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EMPLOYING THE BIM-BASED APPROACH TO ANALYZE AND IMPROVE THE QUALITY OF DETAIL CONSTRUCTION COST ESTIMATION ACCORDING TO NRM 2 AND SMPI

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Abstract

Construction projects have become increasingly complicated and challenging to manage in recent years, especially in analyzing the quantity and cost estimation of construction work to get accurate results and overrun costs. The interdependence among different work items involved, such as architects, civil and electrical works, is one of the fundamental reasons. Besides that, the differences in standards used in analyzing the quantity and unit cost per work item made it more complicated. This study investigated the existing modeling based on the measurement rules and unit cost standards to analyze the problem which has been explained above. Understanding the items was considered when examining the wall's quantity to ensure the information was included. In addition, measurement rules standards are utilized to calculate QTO, including NRM 2 standards from the UK and SMPI standards from Indonesia, to calculate the cost based on Indonesia's standard SNI-AHSP. Furthermore, using visual programming Dynamo to analyze the quantity of wall works based on the required data, extract the data/information needed to calculate the cost based on unit cost standard, and check if the walls intersect with other elements to avoid excess quantity. Finally, using BIM technology based on standard measurement rules and overlapping element analysis to calculate the amount and cost produced accurate quantity results and obtained the full cost detail per work item. Moreover, generate information about the analysis results by utilizing the intelligent module to present the information needed on the wall works, which improves the inadequacy of BIM. Indeed, it could save more time than calculating them manually and reduce human errors.

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1. Introduction

In performing a construction project, quantity and cost estimation are the stages that have important roles in realizing construction projects. The estimated quantity and cost determine the amount of material, labor, and equipment used to complete a construction project accurately and within schedule. Quantity take-off is a detailed measurement of the material required to complete a construction project (Ghodoosi et al., 2021). To accurately measure the quantity, the calculation should be in detail and accurate to avoid miscalculations that could significantly impact the quantity of the final results of the work and the cost incurred. Cost estimation in construction is the process of forecasting the costs of constructing a structure.

There are several measurement standards used around the world, such as RICS – NRM (New Rules Measurement), POMI (Principle of Measurement International, Hongkong Standard Method of Measurement of Building Works, ISMM (Indonesian Standard Method of Measurement), and so on. Therefore, it is hoped that the quantity surveyors can calculate the quantity and cost correctly and acceptably. Each country has rules for measuring a work item. For example, in Indonesia, SMPI is a measurement standard compiled by Mr. Peter Robinson and Mr. Steve Osborne, based on Master Format: Master List of Numbers and Titles for the Construction Industry (Sinatra & Taasoobshirazi, 2015). However, in reality, SMPI is still rarely used by QS in measuring a work item. Meanwhile, RICS-NRM has three standards NRM 1, NRM 2, and NRM 3. However, in estimating quantity and cost, NRM 2 is used as a standard measurement rule to calculate the quantity of work items. NRM 2 is a measurement standard that is widely used in other countries apart from the UK. NRM 2 is mainly intended primarily for the creation of the bills of quantities and construction work schedules. However, the rules will also help plan and develop standard or bespoke rate schedules (Smith, 2016).

While calculating the total quantity of each work item, quantity surveyors can perform the traditional calculation method. However, Monteiro and Martins (2013) said that the traditional process had been carried out manually using a human interpretation of 2D construction drawings. Quantity surveyors must interpret a set of construction drawings, including floor plans, elevations, sections, and detail drawings, and measure each element according to element-specific measurement rules (Monteiro & Martins, 2013). Then, using computer-aided design (CAD) software, construction drawings are created, and lengths, areas, and volumes are calculated from those drawings. However, because quantity measurement requires manual labor and human interpretation, the overall process remains usually susceptible to error (Khosakitchalert et al., 2019). As a result, though, along with technology development, especially in the construction world, quantity and cost estimation calculations have been developed using the BIM method. This strategy gives more outstanding unwavering quality, exactness, and speed than the conventional amount departure technique (Khosakitchalert et al., 2020). Be that as it may, if the BIM model is inadequate or inaccurate, the amounts extricated can be deficient or go astray from genuine qualities. Therefore, a BIM model should contain suitable subtleties for an amount departure reason (Blay et al., 2019).

