
ANALYSIS OF THE EFFECTIVENESS OF USING AUTODESK REVIT APPLICATIONS IN INCREASING WORK PRODUCTIVITY: A CASE STUDY OF THE CONSTRUCTION OF THE AL-MULTAZAM ISLAMIC BOARDING SCHOOL BUILDING, KUNINGAN

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ABSTRACT

In the implementation of construction work, there are still many problems, namely schedule mismatches, delays, and cost calculations that are sometimes inaccurate because they still use conventional methods. In the Al-Multazam Islamic Boarding School Building Construction project, Kuningan still uses traditional methods, where this method has the potential for human error because in making calculations it can be wrong to enter data which will ultimately change the calculation results to be greater. This research aims to show that the BIM method is very important to be applied in construction projects to streamline work productivity in building construction projects. In this case, there are differences in the results of the calculation of Quantity Take Off on the project, the difference in the results of the analysis shows that there is a difference between the existing volume and the volume of the Quantity Take Off results using the BIM concept, Foot plate foundation work has an average difference of 6.67%, Tie Beam has a difference of 7.62%, Beams have a difference of 5.30%, Columns have a difference of 8.26%, and Floor Plates have an average difference of 2.51%. This research has implications for the application of BIM to enable a more structured, efficient, and accurate planning and implementation process, thereby reducing the potential for errors caused by human factors. In addition, the use of BIM can also increase efficiency in overall project management, including in schedule monitoring, cost estimation, and resource management, which in turn can increase work productivity on building construction projects.

Keyword: Autodesk Revit, BIM, Effectiveness, Construction, Quantity Take Off.

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INTRODUCTION

In Indonesia the development of the construction sector in the era of globalization is developing very rapidly, it has a positive impact because the construction industry is a very important part and one of the aspects that can encourage the progress of a country (Utari & Pradana, 2023). In the field of the construction industry around the world, the use of information and communication technology in digital formats has often been found. The application of digital technology, especially Building Information Modelling (BIM), has had a significant impact on accelerating infrastructure development by increasing its efficiency and productivity (Hermawan; et al., 2021). BIM is a concept based on technology and methodology, used to plan and execute construction projects by utilizing information related to all aspects of building construction, BIM enables comprehensive data

integrity, simulation analysis, and complete information management to improve efficiency and quality in construction (Rodrigues et al., 2022).

Building Information Modeling (BIM) Also covering all the physical and functional aspects of a building, this model includes not only the geometry of the building, but also related information such as materials, dimensions, and building specifications (Machado & Vilela, 2020). BIM can improve project efficiency but is hampered by high initial investment costs, inadequate human resources, low demand, and inadequate technology development, in the application of BIM can save construction project material procurement costs by as much as 20% (Yuvita & Budiwirawan, 2022). By using BIM 7 dimensions characterize the full functionality of the BIM system (Ershadi et al., 2021) where:

BIM 1D (Documentation): The first foundation of BIM is to document all the requirements related to the life cycle of a construction project. This documentation clarifies the production process and shares important information during the trial period of infrastructure construction projects.

BIM 2D (Computer-Aided Design): Planning is mainly done in two dimensions, connecting constraints and objectives to project specifications. BIM 2D as the earliest form of construction modeling, allows basic planning activities to be carried out faster and in a simpler format.

BIM 3D (Visualization): Design and planning in a three-dimensional environment improve process clarity and rigor. This requires the integration and visualization of graphical and non-graphic information, from spatial and isometric relationships to quantity estimation. Potential physical collisions between various construction components can be simulated, allowing designers to improve the quality of results.

BIM 4D (Schedule): It is the unification of schedules into the 3D model of the facility allowing error detection in the time and sequence of activities, the progress of scheduled activities is simulated using BIM analysis tools so that the activity network can be optimized and improved. Sequential development of installation, excavation, and other construction activities, as well as delays such as drying time, are displayed during this process to ensure constructively and consistency of schedules.

BIM 5D (Cost): This BIM dimension integrates cost estimation into 4D BIM to enable integrated cost planning and project budgeting. Budgeting software, scheduling software, and BIM 3D models operate smoothly, allowing estimators to analyze capital and operational costs during the construction phase. 5D BIM elements must be able to extract and visualize accurate cost information, which can be shared among estimators, owners, investors, and contractors.

BIM 6D (Energy Performance): BIM 6D optimizes energy consumption and reduces the long-term costs associated with facilities, as well as improving their performance. This BIM dimension significantly contributes to sustainability goals and creates green infrastructure through energy efficiency in the infrastructure construction sector.

BIM 7D (Facility Lifecycle): The literature does not provide a firm boundary between 6D and 7D. Further explanation of related tools shows that BIM 7D includes more complete information on the lifecycle required to achieve energy efficiency and sustainability throughout the project lifecycle. The information includes asset attributes, details of operation and maintenance during the project commissioning period, facility specifications, installation and warranty details, maintenance schedules, manuals, and equipment configurations required for optimal performance.

