The Use of BIM Application for Schedule Planning and Real of Costs Estimation in Promenade Bridge Construction Project, Taman Mini Indonesia Indah

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ABSTRACT

Scheduling and cost estimation are essential for successful construction projects, including the revitalization of Taman Mini Indonesia Indah and the Promenade Bridge development. To improve efficiency and effectiveness, this study applies Building Information Modeling (BIM), using Tekla Structures 2022 for 3D modeling and Quantity Take-Off. The model provides detailed volume data, which—alongside daily and weekly reports—is used for cost analysis and scheduling. BIM integration enables better visualization, planning, and resource management throughout the project lifecycle. The result of the study shows that the total Real of cost estimation of Rp13.136.571.631,44 with the duration of work based on an analysis of daily reports and weekly reports for 155 working days starting on January 6th, 2021 until May 21st, 2021. The use of Tekla Structures supports accurate modeling and work volume calculations, helping streamline budgeting and scheduling processes. The use of Building Information Modeling (BIM) in construction projects significantly accelerates the scheduling and cost estimation process even though certain limitations must be considered during project planning and execution.

Keywords: *Building Information Modelling, Scheduling, Real of Cost Estimation*

1. INTRODUCTION

The use of technology is growing faster along with the times, including in the industrial sector. This growth requires humans to continue to develop and adapt to the changes throughout times. Faster changes continue to spread to various fields of work, including the architectural, engineering and construction industries. In the architectural, engineering and construction (AEC) industry, techniques are needed that can increase productivity and quality of work in order to obtain effective costs and maximize project duration. These problems can be solved in several ways, one of which is by using BIM or commonly known as Building Information Modeling. BIM is a system that can integrate several design software to planning. BIM can simulate 3D modeling of building construction planning and can make advanced modeling such as scheduling (4D), financing (5D), sustainability (6D), application in managing facilities (7D), to safety (8D). This is a solution to several potential problems in construction such as design clashes, excessive construction costs, project delays, and others [1]. Other advantages of BIM can be seen at the design stage, one of which is in the design of the implementation budget which is carried out based on the implementation method in the field with the realization cost of the entire work. This construction method can be modeled using BIM so that the progress of a project can be seen from the beginning of the work to the end of the work in accordance with the sequence of the construction methods used. BIM implementation in Indonesia, as quoted from the BIM PUPR website, Indonesia has planned four phases of BIM implementation from 2017 to 2024, namely the adoption phase, the digitization phase, the collaboration phase, and the integration phase[2]. Nonetheless, according to Pantiga & Soekiman (2022), the adoption of the use of BIM in Indonesia is still limited to a number of construction actors which may be due to a lack of BIM implementation standards and a lack of understanding and knowledge of the BIM concept[3]. One of these drawbacks can be seen in the use of the BIM application for bridge building, which is still lacking in interest or does not delve further into the application, such as the Tekla Structures application. Taman Mini Indonesia Indah (TMII) is one of several amusement parks located in East Jakarta City, Special Capital Region. The place underwent revitalization and reconstruction as a form of government support for organizing international events or better known as the G20 Summit. As a project appointed directly by the government, the revitalization and reconstruction of TMII is intended as an accelerated project with the type of integrated engineering project. This makes the project require sufficient productivity to support the needs so that implementation can be achieved at a predetermined time efficiently and effectively. One of the work batches being carried out is structuring the landscape of the islands in the Archipelago Lake. This batch involves the construction of a pedestrian pavilion, amphitheater and promenade. In the promenade work, there is a project to build a pedestrian bridge that connects the miniature islands of Java and Sumatra, known as the Promenade Bridge.

The promenade bridge is 67.7 m long and 3 m wide, consisting of six spans with a span length of 12 m and 8.5 m respectively. The pedestrian bridge applies the Green Building concept and is a beautiful composite bridge both during the day and at night. Further details regarding the dimensions of the bridge can be seen in the top view and side view as referred to in Figure 1.