This research will discuss how to get more accurate quantity and cost estimates by utilizing BIM based on two measurement rules, namely RICS – NRM 2 and ISMM/SMPI. Perform a comparative analysis of the quantity and cost calculations between BIM-Based calculations using ISMM/SMPI with original data without using BIM and according to company measurement rules standard. Besides, to understand the advantages and disadvantages of using this method to calculate the quantity and cost of the construction project, find out which methodology is more efficient.

2. Materials and Methods

2.1 Building Information Modelling

Building information modeling (BIM) is software u sed to create and manage the data or model in 2D a nd 3D models for the design, construction work, an d operational process work. Along with this, professionals can use this platform to do their jobs better and effectively (Azhar et al., 2008).

2.1.1 Autodesk Revit

Revit is a 3D modeling software that allows users to model various building elements to visualize them before working in the field (Zolotova et al., 2015). Revit 2022 was used to help develop a quantity take-off BIM-based calculation in carrying out this research (Nguyen et al., 2022). Therefore, this software is beneficial in providing the output that is needed to research this.

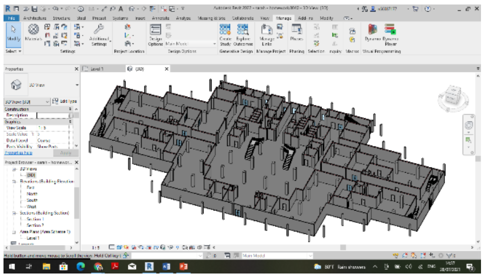

Fig 1. Autodeks Revit 2022

2.1.2 The Revit Hierarchy

Revit provides a way to determine the approach when modeling a design and understand when changes can affect the existing model. When this happens, all types of objects that exist in the built model will respond to the hierarchy that governs the data in the created model. Thus, all objects built using Revit software, specific or views are built by the same logic and elemental hierarchy (Mikhailov et al., 2020).

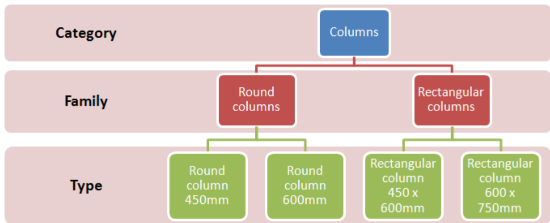

Fig 2. Revit Hierarchy System

Category: Provides all elements in Revit and must fall into one of these categories, according to this list.

Family : In family, an element in a project refers to a specific category and represents a physical item or organizing concept.

Type : In type the element that focuses on a variety of type of family-based on the standard of sizes, or other characteristics/

Instance : This is an element that focuses on an actual physical element based on their category and family type.

2.1.2 Level of Development

Level of Development is the scope in which the components "specification, geometry and related information were considered - in which he can depend on the extent to which project team elements can depend on the information when the model is used (*https://united-bim.com*). The LOD specification can be used in several ways, namely as an attachment to a construction contract and as a draft plan to check the work plan of the BIM. In addition, in table 1, LOD is also used as a general standard reference to explain information management. In this research, we will use LOD 350 to determine the specifications of the wall modeling components (Wu et al., 2010). LOD 350 makes it easier to perform the calculation quantity take-off for each material to be used separately from the initial material of the walls.

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Level of Development has six levels (LOD 100, 200, 300, 350, 400, and LOD 500) that represent a different stage of the design construction process that refers to specific building systems and components depending on which level will be used in the project (Latiffi et al., 2015).

