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Utilizing Building Information Modelling in the Tax Assessment Process of Apartment Buildings

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Abstract. The increasing demand for vertical residential development, particularly in urban areas, contributes to regional income growth through the collection of building taxes. In Indonesia, the vertical building is one of the non-standard objects applying an individual tax building assessment based on the building component cost list (BCCL) table in determining the value of the payable tax. However, the existing assessment system still cannot show the actual value of the building due to its limitations. Consequently, the building tax assessment process is ineffective and inefficient regarding assessment time and value accuracy. This study investigates the utilization of Building Information Modelling (BIM) in the assessment process of building taxation, considering a high-rise apartment building in Indonesia as the case study. The findings show that compared to the existing system, the final building value used as the basis in the tax assessment can be generated more accurately, involving a detailed calculation of dimensions and variations of building materials. It can be concluded that BIM's capability to recognize building objects, extract quantity, and calculate automatically can help improve the objectivity of the assessment results and time efficiency in the tax assessment process.

Keywords: Apartment; Building Information Modeling; Tax assessment

1. Introduction

The high rate of urbanization has increased the demand for housing in urban areas. However, this growth faces some challenges regarding physical infrastructure development, one of which is limited land availability (Qin & Wang, 2019; Habibi & Asadi, 2011). Some major cities in developing countries develop residential buildings in a vertical direction as one of the strategies to meet the housing needs of city inhabitants (Lau, 2011; Wong, 2004). In addition to solving the housing demand problem, these developments also bring a stream of income for regional governments through the tax on buildings (Berawi et al., 2021; Cho & Choi, 2014).

Based on the Law of the Republic of Indonesia Number 28 of 2009 concerning Regional Taxes and Levies, a vertical housing unit is indicated as a tax object, the tax imposition of which is determined through an individual assessment scheme. This building tax assessment is based on the building component cost list (BCCL), carried out by involving

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several documents, such as Tax Object Notification Letters, Tax Object Notification Letters' Attachments, and Tax Object Worksheets. This assessment process needs to be conducted at least every three years to renew the selling value of the building (Asher, 2002). However, assessments are only done for new tax objects due to limited resources (Anwar, 2019).

Implementing the individual building tax assessment reports used by the appraisers from relevant agencies in the BCCL method is expected to enable the assessment results to be followed by performing the steps of the appraisal process. However, this assessment method has not fully answered the needs of appraisers or surveyors in following and reconstructing the assessment process because, in reality, the delivery of assessment results is still limited to verbal descriptions, writing, and images (Hendriatiningsih et al., 2019; Haldenwang et al., 2015). Furthermore, assessment using 2D images lacks accurate projection for the 3D physics of a building (Rajabifard et al., 2018; Shojaei et al., 2013).

3D visualization has been widely known to have the ability to show better accuracy in understanding and interpreting data, as well as displaying a more solid form, improving the delivery of information from existing physical buildings (Seipel et al., 2020; Hassan et al., 2008). Previous studies have supported this statement; Atazadeh et al. (2016) demonstrate how 3D digital data associated with various complex ownership spaces can be visualized and managed by developing a prototype Building Information Modelling (BIM) model for a multi-story building. Moreover, Atazadeh et al. (2021) also proposed a prototype BIM model showcasing that land administration and its registry information can be mapped into a 3D BIM environment.

Correspondingly, the building information's completeness and disclosure from the 3D visualization can be utilized to improve the accuracy of the individual building tax assessment reports (Isikdag et al., 2014). On top of that, an assessment system with a high-speed updating process is required to support the accuracy of tax revenue assessment. Therefore, this study attempts to investigate the solution to the need for a relatively faster and more accurate updating process of building tax assessments by utilization of BIM technology. The fifth dimension of BIM was employed, which has the capability of design planning, cost estimation, and scheduling of a construction project (Kisel, 2021).