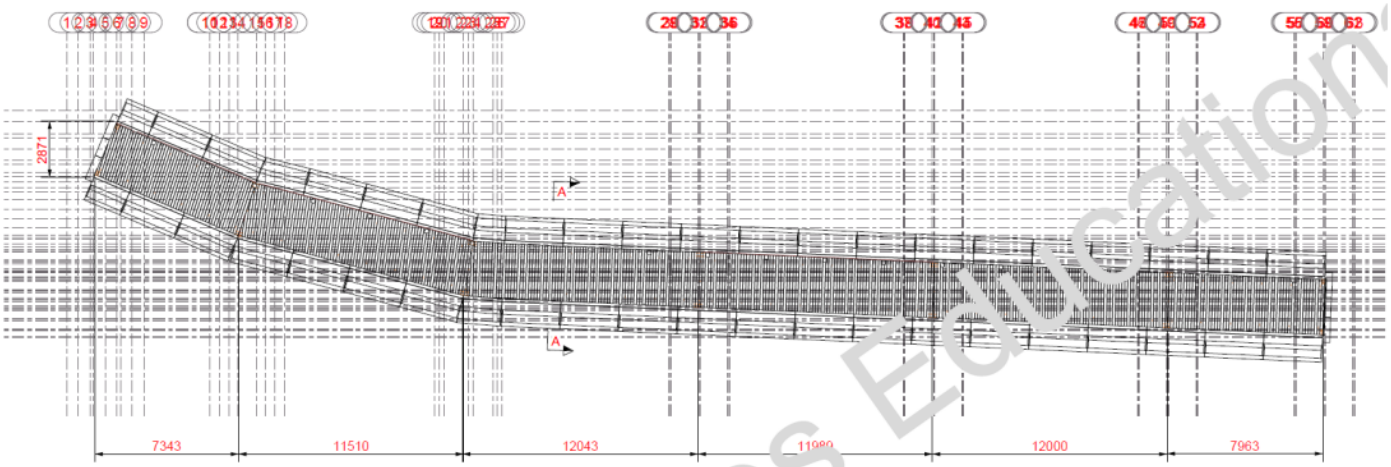

Figure 1 Design of Promenade Bridge using Tekla Structures

The objective of this study is to develop a three-dimensional (3D) model of the Promenade Bridge located in Taman Mini Indonesia Indah using Tekla Structures software. The resulting quantity take-off generated from the model will be utilized to calculate a Real Cost Estimation (RAP) for the project. In addition to the modeling and cost analysis, the study incorporates secondary data sources such as unit price analysis, daily and weekly project reports, and documentation related to the construction methods employed, to support and validate the estimation process

2. METHODS

The method used in planning the scheduling and implementation costs of the Taman Mini Indonesia Indah Promenade Bridge uses software based on Building Information Modeling. The software used is Tekla Structures as an application that helps in modeling to produce structure volume results. The volume is then analyzed according to the deadline to produce real of costs estimation. The stages up to the completion of the research are attached in the Figure 2.

2.1 Secondary Data Collection

Data from literature and project was collected during this study. A literature study was conducted to study various matters relating to the design of budgets and scheduling, especially in designing using BIM. Literature studies conducted come from similar final assignments, other research journals, theoretical studies of design objects, and NSPM (Norms, Standards, Guidelines, and Manuals) that apply and are related to financing and schedule planning.

Some data is needed to support this research. One of them is by collecting secondary data obtained from the contractor. The data collected were as built drawing, Cost Plan Estimates, Work Plan and Requirements (RKS), Unit Price Analysis, Weekly and daily reports, and Method of construction. Furthermore, the collected were processed using Tekla structures, Microsoft Project and Microsoft Excel.

2.2 Promenade Bridge 3D Modeling

3D modeling was carried out based on the as-built drawings of the Promenade Bridge which was carried out after checking the applicable standards. If the existing design is deemed not in accordance with the standards, then a redesign is carried out in accordance with applicable standards such as geometric standards, dimensions, slope, completeness of facilities and others so that two models are made (model according to drawings and model that has been adjusted to standards). Meanwhile, if the existing design is in accordance with the standard, then only one modeling is done. Modeling begins with processing the coordinates of each bridge element. These coordinates are made to make it easier to place each bridge component to be modeled in 3D. These coordinate points then become a reference in modeling each bridge element according to the dimensions and materials used. Next, detailing the bridge

elements by adding reinforcement, joints, welding, and architectural work. After completing the 3D modeling, a report is issued in the form of the quantity take-off value from the modeling.