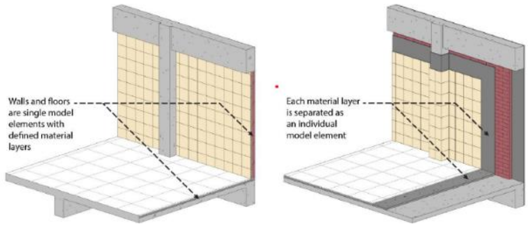

Fig 3. LOD 300 and 350 spesification for Walls

In this research, we will use LOD 350 to determine the specifications of the wall modeling components. LOD 350 makes it easier to perform the calculation quantity take-off for each material to be used separately from the initial material of the walls

2.2 Research Significance

This research focused on determining the quantity of wall work based on measurement rules in Indonesia and the UK, namely NRM 2 and SMPI. The standard is used to analyze cost and quantity and get the accurate quantity values for wall work items based on standard measurement rules BIM-based by using Visual Programming Dynamo to extract information or data from modeling wall work (Jin et al., 2015).

2.3 Result and Discussion

2.3.1 Compound Element and Level of Development

In Fig 3, finishing walls and core structure walls must be measured separately. However, the quantity calculation based on compound elements from several layers of materials is quite complicated, both traditional and BIM-based. This is because each layer of material from the core structure, exterior layer, and interior layer has different sizes, thicknesses, and material types are different from each other.

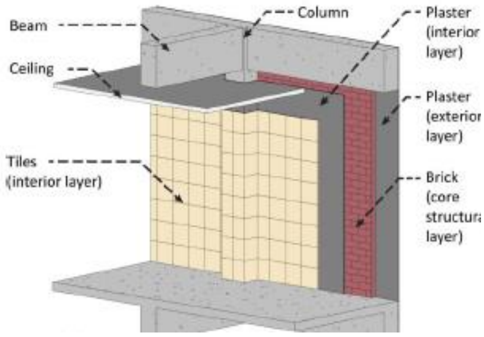

Fig 4.Compound Element of Wall Work Item using LOD 350

This research refers to the LOD Specification developed by the BIM Forum of the Associated General Contractors of America (AGC) and the American Institute of Architects (AIA). Their components will utilize LOD 350 as a reference for modeling settings. In table 2 explain what information will take from the wall element of each compound by developing LOD 350 into our project construction.

For finishing work, wall measurement is separated between external and interior wall finishing. The finishing layer can have more than one finishing layer (plaster, painting, ceramic, etc.). Based on NRM 2 and SMPI, things must be considered when calculating the quantity of work items of external and interior walls based on the work items being worked on and do it separately. For example, the height of the outer and inner wall finishing work has different dimensions if the inner wall has a ceiling, but if the inner wall is not connected to the ceiling, the height of the outer and inner walls is the same (Zaki et al., 2020).

2.3.2 Quantity Take-Off BIM Based

In calculating the BIM-Based QTO based on standard measurement rules, internal and external work will calculate separately (Olsen & Taylor, 2017). External and internal wall work has different sizes, functions, relationship-building elements, and wall height. To generate the quantity take-off BIM Based, Dynamo will help us calculate and analyze the quantity of wall, as shown in Fig 4, the flowchart to analyze the quantity results based on measurement rules standard used.

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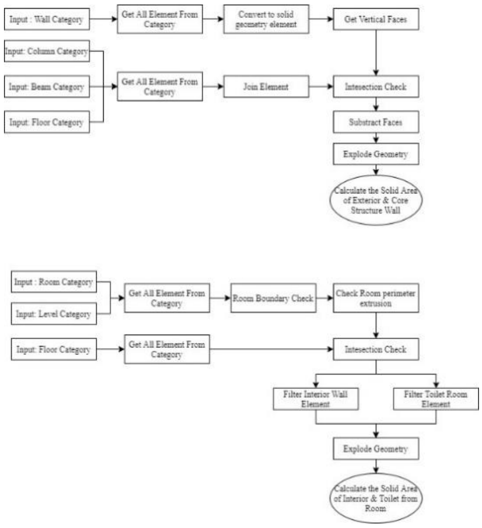

Fig 5. Dynamo Workflow Process

2.3.3 Exterior and Structural Wall QTO

Based on the measurement rules, each element related to the wall will be extracted information. For the next step, check whether each element is intersected/overlapping and whether their geometry is joined for each element with walls.

