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COMPARISON OF THE EFFECTIVENESS OF BUILDING INFORMATION MODELING BASED COST ESTIMATION AGAINST THE CONTRACTOR'S COST BUDGET PLAN IN DEVELOPMENT PROJECT OF BANJARBARU BAUNTUNG MARKET

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ABSTRACT

This study focuses on the use of Building Information Modeling (BIM) which begins with creating a 3D digital model (virtual building) which serves as a means for planning, designing, implementing development, and maintaining the building and its infrastructure for all parties involved in the project. Unlike other studies that use concrete structures, this study refers to the Bauntung Banjarbaru Market building with a steel structure. BIM software program is specific and correct. Specific is within the use of BIM information is taken and adapted to real conditions within the area. Correct is a constructible model, that is, the model that is created is the same as the model that was constructed. Besides, when there is a change in the model, the resulting cost estimate can change automatically.

Modeling of building structures includes modeling of reinforced concrete structures and steel structures. The modeling is done using a software called Tekla Structures with a South-East Asia environment that refers to the plan drawing. After the modeling is complete, the work unit price is inputted into the software. The output of this modeling is direct cost estimation for structural work. For manual cost estimation using cost budget plan that has been obtained from the contractor in the form of a Microsoft Excel file.

From the results of the analysis of the two cost estimates, the resulting comparison of the cost difference is quite scanty. The difference between manual cost estimation and BIM based cost estimation is 0.26%. So, it can be concluded that the use of BIM based cost estimation can be used because it produces cost estimates that are faster than using manual calculations made by contractors.

The use of BIM can reduce costs and inaccuracies in the calculation of estimates in projects because it can be done more thoroughly.

Keywords: BIM-based cost estimation, Tekla Structures, building structures

1. INTRODUCTION

According to Lai (2006), cost estimation is the initial stage for any construction project. This helps to evaluate project viability, cost control, and tender process. There are two types of cost estimates, namely rough cost estimates and detailed cost estimates. A rough cost estimate can be an

approximate estimate to find cost estimates based on area rates very quickly and therefore allow concerned authorities to take into account the financial scheme for the design (Ullah, 2019). Meanwhile, detailed cost estimates include specific details consisting of quantity, rates, and costs for all items including technical sanctions, tenders, and satisfactory project completion (Dobre, 2016).

There are two types of cost estimation based on generation, namely Manual and Building Information Modeling (BIM) (Abanda, 2017). In the manual cost estimation approach, the center line method is used for estimation calculations in buildings without cross walls. To prepare a detailed manual cost estimate, the estimator must have a drawing of the work to take measurements, identify the material specifications to be used, and the price per work item in accordance with the Work Unit Price Analysis (AHSP) from the local government of the project location to obtain a Bill of Quantities (BOQ) (Haider et al., 2020).

Meanwhile, BIM is a process that begins with developing a 3-D digital model (virtual building) and contains all of the information about the building, which serves as a way for making plans, designing, implementing development, and maintaining the building and its infrastructure for all parties involved in it such as consultants, owners, and contractors (CAD.MEDIA, 2016).

BIM software itself can generate specific and correct cost estimates. In this context, what is meant by specific is in the use of BIM data is taken and adapted to real conditions in the field. Meanwhile, what is meant by correct is a constructible model, namely the model that is made the same as the model that was built. BIM produces accurate information and allows the parties responsible for the project to easily access transparent information during construction work.

The dimensional approach in BIM is known to have advantages, in contrast to conventional software which is generally still limited to the 3D stage. BIM is known to be used up to the concept of 4D (scheduling), 5D (estimating), 6D (sustainability), and 7D (facility management applications).

The implementation of BIM on a building project can have a direct impact on the success of the financing management of a construction project, especially the factors of Project Cost Planning , Cost Implementation , Cost Control , and Cost Assurance (Simanjuntak & Baskoro, 2020).

With these issues, one of the preferred 5D BIM software that can create and control data appropriately and in detail is Tekla structures (hereinafter called Tekla). With this software, it is easier to work in the field of structural engineering. Tekla can also be used to generate 3-d structural models without losing sight of complicated materials and structures. In addition, Tekla can cover all stages of the construction work of a task, from the design concept to fabrication, erection, to construction management (Fakhruddin et al., 2019).