Previous studies have also explored the use of BIM-based 3D visualization in various areas of building cost estimation. El Yamani et al. (2019) demonstrated the potential of BIM as an emerging technology to improve the housing valuation system based on the hedonic approach, arguing that 2D applications are limited in communicating the complexity of a 3D building structure. Furthermore, Sladić et al. (2020) proposed a more efficient process model for building a public registry in Serbia incorporating BIM-based 3D information. On the city scale, Arcuri et al. (2020) developed an automated calculation of the depreciated reconstruction cost (DRC) by integrating geographic information systems (GIS) technology and BIM 5D. However, minimal studies have been found to have compared the calculation of building valuation between the manual and BIM-based assessment methods. This study is expected to contribute to building valuation and tax assessment literature.

2. Methods

This study was conducted in two steps to obtain its research objective, adopting both qualitative and quantitative approaches. In the first step, the qualitative method was carried out through a literature study and in-depth interviews with experts to identify the variables from individual building tax assessments that can be integrated into BIM. Accordingly, the second step used the quantitative approach to utilize the BIM application as an alternative for apartment building tax assessments. The variables identified in the first step were used to perform cost calculations and BIM model prototyping, applied to the case study, an apartment building in Jakarta, Indonesia, called the MS apartment.

The information from the BIM model is used as the basis for the building value calculation, conducted in several steps as implemented in Hendriatiningsih et al. (2019):

1) Determining the construction work type based on data from the construction work unit, completed with material composition and coefficients.
2) Specifying the cost of work types based on the volume calculated from the BIM model
3) Selecting the building facilities' procurement cost from the information in BIM.
4) Calculating the building's Replacement Cost New (RCN), an estimate of the construction cost based on current labor and material prices for new construction of the same usability, size, and design. The construction work units issued by the Indonesian Ministry of Public Works were used to determine the price of building materials for each building component. The value obtained from the RCN calculation is then reduced by the depreciation value to get the final building value. The process is explained in Figure 1.
5) Calculating the depreciation value (DV) using the Straight Line Method (SLM), based on the number of months computed using the following Equation (1):

$$DV = (IDR) = \frac{Number\ of\ years\ from\ built\ to\ assessed}{Economic\ Life\ (in\ years)} \times RCN \quad (1)$$

6) Calculating the building's practical life (BPL) as one factor of physical depreciation, using Equation (2) below:

$$PL = \frac{(tax\ year - built\ year) + 2(tax\ year - renovated\ year)}{3} \quad (2)$$

Noting that,
If $(year - built\ year) < 10$ and $renovated\ year = 0$
then $BEL = (tax\ year - built\ year)$
If $(tax\ year - built\ year) > 10$ and $renovated\ year = 0$
or $(tax\ year - renovated\ year) > 10$ $renovated\ year = tax\ year - 10$ is considered
then BEL is calculated using Equation (2)

7) Calculating the final value of the building that becomes the building's Sales Value of the Tax Object (SVTO), which is calculated using Equation (3).

$$SVTO(IDR) = RCN - DV \quad (3)$$

After the building costs had been calculated using the BIM 3D model, a comparative analysis between conventional BCCL and the BIM-based methods was conducted. The collected primary and secondary data used in this study include:

1) The apartment building's tax assessment reports were obtained from the Office of Regional Tax and Levy Service at the sub-district level, where the apartment is located
2) Building historical data of the case study in the form of geometric and non-geometric data obtained from the project construction service company
3) Field survey data are taken from surveys and field documentation to supplement building information

Finally, in-depth interviews were conducted to validate and obtain feedback from building tax professionals (Berawi et al., 2019), particularly regarding the proposed BIM-based building tax assessment approach. Figure 1 shows the research workflow.

