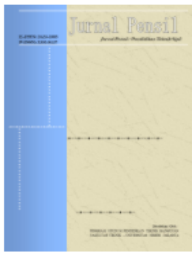
Available *online* at: http://journal.unj.ac.id

Jurnal Pensil | Pendidikan Teknik Sipil

Journal homepage: http://journal.unj.ac.id/unj/index.php/jpensil/index



ANALYSIS OF THE CALCULATION OF REBAR BEAM STRUCTURE OF FLOOR 6 ZONE 1 INDIGO BANDUNG HOTEL PROJECT USING BUILDING INFORMATION MODELING (BIM)

Parmono[1], Ira Nurainí[2], Nandan Supriatna[3], Dedy Suryadi[4]*

[1,2,3,4] Pendidikan Teknik Bangunan, Fakultas Pendidikan Teknologi dan Kejuruan, Universitas Pendidikan Indonesia

Jalan Dr. Setiabudi No. 229, Bandung, Jawa Barat, 40154, Indonesia

[*1]parmono97@upi.edu [2]iranrn@upi.edu [3]nandan@upi.edu [4]dedy.suryadi@upi.edu

P-ISSN: 2301-8437
E-ISSN: 2623-1085

ARTICLE HISTORY

Accepted:
17 Maret 2023
Revision:
29 Mei 2023
Published:
30 Mei 2023

ARTICLE DOI:
10.21009/jpensil.v12i2.34645

Abstract

This study aims to find out the results of calculating the requirements for rebar beam structures in the Hotel Indigo Bandung Development Project using the Building Information Modeling (BIM) method with the help of Autodesk Revit 2020 software, to be further studied against conventional methods. The type of research used in writing the review is quantitative research. The methods used in collecting data in this study are observation, interviews, and documentation studies. Data collection is used to find the truth and accuracy of the data obtained carefully and accurately so that the truth can be accounted for. The results showed that the total calculation of rebar requirements using the conventional method weighed 18843.211 kg, the total calculation of rebar requirements using the Building Information Modeling method with the help of Autodesk Revit 2020 software was 18272.58 kg, there was a difference of 570.628 kg or a difference of 3%.

Keywords: Beam Structure, Building Information Modeling, BIM, Autodesk Revit 2020

Introduction

The majority of practitioners in the field of construction are generally familiar with Computer Aided Design (CAD) (Marizan, 2019), The role of Computer Aided Design (CAD) which has long been known for its role in replacing manual drawing concepts (drawing table, rapido , tracing paper, lightdruk) in the field of building construction (Architecture, Structure and Mechanical Electrical Plumbing (MEP), it seems that the CAD drawing paradigm, in the future, will be replaced with the BIM concept paradigm (Marizan, 2019), this paradigm shift is not without cause, given the advantages BIM is compared to CAD, in terms of facilities and efficiency (Muhsin et al., 2021), along with rapid technological developments impacting the field of construction modeling which eventually replaced CAD with construction BIM (Anggaraini et al., 2022; Yuvita & Budiwirawan, 2022).

The history of research related to BIM was discovered in 2013, which discussed the implementation of BIM in several Indonesian construction projects, in this study it was stated that 2012 was the year the first discovery of the use of BIM in Indonesian construction projects. The concept of BIM has actually existed since the 1970s, but the term BIM first appeared in a paper by GA van Nederveen and FP Tolman (Bhanu Rizfa Hakim et al., 2021; John et al., 2015). Apart from the history of use above, according to Fundra in (Adhitama et al., 2020), states that Indonesian construction has not optimally used the BIM concept, due to the limited capabilities of Human Resources (HR). The concept of BIM in Indonesia has not been fully maximized, sometimes the use of BIM is still partial, such as responding to labor needs and costs, this is still far away when compared to other countries (Apriani et al., 2022; Fakhruddin et al., 2019).

From research (Apriani et al., 2022), states that in the city of Palangkaraya the majority of contractors are confused in implementing BIM, this is conveyed by contractors who do not understand the concept of BIM. In addition to the HR factor which is an obstacle related to the use of the BIM concept, there are other obstacles, including the high cost of software and the lack of motivation for company leaders to change the work concept that has been carried out in their company (Fitriani et al., 2021; Prasetyono & Dani, 2022). The limitations of BIM experts who are used to using BIM in their workflow, have not optimally shared or trained equally for all levels of construction (Purnomo et al., 2022). In line with obstacles such as the need for BIM human resources, several academics and practitioners are currently making various efforts to educate small contractors (Hatmoko et al., 2020). The Ministry of Public Works and Public Housing is an authority with a strong interest in accelerating infrastructure development. Several PUPR efforts in accelerating this development are by socializing the use and application of BIM for adoption in the curriculum at the SMK level, as a competency (Ramadhan & Maulana, 2020). This is very much in line with the 2016 SMK spectrum, the Building Engineering Drawing (TGB) expertise competency which changed to Building Modeling and Information Design (DPIB) (Ramadhan & Maulana, 2020). The use of Autodesk Revit software as a BIM application for volume calculations is still rarely used in the Indonesian construction world, they still use manual calculations with the help of Excel (Hussin et al., 2013; Reista & Ilham, 2022). Calculation of Unit Price Analysis (AHS) for concrete volume work requires calculation of the volume of rebar in mass units of reinforcement weight, volume of concrete mix in cubic units, and formwork molds in units of square area. Along with the development of the times, the construction of high-rise buildings is increasing, in addition to the general requirements that are used as a reference in the construction of a high-rise building (sturdy but still economical), other requirements certainly demand that planning documents be more thorough, accurate, informative and fast in planning.