The use of Tekla software is done because modeling with the software can help complete a project from the planning process (modelling, structural analysis, detailing), to the implementation process (fabrication, and construction management) and make project completion faster (Oli, 2016). Based on the Regulation of the Minister of Public Works and Public Housing of the Republic of Indonesia (2018) Number 22/PRT/M/2018 concerning the Construction of State Buildings, it is stated that the use of Building Information Modeling (BIM) must be applied to non-simple State Buildings with criteria of area above 2000 m^2. (two thousand square meters) and above 2 (two) floors. Therefore, this study will raise the issue of the application of BIM 5D in the steel structure Banjarbaru Bauntung Market Development Project, with a floor area of 15.336 m^2 using software Tekla to compare the effectiveness of the use of BIM based cost estimation of the cost estimates obtained from the contractor of the project.

2. LITERATURE REVIEW

Building Information Modeling (BIM)

With the building information Modeling (BIM) in a building construction project, all work will go into the chosen model and the information inside the database may be edited and reviewed in a format that is familiar to each party

concerned. As a consequence, cooperation among stakeholders can effectively exchange information.

BIM 5D Implementation

Using BIM 5D allows us to define an estimated measurement for each metric article, as it comes directly from the planner who creates the layout within the CAD drawing. 4D / 5D integration indicates how a great deal have an effect on planning has on costs and the relationships among them.

Tekla Structures

Tekla Structures software is an application in the field of structural engineering that has several advantages over other application programs. Tekla Structures is a project encyclopaedia-based BIM software that allows you to create and manage data accurately and in detail, and can create 3D structural models without forgetting complex materials and structures (Saputri & Raimadoya, 2012). These Tekla Structures models can cover the entire building construction process from concept design to fabrication, installation, and construction management. AEC activities (architect, engineering, construction) are integrated in one model that can be accessed in real time (Azhar et al., 2008).

Sustainable Steel Structure Modeling by Tekla Structures

Tekla structures can serve a huge variety of detailed needs in the steel structure and steel construction industry. Tekla structures comes with tools to develop detailed 3- D models that can then be used to supply steelworks and cost reports automatically withnearly 100% accuracy (Firoz & Rao, 2012).

Level of Development (LOD)

Level of Development (LOD) is a reference tool intended to improve the quality of communication between BIM users about the characteristics of elements in a model. The LOD does not specify what level of development should be reached at a point in the project, but leaves the specification of the development model for the users of this document (Center for Natural

Resources and Construction Education and Training, 2018). LOD specification is a reference that allows practitioners in the construction industry to define and articulate with clarity the level of content and reliability are high at various stages in the design and construction process (Education and Training Center for Water Resources and Construction, 2018).

Quantity Take-off (QTO)

Quantity Take-Off (QTO) is a very important task in any construction project because the measurements applied to buildings must be accurate and consistent (Cartlidge, 2009). In general, QTO is done manually or using software from 2D or 3D Computer-Aided Design (CAD) drawings. BIM is becoming increasingly accepted in the construction industry and in the use of Building Information Modeling (BIM) it is possible to significantly automate the QTO process using BIM QTO software through model-based quantity extraction techniques.

Cost Estimation

Cost estimation accuracy reduces project risk and also increases profits. Collaboration from the outset is needed if reliable and useful data is needed. However, this is often not possible, many important aspects are not taken into account and the dimensions of 5D BIM are reduced to quantity take-off (Mitchell, 2012). The prevailing price for steel is derived from the tendered price, and reflects the current active market conditions. Obviously, tariffs for these steel materials can fluctuate, depending on the complexity of the project and the prevailing market for steel fabrication and construction, which is reflected in the rates applied in this study. Tariffs for components related to steel, such as fire protection, steel decking, etc., are also applied based on the price at the tender. When applying rates for fire protection, adjustments have been made to take into account the complexities involved in the construction of steel.

3. RESEARCH METHOD

Research Procedure

The object of this research is the Banjarbaru Bauntung Market Development Project. This research focuses more on the steel structure. The application used in this research is Tekla Structures 2020 for modeling and for calculating cost estimates. The research flow chart can be seen in Figure 1.