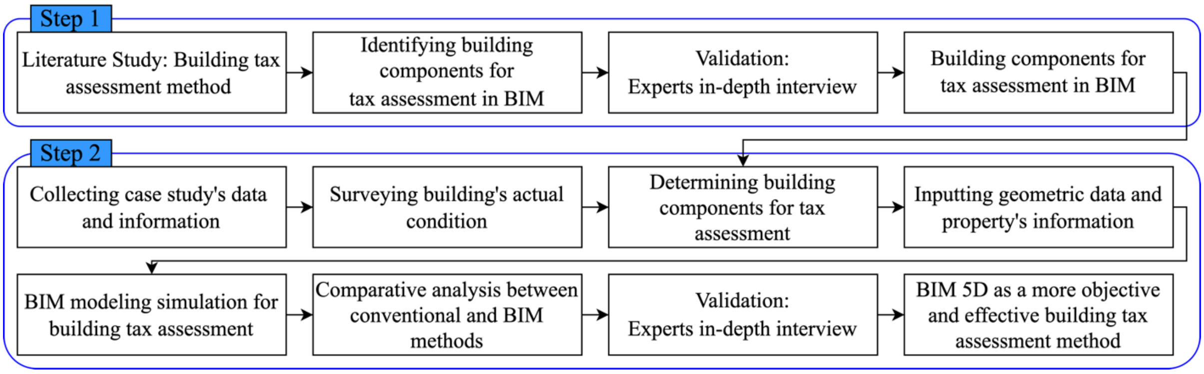

Figure 1 Research Workflow

3. Results and Discussion

3.1. Building Components for Tax Assessment Integrated into BIM

The literature study conducted to determine the variables of building tax assessments that can be integrated into BIM examines the literature discussing the use of 3D variables in property valuation. The variables obtained are classified into indoor and outdoor variables. However, it was found that the BIM model is more suitable for reviewing indoor variables because it has semantic and geometric capabilities at the scale of building elements (Zhao, 2017; Domínguez et al., 2011). Therefore, the 3D building variables modeled in BIM significantly affect the building value for tax assessment were focused on indoor variables. It is in line with previous research on 3D modeling for property valuation, stating that 3D building variables considered in tax assessments were indoor structural variables, namely property geometry, size, level, cost, and quality. In contrast, the outdoor building variable is generally used for land tax assessment (Yamani et al., 2021; Arcuri et al., 2020).

Moreover, a comparison between the data structure of the Tax Object Notice and the BIM model in Autodesk Revit was carried out to identify 3D building components for tax assessment handled in BIM applications. The specified building components and the identity data in the BIM model are summarized in Tables 1 and 2, respectively.

Table 1 Building Components for Tax Assessment in BIM Autodesk Revit

Building Components					
1	Air terminals	11	Basement Floor Area	21	Gate
2	Ceilings	12	Flooring	22	Hot water system
3	Communication devices	13	Roof	23	Sewage treatment system
4	Electrical power	14	Structural column material	24	ArtesianAquifer
5	Genset equipment	15	Exterior wall material	25	Reservoir
6	Fire protection	16	Interior wall material	26	SwimmingPool
7	Lightning rod	17	Exterior wall coating material	27	Tennis Court
8	Number of building floors	18	Interior wall coating material	28	Road Pavement
9	Number of basements	19	Type and number of lifts	29	Sound System
10	Building area	20	Type and number of escalators	30	TV System

Table 2 Components' Identity Data in BIM Autodesk Revit

Identity Data					
1	Area	6	High	11	Type
2	Cost	7	ID Material	12	Volume
3	Count	8	Length	13	Work Breakdown Structure
4	Family	9	Level	14	Width
5	Family and Type	10	Material: Name	15	Total Cost (Customize)

3.2. Utilizing BIM for Tax Assessment of Apartment Building

3.2.1. Developing 3D Model in BIM for Property Value

Historical data of the investigated apartment building, results of field surveys, and additional data collected were then inputted as the basis for developing a 3D model in Autodesk Revit as the BIM tool used in this study. In the early modeling stages, the BIM model's objectives and detail need to be defined. In this study, BIM modeling is intended to estimate the RCN of a building; therefore, the approach used is the BIM 5D, which can estimate building costs (Reizgevičius et al., 2018). The accuracy of the information used and the model's ability to meet this objective need to be adjusted to a specific Level of Development (LOD) (Latiffi et al., 2015). Therefore, the LOD 300 was used in this study for its ability to define the approximate quantity, size, shape, and location, making its model components expressed with the correct dimensions in a precise position.

The BIM model development was started by determining the constituents of building information, which include the main building components, material components, facility components, datum elements, and annotation elements. Consequently, data on the determined components and features were then collected from the 2D and 3D technical drawing documents of the MS Apartment project. The identities of building components used in the BIM modeling in this study include the size data of the building components, work unit price analysis, Material ID, and the WBS code. Building component size data were obtained automatically from the BIM model quantity extraction results. Meanwhile, the identity data for analysis of work unit prices, Material IDs, and WBS codes used were generated from the MS Apartment project documents.