The principle of every building construction plan is that the structure can withstand the loads of the building. The structural components themselves are divided into two, namely the lower structure (foundation) and the upper structure (columns, beams, slabs and roof trusses). Each of these structural elements has a different function and structural behavior. The review of the structural elements in this study is regarding the upper structure, namely the beam structure (structural beams and reinforced concrete joists). From the load received by the structure of the beam, it will produce an internal force (latitudinal, moment, normal or torsion). It is from this internal force that the combination of reinforcement that must be used is obtained, for example the diameter of the reinforcement and its number.

Human Resources is an important element in supporting technological progress and survival, both in the world of business and industry. The rapid development of the construction industry is due to the fact that construction is an important part of the country's development. Construction service providers will be required to work more effectively and efficiently due to the rapid development of construction. In the world of construction, the calculation of the need for rebar work is a very important part because if an error occurs in the calculation of the need for rebar, it will cause huge losses.

The BIM is a digital system that uses software assistance to do 3D modeling. The effectiveness and efficiency of building modeling with BIM can be achieved considering that all information can be represented in one integrated file (Khairi et al., 2022; Pendidikan et al., 2020). With the BIM method, construction implementation is more transparent and integrated with each other more quickly and easily, facilitating coordination between architectural, civil and MEP disciplines, as well as helping the owner in making decisions, other things in the accuracy of RAB calculations and project scheduling can be implemented (Adistana et al., 2022; Sangadji et al., 2019).

Regulations related to BIM in the world of Indonesian construction are regulated in the Regulation of the Minister of PUPR Number 22/PRT/M/2018 concerning Guidelines for the Development of State Buildings which reads "The use of BIM (Building Information Modeling) must be applied to Non-Simple State Buildings with the following criteria: area above 2000 m2 and above 2 floors" (Kementrian PUPR, 2018). The use of software that is integrated with BIM will provide convenience at the design stage and reduce errors. The modeling design process is made with the BIM concept, then the volume quantity of each structural element will be directly obtained (Saputra et al., 2022), automated due to the concept of BIM model depiction (Noviani et al., 2021) stated that in his research it increased the efficiency of volume calculations by 57%, using Revit was able to increase efficiency by up to two times or 50% (Anjani et al., 2022; Dwiarti et al., n.d.), Autodesk Revit is a BIM concept that can perform quantity take-off calculations and is very suitable for use because of its 3D nature (Witjaksana, 2022). This is reinforced by the opinion (Ferial et al., 2022) which states that, unlike volume calculations that are done manually, inaccuracies are still found due to human error, either misreading dimensions or inputting data. Calculating the quantity take-off manually if there is a design change will be long and complicated to complete, besides that the use of conventional concepts positions the design working drawings separately, because they are usually 2D"(Hendra et al., 2022; Murtinugraha, 2017). In calculating rebar according to the BIM concept has a better level of accuracy than the manual concept.

Support continues to come for Autodesk Revit, with the emergence of plug-in applications (Revit additional applications) to help analyze other construction needs (Enda & Destriyana, 2022). In several studies, the RAB results were not different from manual calculations or BIM, as in research (Farhana & Abma, 2022) the difference between manual calculations and BIM concept calculations was a difference of

7%. BIM can save planning time which has an impact on cost efficiency, because it can synergize communication between various disciplines (Novita & Pangestuti, 2021). In research (Johartiming et al., 2021; Nicholas et al., 2012), there were nine construction companies in Surabaya, stating that BIM is very helpful in visualization and 3D modeling. Modeling that uses the BIM concept from the start can immediately detect errors (Saputra et al., 2022), so that this can help draw decisions from related parties from the planning side. Research (Noviani et al., 2021)stated that of the 37 research samples, both contractors and consultants stated that the use of BIM 5D (Volume) contributed to minimizing construction claims. Delays in drawing shop drawings in several construction projects usually account for 22%.

Research related to BIM, in fact, is developing considering the complexity that arises in the BIM concept itself, as in research (Nugroho et al., 2022) in his research BIM can be used for the purposes of the pre-construction, construction and post-construction stages related to building fire safety -building construction. BIM is one of the technologies in the field of AEC (Architecture, Engineering and Construction) that can model a 3D representation of a building which contains information on building elements and these elements are collaborative in digital media (Albab & Erizal, 2021). BIM wants to change the conventional paradigm which is felt to be inefficient due to lack of integration into a collaborative concept (Nugrahini & Permana, 2020), and not only in one scientific discipline, but the integration of architecture, civil and MEP (Purnomo et al., 2022). The emergence of the BIM concept requires industry 4.0 players in the construction sector to be more competitive (Putera, 2022).