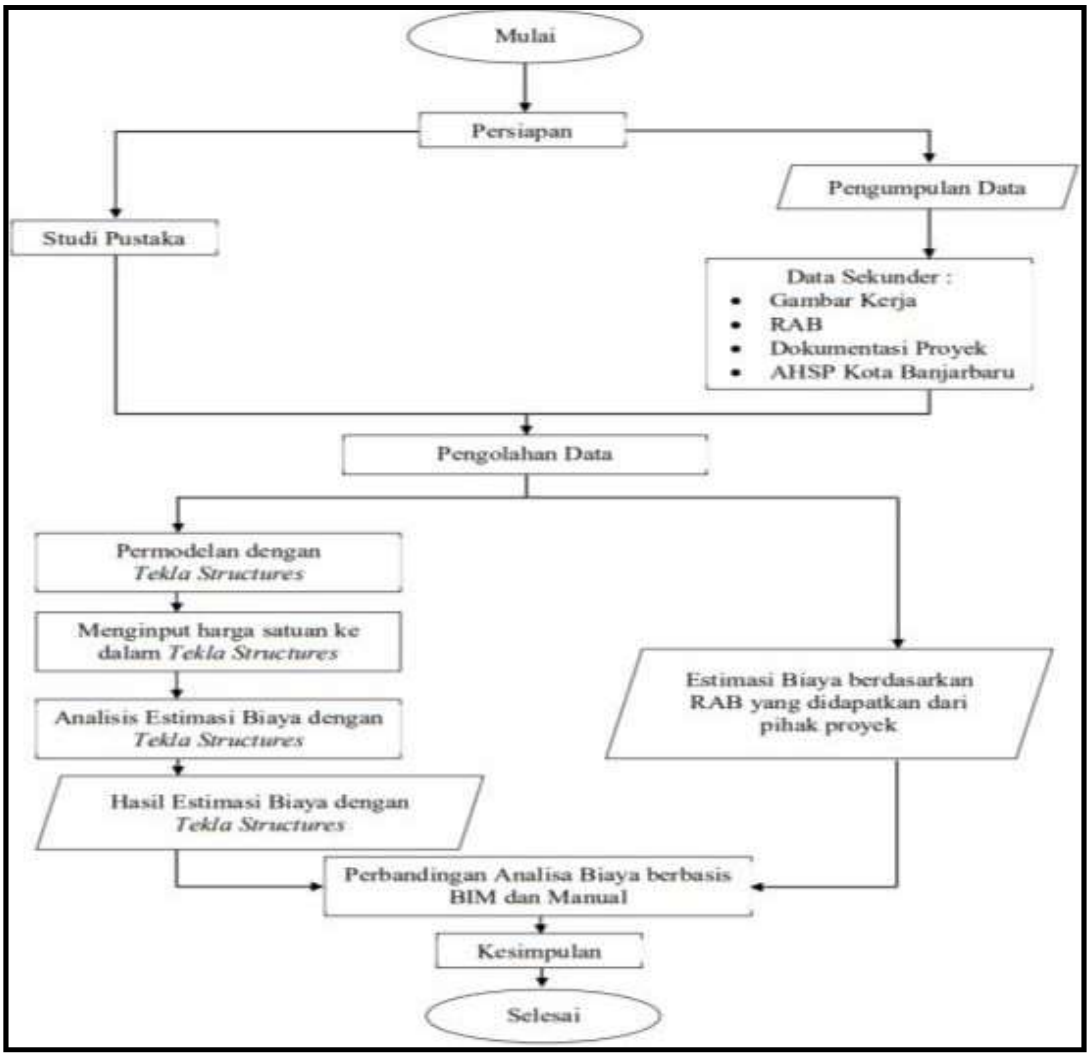

Figure 1. Research flow chart

4. RESULTS AND DISCUSSION

Modeling

The modeling is made using the Tekla structures 2020 software with the advent of 3D models based on the reference plan drawings. Prior to the modeling level, the grid is made according to the plan drawings. Next is to make the materials used in accordance with the materials used within the project.

In this study, the modeling made is the structural part of the steel constructing, particularly the pedestal column, steel column, truss, regel, and girder. The results of the modeling of the building structure can be seen in Figure 2.

