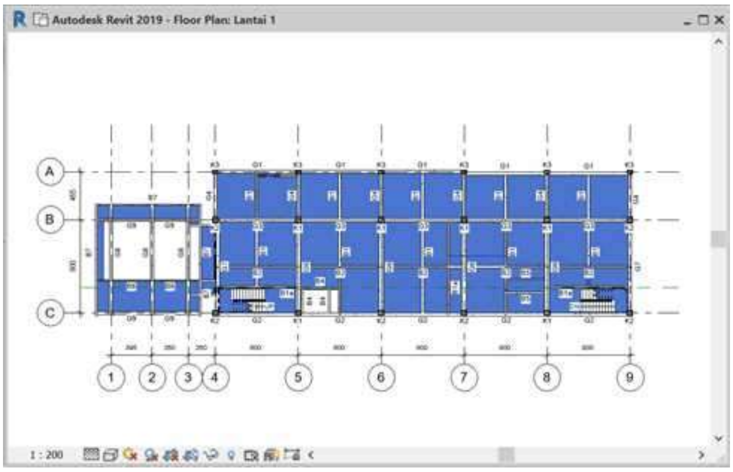


Figure 17. Floor Plate Plan

Figure 17 shows the modeling of the floor plate structure plan for the BRI Bank Building construction project using Autodesk Revit.

2) 3D Modeling of Floor Plate Structures

Next, 3D modeling of the floor plate structure is carried out according to the points determined on the structural plan.

Figure 18. 3D Modeling of Floor Plate Structures

Figure 18 shows the 3D modeling of the floor plate structure, then the 3D modeling results are checked again so that the modeling really matches the planning results made by the consultant.

3) Floor Plate Reinforcement Details

The reinforcement in this floor plate is in accordance with the planned reinforcement.

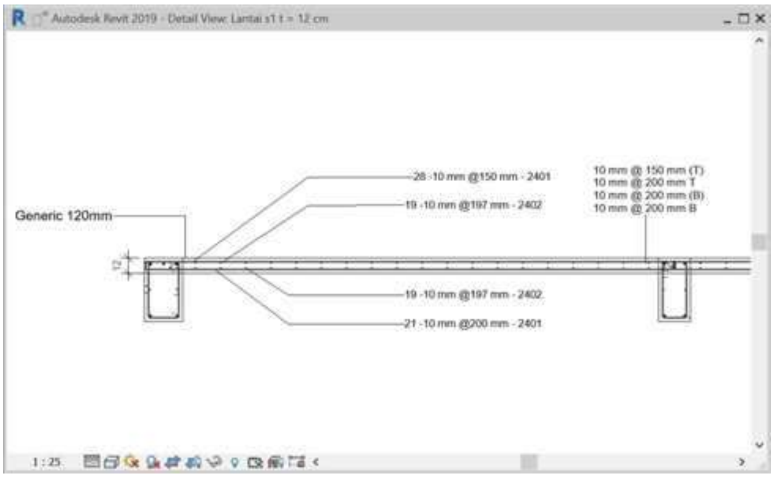


Figure 19. Reinforcement of Floor Plate Structures

Figure 19 modeling of the floor plate structure. The process of modeling reinforcement in beam structures must pay attention to dimensions because this will have an impact on the costs incurred.

4) *Schedules* Floor Plate Structure

Display schedules on the finished floor plate and modeled via Autodesk Revit.

3D Keseluruhan Balok - Kolom | 3D Kolom Lt. Dasar | 3D Lt. 1 | 3D Lt. 2 | 3D Lt. 3 | Sch