BIM Software in this study used Autodesk Revit 2020, which can produce quantity take offs and perform needs calculations or RAB calculations (Laorent et al., 2019). Therefore, in the case studies reviewed in calculating the need for rebar, conventional methods and BIM were used with the help of Autodesk Revit 2020 software. The use of Revit software in applying the BIM concept in this study was based on its level of popularity. The Revit software, its popularity level from 2008 cannot be surpassed by other software (Ikhwanuddin et al., 2018; Iphonk, 2022). Based on the statements that have been put forward, the researchers are interested in conducting a study entitled "Analysis of Calculation of Rebar Needs for Floor 6 Beam Structures Zone 1 Hotel Indigo Bandung Project using BIM".

Research Methodology

This research took place at the Indigo Bandung Dago Pakar Hotel Development Project which is located at Jl. Raya Resort No. 16, Ciburial, Cimenyan District, Bandung Regency, West Java 40198. Then, data collection techniques are used to find the truth and accuracy of the data obtained carefully and accurately so that the truth can be accounted for. Data collection techniques used in this study are observation, interview, and documentation studies. The stages of the research are as follows:

1) Literature study is the basic guideline taken to analyze this research. Literature study covers all matters related to BIM-based building modeling.
2) The data collected is in the form of Detailed Engineering Drawing (DED) which is an estimate of the planned rebar requirements for beam structures using conventional methods. Then, the data that has been collected is used as a comparison with the results of calculating the need for steel beam structures using Autodesk Revit 2020 BIM which is assisted in its processing by Microsoft Excel software.
3) At this stage, the data input that has been obtained from the project is carried out, because the data obtained from the project is only DED (2D) with conventional methods. Therefore, the data obtained from the project is imported from 2D Autocad drawing data to Revit 2020. Then it is redrawn.

The following are the steps for calculating rebar requirements using Autodesk Revit 2020:

1) Make beams, toolbar "Structure" with the option "Beam"

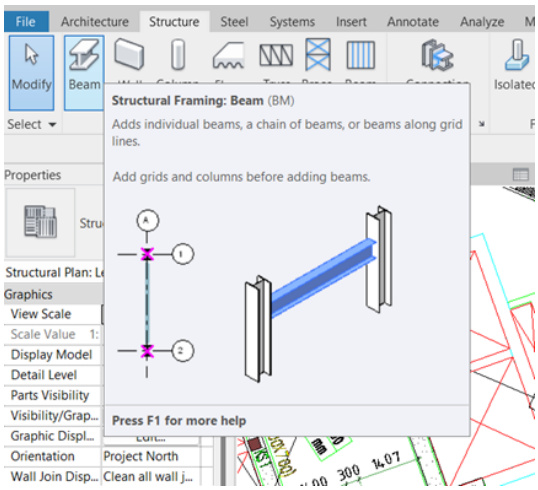


Figure 1. Making beam in Autodesk Revit 2020

2) Selection of beam dimensions to be used

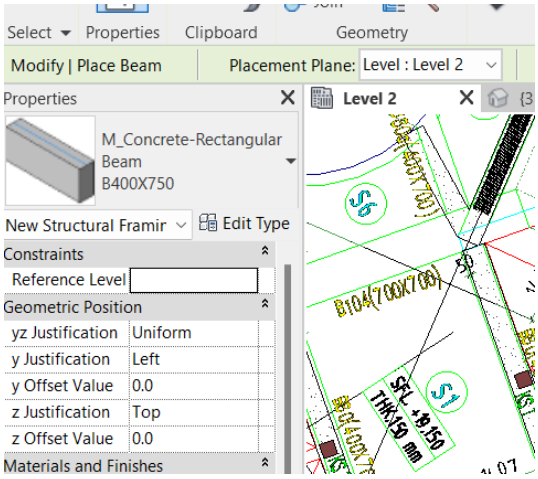


Figure 2. Selection of beam dimensions to be used

3) The process of drawing the reinforcement according to the details of the reinforcement in the DED drawings. With the help of the "Naviate Rex" plugin