2.3.4 Input Data of Element

In Fig 3. exterior walls and core walls will have elements interconnected with other elements such as floors, beams, and columns. Dynamo helps us extract the information needed, analyze the quantity of the wall, and check if the wall clashes with other interconnected elements in the modeling that has been made.

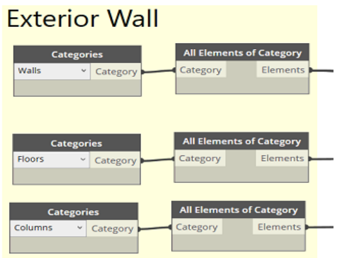

Fig 6 Data Input Dynamo Workflow

2.3.4 Filter element area ≤ 1m²

In the standard measurement of NRM 2 and SMPI, several rules need to be considered in calculating an accurate quantity. One of them is to avoid subtraction of voids if the area is less than 0.5m^2 from NRM 2 and 1m^2 from SMPI for plaster, painting, and masonry works, but for tile work, both standards have the same rules for deduction for a void area less than 1 m^2.

In Fig 6. described dynamo workflow to filter the opening/void area, which is less than 1m^2. Using nodes *Family Types* to filter the element have a total area less than 0.5 m^2 or 1 m^2, then use *Element.Set Parameter By Name* to extract element needed, and last used nodes *Pass Through* to eliminate elements that do not meet the requirements of the wall elements. In order to get results that follow the requirements standard of NRM 2 and SMPI measurement rules without changing the modeling that has made in the construction modeling (Barten & Ernst, 2004).

Dynamo helps us to filter areas/elements that are not following the rules. It is constructive because when creating 2D/3D modeling, we cannot delete the element of the door, window, pipes, etc., whose area is less than 0.5 m^2 or 1m^2. Because it will confuse construction workers, the designer or engineer will make two models of the construction project, one for QS to calculate the quantity and cost and the other for site workers. As seen in Fig 6, in dynamo, the void is ignored while drawing the void still input in the construction.

2.3.5 Intersection / Overlapping Element

In calculating the quantity of the work item, the element model will be carried out according to the required document. If the method used in the developed modeling is not following the existing elements, it will result in inaccurate quantity results. For example, Fig 7 is inappropriate modeling or overlapping or intersection between wall elements and other elements such as columns, beams, or even walls.

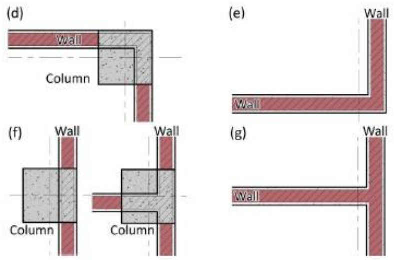

Fig 7. Intersection of All Element Building

Manually checking the intersecting building elements will take a very long time and is quite tiring. For example, overlapping and intersect checks are carried out between wall elements and floors, columns, and beams for core structure elements and exterior work items. In contrast, checks are made between floors, columns, beams, or ceilings and rooms for internal walls. This spilled area between the wall and other elements can cause an excess of the total quantity of the work.

Fig 6 uses a workflow dynamo to check the overlap or intersect between interconnected elements. We checked the overlapping between walls and interrelated elements using *Geometry.DoesIntersection* nodes to get solid elements from walls and other elements. Then, using the *List.Contains* node, we get solid elements that are final and do not overlap each other.

2.3.6 Extract Wall Geometry

After checking the overlapping and intersect between the wall elements and the interconnected elements, it is necessary to convert the wall geometry to separate the wall elements from the interconnected elements.

Employing dynamo nodes in analyzing the massive quantity calculation of the quantity of a good job and right, especially if it has a model element that has the type, size and location are different from each other (Bufferand et al., 2019).

2.3.7 Extract Quantity Data

In calculating the quantity of the material/layer of wall elements, each wall layer, both finishing and core structure, is modeled separately. Based on NRM 2 and SMPI, each layer used in wall construction must be measured separately. NRM 2 will calculate the quantity separately between the wall and the elements covered by the wall finishing. Meanwhile in SMPI, the calculations between walls and columns are carried out simultaneously, only performing separate calculations on the beam elements.

