COMPARISON OF ESTIMATION OF REINFORCED CONCRETE STRUCTURE WORKING COSTS BASED ON THE CONCEPT OF COMPUTER-AIDED DESIGN (CAD) AND BUILDING INFORMATION MODELING (BIM)

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ABSTRACT
The cost estimation process is an important aspect of project management. In line with industry 4.0 development, a new concept called building information modeling (BIM) was introduced. However, in the Indonesia construction sector itself, the application of the BIM concept is still not optimal. Many construction actors still using conventional concept using computer aided design (CAD) drawing in estimating project cost. This case study aims to compare the project cost estimation between conventional calculation based on CAD drawing dan calculation with the BIM concept. This case study was designed with quantitative approach where the unit price analysis will refer to The PUPR regulation no 1 of 2022. From the result, it was found that the project cost estimation using conventional calculation based on CAD drawing was Rp.39.249.184.000 meanwhile the project cost estimation based on BIM concept was Rp.38.978.799.000. It can be concluded that the calculation using the BIM concept result a lower cost estimation of RP.270.385.00 or worth 0.69% compared to the cost estimation based on conventional calculation.

INTRODUCTION
The cost estimation process is one of the important aspects in project management, because it is one part of the triple constraint. In estimating implementation costs, the volume of work is the most influencing factor. In construction projects in Indonesia, there are still many construction actors who use conventional methods to calculate the volume of work. This conventional method is carried out with the help of AutoCAD and Microsoft Excel which is guided by the Standard Method of Measurement (SMM). However, the application of this conventional method is considered less effective because it takes a long time to process and human errors
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often occur so that it will affect the level of accuracy in estimating the implementation costs.

In line with the development of the Industry 4.0 era which also affects the construction sector, new methods that are more effective and efficient in calculating the volume of work and costs of a construction project have been started. This method is called Building Information Modeling (BIM), which is a project simulation consisting of a 3D model of a project component that can be linked with all the required information and is connected to project planning, construction or operations, and decommissioning (Kymmell, 2008). The use of BIM in the Indonesian construction sector is also listed in the PUPR Ministerial Regulation No. 22 of 2018 concerning the Construction of State Buildings.

BIM has begun to be used in the Indonesian construction world, but its use is still very low and limited. Most construction workers already know and recognize several BIM software such as Autodesk Revit, ArchiCAD, Tekla, StaadPro, and so on. However, the use of BIM software is generally only used at level one, namely for conceptual design work with 3D modeling without any interdisciplinary data exchange (Pantiga & Soekiman, 2021).

The use of BIM can make construction work more transparent and the coordination process can run faster and easier. From the architect's and engineer's perspective, the use of BIM can make it easier if there are changes to the work components. Meanwhile, from the Owner's side, the use of BIM can help to make decisions regarding the costs to be incurred from all work (Saputra, 2019).

Revit was introduced by Autodesk in 2002 after Autodesk acquired the Revit program from a startup company. Revit is a separate platform from AutoCAD, with a different basic code and file structure. Revit integrates architectural, structural, and MEP work. Revit can be run on Windows OS and on Macs (Eastman, Eastman, Teicholz, Sacks, & Liston, 2011).

The use of Autodesk Revit can prevent and minimize errors due to human errors that usually occur when performing calculations using conventional methods using AutoCAD and Ms Excel (Novita & Pangestuti, 2021).

Autodesk Revit can directly calculate the volume of work that has been modeled. The results of the calculation of the volume of concrete from Revit have accurate results on the structural components of columns and beams, because the volume of the column is calculated based on elevation to elevation while the beam calculation is calculated based on the clear span of the beam from the inside of the column. But for the calculation of the slab structural components, Revit directly calculates the volume of concrete according to the modeled slab without reducing the overlap of the concrete volumes of columns and beams. The use of Revit to calculate the volume of work has a
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faster time, because the results of the volume calculation can be seen immediately after modeling. This will also simplify calculations in the event of a design change, without the need to calculate from scratch (Laorent, Nugraha, & Budiman, 2019).

The application of Building Information Modeling (BIM) in building construction projects in Indonesia has not been widely carried out, this has prompted the author to conduct research that discusses the comparison of cost estimates between conventional methods and the concept of Building Information Modeling (BIM).

METHOD
Research Stages

The object of this research is the Gateway Park LRT City Apartment project which is located on Jl. Kapin Raya, Pondok Gede, Bekasi City. This research consists of several stages of analysis which are further elaborated in the research flow chart as below:

![Research Flowchart](image)

Figure 1. Research Flowchart
Research Design

This research was designed with a quantitative approach consisting of conventional methods using computer-aided design (CAD)-based drawings and building information modeling (BIM) concepts to compare cost estimates for reinforced concrete structures.

In the BIM concept, the work volume will be generated automatically from the material takeoff quantity after 3D modeling is completed. The calculation of the unit price analysis (AHS) will refer to the Minister of Public Works and Public Housing Regulation No. 1 of 2022 concerning Guidelines for Compiling an Estimated Cost of Construction Works in the Public Works and Public Housing Sector. The price of materials, labor, and tools will be adjusted to the project location.

Data Collection Methods

The data used in this study include 2 types of data, namely primary data and secondary data. Primary data is data obtained directly from the main source consisting of working drawings, technical specifications, work volume. While the secondary data used consists of material unit price, labor unit price, tool unit price, work unit price analysis coefficient.