In the BCCL assessment, the structural component of a building has become an integral part of the main building; therefore, the structure's modeling for the building valuation was not carried out in this study. Furthermore, there was a lack of information obtained for facility components. Consequently, the values for the main structure and facility components used as the assumption were adopted from the assessment reports manually submitted in the BCCL method. Hence, the comparative data in this study was conducted for the value of building components consisting of inner wall materials, inner wall cladding, outer wall materials, outer wall cladding, ceilings, roof coverings, and ceiling coverings. Figure 2 shows the process of developing the BIM model.

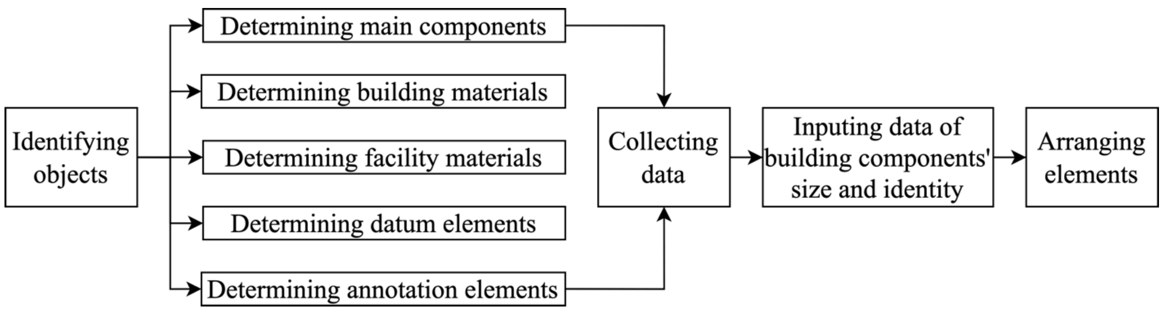

Figure 2 The Process of 3D Modeling in BIM Revit

The BIM model was developed starting from the building components, such as walls, floors, and the roof system, followed by the identity data. The 3D model of three apartment floors being developed in BIM with its identity data is shown in Figure 3.