Quantity calculations also need to be analyzed per work floor. This is because the information needs to analyze BOQ and calculate the materials so that there is no overrun cost because each floor has different models. So it can be concluded that the use of a dynamo in analyzing quantity calculations and the materials needed in a wall job will significantly facilitate the work of the QS in the future (An, J. W., & Yun, 2017). The requirement is that if one wants to calculate the equipment needed must be calculated manually based on the information that has been extracted from the BIM modeling.

2.4 Summary

The author has employed the BIM model to calculate the quantity and generate the information needed to fulfill the needs of every work item and be used to calculate the cost and create a BOQ. However, this study understands the information needed at each stage by building an information flow structure. Import and export information, and then analyze cost work items and information required in creating a BOQ template according to the NRM 2 and SMPI measurement rules standards. Next, build according to the modeling rules to meet the requirements of BIM. After that, a smart module identification develops project information and outputs that meet the information needed from the work item and generate the required content of each work item by component element. Moreover, to perform filtration on walls that have voids from doors or windows where when using SMPI as a measurement rule when analyzing wall quantity calculations, it does not reduce the void element whose area is smaller than 1 m^2 while in NRM 2, the area is smaller than 0.5 m^2.

3. Result and Discussion

3.1 Case Study Description

In this stage, to validate the research methodology results that have been done in the previous chapter, a case study method will be used. The case study used is one of the construction projects in Indonesia that functions as a local government office, as shown in Fig 8. The description of the construction project is:

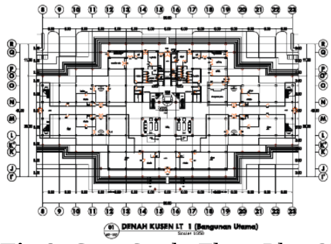

Fig 8. Case Study Floor Plan 2D

Project Name : New Construction of Regent's Office in Lampung, Indonesia
Building Scale : Main Building, 3 Floors
Durasi proyek : 2019 – December 2021
Case Study : Architect Walls

Table 1. Describes the specifications of the work items that will be used to analyze this research based on the case study document.

Material	Layers	Specification
Brick Wall	Core structure layer	Half brick with 240 mm x 110 mm x 52 mm ; 1:3 cement mortar
Plaster	Finishing for both side of wall	Cement and coarse sand with 15mm thickness
Painting	Finishing for both side of wall	2 Layers of Painting exterior 1 layer of panainting interior
Tile	Toilet finishing	Ceramic ; 240 x 240 mm with 0,01 mm thickness

3.2 Case Study Analysis

At this stage, the author will be discussing the analysis result of quantity take-off BIM Based on the case study by employing the measurement rules standard NRM 2 and SMPI. They analyzed the standard to get the quantity result of walls and the required information that can directly be extracted from the modeling to determine if any information or data needed to be calculated or created manually to create a BOQ. (An, J. W., & Yun, 2017).

3.2.1 Case Model Development

We were using two measurement rules standards to analyze the quantity of work items. It aims to understand the information that needs to be calculated and analyzed to get an accurate quantity and avoid differences in analyzing the quantity of a work item. In carrying out this research, the standards were also used to understand and analyze the data and information needed in making BOQ and calculating quantity. Table 2 describes the differences between the two standards in analyzing the measurement rules for the work items analyzed in this case study (An, J. W., & Yun, 2017). From the table above, it is known that the two standards almost have the same measurement rules. However, NRM 2 provides a more detailed item to analyze quantity calculations and explain step-by-step for making the bill of quantity.

Table 2. Rules Measurement SMPI and NRM 2 Comparation

Work Item	NRM2	SMPI
Masonry	No deduction will be made for voids or build less than 0.5 m²	No deduction will be made for voids or build less than 1.00 m²
	There are 22 works item to be measured	There are 15 works item to be measured
Cladding	There is no deduction made for voids < 0.5 m²	No deduction is made for voids < 1.00 m².
Tile	There are 8 kind of tiles in this clasification table	There are 23 kind of tiles in this clasification table
Painting	No deduction made for voids ≤ 1.00 m².	No deduction made for voids < 1.00 m².
	There are 12 kind of tiles in this clasification table	There are 21 kind of tiles in this clasification table

3.2.2 BIM Identification Work Item Information

From the results of data analysis, the use of BIM is beneficial in extracting data that is not attached. Based on the analyzed work items, the total quantity was assisted by using a dynamo in exporting the information needed in BIM modeling. As shown in Fig 9, the information of wall layers also the total quantity of work items inside the room. This information cannot be extracted directly from the modeling except by filling in the information box manually. it is also possible to see the room's number and function, the layer used in the wall work according to the work item stated in the measurement standard, and the total quantities based on the analysis result (Lee et al., 2014).