Figure 3. Manufacture of steel reinforcement

4) Enter main reinforcement combination data according to DED

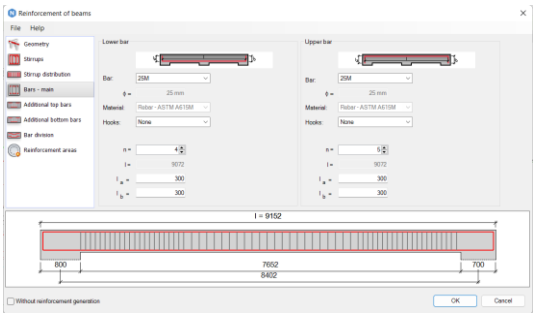


Figure 4. Main rebar data entry

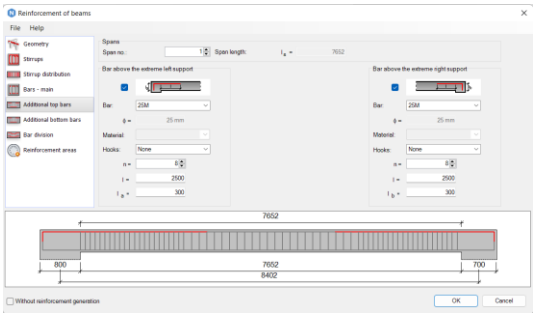


Figure 5. Top main rebar data entry

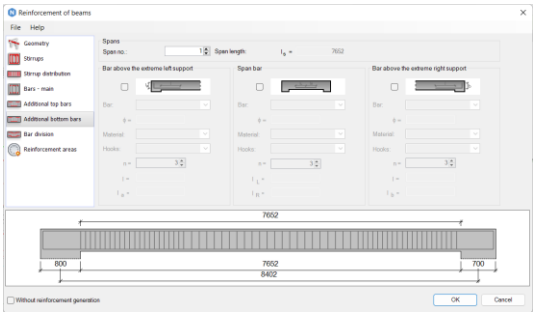


Figure 6. Bottom main rebar data entry

5) Also enter the stirrup reinforcement data and tie reinforcement according to what

is stated in the details of the beam reinforcement

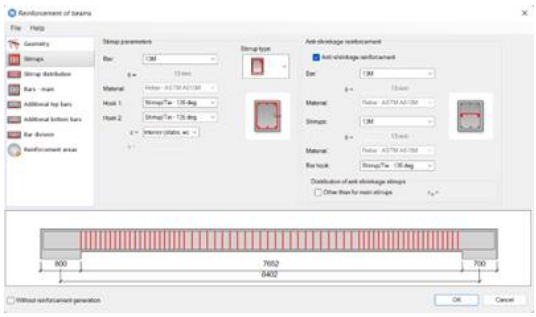


Figure 7. Data entry of stirrup and ties rebar

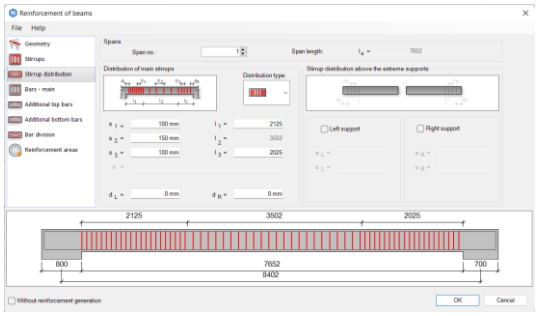


Figure 8. Data entry distance stirrups

6) Then, to check or compare the rebar requirement data from the Autodesk Revit 2020 BIM calculation results with the calculation results of conventional methods by making "Schedule/Quantities" blocks.

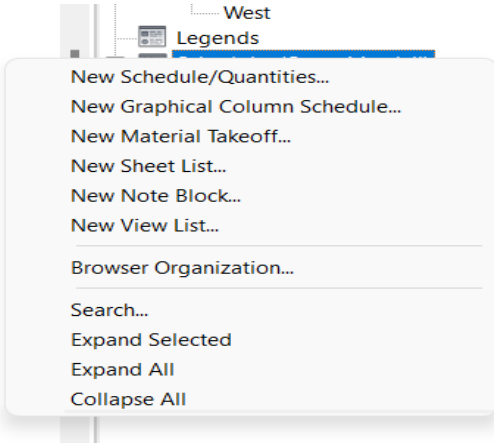


Figure 9. Preparing of schedule/quantities

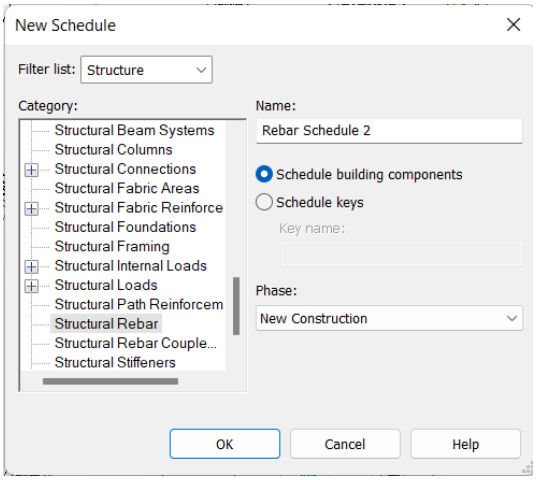


Figure 10. Making schedule rebar

7) Selection of schedule Quantities display "Fields", (Host Mark, Bar Diameter, Bar Length, Total Bar Length, Reinforcement Needs and Weight)

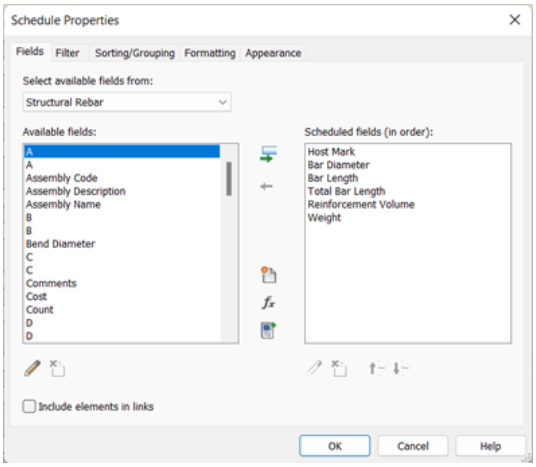


Figure 11. Selection fields (the data will show in rebar schedule)