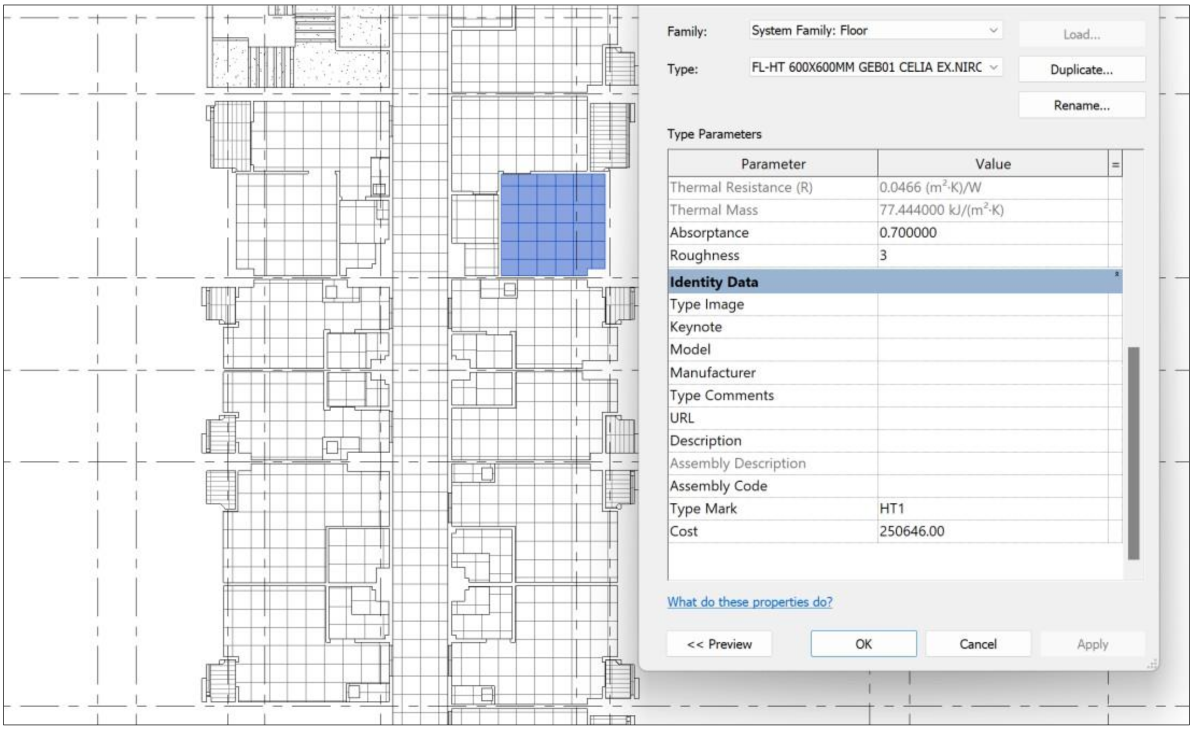

Figure 3 Inputting identity data to the floor components of the 3D model in BIM Revit

Moreover, the BIM 5D can estimate building costs through automatic quantity extraction in Revit and can be used to display information on the take-off material from 3D models. The non-graphical data from the 3D model was extracted and generated as tabular data, which was then exported into a spreadsheet application. Figure 4 shows the information display generated for the floor material from the third basement to the ground floor.

Floor Material Takeoff (LT B3-GF)

<Floor Material Takeoff (LT B3-GF)>

A	B	C	D	E	F	G	H
Family and Type	Material: Name	Level	Material: Area	Cost	Total Cost	ID MATERIAL	WBS
ANDESIT 200X200MM BLACK FLAME 2CM							
<varies>	ANDESIT 200X200MM BLACK FLA	GROUND FL MIDHIGH	158.38 m²	465886.00	73,787,423		1117048-1-03-03-
ANDESIT 200X200MM BLACK FLAME 2CM			158.38 m²		73,787,423		
ANDESIT 200X200MM BLACK HONED 2CM							
<varies>	ANDESIT 200X200MM BLACK HON	GROUND FL MIDHIGH	23.44 m²	465886.00	10,919,134		1117048-1-03-03-
ANDESIT 200X200MM BLACK HONED 2CM			23.44 m²		10,919,134		
ANDESIT 200X600MM BLACK HONED 2CM							
Floor: FL- ANDESIT BLACK HONED 200X600MM 2CM	ANDESIT 200X600MM BLACK HON	GROUND FL MIDHIGH	47.17 m²	465886.00	21,974,615		1117048-1-03-03-
ANDESIT 200X600MM BLACK HONED 2CM			47.17 m²		21,974,615		
ANDESIT 300X600MM BLACK FLAME 2CM							
Floor: FL- ANDESIT BLACK FLAME 300X600MM 2CM	ANDESIT 300X600MM BLACK FLA	GROUND FL MIDHIGH	3.19 m²	465886.00	1,487,611		1117048-1-03-03-
ANDESIT 300X600MM BLACK FLAME 2CM			3.19 m²		1,487,611		
ANDESIT 600X600MM BLACK FLAME 2CMM							
Floor: FL- ANDESIT BLACK FLAME 600X600MM 2CM	ANDESIT 600X600MM BLACK FLA	GROUND FL MIDHIGH	929.01 m²	465886.00	432,811,218	1100000673	1117048-1-03-04-
ANDESIT 600X600MM BLACK FLAME 2CMM			929.01 m²		432,811,218		
Andesit Flame Honed 300x600							
<varies>	Andesit Flame Honed 300x600	GROUND FL MIDHIGH	25.38 m²	465886.00	11,824,505	1100000673	1117048-1-03-04-
Andesit Flame Honed 300x600			25.38 m²		11,824,505		
BATU CORAL							
Floor: FL-PABBLE STONE	BATU CORAL	GROUND FL MIDHIGH	125.83 m²	222750.00	28,028,939		1117048-1-03-03-
BATU CORAL			125.83 m²		28,028,939		
CMST (CEMENT MORTAR STEEL TROWEL)							
Floor: FL-ISLAND DPP CMST	CMST (CEMENT MORTAR STEEL T	<varies>	192.75 m²	90726.00	17,487,888	1100001775	1117048-1-03-03-
CMST (CEMENT MORTAR STEEL TROWEL)			192.75 m²		17,487,888		
Concrete, Cast-in-Place gray							
<varies>	Concrete, Cast-in-Place gray	<varies>	2,097.27 m²	<varies>	744,739,768	<varies>	1117048-1-03-03-
Concrete, Cast-in-Place gray			2,097.27 m²		744,739,768		
CT-1 300X300MM NEVADA GREY EX.MULIA TILE							
Floor: FL-CT 300X300MM NEVADA GREY EX. MULIA TILE	CT-1 300X300MM NEVADA GREY	<varies>	68.26 m²	253787.00	17,322,688	1100001946	1117048-1-03-03-
CT-1 300X300MM NEVADA GREY EX.MULIA TILE			68.26 m²		17,322,688		
CT-2 300X300MM BRISTOL WHITE							
Floor: FL-CT 300X300MM BRISTOL WHITE t=100mm	CT-2 300X300MM BRISTOL WHITE	B3	36.67 m²	253787.00	9,307,431	1100001775	1117048-1-03-03-
CT-2 300X300MM BRISTOL WHITE			36.67 m²		9,307,431		