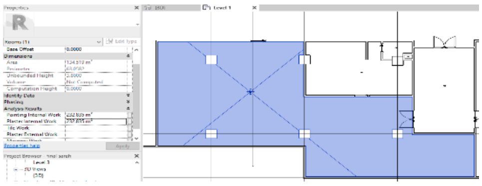

Fig 9. Information About Interior Work Based on Rooms

Fig 10 is the result of extracting information and calculating the quantity and data requirements needed for exterior, interior, and core structure walls.

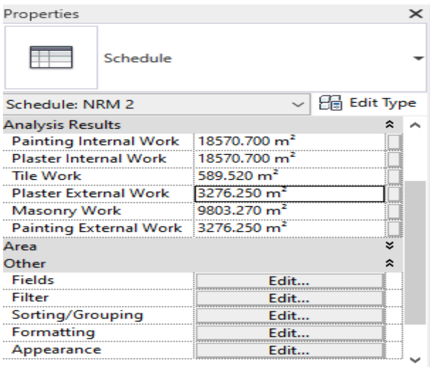

Fig 10. Information of Architectural Wall Quantity

Intersection/Overlapping Analysis

From the results of the analysis that has been done, checking intersections/overlapping and joining geometry between walls and other building elements of BIM modeling, which is interconnected, helps in getting accurate quantity calculations. Fig 5.4. explains the 3D modeling, masonry work, and also exterior walls (plaster and painting) (Siontis et al., 2013). The analysis results differ by checking whether the modeling experiences overlap or intersect each element related to the core structure and exterior wall. Especially when inputting modeling data, the wall height is attached to 2 floors or unconnected, as shown in Fig 5.5, and if we did not change the wall height under the floor or ceiling or beam, the wall quantities would not be accurate. That is why an intersect/overlapping analysis is needed to avoid quantity inaccuracies.

Result Analyze and Comparation

From the analysis above, BIM Based quantity take-off results are obtained following the type and unit of each wall finish used in interior and exterior work and core wall structure. Table 3 is the result of the quantity take-off BIM Based based on the standard NRM 2 and SMPI measurement rules.

Table 3. Quantity Take-Off BIM Based of NRM 2 and SMPI

Work Item	NRM 2 (m^2)	SMPI (m^2)	Deviation (%)
Masonry	9803.28	9808.35	0.0517
Plaster Ext	3276.25	3276.25	0.0000
Plaster Int	18570.7	18579.79	0.0489
Painting Ext	3276.25	3276.25	0.0000
Painting Int	18570.7	18579.79	0.0489
Toilet	589.52	589.52	0.0000

From the analysis of the results of two standards' measurement rules are compared. Several work items have the same quantity values, and some have different results, especially masonry, painting, and plaster interior work items. This is because there are differences in the rules of the two standards is no deduction less than 0.5 m^2 and 1 m^2. In the case study, there are voids area less than 1 m^2 (0.9 m^2), as shown in Fig 5.5. Therefore, the QTO BIM Based SMPI result is more extensive than NRM 2 of 0.0489 - 0.0517 %. However, plaster and exterior painting have the same result because there is no void area less than 0.5 m^2 and 1 m^2 and have the same rules for deducing void less than 1 m^2 (Eynon, 2016). The original data is used to perform the comparative analysis in a construction project that does not employ BIM technology in conducting cost and quantity analysis on architect walls. In addition, the original data did not use the SMPI measurement rules standard as a basis for analyzing the quantity of architect walls' work (Pidgeon & Dawood, 2021). In table 4, the comparison results between the original data and data analysis using SMPI QTO BIM Based.