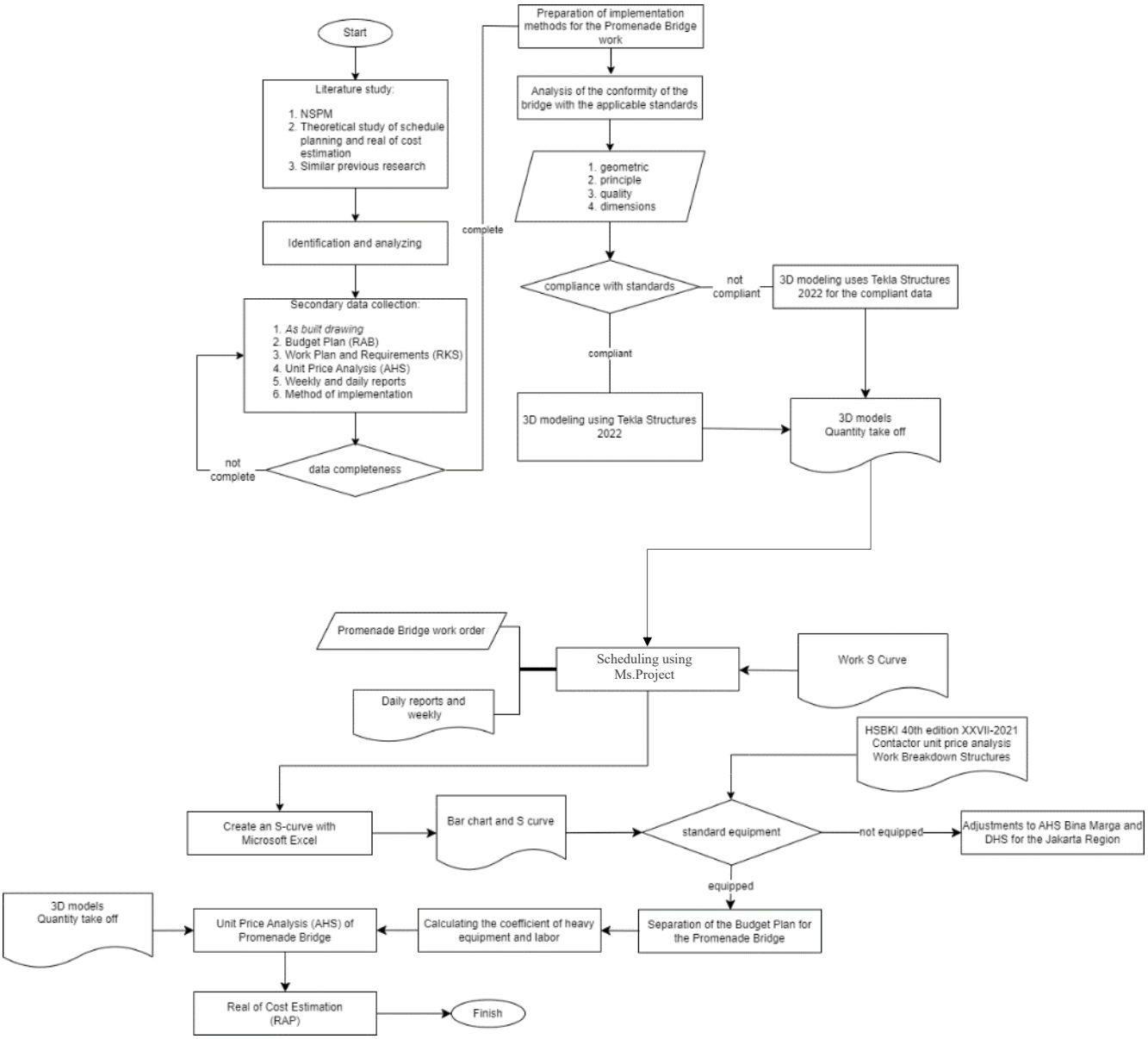

Figure 2 Flowchart of Method

2.3 Promenade Bridge Schedule planning

The scheduling that is carried out is scheduling with reference to the daily report data and weekly reports obtained previously. Based on these data, an analysis of the approach to the method of implementation in the field, heavy equipment, materials and labor required for each job is carried out. This analysis is then inputted into the Microsoft Project by adjusting the relationships between jobs in a project and the duration needed to complete a project. work.

2.4 Real of Cost Estimation of Promenade Bridge

Calculation of real of costs estimation begins with analyzing the unit price of each work item. The analysis refers to the contractor's unit price list previously obtained. The calculation results are then recapitulated by entering the work volume from the modeling

results using Tekla Structures. These data are then processed to become an Real of Cost Estimation (RAP) for the Promenade Bridge project.

3. ANALYSIS

3.1 Analysis of Conformance of the Design and Quality of the Promenade Bridge against Standards

Conformity analysis is carried out to determine whether the design of the Promenade Bridge is in conformance with the standards. The standards used include the Composite Girder Bridge Standard issued by Bina Marga, SNI 1725-2016, Tata Cara Perencanaan Jembatan Penyeberangan Untuk Pejalan Kaki di Perkotaan No: 027/T/Bt/1995, General Specification by Bina Marga 2018, Kriteria Perencanaan Jembatan dan Pembebanan Jembatan, on the Work Plan Document and Conditions (RKS) for the Taman Mini Indonesia Indah Promenade Bridge[4][5][6][7]. Based on the analysis in Table 1, there are several items that are not up to standard because the bridge functions as a pedestrian bridge so that the load received is not as big as bridges in general and rainfall is based on an analysis of air discharge which can still be accommodated by the Danau Nusantara channel system.

Table 1. Analysis of Conformance of the Design and Quality of the Bridge against Standards