Figure 4 Information display for the floor material in BIM Revit

Figure 5 shows the 3D model fully developed in BIM 5D. The utilization of a BIM-based 3D model in calculating the building value based on its geometric form in the model and the cost aspect is discussed in the next section.

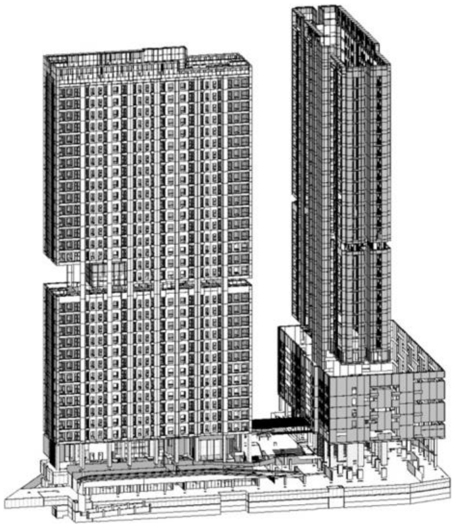

Figure 5 3D Model of MS apartment building developed in BIM Revit

3.2.2. Comparative Analysis of Property Value Between BIM-based and Manual Methods

The building component costs in the BIM method were calculated based on their volume on the BIM 3D model. The comparative analysis of the building component costs from both the BCCL and BIM-based calculations is detailed in Table 3 below.

Table 3 The Calculation of Building Component Cost

BCCL		BIM	
Material Name	Total Cost	Material Name	Total Cost
Interior Wall Material		**Interior Wall Material**	
Half Brick Wall	IDR 8,234,284,604	75mm lightweight brick	IDR 3,899,640,972
		100mm lightweight brick	IDR 5,354,063,067
		125mm lightweight brick	IDR 734,828,187
		6mm Calciboard	IDR 29,900,811
		GRC	IDR 31,536,741
		9mm Gypsum	IDR 14,200,268
		9mm Gypsum WR	IDR 810,925
Interior Wall Coating Material		**Interior Wall Coating Material**	
Paint	IDR 868,624,750	Interior Paint	IDR 1,588,205,928
		Oil Paint	IDR 305,409,148
		Ceramics	IDR 27,074,143
		Homogeneous Tiles 1	IDR 28,531,748
		Homogeneous Tiles 2	IDR 7,006,202,673
		Homogeneous Tiles 3	IDR 39,906,667
Granite	IDR 329,440,860	Metal Ceiling	IDR 106,887,500
		Teracota	IDR 426,462,636
		Andesite	IDR 221,935,248
		Marble	IDR 2,683,915,511
		Artificial Wood	IDR 218,917,455
Exterior Wall Material		**Exterior Wall Material**	
Precast Concrete	IDR 36,029,657,496	Precast Concrete	IDR 15,562,370,996
		8mm GRC Panel	IDR 6,998,061,906
Exterior Wall Coating Material		**Exterior Wall Coating Material**	
Paint	IDR 3,146,615,010	Exterior Paint	IDR 659,703,270
Ceiling		**Ceiling**	
Gypsum	IDR 25,129,980,120	9mm Gypsum	IDR 9,419,550,533