This BIM method has a more sophisticated system, which can integrate important aspects of project implementation such as Clash Detection, Lean construction, and automation. Analysis Clash Detection is a fundamental aspect of the BIM process, it can allow for pre-production assessments

in design models or on-site settings (Yönder & Çavka, 2024). Clash Detection is an important problem in the development of Building Information Modeling, which is related to the detection of problems and clashes in the elements in the image (Abdalhameed & Naimi, 2023). Lean construction is a reduction-focused management approach to Waste and meets customer needs in construction projects (Michalski et al., 2021). Lean construction aims to improve the efficiency and effectiveness of construction projects by reducing waste and maximizing value for customers (Moradi & Sormunen, 2023). In this case, it is necessary to use a supporting concept, namely by using Building Information Modeling (BIM) as a trusted means to achieve Waste which is minimal in the work of a construction project (Akanbi et al., 2019). Project Management is a complex process that involves managing human resources, time, cost, and risk to achieve construction project objectives efficiently and effectively (Mesároš et al., 2022). These construction projects encompass a project development process of great size and complexity, which is based on the use of technology to manage information, plan resources, and coordinate various aspects of the project. Efficient information processes and good integrity between the various parties involved are essential in maintaining the smooth and successful running of construction projects (Sampaio, 2021).

In the implementation in the field, there are still many problems that can be obtained, including schedule inconsistencies, delays, to cost calculations that are sometimes inaccurate because they still use conventional methods, this method has the potential for human error because in calculating it can be incorrect to enter data which will eventually change the results of the calculation to be greater, the impact obtained on the project will eventually incur costs larger.

Therefore, this study aims to show that this BIM method is critical to be applied in construction projects to effectively work productivity in the Al-Multazam Islamic Boarding School Building Construction Project located in Maniskidul, Jalaksana District, Kuningan Regency, West Java. Meanwhile, in work productivity, one of the aspects includes structural work. In this study, the author only analyzes the effectiveness of construction in Structural Work, Structural Work is the work of building frames that are on top of the foundation work and the foundation itself with the form of components in the form of foundations, sloofs, columns, beams, beam joints, and floor plates, walls, and stairs (Riztria Adinda et al., 2021). Thus, the benefits of this research are expected to provide a deeper understanding of the application of BIM in improving the effectiveness and efficiency of structural work in construction projects, especially in the context of the Al-Multazam Islamic Boarding School Building Development.

METHOD

The Quantitative Method was considered scientific because it adhere to scientific principles such as concrete, objective, measurable, rational, and systematic. In addition, discovery methods also allow for the discovery and development of new sciences (Sembiring et al., 2023). This research began by conducting a literature study on the title of the research. This was done to gain a deep understanding of the research topic and a strong theoretical foundation. Next, a search for a research project was carried out. The research conducted at Al-Multazam Islamic Boarding School Building Project. There were two types of quantitative research methods in data collection, including primary data in the form of working drawings and structural BOQ and then collected. This data was used to verify and validate the developed model. In addition, secondary data in the form of books and journals related to modeling steps Software Revit was used as a guide in the modeling process.

In this study, the author used applications related to Building Information Modelling (BIM) namely to analyze the efficiency of BIM use in increasing work productivity. Platform BIM which was used in making the Building Design model is Revit Autodesk Software. Revit Autodesk is a 3D model information program that can be used for project management and also provides a facility for sketching, which allows an architectural object to be analyzed from all angles, levels, and views as a form of information presentation from the same database, working in the view of the underlying building model image (Yaquini Ticllacuri et al., 2023).

Revit Autodesk is a software-based Building Information Modeling (BIM) 3D used for architectural, structural, mechanical, electrical, and plumbing (MEP) design. Moreover, Revit Autodesk has the advantage of being able to estimate costs by including the material price for each component made in the modeling (Husnul Khatimi, Muhammad Reza Fardian, 2021).

In this study, the author conducted a case study on the construction project of the Al-Multazam Islamic Boarding School Building located in Maniskidul Village, Jalaksana District, Kuningan Regency, West Java. This location was chosen because there will be development as our reference in collecting data and research materials.



Figure 1. Research Location

This case study used a comparison between BIM Methods and conventional methods. The planning method began by collecting and studying literature related to construction management and related to BIM. Furthermore, field data was collected to be used as data in objects. The data that has been collected can be analyzed with the steps shown in Figure 2.

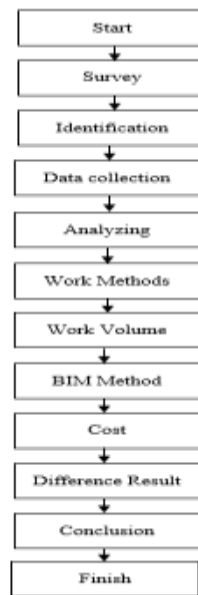


Figure 2. Flowchart

The volume calculation can be calculated precisely according to the plan drawings made. In the calculation of each volume of work, the following formula is obtained:

Volume Formula:

$$V=p \times l \times t$$

Information:

V = Volume (m3)

p = Length (m)

l = Width (m)

t = Height (m)

Concrete Cost Formula:

$$\text{Total Cost} = \text{Volume m3} \times \text{Concrete Price/m3}$$

Completing a 3D building information model was an important first step to improving the quality of a construction project. This allows for better coordination between site planning, sequence of activities, site organization, and site management, as well as clash detection tests with other professional work (Lee et al., 2020).