Variables	Parameters	Conformity	Explanations
Geometric Principle	Bridge width of at least 2m	Conformed	Bridge width 3 m
	Suitability with the environment	Conformed	Adapting to the green building theme and increasing people's desire to walk
	Accessibility	Conformed	Easy to access the islands from nearby
	Continuity	Conformed	Connecting and shortening travel routes for pedestrians
	Pedestrian safety, security, and comfort	Conformed	Bridge construction is in accordance with the principles of safety, security and pedestrian comfort
Structural	Concrete floor strength at least K-225	Conformed	Using concrete K-300
	Maintenance height for 50 years 0,5 meter	Conformed	Maintenance height at 0,5 meter
	Load calculation according to SNI 1725-2016	Conformed	Calculation of dead load, live load, earthquake load
	28 day concrete age	Conformed	Concrete age 28 days
	Steel construction joints for A325 bolts Type 1	Conformed	Using A325 Type 1 bolts
	Type of placement using electromagnetic bearing with steel plates	Not Conformed	Elastomeric bearings use styrofoam
	4”rainwater pipe diameter	Not Conformed	Rainwater pipe diameter 3”

3.2 Promenade Bridge Modelling

The modeling of the Promenade Bridge is intended to make it easier to analyze existing bridges at a certain scale and application. Modeling is done using the Tekla Structures application in the form of bridge shapes and other details such as repetition and connection. Modeling is carried out in stages starting from making grids, making piles, making pile cap, making bridge pillars, making pier heads, installing girders, installing joints, installing bond deck, shears connectors and pipelines, manufacture of floor slabs, manufacture of planter boxes, manufacture of dilation and joints, installation of cement fiber, and MEP installation. Modeling using the Tekla Structures application produces output in the form of quantity take off (QTO) or the volume of the bridge model so that further analysis can be carried out regarding the scheduling and costs involved. The recapitulation of QTO Modeling shown in Table 2.