8) Rebar Schedule displat results as below

<Rebar Schedule>

B	C	D	E	F
Bar Diameter	Bar Length	Total Bar Length	Reinforcement Volume	Weight
10 mm	5728 mm	39580 mm	2805.52 cm³	22.023 kg
	5728 mm	39580 mm	2805.52 cm³	22.023 kg
19 mm	21928 mm	21900 mm	6274.81 cm³	49.257 kg
	21928 mm	21900 mm	6274.81 cm³	49.257 kg
	27657 mm	61480 mm	9080.33 cm³	71.281 kg
10 mm	20610 mm	217730 mm	15433.18 cm³	121.150 kg
	20610 mm	217730 mm	15433.18 cm³	121.150 kg
25 mm	147819 mm	147770 mm	74876.16 cm³	587.778 kg

Figure 12. Rebar schedule calculation results on Autodesk Revit 2020

Research Results and Discussion

From several previous studies, such as research conducted by Ferial et al., (2022), his research described a level of difference between manual concepts and Revit of 9%. The percentage of this difference, according to researchers, can be viewed from several aspects of accuracy, both in terms of the accuracy of the concept of manual calculations and the concept of calculations using BIM. Because in fact if both are careful then there will not be a significant percentage difference.

From the research we conducted, from the Processing of Hotel Indigo Detailed Engineering Design (DED) documents, according to the data we obtained supported by interviews with contractors, in the interviews it was revealed that the documents did not use the BIM concept, which we hereinafter refer to as "conventional" system, the conventional method we mean in this study is calculations using MS Excel and Autocad in drawing, this conventional system does not make a unified relationship between drawings and volume calculations. So that between the two in the process is done partially. The following is research data and a comparison table between manual calculations and Revit BIM concepts.

General Data of Hotel Indigo Bandung

a. Building area: 36,994 m^2
b. Count of beam type: 166 type
c. Main rebar: D16, D19, D22, and D25
d. Stirrup beam: D10-100, D10-150, D10-200, 2D10-100, D13-100, D13-150, 2D13-100, and 2D13-150
e. Ties rebar: D10-100, D10-150, D13-100, and D13-150
f. Concrete qualification: fc' 35 with slump 12±2

Results of Comparison of Calculation of Rebar Needs for Beam Structures using BIM and Manual

Table 1. Results of comparison calculations using BIM and manual

No	Type in Manual	Type in Revit	Total Weight Manual Vs Revit		Deviation
1	B73 (300x600)	B H'1	117.574	117.276	0.298
2	B70 (300x600)	B H'2	186.194	172.151	14.043
3	B91 (400x700)	B G'4H	437.715	416.639	21.076
4	B91 (400x700)	B G'3H	368.840	340.964	27.876
5	B101 (500x700)	B H3	728.543	725.514	3.029
6	B100 (500x700)	B H2	768.459	753.547	14.912
7	B92 (400x700)	B H1H	154.230	149.896	4.334
8	B92 (400x700)	B H2H	78.694	64.420	14.274
9	B100a (500x700)	B H1	221.451	199.957	21.494
10	B68a (300x600)	B G'1	55.022	36.021	19.001
11	B100a (500x700)	B G1	179.006	175.603	3.403
12	B69a (300x600)	B G4	50.219	39.716	10.503
13	B69a (300x600)	B F'4	58.432	42.743	15.689
14	B69 (300x600)	B G'3	290.753	267.537	23.216

No	Type in Manual	Type in Revit	Total Weight Manual Vs Revit		Deviation
15	B68 (300x600)	B G'2	218.178	203.251	14.927
16	B102 (400x750)	B G3	943.409	934.251	9.158
17	B100 (500x700)	B G2	768.459	763.829	4.630
18	B106 (200x500)	B F'5H	63.835	41.719	22.116
19	B88 (400x700)	B F'4H	171.878	152.889	18.989
20	B73 (300x600)	B F'3H	144.141	135.358	8.783
21	B71 (400x700)	B F'3	210.971	182.078	28.893
22	B97(450x700)	B F'2H	666.486	658.083	8.403
23	B98(450x700)	B F'6H	518.295	489.072	29.223
24	B70 (300x600)	B F'2	164.441	163.656	0.785
25	B70a (300x600)	B F'1	79.598	66.878	12.720
26	B81 (400x700)	B F'1H	717.802	705.797	12.005
27	B95 (400x750)	B F3	852.263	828.963	23.300
28	B81 (400x700)	B E'1H	696.284	689.703	6.581
29	B81 (400x700)	B D'1H	717.802	708.928	8.874
30	B81 (400x700)	B E'3H	717.802	705.797	12.005
31	B81 (400x700)	B D'3H	624.559	618.147	6.412
32	B81 (400x700)	B G'1H	825.390	816.617	8.773
33	B90 (400x700)	B G'2H	732.147	721.566	10.581
34	B96 (450x600)	B F2	528.441	515.723	12.718
35	B69 (300x600)	B E'2	170.488	168.604	1.884
36	B69 (300x600)	B E'3	253.280	252.049	1.231
37	B85 (400x700)	B E'2H	746.609	742.230	4.379
38	B74 (400x600)	B E2	514.881	510.715	4.166
39	B95 (400x750)	B E3	852.263	829.122	23.141
40	B85 (400x700)	B D'2H	754.376	751.936	2.440
41	B96a (450x600)	B F1	137.170	134.166	3.004
42	B69a (300x600)	B E'1	55.260	49.250	6.010
43	B69a (300x600)	B E'4	66.918	62.228	4.690
44	B95a (400x800)	B E4	175.760	169.627	6.133
45	B95a (400x800)	B F4	175.760	169.627	6.133
46	B74a (400x800)	B E1	80.238	76.749	3.489