RESULTS AND DISCUSSION

Data Input into Autodesk Revit Software

BIM planning starts with making structural modeling of buildings.

1. The process of stages of entering structural component specifications in 3D modeling using Autodesk Revit Software where there are steps in the process, including:

a. Opening structural template and setting project structural and common units

In the default view select project structural template. Then, select the manage toolbar on the taskbar above then select project units, the first is to change the units in the common discipline to metric because this discipline has a general effect on the modeling work later, after that change the discipline to structural to manage the units structural that will be used according to the needs.



Figure 3. Autodesk Revit Home View

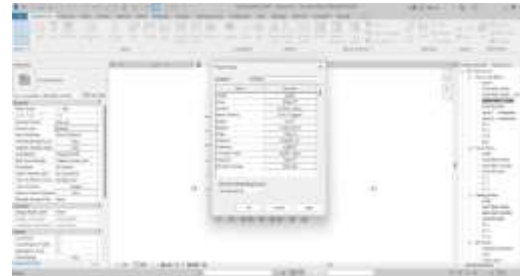


Figure 4. Display of Project Unit Settings

b. Integrate project architecture into structural templates

To incorporate architectural projects into structural templates. Select Insert on the taskbar, then click Command Link and select Revit Link. Because it is in a block format, Structural Templates are only focused on creating structural blocks and columns.

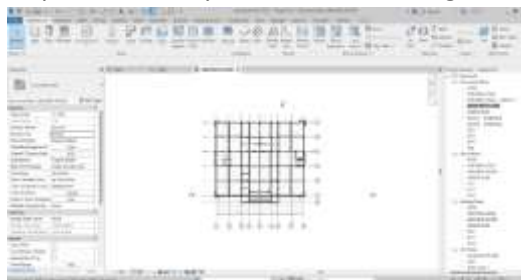


Figure 5. Autodesk Revit Home View



Figure 6. Integration Results Display

c. Input of footplate foundation structure into modeling

Select the taskbar structure, then select insulated, and then arrange it according to the planned design. In the ironing section, click the footplate section select the rebar then model the design that has been planned. Input the sloof structure by selecting the taskbar structure then selecting the beam and beam shape according to the sloof, then arranging it according to the planned design.

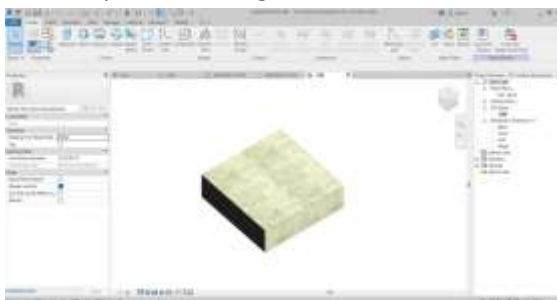


Figure 7. View of Entering the Foot Plate Foundation Structure into Modelling

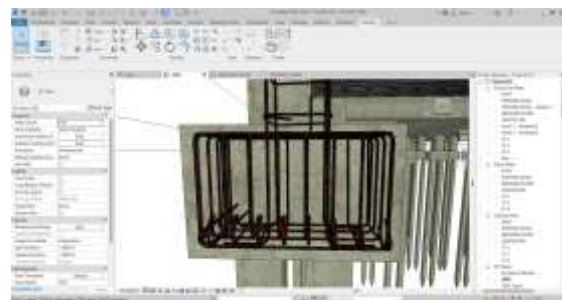


Figure 8. Foot Plate Foundation Ironing Display



Figure 9. Viewing Input Sloof Structure into Modelling

d. Input column and beam structures into modeling

Select the taskbar structure then select Column and Beam and arrange it according to the design that has been planned. In the ironing section, click on columns and beams and then select Rebar to adjust the planned model.

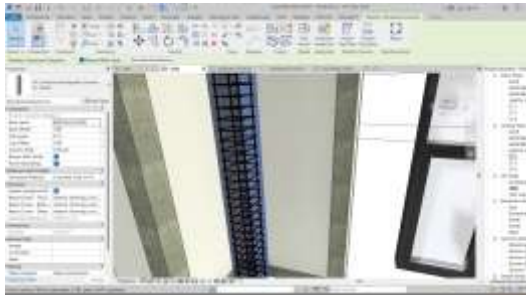


Figure 10. Column Structure Ironing Display

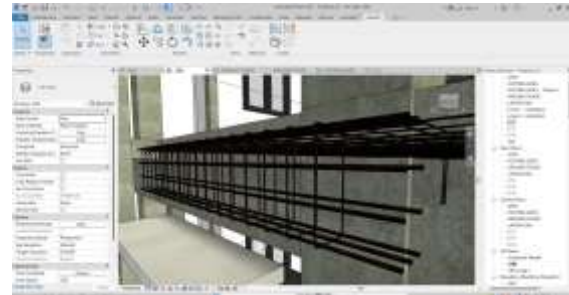


Figure 11. Beam Structure Ironing Display

e. Input of floor plate structures into modeling

Select the taskbar structure then select the structural floor, select the pick line click on the side where the floor plate will be installed after finishing select trim connect each side select finish edit mode, then arrange according to the planned design. On the ironing model as planned click on the floor plate section and select Rebar.