BCCL		BIM	
Material Name	Total Cost	Material Name	Total Cost
		9mm Gypsum WR	IDR 2,739,888,661
		Skimcoat	IDR 533,879,627
		Aluminium Composite	IDR 279,303,712
		Metal Ceiling 1	IDR 7,202,301,600
		Metal Ceiling 2	IDR 482,104,714
Roof		**Roof**	
Concrete	IDR 357,347,956	Concrete	IDR 1,105,887,724
Flooring		**Flooring**	
Cement	IDR 469,759,360	Andesite	IDR 1,393,777,170
Loka Marble	IDR 1,410,347,500	Coral Stone	IDR 16,084,813
Stone CERAMICS	IDR 7,388,719,632	Cement	IDR 698,769,837
		Ceramics 1	IDR 153,310,189
		Ceramics 2	IDR 43,764,400
		Floor Hardener 1	IDR 221,489,592
		Floor Hardener 2	IDR 455,135,570
		Homogeneous Tiles 1	IDR 8,028,604,946
		Homogeneous Tiles 2	IDR 56,977,275
		Homogeneous Tiles 3	IDR 5,328,471
		Pebble Stone	IDR 414,315
		Artificial Wood	IDR 27,092,428
		Marble	IDR 506,883
		Gutter Grill	IDR 17,261,100

Table 4 compares the component costs of the building's RCN value used as a constituent of the building tax expected value and the existing BCCL method.

Table 4 Comparison of Apartment's RCN Value between BCCL and BIM-Based Methods

No.	Building Component	Building's RCN Value	
		BCCL Method	BIM-Based Method
1	Main components	IDR 253,933,278,610	IDR 253,933,278,610
2	Interior wall material	IDR 8,234,284,604	IDR 10,064,980,971
3	Interior wall coating material	IDR 1,198,065,610	IDR 12,653,448,657
4	Exterior wall material	IDR 36,029,657,496	IDR 22,560,432,902
5	Exterior wall coating material	IDR 3,146,615,010	IDR 659,703,270
6	Ceiling	IDR 25,129,980,120	IDR 20,506,915.28
7	Roof	IDR 357,228,478	IDR 1,105,887,723.79
8	Flooring	IDR 9,268,826,491	IDR 11,524,303,089
9	Sanitation	IDR 42,216,015,504	IDR 42,216,015,504
10	Plumbing	IDR 16,431,360,218	IDR 16,431,360,218
11	Supporting facilities	IDR 90,604,103,440	IDR 90,604,103,440
	RCN Value (before depreciated)	IDR 486,549,415,582	IDR 461,775,969,523.14

From the table above, the values of the main structural and facility components produced in both methods are the same since they are not included in this research. Meanwhile, the material elements are composed of interior walls, exterior walls, ceilings, roofing, and floorings; therefore, there are differences between the values of the two methods.

There is a difference in the value of the new replacement costs, particularly in the material of building components investigated in the study. This difference in the material components' values was influenced by the detailed calculations of dimensions and building material variations of the BIM model compared to the BCLL method, as well as differences in the analysis of the unit price of work used. The comparative analysis shows that in the BCCL method, element variables, building element quantity variables, and quality variables are still general and do not describe the actual condition of building components.

The value generated in the BIM method shows results that better describe the actual condition of the building compared to the BCCL method, which has limitations in reviewing building elements, quantities of the building elements, and the quality of the building elements. These limitations were evidenced by the presence of material not included in the BCCL method's list of tables; therefore, it cannot be considered in the building value calculation.

For example, the BCCL method can only review one type of interior wall material (half brick wall) with building area information (outside the basement) of 42,098 square meters used as the component quantity assumption. In contrast, the BIM-based method can show that the interior wall elements are composed of 75 mm, 100 mm, 150 mm lightweight brick, Calciboard, GRC, 9 mm gypsum, and 9 mm gypsum WR.