No	Type in Manual	Type in Revit	Total Weight Manual Vs Revit		Deviation
47	B66 (300x600)	B D'3	307.568	291.341	16.227
48	B66 (300x600)	B D'2	218.290	201.100	17.190
49	B66a (300x600)	B D'1	74.406	71.281	3.125
50	B66a (300x600)	B D'4	74.406	71.090	3.316
51	B64B (200x500)	B F"1	128.224	117.179	11.045
Total			**18843.211**	**18272.58**	**570.628**
Total Deviation (kg)				**570.628**	
Total Deviation (%)				**3%**	

Conclusion

The conclusions from the Analysis of Calculation of Rebar Needs for Floor 6 Zone 1 Beam Structures of the Indigo Bandung Hotel Project using BIM are as follows:

1. The amount of calculation of rebar requirements using the conventional method is 18843.211 kg.
2. The amount of calculation of rebar requirements using the BIM Autodesk Revit 2020 method is 18272.58 kg.
3. In calculating the need for rebar for beam structures using the BIM Autodesk Revit 2020 method and with the conventional method there is a difference of 570.628 kg or a difference of 3%. Then, this shows that the results of calculations using BIM Autodesk Revit 2020 get smaller results compared to conventional calculation results because calculations with BIM Autodesk Revit 2020 are more detailed or detailed results.

References

Adhitama, A. R., Ratnaningsih, A., & Kriswardhana, W. (2020). Penerapan Metode Building Information Modeling (BIM) Pada Pembangunan Gedung Integrated Laboratory for Natural Science and Food Technology Universitas Jember. *Jurnal Rekayasa Sipil Dan Lingkungan*, *4*(2), 113. https://doi.org/10.19184/jrsl.v4i2.11683

Adistana, G. A. Y. P., HS, M. S., Mahardi, P., & Sofianto, M. F. (2022). Assessment of E-Procurement Subjects' Missteps for Construction and Consultancy Services Throughout the Surabaya City Area As an Educational Adjunct for Project Tender Courses. *Jurnal PenSil*, *11*(1), 1–9. https://doi.org/10.21009/jpensil.v11i1.25294

Albab, A. U., & Erizal. (2021). Analisis Kinerja Waktu dan Penerapan Building Information Modeling pada Proyek Pembangunan Jasmine Park Apartment Bogor. *Jurnal Teknik Sipil Dan Lingkungan*, *06*(01). https://doi.org/10.29244/jsil.6.1.11-22

Anggaraini, N. L., Sat, D., Yuwana, A., & Rafi, A. (2022). Perbandingan Volume pada Pekerjaan Struktural antara Perhitungan dengan Building Information Modeling. *Journal Rice: Reviews in Civil Engineering*, *6*(2), 78–84.

Anjani, A., Bayzoni, Husni, H. R., & Niken, C. (2022). Penerapan Building Information Modeling (BIM) pada Bangunan Gedung Menggunakan Software Autodesk Revit (Studi Kasus: Gedung 5 RSPTN Universitas Lampung). *Journal Rekayasa Sipil Dan Desain (JRSDD)*, *10*(1), 15–026. https://media.neliti.com/media/publications/486228-none-33a1d680.pdf

Apriani, Uda, S. A. K. A., & Nuswantoro, W. (2022). Penilaian Kontraktor di Palangka Raya Tentang Penerapan Building Information Modelling pada Proyek Konstruksi. *Jurnal Serambi Engineering*, *7*(3), 3262–3270. https://doi.org/10.32672/jse.v7i3.4217

Bhanu Rizfa Hakim, Musthafa A.P, H., Hidayati, Z., & Thamrin, N. H. (2021). Pelatihan Autodesk Revit Bagi Komunitas Samarinda Young Architect Forum. *Jurnal Pengabdian UntukMu NegeRI*, *5*(1), 5–11. https://doi.org/10.37859/jpumri.v5i1.2265

Dwiarti, R., Suwitri, S., & Widowati, N. (n.d.). *dampak kebijakan pembangunan karakter bangsa terhadap siswa sekolah menengah kejuruan (smk) negeri 7 semarang*. 1–11. https://doi.org/10.1017/CBO9781107415324.004