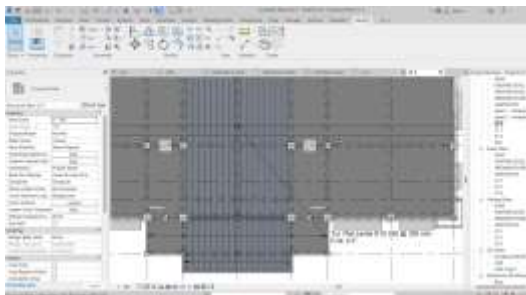


Figure 12. Structural Ironing Display Floor Plate

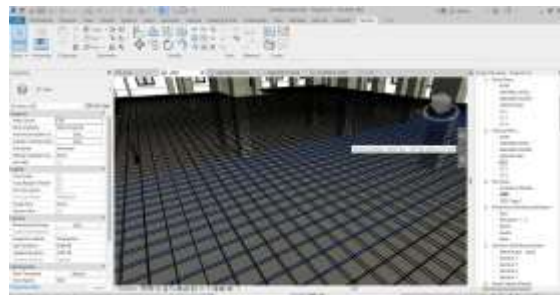


Figure 13. Structural Component Result Display

f. Results of structural components and 3D view

To ensure optimal validation and accuracy, modeling has been done in stages along with detailed engineering design case studies of the projects used. Display of the results of the visualization of steel and structural components in 3D as shown in the image

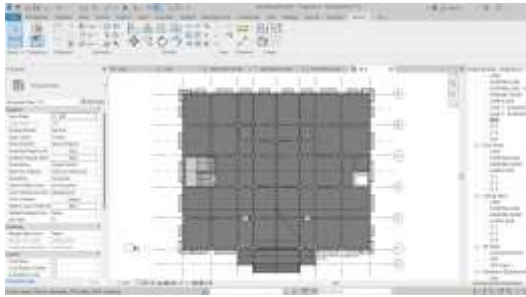


Figure 14. Structural Component Result Display

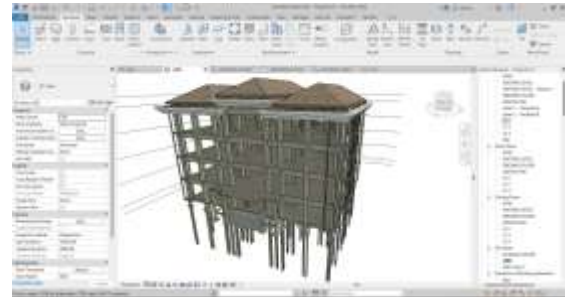


Figure 15. 3D View Results Display

2. Quantity Take-Off Structural Components

To analyze the quantity take-off of structural work using Revit, the steps are as follows: first, select the schedules quantities option on the report's taskbar located in the analyze command. After that, set the schedule quantities as needed. Next, on the filter list, select the structure, and on the category, select the multi-category to create the multi-category schedule.

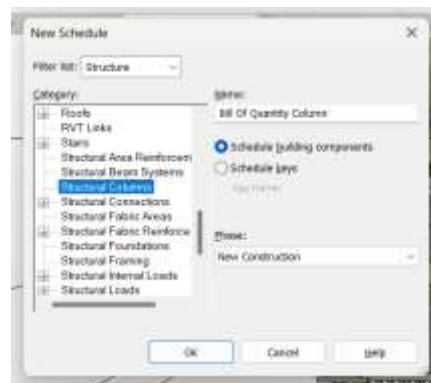


Figure 16. New Schedule Display

After selecting a structure such as structural columns and structural floor plates on the filter list, select the multi-category to create a multi-category schedule. Next, specify the pa fields that will be displayed as the final information report from Autodesk Revit Software. Manufacturer, type, length, type comments, descriptions, and cost are the fields that need to be displayed.

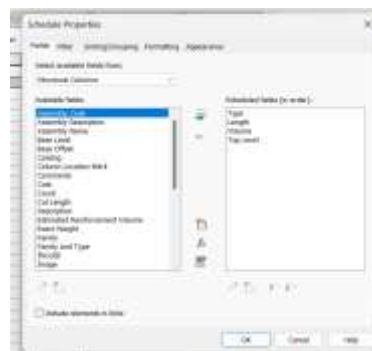


Figure 17. Fields View

Then, rename the fields according to the formatting schedule properties. The results of each field that has been qualified to be displayed in the quantity take-off report using Autodesk Revit software, with the overall total value on the volume fields in each job description.