<Schedule Floor>

A	B	C	D	E	F	G	H
Family and Type	Level	Area	Function	Structural Material	Volume	Cost	Jumlah
Floor: Generic 120mm	Lantai Dasar	538 m²	Interior	K250	64.53 m³	4,006,572	258,551,687
Lantai Dasar: 1					64.53 m³		258,551,687
Floor: Generic 120mm	Lantai 1	472 m²	Interior	K250	56.65 m³	4,006,572	226,988,430
Floor: Generic 200mm	Lantai 1	25 m²	Interior	K250	5.09 m³	4,591,346	23,346,994
Lantai 1: 2					61.74 m³		250,335,425
Floor: Generic 120mm	Lantai 2	425 m²	Interior	K250	50.98 m³	4,006,572	204,254,796
Floor: Generic 200mm	Lantai 2	25 m²	Interior	K250	5.09 m³	4,591,346	23,346,994
Lantai 2: 2					56.06 m³		227,601,791
Floor: Generic 120mm	Lantai 3	451 m²	Interior	K250	54.16 m³	4,006,572	217,008,917
Lantai 3: 1					54.16 m³		217,008,917
Floor: Generic 120mm	Dak Atap	221 m²	Interior	K250	26.50 m³	4,006,572	106,177,964
Dak Atap: 1					26.50 m³		106,177,964
Grand total: 7					263.00 m³		1,059,675,783

Figure 20. Display Schedules for Floor Plate Structure

Figure 20 displays the plate structure schedules resulting from Autodesk Revit modeling. This schedule contains the item name, volume, size, cost, and total cost.

3.5. Stair Structure

1) Stair Structure Plan

Stair structure modeling in Autodesk Revit, stairs are not included in the structural tools but are included in the architectural tools.

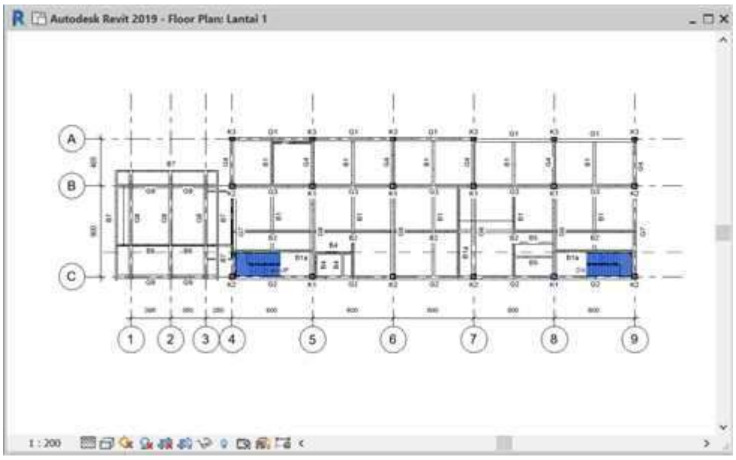


Figure 21. Stair Structure Plan

Figure 21 shows the modeling of the stair structure plan for the BRI Bank Building construction project using Autodesk Revit.

2) 3D Modeling of Stair Structures

Next, 3D modeling of the stair structure is carried out according to the points determined on the structural plan.

Figure 22. 3D Modeling of Stair Structures

Figure 22 shows the 3D modeling of the stair structure, then the results of the 3D modeling are checked again so that the modeling really matches the results of the plans made by the consultant.

3) Reinforcement of Stair Structures

The process of reinforcing the stair structure must be made yourself because there are some reinforcements that are not provided in the Autodesk Revit libraries. Therefore, the modeling of the stair structure must be depicted directly.

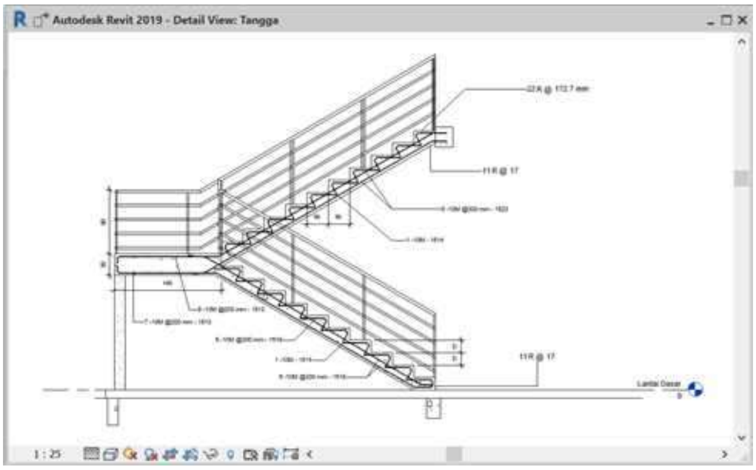


Figure 23. Reinforcement of Stair Structures

Figure 23 shows the 3D modeling of the stair structure reinforcement, then the 3D modeling was checked again so that the modeling really complies with the planning results made by the consultant.