RESULT AND DISCUSSION

Comparison of Work Volume of Reinforced Concrete Structures

The difference in the calculation of concrete volume between Conventional concepts with Computer Aided Design (CAD) and Building Information Modeling (BIM) concepts is caused by:

a. In calculating the volume of conventional concrete beams, floors with typical beam plans, the volume of concrete is considered the same without taking into account any reduction in the size of the column or corewall

b. In the calculation of the volume of conventional slab concrete, the slab area is calculated from As to As, while in the calculation of the BIM concept, the slab is modeled to cover the ends of the column/beam

c. Meanwhile, for the volume of concrete columns, elevator separator columns, and corewalls, there is no difference in volume between conventional calculations and calculations with BIM

The difference in the calculation of the reinforcement volume between the Conventional concept with Computer Aided Design (CAD) and the Building Information Modeling (BIM) concept is caused by:
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a. In calculating the volume of beam reinforcement, Revit will automatically adjust the amount of stirrup reinforcement and the length of the main reinforcement if there is a reduction in the column or corewall

b. There is a difference in the length of reinforcement between CAD drawings and Revit 3D modeling as can be seen in Figure 2 and Figure 3

Recapitulation of the volume of concrete and reinforcement from the results of conventional calculations and the BIM concept can be seen in Table 1.

**Table 1. Recapitulation of the Volume Comparison of Concrete and Reinforcement**

<table>
<thead>
<tr>
<th>Keterangan</th>
<th>Vol. Beton (m³)</th>
<th>Vol. Tulangan (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Konvensional</td>
<td>9775.19</td>
<td>1649853</td>
</tr>
<tr>
<td>Revit 2022</td>
<td>9868.91</td>
<td>1615230</td>
</tr>
<tr>
<td>Selisih</td>
<td>93.72</td>
<td>-34623</td>
</tr>
<tr>
<td></td>
<td>0.959%</td>
<td>-2.099%</td>
</tr>
</tbody>
</table>

Based on Table 1, the volume of concrete work from conventional calculations is 9775.19 m³ while the results of Autodesk Revit 2022 calculations are 9868.91 m³ so that there is a difference of 93.72 m³ or 0.959% where the Autodesk Revit 2022 calculation results in a higher volume of concrete work, large compared to the results of conventional calculations. The volume of reinforcement work from the results of conventional calculations and Autodesk Revit 2022 is 1,649,853 kg and 1,615,230 kg so that there is a difference of 34,623 kg or 2,099% where the calculation with Autodesk
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Revit 2022 results in a smaller volume of reinforcement work compared to the conventional calculation results.

**Comparison of Cost Estimation of Reinforced Concrete Structures**

The preparation of the Work Unit Price Analysis (AHSP) refers to the PUPR Ministerial Regulation No. 1 of 2022 concerning Guidelines for Compiling an Estimated Construction Work Cost for the Public Works and Public Housing Sector. Prices for materials, labor, and tools are adjusted for the Jakarta location. The recapitulation of the unit price of work can be seen in Table 2.

<table>
<thead>
<tr>
<th>Work</th>
<th>Unit Price (Rp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 m³ Concrete Casting fc' 45 Mpa Using Ready Mixed and Concrete Pump</td>
<td>1,934,600</td>
</tr>
<tr>
<td>1 m³ Concrete fc' 35 Mpa Using Ready Mixed and Concrete Pump</td>
<td>1,844,800</td>
</tr>
<tr>
<td>1 m³ Concrete fc' 30 Mpa Using Ready Mixed and Concrete Pumps</td>
<td>1,799,900</td>
</tr>
<tr>
<td>Reinforcement Plates for Steel and Concrete Semi-Mechanical Method</td>
<td>12,608</td>
</tr>
<tr>
<td>of columns, beams, ring balks, and sloof</td>
<td>12,916</td>
</tr>
</tbody>
</table>

The calculation of the estimated cost is done by multiplying the volume of work by the unit price of work in Table 2. The estimation of costs for conventional and BIM concept work can be seen in Table 3.

<table>
<thead>
<tr>
<th>Lantai</th>
<th>Total Harga</th>
</tr>
</thead>
<tbody>
<tr>
<td>Konvensional</td>
<td>BIM</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The difference or difference in cost estimates between conventional calculations and BIM calculations is Rp. 270,385,000 where the estimated costs with BIM calculations produce a smaller cost estimate of 0.69% compared to conventional cost estimates. This cost estimation difference occurs due to differences in the results of calculating the volume of concrete and reinforcement work between conventional methods based on CAD drawings and BIM methods using Autodesk Revit.

**CONCLUSION**

Based on the results of the analysis and discussion, the following conclusions can be drawn:

1. The estimated cost of implementation with conventional calculations is Rp. 39,249,184,000 (thirty-nine billion two hundred forty-nine million one hundred and eighty-four thousand rupiah)

2. Estimated cost implementation with the calculation of the BIM concept is Rp. 38,978,799,000 (thirty eight billion nine hundred seventy eight million seven hundred ninety nine thousand rupiah)

3. The difference between the estimated implementation costs with conventional calculations and the calculation of the BIM concept is Rp. 270,385,000 (two hundred
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seventy million three hundred eighty five thousand rupiah), where the estimated cost with the BIM concept is 0.69% lower than the estimated cost of conventional calculations.

**REFERENCE**