<Structural Framing Schedule>				
A	B	C	D	E
Type	Length	Volume	Volume	Volume
BT 1/2/3/4/5/6/7/8/9/10/11/12/13/14/15/16/17/18/19/20/21/22/23/24/25/26/27/28/29/30/31/32/33/34/35/36/37/38/39/40/41/42/43/44/45/46/47/48/49/50/51/52/53/54/55/56/57/58/59/60/61/62/63/64/65/66/67/68/69/70/71/72/73/74/75/76/77/78/79/80/81/82/83/84/85/86/87/88/89/90/91/92/93/94/95/96/97/98/99/100/101/102/103/104/105/106/107/108/109/110/111/112/113/114/115/116/117/118/119/120/121/122/123/124/125/126/127/128/129/130/131/132/133/134/135/136/137/138/139/140/141/142/143/144/145/146/147/148/149/150/151/152/153/154/155/156/157/158/159/160/161/162/163/164/165/166/167/168/169/170/171/172/173/174/175/176/177/178/179/180/181/182/183/184/185/186/187/188/189/190/191/192/193/194/195/196/197/198/199/200/201/202/203/204/205/206/207/208/209/210/211/212/213/214/215/216/217/218/219/220/221/222/223/224/225/226/227/228/229/230/231/232/233/234/235/236/237/238/239/240/241/242/243/244/245/246/247/248/249/250/251/252/253/254/255/256/257/258/259/260/261/262/263/264/265/266/267/268/269/270/271/272/273/274/275/276/277/278/279/280/281/282/283/284/285/286/287/288/289/290/291/292/293/294/295/296/297/298/299/300/301/302/303/304/305/306/307/308/309/310/311/312/313/314/315/316/317/318/319/320/321/322/323/324/325/326/327/328/329/330/331/332/333/334/335/336/337/338/339/340/341/342/343/344/345/346/347/348/349/350/351/352/353/354/355/356/357/358/359/360/361/362/363/364/365/366/367/368/369/370/371/372/373/374/375/376/377/378/379/380/381/382/383/384/385/386/387/388/389/390/391/392/393/394/395/396/397/398/399/400/401/402/403/404/405/406/407/408/409/410/411/412/413/414/415/416/417/418/419/420/421/422/423/424/425/426/427/428/429/430/431/432/433/434/435/436/437/438/439/440/441/442/443/444/445/446/447/448/449/450/451/452/453/454/455/456/457/458/459/460/461/462/463/464/465/466/467/468/469/470/471/472/473/474/475/476/477/478/479/480/481/482/483/484/485/486/487/488/489/490/491/492/493/494/495/496/497/498/499/500/501/502/503/504/505/506/507/508/509/510/511/512/513/514/515/516/517/518/519/520/521/522/523/524/525/526/527/528/529/530/531/532/533/534/535/536/537/538/539/540/541/542/543/544/545/546/547/548/549/550/551/552/553/554/555/556/557/558/559/560/561/562/563/564/565/566/567/568/569/570/571/572/573/574/575/576/577/578/579/580/581/582/583/584/585/586/587/588/589/590/591/592/593/594/595/596/597/598/599/600/601/602/603/604/605/606/607/608/609/610/611/612/613/614/615/616/617/618/619/620/621/622/623/624/625/626/627/628/629/630/631/632/633/634/635/636/637/638/639/640/641/642/643/644/645/646/647/648/649/650/651/652/653/654/655/656/657/658/659/660/661/662/663/664/665/666/667/668/669/670/671/672/673/674/675/676/677/678/679/680/681/682/683/684/685/686/687/688/689/690/691/692/693/694/695/696/697/698/699/700/701/702/703/704/705/706/707/708/709/710/711/712/713/714/715/716/717/718/719/720/721/722/723/724/725/726/727/728/729/730/731/732/733/734/735/736/737/738/739/740/741/742/743/744/745/746/747/748/749/750/751/752/753/754/755/756/757/758/759/760/761/762/763/764/765/766/767/768/769/770/771/772/773/774/775/776/777/778/779/780/781/782/783/784/785/786/787/788/789/790/791/792/793/794/795/796/797/798/799/800/801/802/803/804/805/806/807/808/809/810/811/812/813/814/815/816/817/818/819/820/821/822/823/824/825/826/827/828/829/830/831/832/833/834/835/836/837/838/839/840/841/842/843/844/845/846/847/848/849/850/851/852/853/854/855/856/857/858/859/860/861/862/863/864/865/866/867/868/869/870/871/872/873/874/875/876/877/878/879/880/881/882/883/884/885/886/887/888/889/890/891/892/893/894/895/896/897/898/899/900/901/902/903/904/905/906/907/908/909/910/911/912/913/914/915/916/917/918/919/920/921/922/923/924/925/926/927/928/929/930/931/932/933/934/935/936/937/938/939/940/941/942/943/944/945/946/947/948/949/950/951/952/953/954/955/956/957/958/959/960/961/962/963/964/965/966/967/968/969/970/971/972/973/974/975/976/977/978/979/980/981/982/983/984/985/986/987/988/989/990/991/992/993/994/995/996/997/998/999/1000/1001/1002/1003/1004/1005/1006/1007/1008/1009/1010/1011/1012/1013/1014/1015/1016/1017/1018/1019/1020/1021/1022/1023/1024/1025/1026/1027/1028/1029/1030/1031/1032/1033/1034/1035/1036/1037/1038/1039/1040/1041/1042/1043/1044/1045/1046/1047/1048/1049/1050/1051/1052/1053/1054/1055/1056/1057/1058/1059/1060/1061/1062/1063/1064/1065/1066/1067/1068/1069/1070/1071/1072/1073/1074/1075/1076/1077/1078/1079/1080/1081/1082/1083/1084/1085/1086/1087/1088/1089/1090/1091/1092/1093/1094/1095/1096/1097/1098/1099/1100/1101/1102/1103/1104/1105/1106/1107/1108/1109/1110/1111/1112/1113/1114/1115/1116/1117/1118/1119/1120/1121/1122/1123/1124/1125/1126/1127/1128/1129/1130/1131/1132/1133/1134/1135/1136/1137/1138/1139/1140/1141/1142/1143/1144/1145/1146/1147/1148/1149/1150/1151/1152/1153/1154/1155/1156/1157/1158/1159/1160/1161/1162/1163/1164/1165/1166/1167/1168/1169/1170/1171/1172/1173/1174/1175/1176/1177/1178/1179/1180/1181/1182/1183/1184/1185/1186/1187/1188/1189/1190/1191/1192/1193/1194/1195/1196/1197/1198/1199/1200/1201/1202/1203/1204/1205/1206/1207/1208/1209/1210/1211/1212/1213/1214/1215/1216/1217/1218/1219/1220/1221/12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**Table 2. Comparison of Tie Beam & Sloof Volume Difference
Between Autodesk Revit and Conventional Software**