4) *Schedules* Stair Structure

Following are the results of the completed staircase structure modeling which are then displayed in the form of schedules in Autodesk Revit.

3D Kolom Lt. Dasar | 3D Lt. 1 | 3D Lt. 2 | 3D Lt. 3 | Schedule Structural Column | Schedule Structural Balok | Schedule Floor | Stair Sc

<Stair Schedule>

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Family	Base Level	Top Level	Total Anak Tangga	T. Anak Tangga	L. Anak Tangga	L. Tangga	P. Bordes	L. Bordes	Tebal Bordes	Vol. Bordes	Vol. Plat Tangga	Vol. Anak Tangga	Volume Total	Cost	Jumlah Harga
Cast-In-Place Stair	Lantai Dasar	Lantai 1	22	17.3 cm	30 cm	115 cm	150 cm	240 cm	30 cm	1.08 m^3	0.62 m^3	0.66 m^3	2.36 m^3	4,538,403	10,699,444
Cast-In-Place Stair	Lantai Dasar	Lantai 1	22	17.3 cm	30 cm	115 cm	150 cm	240 cm	30 cm	1.08 m^3	0.62 m^3	0.66 m^3	2.36 m^3	4,538,403	10,699,444
Lantai Dasar: 2													4.72 m^3		21,398,888
Cast-In-Place Stair	Lantai 1	Lantai 2	22	17.3 cm	30 cm	115 cm	150 cm	240 cm	30 cm	1.08 m^3	0.62 m^3	0.66 m^3	2.36 m^3	4,538,403	10,699,444
Cast-In-Place Stair	Lantai 1	Lantai 2	22	17.3 cm	30 cm	115 cm	150 cm	240 cm	30 cm	1.08 m^3	0.62 m^3	0.66 m^3	2.36 m^3	4,538,403	10,699,444
Lantai 1: 2													4.72 m^3		21,398,888
Cast-In-Place Stair	Lantai 2	Lantai 3	22	17.3 cm	30 cm	115 cm	150 cm	240 cm	30 cm	1.08 m^3	0.62 m^3	0.66 m^3	2.36 m^3	4,538,403	10,699,444
Cast-In-Place Stair	Lantai 2	Lantai 3	22	17.3 cm	30 cm	115 cm	150 cm	240 cm	30 cm	1.08 m^3	0.62 m^3	0.66 m^3	2.36 m^3	4,538,403	10,699,444
Lantai 2: 2													4.72 m^3		21,398,888
Cast-In-Place Stair	Lantai 3	Dak Atap	22	17.3 cm	30 cm	115 cm	150 cm	240 cm	30 cm	1.08 m^3	0.62 m^3	0.66 m^3	2.36 m^3	4,538,403	10,699,444
Lantai 3: 1													2.36 m^3		10,699,444
Grand total: 7													16.50 m^3		74,896,107

Figure 24. Stair Structure Schedules Display

Figure 24 displays the ladder structure schedule resulting from Autodesk Revit modeling. This schedule contains the item name, volume, size, cost, and total cost.

3.6. Whole Structure Modeling

The following is the modeling of the entire structure that has been completed using Autodesk Revit.