Table 4. Comparation QTO BIM Based and Original Data

Comparation between SMPI and Previous Data			
Work item	**SMPI (m^2)**	**Original Data (m^2)**	**Deviation (%)**
Masonry	9808.35	10034.92	2.31
Plaster Ext	3276.25	3469.09	5.56
Plaster Int	18579.79	18969.04	2.10
Painting Ext	3276.05	3469.09	5.56
Painting Int	18579.79	18969.04	2.10
Tile	589.52	621.76	5.19

From the results of the analysis above, it can be seen that there is not much difference in the quantity take-off of each work item from the original data and SMPI BIM-Based (Lim & Latief, 2020). SMPI measurement rules standard, the four work items have rules of no deduction voids whose area is <1m^2, while the measurement rules used by the original data do not have the same rules SMPI. The exterior wall does not have a void area <1m^2, which is 5.56% original data bigger than SMPI QTO BIM Based (Ghosh et al., 2013). The difference between the two data caused by human error, double calculation, uncounted data, and the information provided from the original data is different from the existing modeling data or a different way of calculating work items due to using different measurement standards shown in table 4 below. Therefore, the cost estimation is obtained from the two data above. The results showed that by using BIM and using SMPI as a measurement guide, it was 3% cheaper than the original data without using BIM and using other measurement standards as a reference for quantity calculations.

Table 5. Cost Estimation Comparation

Work item	**SMPI**	**Original Data**
Masonry	Rp 1.831.525.455,94	Rp 1.873.833.155,25
Plaster	Rp 2.276.743.686,80	Rp 2.337.380.002,10
Painting	Rp 3.321.763.120,78	Rp 3.410.262.553,77
Tile	Rp 197.489.642,14	Rp 211.640.073,82
Total	Rp 7.627.521.905,65	Rp 7.833.115.784,94
Deviation	**3%**	

Additionally, after comparing data analysis between BIM - Based use SMPI and original data, it can be seen in Fig 11 BOQ templates commonly used in construction projects in Indonesia, especially those also used in original data.

No	Description	Code	Qty	Volume	Unit Price	Total Price
B	Architecture Work					
I	Wall Work					
I.1	Wall Work 1st Floor					
1	Half Brick Wall Work	A.4.4.1.8	m2	3912,8	IDR 186.731	IDR 730.634.566
3	Plester of Brick Wall	A.4.4.2.4+A.2.2.	m2	7420,4	IDR 104.170	IDR 772.983.068
4	Bathroom Wall Ceramic 24/24	Supl A.4.4.3.50	m2	135,9	IDR 335.001	IDR 45.526.602
	Total I.1					IDR 1.549.144.236
I.2	Wall Work 2nd Floor					
1	Half Brick Wall Work	A.4.4.1.8	m2	3906	IDR 186.731	IDR 729.368.528
3	Plester of Brick Wall	A.4.4.2.4+A.2.2.	m2	8438,2	IDR 104.170	IDR 879.007.294
4	Bathroom Wall Ceramic 24/24	Supl A.4.4.3.50	m2	176,8	IDR 335.001	IDR 59.228.133
	Total I.2					IDR 1.667.603.954
I.3	Wall Work 3nd Floor					
1	Half Brick Wall Work	A.4.4.1.8	m2	4046,6	IDR 186.731	IDR 755.626.676
3	Plester of Brick Wall	A.4.4.2.4+A.2.2.	m2	9018,3	IDR 104.170	IDR 939.439.436
4	Bathroom Wall Ceramic 24/24	Supl A.4.4.3.50	m2	397,06	IDR 335.001	IDR 133.015.398
	Total I.3					IDR 1.828.081.510
II	Painting Work					
1	Wall Painting Work	A.4.7.1.10a	m2	24877	IDR 151.985	IDR 3.780.923.938
	Total II					IDR 3.780.923.938

Fig 11. BOQ Template of Original Data

From the template above, in order to be able to find information about the measurement rules, type of materials, and the equipment that will be used, stakeholders and the workers must read the project standard book that the company has made. This standard cannot be used for all construction projects, and it is because the standard is only for this project. For example, Fig 11 is a measurement rules standard made by a company that is not based on standard measurements such as NRM 2 or SMPI.