In modeling, the model is then checked to find out whether there is a clash in the model that has been made in Tekla Structures. Based on the results of the analysis carried out, the clash can be ignored with the note that it will have an impact on the calculation of the volume of work for the calculation of the unit price analysis which will affect the cost of implementation.

3.3 Scheduling

Scheduling is done based on the S-Curve data which is then separated to obtain the entire schedule for the Promenade Bridge work. In addition to the separation of bridge works in the S Curve, scheduling is also carried out on the basis of project daily reports and weekly reports. Scheduling is carried out using the help of the Microsoft Project to obtain output in the form of the duration of each job, bar charts, weight of each job, and network planning.

Table 2. Recapitulation of QTO Modeling Results

Name	Type	Specification	Height (mm)	Length (mm)	Width (mm)	Volume (m^3)	Weight (T)	Number of Item
Grouting	Concrete	C45/55	400	780	25	0,1092	0,014	14
Transverse girder	Steel	WI250-6-9*125	300	2260	125	0	3,036	44
Elongated girder	Steel	WI588-12-20*30	588	11963	480	2,4	22,656	12
Lamp	Steel		200	1000	200	0,2415	0,09	21
Lean concrete	Concrete	C45/55	3	2902	11915	23,7	56,818	11
Dilatation	Concrete		120	2900	50	0,087	0	5
Lean concrete	Concrete	C16/20	3800	3800	50	5,054	24,262	7
Panel			50	2890	900	9,6237	0	74
Pier Head	Concrete	C45/55	1239	3655	700	9,9	24,563	13
Pile	Concrete	C45/55	1000	2500	700	12,3	29,566	7
Pile Cap	Concrete	C45/55	3800	3800	900	91	218,33	7
Plate	Steel	PL25*400 / PL24*200 / PL 5*100	2425 / 2425 / 2900	200 / 400 / 123	25 / 25 / 5	0,1694	1,005	19
Cable pipe		Tubes 50.8*10	51	3000	51	0,0735	0	12
Planter box pipe		Tubes 25,4*2,5	25	131	25	0,0029	0	45
Pipeline		Tubes 76,2*5	76	320	326	4,0578	0	76
Planter box	Concrete	C30	1406	3000	1020	41	95,612	41
	Concrete	C30	680	1043	50	0,2161	2,87	41
	Concrete	C30	680	1043	50	0,2161	2,87	41
	Concrete	C30	410	3000	120	4,1	14,801	41
Slab	Concrete		2893	454	20	11,5844	9,261	441
Pancang pile	Concrete	C50	250	6000	250	25,2	57,834	63
Andesit	Tiles	30*750	570	570	30	734,274	4,294	226
Platform	Concrete	C30	3	2901	7938	0,415	0	6

3.3.1 Work Duration

In the Promenade Bridge project, the duration of each work item is described and matched with daily reports so as to obtain the appropriate duration of work during the construction period. The calculation of the duration of the work, both mechanically and manually, is then entered into the Microsoft Project to be processed into an S Curve, Table 3 is the result of calculation and analysis of the duration of the Promenade Bridge implementation.

Table 3. Work Duration of Promenade Bridge

Job Description	Duration (Day)
Sub Structures	
Square pile	22
Pile cap	90
Super structures	
Pier and pier head	74
Bearing pad installation	1
Erection girder	13
form work and bond deck	5
Lean concrete and planter box	25
Architectural works	
Floor deck installation	31
Bougainvillea planting	3
MEP works	
Lamp installation	3
Watering system installation	7

3.3.2 Network Planning

Network planning is the output of scheduling to convey the sequence of work carried out according to the method implementation. In network planning, it is known that the work is carried out simultaneously or the work that is carried out after another job is done or vice versa. The implementation of the Promenade Bridge work was carried out with a majority start to start and finish to start work. The analysis is then processed in the Microsoft project application so that It is known that pillar and pier head 2 work is critical work with a total duration of 17 days marked with red color on the Gantt chart.