No	Job Description Multi Split Level Structural Work	Unit	Volume Software	Project Volume	Difference (M3)
B	TIE BEAM & SLOOF Work				
1	TB 1 (150 × 200 mm)	M3	0,84	1,08	0,24
2	TB 2 (150 × 250 mm)	M3	1,28	1,56	0,28
3	TB 3 (150 × 300 mm)	M3	1,53	1,57	0,04
4	TB 4 (200 × 350 mm)	M3	5,15	5,36	0,21
5	TB 5 (250 × 500 mm)	M3	3,95	4,75	0,80
6	TB 6 (300 × 600 mm)	M3	3,56	3,60	0,04
7	TB 7 (350 × 700 mm)	M3	6,11	6,35	0,24
	Total		22,42	24,27	1,85

In the results of the comparison of tie beam and aloof work volumes, it can be seen that the difference between the volume of Autodesk Revit Software usage and the project volume tends to be more efficient in the use of BIM methods. In each BIM method work, the volume obtained is lower than that of conventional methods. The result of the difference in the tie beam and sloof cap work was obtained at 1.85 m3.

**Table 3. Comparison of Column Volume Difference
Between Autodesk Revit and Conventional Software**

No	Job Description Multi Split Level Structural Work	Unit	Volume Software	Project Volume	Difference (M3)
C	1st Lt. Structure Column Work				
1.	K1 (300 × 300 mm)	M3	3,30	3,44	0,14
2.	K2 (350 × 350 mm)	M3	7,48	7,30	-0,18
3.	K3 (400 × 400 mm)	M3	7,98	8,12	0,14
4.	K4 (450 × 450 mm)	M3	13,87	13,95	0,08
5.	K5 (700 × 700 mm)	M3	3,70	3,75	0,05
6.	K (150 × 150 mm)	M3	1,65	1,75	0,1
	Total		37,98	38,31	0,33
	2nd Lt. Structure Column Work				
1.	K1 (300 × 300 mm)	M3	1,98	2,00	0,02
2.	K2 (350 × 350 mm)	M3	7,48	7,81	0,33
3.	K3 (400 × 400 mm)	M3	8,70	8,6	-0,1
4.	K4 (450 × 450 mm)	M3	12,41	12,12	-0,29
5.	K5 (700 × 700 mm)	M3	3,70	3,82	0,12
6.	K (150 × 150 mm)	M3	1,65	1,75	0,10
	Total		35,92	36,10	0,18
	3rd Floor Structure Column Work				
1.	K1 (300 × 300 mm)	M3	1,98	2,00	0,02
2.	K2 (350 × 350 mm)	M3	7,92	7,40	-0,52
3.	K3 (400 × 400 mm)	M3	8,70	9,13	0,43
4.	K4 (450 × 450 mm)	M3	13,14	13,24	0,10
5.	K5 (700 × 700 mm)	M3	3,70	3,82	0,12
6.	K (150 × 150 mm)	M3	1,65	1,75	0,10
	Total		37,09	37,34	0,25
	4th Floor Structure Column Work				
1.	K1 (300 × 300 mm)	M3	6,60	6,67	0,07
2.	K2 (350 × 350 mm)	M3	4,30	3,65	-0,65
3.	K3 (400 × 400 mm)	M3	6,38	6,84	0,48
4.	K4 (450 × 450 mm)	M3	8,76	8,84	0,08