Enda, D., & Destriyana, E. (2022). Penerapan Metode Building Information Modelling (BIM) Pada Pekerjaan Struktural Gedung Kuliah Terpadu III (GKT III) Politeknik Negeri Bengkalis. *Seminar Nasional Industri Dan Teknologi (SNIT), Politeknik Negeri Bengkalis*, *November*, 193–202. http://eprints.polbeng.ac.id/6657/

Fakhruddin, Parung, H., Tjaronge, M. W., Djamaluddin, R., Irmawaty, R., Amiruddin, A. A., Djamaluddin, A. R., Harianto, T., Muhiddin, A. B., Arsyad, A., & Nur, S. H. (2019). Sosialisasi Aplikasi Teknologi Building Information Modelling (BIM) pada Sektor Konstruksi Indonesia. *JURNAL TEPAT (Teknologi Terapan Untuk Pengabdian Masyarakat)*, *2*(2), 112–119. https://doi.org/10.25042/jurnal_tepat.v2i2.82

Farhana, A., & Abma, V. (2022). Implementasi Konsep BIM 5D pada Pekerjaan Struktur Proyek Gedung. *JURNAL RAB CONTRUCTION RESEARCH*, *7*(2), 116–127. https://doi.org/10.36341/racic.v7i2.3004

Ferial, R., Hidayat, B., Pesela, R. C., & Daoed, D. (2022). Quantity Take-Off Berbasis Building Information Modeling (BIM) Studi Kasus: Gedung Bappeda Padang. *Jurnal Rekayasa Sipil (JRS-Unand)*, *17*(3), 228. https://doi.org/10.25077/jrs.17.3.228-238.2021

Fitriani, H., Budiarto, A., Rachmadi, A., & Muhtarom, A. (2021). Analisis Persepsi Perusahaan Architecture, Engineering, Construction (AEC) terhadap Adopsi Building Information Modeling (BIM). *Media Teknik Sipil*, *19*(1), 25–32. https://doi.org/10.22219/jmts.v19i1.14281

Hatmoko, J. U. D., Wibowo, M. A., Kristiani, F., Khasani, R. R., Hermawan, F., RizkiFatmawati, & Sihaloho, G. D. (2020). Edukasi Building Information Modeling (BIM) pada Kontraktor Kecil. *Jurnal Pasopati*, *2*(3), 198–202. http://ejournal2.undip.ac.id/index.php/pasopati

Hendra, Deni, Karsono, B., Olivia, S., & Azhar. (2022). Pengenalan Peran Platform Digital Bim (Building Information Modelling) Dalam Program Autodesk Revit Bagi Masyarakat Pelajar Kota Lhokseumawe. *Jurnal Solusi Masyarakat Dikara*, *2*(3), 166–171.

Hussin, J. M., Abdul Rahman, I., & Memon, A. H. (2013). The Way Forward in Sustainable Construction: Issues and Challenges. *International Journal of Advances in Applied Sciences*, *2*(1), 31–42.

https://doi.org/10.11591/ijaas.v2i1.1321

Ikhwanuddin, I., H., S., Hariyanto, V. L., & Hasan, A. (2018). Self-Regulated Learning with a Module to Improve Learning Achievement. *Jurnal Pendidikan Teknologi Dan Kejuruan*, *24*(2), 213–221. https://doi.org/10.21831/jptk.v24i2.18287

Iphonk, P. (2022). *1 Jam Menguasai Revit*. Youtube. https://www.youtube.com/watch?v=Ps7Bm0bZPxA

Johartiming, E. F., Winarto, J. S., Chandra, H. P., & Ratnawidjaja, S. (2021). Investigasi Implementasi Building Information Modelling Pada Sektor Konstruksi Di Surabaya. *Jurnal Dimensi Pratama Teknik Sipil*, *10*(02), 60–67. https://publication.petra.ac.id/index.php/teknik-sipil/article/download/11756/10362

John, C., Mor, Y., & Santos, P. (2015). ideas in mobile learning. *Journal of Interactive Media in Education*, 1–2. https://doi.org/10.5334/jime.aw

Khairi, I. F., Bayzoni, Husni, H. R., & Siregar, A. M. (2022). Penerapan Building Infromation Modeling (BIM) Menggunakan Software Autodesk Revit Studi Kasus Gedung 6 RSPTN Universitas Lampung. *Journal Rekayasa Sipil Dan Desain (JRSDD)*, *10*(1), 15–026. https://media.neliti.com/media/publications/486228-none-33a1d680.pdf

Laorent, D., Nugraha, P., & Budiman, J. (2019). Analisa Quantity Take-Off Dengan Menggunakan Autodesk Revit. *Dimensi Utama Teknik Sipil*, *6*(1), 1–8. https://doi.org/10.9744/duts.6.1.1-8

Marizan, Y. (2019). Studi Literatur Tentang Penggunaan Software Autodesk Revit Studi Kasus Perencanaan Puskesmas Sukajadi Kota Prabumulih. *Jurnal Ilmiah Beering's*, *06*(01), 15–26.