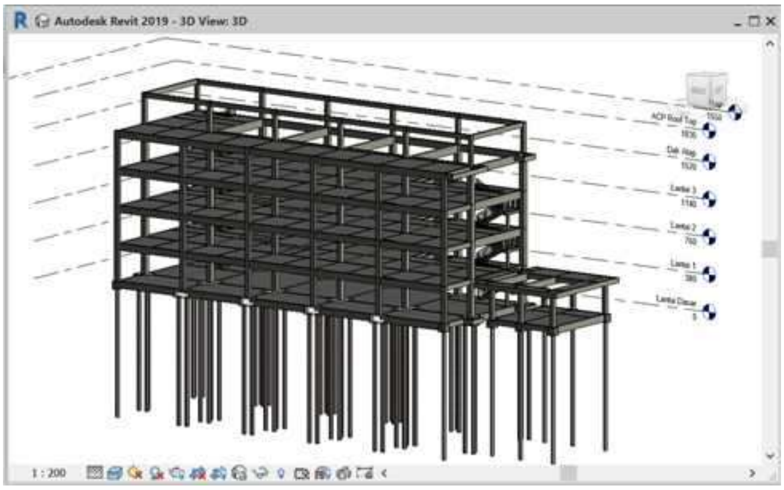


Figure 25. 3D Modeling of Entire Structure

Figure 25 shows the 3D modeling the entire structure that has been completed is carried out via Autodesk Revit, then the completed 3D modeling is checked again so that the modeling really matches the planning results made by the consultant.

3.7. Cost and Volume Budget Using Autodesk Revit

The following are the results of evaluating budget plan calculations for structural work by calculating volume and costs, as can be seen in Table. 1 and Table. 2 below.

Table 1. Volume Structure Using Autodesk Revit

Structure	Volume (m^3)	
	Revit	**BoQ Consultant**
Bore Pile	832 m	832 m
Pile Cap	47.58	46.14
Column	82.93	87.02
Beam	300.30	345.44
Platform	263.00	295.45
Ladder	16.50	18.06

Table 1 shows the differences in structural volume calculations using *Autodesk Revit* smaller, namely 16.50 m3 when compared to the consultant's calculation, namely 18.06 m^3. *Autodesk Revit* has advantages in the volume calculation process, namely a very short time and faster than conventional. Because when modeling is created, the volume of the modeling will automatically be calculated. If there is a change in size or dimensions in the modeling, then you only need to change the elements according to the changes, then the volume will automatically change.

Table 2. Budget Cost Structure Using Autodesk Revit

Structure	Cost Budget (Rp)	
	Revit	**Consultant**
Bore Pile	119,491,840	119,491,840
Pile Cap	112,043,682	108.774.911
Column	416,682,155	437,705,937
Beam	1,193,817,594	1,351,732,370
Platform	1,059,675,783	1,190,805,539
Ladder	74,896,107	81,963,560
Grand Total	2,976,607,161	3,290,474,157

Table 2 shows that the cost budget plan calculation occurred in optimization due to differences due to differences in structural volume calculations using Autodesk Revit, which is equal to Rp. 2,976,607,161,- while the total costs previously calculated by the planning consultant using conventional methods were Rp. 3,280,583,049,-.

Using Autodesk Revit can also minimize the occurrence of errors due to data input errors. However, Autodesk Revit also has weaknesses that need to be considered, such as the ability to use the application when modeling and requiring qualified technological devices. At the time of modeling, you also have to really pay attention, that is, the model must really match the plans that have been made previously so that there are no differences in terms of structure, dimensions and volume.

4. CONCLUSION

Based on the results of the cost budget plan comparative analysis for the structural work for the construction of the BRI Bank Building on Jl. Sisingamangaraja No. 241 Gg. Indrajid Kel. Sudirejo-II District. Medan City, it can be concluded that the RAB calculation using Autodesk Revit results in a total cost of Rp. 2,976,607,161,- while the total costs previously calculated by the planning consultant using conventional methods were Rp. 3,280,583,049,- Evaluation carried out using Autodesk Revit can optimize costs that are 9.27% smaller than the total costs calculated conventionally.

5. ACKNOWLEDGMENTS

On this occasion, we would like to thank BRI and planning consultants for the opportunity to access this research data.

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