No	Job Description	Unit	Volume Software	Project Volume	Difference (M3)
	Multi Split Level Structural Work				
5.	KP	M3	1,65	1,80	0,15
	Total		27,69	27,80	0,11
	4th Floor Structure Column Work				
1.	K1 (300 × 300 mm)	M3	4,16	5,26	1,10
2.	K4 (450 × 450 mm)	M3	1,16	3,44	2,28

In the results of the comparison of column work volume, it can be seen that the difference between the volume of Autodesk Revit Software usage and the project volume tends to be more efficient in the use of BIM methods. In each BIM method work, the volume obtained is lower than that of conventional methods. The results of the total difference in column work were obtained 0.33 m3 in the first-floor structure, 0.18 m3 difference in the second-floor structure, 0.25 m3 difference in the third-floor structure, 0.11 m3 difference in the fourth-floor structure, and 3.38 m3 difference in the dak floor structure.

Table 4. Comparison of Beam Volume Difference Between Autodesk Revit and Conventional Software

No	Job Description	Unit	Volume Software	Project Volume	Difference (M3)
	Multi Split Level Structural Work				
D	1st Lt Structure Beam Work				
1	RB1 (150 x 200 mm)	M3	0,95	1,04	0,09
2	RB2 (150 x 250 mm)	M3	1,15	1,39	0,24
	Total		2,10	2,43	0,33
	2nd Floor Structure Beam Work	M3			
1	B1 (150 x 200 mm)	M3	1,14	1,08	-0,06
2	B2 (150 x 250 mm)	M3	1,27	1,34	0,07
3	B3 (150 x 300 mm)	M3	1,78	1,50	-0,28
4	B4 (200 x 350 mm)	M3	5,19	5,26	0,07
5	B5 (250 x 500 mm)	M3	2,96	3,13	0,17
6	BA5 (250 x 500 mm)	M3	1,72	1,75	0,03
7	B6 (300 x 600 mm)	M3	3,59	3,62	0,03
8	B7 (350 x 700 mm)	M3	6,11	6,27	0,16
	Total		23,76	23,95	0,19
	3rd Floor Structure Beam Work	M3			
1	B1 (150 x 200 mm)	M3	0,62	1,14	0,52
2	B2 (150 x 250 mm)	M3	1,23	1,40	0,17
3	B3 (150 x 300 mm)	M3	1,72	1,55	-0,17
4	B4 (200 x 350 mm)	M3	5,12	5,31	0,19
5	B5 (250 x 500 mm)	M3	2,24	2,42	0,18
6	BA5 (250 x 500 mm)	M3	1,72	1,75	0,03
7	B6 (300 x 600 mm)	M3	3,59	3,67	0,08
8	B7 (350 x 700 mm)	M3	6,11	6,27	0,16
	Total		22,35	23,51	1,16
	4th Floor Structure Beam Work	M3			
1	B1 (150 x 200 mm)	M3	0,62	1,19	0,57
2	B2 (150 x 250 mm)	M3	1,20	1,12	-0,08
3	B3 (150 x 300 mm)	M3	1,78	1,84	0,06
4	B4 (200 x 350 mm)	M3	5,15	4,48	-0,67
5	B5 (250 x 500 mm)	M3	2,28	2,37	0,09
6	BA5 (250 x 500 mm)	M3	1,77	1,81	0,04

Job Description					
No	Multi Split Level Structural Work	Unit	Volume Software	Project Volume	Difference (M3)
7	B6 (300 x 600 mm)	M3	3,64	3,79	0,15
8	B7 (350 x 700 mm)	M3	6,11	6,27	0,16
	Total		22,55	22,87	0,32
	DAK Lt Structure Beam Work	M3			
1	B2 (150 x 250 mm)	M3	1,15	1,43	0,28
2	B3 (150 x 300 mm)	M3	1,80	3,83	2,03
3	B4 (200 x 350 mm)	M3	5,29	3,64	-1,65
4	B5 (250 x 500 mm)	M3	2,31	2,75	0,44
5	B7 (350 x 700 mm)	M3	6,39	6,33	-0,06
	Total		16,94	17,98	1,04

In the results of the comparison of beam work volume, it can be seen that the difference between the volume of use of Autodesk Revit Software and the volume of the project tends to be more efficient in the use of the BIM method. In each BIM method work, the volume obtained is lower than that of conventional methods. The results of the total difference in beam work were obtained 0.33 m3 on the first-floor structure, 0.19 m3 on the second-floor structure, 1.16 m3 on the third-floor structure, 0.32 m3 on the fourth-floor structure and 1.04 m3 on the dak floor structure.

Table 5. Comparison of Floor Plate Volume Difference Between Autodesk Revit and Conventional Software

No	Job Description Multi Split Level Structural Work	Unit	Volume Software	Project Volume	Difference (M3)
E	Floor Plate Work				
1.	Betok floor plate 120mm thick	M3	55,20	56,62	1,42

In the results of the comparison of floor plate work volume, it can be seen that the difference in the volume of use of Autodesk Revit Software and the volume of projects tends to be more efficient in the use of BIM methods. In each BIM method work, the volume obtained is lower than that of conventional methods. Until the results of the total difference in floor plate work were obtained 1.42 m3.