3.4 Unit Price Analysis

Analysis of the unit price of work is carried out by calculating the coefficient, productivity, tool requirements, resource requirements, material requirements, and the price of each component to calculate the total cost required in one job. The unit price used in this calculation is the price of the consultant and contractor for the construction of the Promenade Bridge. The AHSP (unit price analysis) calculation is carried out with reference to the 2021 Bina Marga AHSP in accordance with the method used for the Promenade Bridge work including structural work, architectural work, and MEP work. The calculation of the coefficients in the AHSP is done manually with reference to the Regulation of the Minister of PUPR Number 1 of 2022 in the analysis of factors related to the coefficients of equipment and materials so that the expected productivity is obtained according to conditions in the field[8].

3.4.1 Bill Of Quantity

The results of the calculation of the unit price analysis for each item on the Promenade Bridge are then recapitulated by adding the total volume obtained from the results of the Tekla Structures QTO, manual calculations, and data obtained from the project.

3.4.2 Real of Cost Estimation

The real of cost estimation is obtained from the results of the BOQ recapitulation which is then duplicated in the RAP table by adding the column duration and work weight from the S Curve. Based on the calculation of the results of the analysis, the total costs incurred are Rp. 13,136,571,631.44. Table 4 is the RAP for the Promenade Bridge for each core work carried out.

Tabel 4. Real of Cost Estimation of The Promenade Bridge

No	Job Description	Total Price
A.1	Structural work	Rp. 1.048.585.400,40
A.2	Floor finishing work	Rp. 3.029.915.412,43
A.3	Planter box work	Rp. 2.491.597.185,57
A.4	Electrical and plumbing	Rp. 6.566.473.633,03

4. RESULT AND DISCUSSION

During the analysis of modeling, scheduling, and calculating implementation costs, several obstacles were found along with their solutions so that the analysis could continue. The following are the constraints and solutions provided.

1. The use of the Tekla tructures Student Version application makes some features inaccessible, so creativity is required in modeling so that the model can describe conditions in the field. The following are the findings and solutions provided.
    a. The bridge feature in Tekla Structures is not fully accessible.
    b. The use of modern formwork in Tekla applications that follow international standards is not the same as the conditions in the field or using conventional formwork, so volume calculations are done manually.
    c. Welding of shear connectors with bond deck cannot be modeled using Tekla so that the calculation of the welding volume is done manually.
    d. The standard used in the Tekla Structures application is British Standard so that there are several steel frames and reinforcing steel that are not identified during modeling.
    e. The volume generated during the quantity take-off (QTO) is the result of rounding and is not specific to three decimal places, as a result the work volume of less than 1 m3 cannot be seen.
    f. When an image is converted to a GA drawing, the grid cannot be hidden, so that in cross-sectional or longitudinal images, the grid will always be there and block the sectional image.
2. The as-built drawings obtained from the contractor were not specific in several elements of the bridge, so several adjustments were made in accordance with applicable standards.
3. There is no data regarding the use of the quality of several items originating from suppliers, so several analysis approaches are carried out based on the data previously obtained in order to best describe conditions in the field.

Despite factors above, according to the Enhassi, Hallaq, and Tayeh (2019), the implementation of Building Information Modelling in construction industry were limited and affected by several factors including technology, cost, management, personnel, and legal categories [9]

5. CONCLUSION

Based on the results of the analysis and discussion that has been carried out in the research, the following conclusions obtained are:

1. 3D modeling of the Taman Mini Indonesia Indah Promenade bridge using as built drawings with the help of the Tekla Structures 2022 application produces output in the form of modeling and work volume (Quantity Take-Off).

2. Scheduling the construction of the Taman Mini Indonesia Indah Promenade Bridge based on daily reports and weekly reports and using the help of the Microsoft Project application resulted in the acquisition of a project duration of 155 days starting on January 6th 2021 until May 21st 2021. Pillar and pier head 2 work is work critical on this project.
3. The implementation budget plan (RAP) of the Taman Mini Indonesia Indah Promenade Bridge Construction Project was produced in the amount of Rp13,136,571,631.44.

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