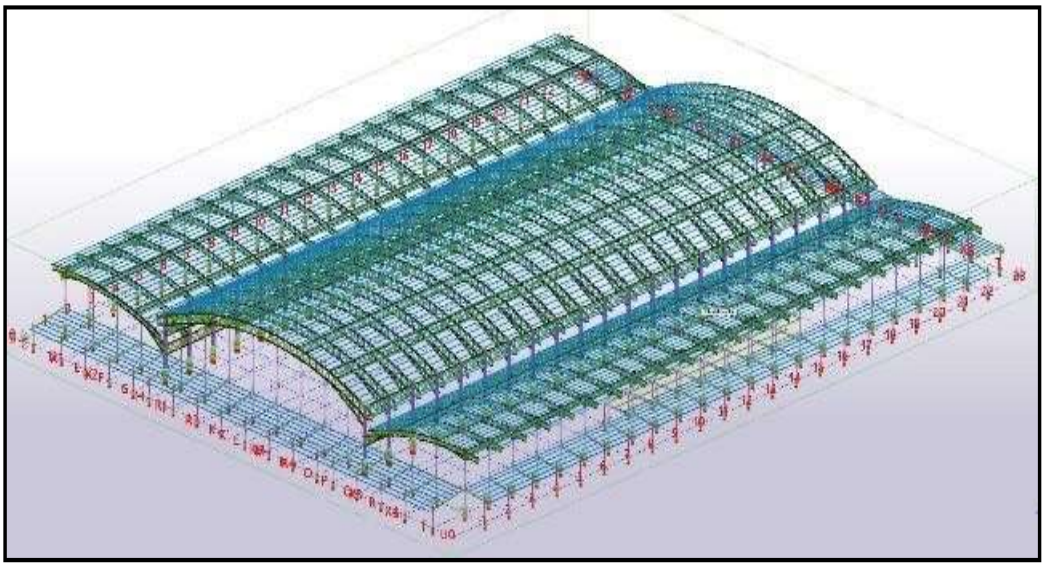

Figure 2. Final result of modeling

Input Unit Price Work

The unit price of work refers to the unit price of work issued by the Banjarbarucity government in 2020. The unit price of the work required is the installation of a WF steel frame, medium quality concrete, iron profiles, and plain or threaded iron. The unit price for the work that will be covered within the BIM application is the unit price listedat the contractor's cost estimation. So, there is no need to re-analyze the price because it uses the outcomes of the rate analysis from the contractor's cost estimation.

After knowing the price of each job, then input the price on the material that has been modeled using User-defined attributes in the BIM application.

Tekla Structures Cost Estimation Output

Output data from this application can be done with the Report tool or it can also be done using the Organizer. To produce output in the form of cost estimates requires a mathematical formula that multiplies the volume by the unit price, therefore it must use the Organizer tool. While the Reports tool can only produce general output.

The cost estimation output using the Organizer is grouped into the estimated cost of concrete work, steel work, and reinforcement work. The output results of the estimated work costs with Tekla Structures can be seen in Tables 1 to 3.

Table 1. Output cost estimation of concrete works with tekla structures

	Volume / m^3	**Harga Satuan / Rp**	**Jumlah Harga Beton / Rp**
Name : PEDESTAL K1 400X300	9,81	Rp1.090.385	Rp10.696.676
Name : PEDESTAL K2 600X300	13,23	Rp1.090.385	Rp14.425.792
Name : PEDESTAL K4 1000X500	38,41	Rp1.090.385	Rp41.881.683

Table 2. Output cost estimation of reinforcement works with tekla structures

	Weight / Kg	**Harga Satuan /Rp**	**Jumlah Harga Tulangan /Rp**
Name : PEDESTAL REINFORCEMENT 400x300	3855,89	Rp11.155,12	Rp43.012.927,56
Name : PEDESTAL REINFORCEMENT 600x300	3422,78	Rp11.155,12	Rp38.181.532,20
Name : PEDESTAL REINFORCEMENT 1000x500	3639,68	Rp11.155,12	Rp40.601.078,40

Tabel 3. Output cost estimation of steel works with tekla structures

	Weight / kg	Harga Satuan / Rp	Jumlah Harga Baja / Rp
Name : G CNP150.65.20.3,2	112.546	Rp19.125,00	Rp2.152.442.250,00
Name : K1 PIPE MEDIUM Ø 6”	63.983	Rp19.125,00	Rp1.223.666.842,50
Name : K1 PIPE MEDIUM Ø 5”	52.686	Rp19.125,00	Rp1.007.627.782,50
Name : K2 PIPE LIGHT Ø 4”	33.380	Rp19.125,00	Rp638.387.990,33
Name : K2 PIPE LIGHT Ø 3”	20.924	Rp21.165,00	Rp442.855.375,07
Name : K1 WF588.300.10.16	70.474	Rp19.635,00	Rp1.383.748.743,30
Name : K2 WF346.174.6.9	21.758	Rp19.635,00	Rp427.219.743,72
Name : K3 WF298.149.6.8	37.212	Rp19.635,00	Rp730.664.757,71
Name : K4 WF248.124.5.8	18.578	Rp19.635,00	Rp364.782.367,95
Name : K5 WF298.149.6.8	1.691	Rp19.125,00	Rp32.349.384,20
Name : K6 WF298.149.6.8	17.479	Rp19.635,00	Rp343.191.022,56
Name : R PIPE LIGHT Ø 4”	29.669	Rp19.125,00	Rp567.417.537,32
Name : R PIPE LIGHT Ø 3”	31.435	Rp21.165,00	Rp665.321.775,00
Name : R PIPE LIGHT Ø 2 1/2”	10.880	Rp21.165,00	Rp230.274.776,70

Discussion

In order to produce cost estimates, a mathematical process is needed, namely multiplying the weight for steel and volume for concrete, with the unit price of work so that the total price is produced. Generating data in the form of volume, unit price and total price can only be done using the Organizer.