Overall Outcome of Structural Work

Several factors cause human error; therefore, a comparison is needed between the results of using Autodesk Revit Software and project documents (conventional methods). The project document compiles an estimate of the total quantity of material take-off based on the 2-dimensional DED, while in the analysis process using Autodesk Revit Software, the reference used is 3-dimensional modeling that has been remodeled based on the 2-dimensional DED. In the results, an estimated cost is included to generate a bill of quantity to find out the difference between each work using the Autodesk Revit BIM method and the conventional method. Thus, the difference is obtained in table 6.

Table 6. Difference Bill Off Quantity of Structural Work Materials

No	Job Description Multi Split Level Structural Work	Unit	Volume Software	Project Volume	Unit Price		Total		Difference (M3)	Percentage Difference (%)
					Wages (A)	Material (B)	Software	Project		
1	CAP Pile Foundation Work	M3	4,88	50,23	430.79 5,75	1.333.90 4,44	82.729.144, 91	88.640.890, 54	3,35	6,67
2	Tie Beam & Sloof Work	M3	22,42	24,27	430.79 5,75	1.333.90 4,44	39.564.578, 26	42.829.273	1,85	7,62

No	Job Description Multi Split Level Structural Work	Unit	Volume Software	Project Volume	Unit Price		Total		Difference (M3)	Percentage Difference (%)
					Wages (A)	Material (B)	Software	Project		
3	1st Lt. Structure Column Work	M3	37,98	38,31	430.79 5,75	1.333.90 4,44	67.023.313, 22	67.605.664, 28	0,33	8,26
4	2nd Lt. Structure Column Work	M3	35,92	36,1	430.79 5,75	1.333.90 4,44	63.388.030, 82	63.705.676, 86	0,18	
5	3rd Floor Structure Column Work	M3	37,09	37,34	430.79 5,75	1.333.90 4,44	65.452.730	65.893.905, 09	0,25	
6	4th Floor Structure Column Work	M3	27,69	27,8	430.79 5,75	1.333.90 4,44	48.864.548, 26	49.058.665, 28	0,11	
7	Column Work of Lt. Dak Structure	M3	5,32	8,70	430.79 5,75	1.333.90 4,44	9.388.205,0 1	15.352.891, 65	3,38	
8	1st Floor Structure Block Work	M3	2,10	2,43	430.79 5,75	1.333.90 4,44	3.705.870,4 0	4.288.221,4 6	0,33	5,30
9	2nd Floor Structure Block Work	M3	23,76	23,95	430.79 5,75	1.333.90 4,44	41.929.276, 51	42.264.569, 55	0,19	
10	3rd Floor Structure Block Work	M3	22,35	23,51	430.79 5,75	1.333.90 4,44	39.441.049, 25	41.488.101, 47	1,16	
11	4th Floor Structure Block Work	M3	22,55	22,87	430.79 5,75	1.333.90 4,44	39.793.989, 28	40.358.693, 35	0,32	
12	Lt. Dak Structure Block Work	M3	16,94	17,98	430.79 5,75	1.333.90 4,44	29.894.021, 22	31.729.309, 4	1,04	
13	Floor Plate Work	M3	55,20	45,62	430.79 5,75	1.333.90 4,44	97.411.450, 49	99.917.324, 76	1,42	2,51
Total			301	313,49			628.586.20 7,68	653.133.18 7,32	13,91	

For pile cap foundation work, there is an average percentage difference of 6.67%, while for tie beam & solo work, there is an average percentage difference of 7.62%. Furthermore, column work shows an average percentage difference of 8.26%, then beam work has an average percentage difference of 5.30%, and floor plate work has an average percentage difference of 2.51%.

Comparison of yield volumes quantity take-off until it is made Bill of quantity shows that there is a difference. Volume calculations in project documents tend to be larger than volume calculations generated by software. The use of BIM-based automatic calculation methods is a solution that can help in compiling cost estimates more efficiently (Husin et al., 2019).

CONCLUSION

The conclusion in this study shows the importance of applying the Building Information Modeling (BIM) method in construction projects to increase work productivity, especially in structural work. The process of determining the Bill of Quantity begins with creating a building structure in Autodesk Revit Software. After the structural model is created, the quantities obtained from Autodesk Revit are then integrated into Microsoft Excel. The findings show that the BIM method significantly improves the accuracy of the structural work, as evidenced by the percentage differences observed in various components: Pile Foundations (6.67%), Tie Beams (7.62%), Beams (5.30%), Columns (8.26%), and Floor Slabs (2.51%). The case study results underscore that the application of BIM can reduce field errors, lower project costs, and improve communication and integration among stakeholders. Thus, it can be concluded that BIM should be applied to all construction projects, both mid-range and high-end, with the flexibility to be used up to 7D or as needed up to 5D, depending on the specific needs of each project.

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