Furthermore, through its ability to perform quantity extraction through the material take-off feature, the BIM method can display the quantity calculation of each material in more detail and more accurately, following the actual conditions of the MS apartment, which applies to other building elements. For example, the roof cover material in the BCCL method was calculated at 271.5 square meters, while it was estimated at 658.819 square meters from the 3D model of the BIM method.

In addition, the factor affecting the difference in the values produced by the two methods is the work unit price analysis used. The BCCL method uses a work unit price table issued by the Provincial Tax and Levy Agency that was compiled using a quantitative survey approach to building models representing each group. While in the BIM-based method, the work unit price analysis comes directly from the 3D model of MS Apartment developed from its project documents.

Accordingly, the cost of the facility component of the MS apartment is IDR 90,604,103,440, based on the data obtained from the Office of Regional Tax and Levy Service. The construction of the MS apartment will be completed in 2022, so it is not renovated yet; hence the renovation year = 0 years. If the assessment process is carried out in 2022, therefore, based on a calculation using Equation (1), the apartment has no depreciation value (IDR 0). After being depreciated, the building value was added with the cost of supporting facilities components that do not need to be depreciated, amounting to IDR 18,704,648,024. The building's value used as a constituent of the building tax payable value compared with the existing BCCL method is shown in Table 5.

Table 5 Comparison of Apartment's Final Value between BCCL and BIM Methods

No.	Cost Component	Building Value	
		BCCL Method	BIM Method
1	RCN Value (before depreciated)	IDR 486,549,415,582	IDR 461,775,969,523.14
2	Depreciation Value	IDR 0	IDR 0
3	Supporting Facilities	IDR 18,704,648,024	IDR 18,704,648,024
	Final Value	IDR 505,254,063,606	IDR 480,480,617,547.14

The final value for the building as the tax object generated from the BIM method is much lower than the building value obtained from the calculation using the BCCL method. It occurred due to the inaccurate material area calculated in the BCCL method; hence, the building material cost was generated higher than the actual condition of the building material. Moreover, the BCCL's limited building material variety corresponding with the material used in the physical building also causes the building value discrepancy from both approaches.

The calculation result from the case study shows that the BIM method does not increase the building's final value calculated in the conventional method; however, it produces accurate cost calculation for each building component that corresponds to the building's physical condition. This statement is backed up by two practitioners from the Provincial Tax and Levy Agency and Provincial Revenue Agency interviewed at the end of this study. Both practitioners stated that BIM 5D has considerable potential as an alternative tax assessment, particularly at the quantity survey stage, tax notices filing, and BOQ analysis. It is owing to BIM 5D's ability to show the accurate size of building components and generate the costs for building components. With its real-time concept, the BIM 5D could objectively display the actual condition of the building. Moreover, the time needed to prepare the building values for tax assessment can be accelerated by automatically reading the information in the BIM model.

BIM's ability to extract quantities can save time by eliminating manual quantity survey and BOQ analysis activities and reducing calculation errors that might occur if done manually. BIM's ability to perform 3D visualization also provides convenience for surveyors and taxpayers by displaying a more perspective and actual form to increase the accuracy of delivering building information. In addition, the utilization of BIM can increase the objectivity of building values where the components calculated in the BIM method can be generated in detail. In addition, the value of the building developed by the 5D BIM method can avoid the consequences of generalizing the building components.

4. Conclusions

The current tax assessment method for vertical buildings, such as apartments, is still conducted manually, which involves a generalization of the building's work unit price, quantity survey through manual measurement, and reports with building component lists that still cannot accurately picture the actual components in the building. This conventional method resulted in inaccurate property values and inefficient building tax assessment. This paper attempted to develop a technology-driven approach for the valuation process of an apartment through a case study. The result of this study shows that the 3D model created in Autodesk Revit as the BIM application completed with building information and identity data can be utilized to efficiently estimate the apartment property value used as the constituent of the building tax payable, with a more accurate result. The proposed BIM-based building tax assessment method can be implemented with the support of integrated cooperation between taxpayers and the authorities involved. Therefore, further research needs to examine the suitability of existing regulations and develop policies for adopting the proposed method.

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