Organizer has an advantage over Reports, which is that it is easy to customize the output data according to user needs. The organizer is able to make a formula for the number of prices that multiplies the weight or volume with the unit price of work, so that the resulting output is directly in the form of cost estimates.

Based on the results of the calculation of the cost estimation analysis, the comparison of the volume difference and the estimated cost of the Tekla calculation with the contractor's cost estimation can be seen in Table 4.

Tabel 4. Comparison of the difference in the cost estimation results using Tekla andcontractor's cost estimation

STEEL STRUCTURE WORK	**Rp 10.314.146.514**	**Rp 10.209.950.349**	**-1,02%**
CONCRETE STRUCTURE WORK	**Rp 186.891.043**	**Rp 188.799.689**	**1,01%**
TOTAL COST OF STRUCTURE WORK	**Rp 10.501.037.557**	**Rp 10.398.750.038**	**-0,98%**

Based on the results of the comparison of the difference between the estimated prices of Tekla and the Contractor's cost estimation as a whole, it does no longer show that the difference is just too big, that is only 0.98%. Steel structure works show nearly the equal price difference, that is 1.02%. In the concrete structure work, the difference isnearly the equal, which is 1.01%.

Because of the contractor's cost estimation and calculations within the BIM software using the same work unit price analysis price, the differentiating factor in the cost estimation outcomes is the calculation of the volume of work finished. Overall, the volume value is almost the equal in every work item. Despite the fact that some look larger than the other items. Comparison of the difference of work volume between Tekla and the contractor's cost estimation can be seen in Table 5.

Table 5. Comparison of the difference of work volume between Tekla and the contractor's cost estimation

NO	JOB DESCRIPTION	CONTRACTOR'S VOLUME	BIM VOLUME	DIFFERENCE
A.	**STEEL WORK**			
1	CNP150.65.20.3,2 mm	114.886,43	112.546,00	-2,08%
2	WF588.300.12.20 mm	70.475,57	70.473,58	0,00%
3	WF346.174.6.9 mm	21.859,02	21.758,07	-0,46%
4	WF298.149.6.8 mm	59.321,60	56.382,37	-5,30%
5	WF248.124.5.8 mm	18.589,15	18.578,17	-0,06%
6	PIPE MEDIUM Ø 6"	63.879,55	63.982,58	0,16%
7	PIPE MEDIUM Ø 5"	51.936,77	52.686,42	1,42%
8	PIPE LIGHT Ø 4"	63.515,46	63.048,66	-0,74%
9	PIPE LIGHT Ø 3"	52.587,87	52.358,95	-0,44%
10	PIPE LIGHT Ø 2 1/2"	10.934,74	10.879,98	-0,50%
B.	**CONCRETE WORK**			
1	Pedestal Column K1 400X300			
	Concrete Fc' 25	9,92	9,81	-1,10%
	Pedestal Reinforcement 400x300	3.857,87	3.855,89	-0,05%
2	Pedestal Column K2 600X300			
	Concrete Fc' 25	13,23	13,23	0,03%
	Pedestal Reinforcement 600x300	3.404,76	3.422,78	0,53%
3	Pedestal Column K4 1000X500			
	Concrete Fc' 25	36,74	38,41	4,35%
	Pedestal Reinforcement 1000x500	3.637,66	3.639,68	0,06%

5. Conclusion

1. The estimated cost of the Bauntung Banjarbaru Market Development Projectstructure using the BIM software Tekla Structures is Rp. 10,398,750,038
2. The difference between the estimated cost structure of the Bauntung BanjarbaruMarket Development Project based on the contractor's cost estimation and the BIM based cost estimation using Tekla Structures is 0.98%. So, it can be concluded that the use of BIM based cost estimation can be used because it produces cost estimates that are faster than using manual calculations carried out by contractors.
3. The differentiating factor in the cost estimation results based on the contractor's cost estimation with BIM based cost estimation is the calculation of the volume ofwork carried out.

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