Muhsin, A., Prawiradinata, R. Y. S., Razaq, Y. N., & Novianti. (2021). Perbandingan Antara Alur Kerja BIM Dengan CAD Pada Proses Renovasi Rumah Tinggal. *Jurnal Arsitektur TERRACOTTA*, *2*(3), 1–11. https://doi.org/10.26760/terracotta.v2i3.4899

Murtinugraha, R. E. (2017). Evaluasi Pelaksanaan Kurikulum 2013 pada SMK Negeri Program Keahlian Teknik Bangunan di Jakarta. *Jurnal Pendidikan Teknik Sipil*, *6*(1), 21–28. https://doi.org/10.21009/jpensil.v6i1.7250

Nicholas, K., Fletcher, J., & Davis, N. (2012). Raising Numeracy and Literacy to Improve Vocational Opportunities. *Journal of Vocational Education and Training*, *64*(4), 433–451. https://doi.org/10.1080/13636820.2012.727850

Noviani, S. A., Mawardi Aman, & Sarwono Hardjomuljadi. (2021). Metode Building Information Modelling 5D Untuk Meminimalkan Klaim Konstruksi yang Ditimbulkan oleh Penyedia Jasa. *Jurnal Konstruksia*, *13*(1), 29–42.

Novita, R. D., & Pangestuti, E. K. (2021). Analisa Quantity Take Off Dan Rencana Anggaran Biaya Dengan Metode Building Information Modeling (BIM) Menggunakan Software Autodeks Revit 2019 (Studi Kasus: Gedung LP3 Universitas Negeri Semarang). *Dinamika Teknik Sipil*, *14*(1), 27–31. https://doi.org/10.23917/dts.v14i1.15276

Nugrahini, F. C., & Permana, T. A. (2020). Building Information Modelling (BIM) dalam Tahapan Desain dan Konstruksi di Indonesia , Peluang Dan Tantangan : Studi Kasus Perluasan T1 Bandara Juanda Surabaya. *AGREGAT*, *5*(2), 459–467.

Nugroho, P. S., Latief, Y., Mulyono, B., & Zaman, A. A. F. N. (2022). Penggunaan BIM Untuk Meningkatkan Keselamatan. *Jurnal Komposit*, *6*(1).

Pendidikan, J., Sipil, T., & Online, T. (2020). *3 1,2,3*. *9*(1).

Prasetyono, P. N., & Dani, H. (2022). Identifikasi Risiko pada Pekerjaan Proyek Konstruksi Bangunan Gedung sebagai Tempat Tinggal. *Publikasi Riset Orientasi Teknik Sipil (Proteksi)*, *4*(1), 42–47. https://doi.org/10.26740/proteksi.v4n1.p42-47

Purnomo, C. C., Hutabarat, L. E., Putri, R., & Gultom, W. (2022). Kajian Tingkat Implementasi dan Hambatan Penggunaan Building Information Modelling (BIM). *Jurnal Rekayasa Teknik Sipil Dan Lingkungan*, *3*(2), 68–76.

Putera, I. G. A. A. (2022). Manfaat BIM Dalam Konstruksi Gedung: Suatu Kajian Pustaka. *Jurnal Ilmiah Teknik Sipil*, *26*(1), 43–52.

Ramadhan, M. A., & Maulana, A. (2020). Pemahaman Konsep BIM melalui Autodesk Revit bagi Guru SMK Teknik Bangunan se-Jabodetabek. *Wikrama Parahita* …. https://e-jurnal.lppmunsera.org/index.php/parahita/article/view/1886

Reista, I. A., & Ilham, A. (2022). Implementasi Building Information Modelling (BIM) dalam Estimasi Volume Pekerjaan Struktural dan Arsitektural. *Journal of Sustainable Construction*, *2*(1), 13–22.

Sangadji, S., Kristiawan, S. A., & Saputra, K. (2019). Pengaplikasian Building Information Modeling (BIM) Dalam Desain Bangunan Gedung. *E-Jurnal Matriks Teknik Sipil*, 381–386.

Saputra, A., Husni, H. R., Bayzoni, & Siregar, A. M. (2022). Penerapan Building Information Modeling (BIM) pada Bangunan Ggedung Menggunakan Software Autodesk Revit (Studi Kasus : Gedung 5 RSPTN Universitas Lampung) Rumah Sakit Pendidikan Perguruan Tinggi Negeri (RSPTN) Universitas Lampung. *JRSDD*, *10*(1), 15–26.

Witjaksana, A. F. P. B. (2022). IMPLEMENTASI AUTODESK REVIT UNTUK QUANTIIY TAKE OFF PADA PEKERJAAN STRUKTUR JEMBATAN. *Jurnal Kacapuri : Jurnal Keilmuan Teknik Sipil*, *Vol 5*, *No 1 (2022): JURNAL KACAPURI : JURNAL KEILMUAN TEKNIK SIPIL (Edisi Juni 2022)*, 408–416. https://ojs.uniska-bjm.ac.id/index.php/jurnalkacapuri/article/view/7603/4045

Yuvita, R. L., & Budiwirawan, A. (2022). Analysis of the Advantages and Disadvantages of Using Autodesk Revit for the Dean Building of the Faculty of Education, Universitas Negeri Semarang. *Jurnal Teknilk Sipil & Perencanaan*, *24*(2), 91–98.