3.1 Summary

For the summary, it is known that NRM 2 in the preparation of BOQ, cost analysis, and also the calculation of quantity is more detailed than using SMPI. However, some work items in NRM 2 and SMPI have similar measurement rules, such as decoration work item (tiles) at NRM 2 and tiles and cover plates work item at SMPI. In that case, it is highly recommended to use NRM 2 as a reference in making and compiling documents ranging from contracts, tenders, drawings, etc. Meanwhile, SMPI does not regulate the stages of work from start to finish. Instead, it only explains the measurement rules and what information is needed to make a BOQ because SMPI still refers to 2D construction modeling or printing. Besides, it is also to avoid over quantity, affecting the total material requirements and overrun costs. Even though BIM Based QTO is advantageous to save time on work in making BOQs, some things using BIM cannot fully extract the required information, so we have to use other calculation methods (manual). Last but not least, the author performed a comparison analysis of the cost and quantity calculation data between SMPI BIM-Based and the original data. The result shows that SMPI BIM Based can provide more accurate and faster calculation results than the original data, almost saves the quantity of material by 2.10 – 5.56%, and for the estimated cost of 3%, BIM Based is more profitable than manual calculations. In addition, the measurement rules of SMPI can be used conventionally in all construction projects in Indonesia

4. Conclusion

Using BIM to calculate the quantity take-off and cost, especially wall work, is very helpful for construction workers in completing the Bill of

Quantity precisely and in a relatively shorter time. It is because it can automatically extract the information needed on a construction project. BIM-Based QTO is hoped to be based on the measurement standard rules issued by the country or standards used worldwide when conducting the analysis. The goal is to calculate QTO based on existing rules like NRM 2, SMPI, etc. The QTO calculation work can be done correctly and structured to avoid repeated or uncountable calculations. This research focuses on architecture walls because walls have more than two relationships with other elements. Furthermore, by using two standards in calculating QTO, it was found that there were differences in the measurement rules of the two standards, especially the area of internal wall work (plaster and painting) and the core wall structure.

The SMPI and NRM 2 measurement standards are equipped with a BOQ writing template to facilitate QS's work in making a good BOQTherefore, when calculating the estimated cost of each work item, there is also no overrun cost. However, in both standards, it was found that some information/data had to be calculated or analyzed manually, which could be done by using Dyanamo's visual programming to extract the required data/information. Information or data that can be taken directly from BIM in writing BOQ is the total quantity per work item, type of walls/materials (based on the material of the walls), thickness, volume, function, and coordinates. However, we cannot find or extract equipment, total quantity for other material used based on unit cost standard, and manpower. Therefore, I need to do it manually by using MS. Excel.

A comparison is made with one of the existing construction projects in Indonesia to know the difference in the cost and total quantity, especially on wall work. From the results of the analysis, it was found that utilizing BIM technology in calculating the quantity of wall works will facilitate the work of QS, especially if in the middle of the work, the owner wants to change the modeling or material of the walls. In addition, by using one standard measurement rules, namely SMPI, how to measure, steps for making BOQ, and what things need and do not need to be done in calculating quantity and cost, every construction project will have the same method and standard.

So that by doing this analysis, it can be one step for QS to be able to take advantage of SMPI BIM-Based in calculating quantity and also calculating cost estimation. in order to avoid the quantity calculation process that is too long, error-prone, and also overrun costs that often occur because in Indonesia there are still many companies that have not utilized BIM and SMPI in estimating a construction project. or even though there are already companies that have used BIM in analyzing quantity and cost, but to get an accurate quantity, checking the intersect or overlap between walls and other elements is still doing data input or editing manually or even not realizing it when modeling walls. So that by utilizing visual programming, it is beneficial for QS to analyze later or even model each wall works automatically on the entire construction project, which saves time and avoids calculations carried out by more than one person, which can give different quantities results.

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