Buffer Time Analysis in Construction Project scheduling with Critical Chain Project Management (CCPM) Method

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Abstract. Construction project scheduling plays the most important role because here you can find out how far the project is late or early so you can know the planned and actual progress of a project. In scheduling construction projects, the estimated time of an activity is basically the time span required to complete an activity from start to finish which is arranged as a network in the completion of a construction project. In estimating time, the scheduler unintentionally often adds safety time to ensure that the activity schedule in the planned construction project is in a safe condition, meaning that the activity can be completed according to the planned time limit. However, the existence of safety time in every activity in a construction project unknowingly hinders the performance of construction implementation. Critical Chain Project Management (CCPM) is a method that achieved by eliminating safety time and providing a buffer at the end of the project. With CCPM the scheduler will be able to streamline the existence of safety time with buffer time, both on critical and non-critical paths. The results showed that the project buffer value obtained was 12 day and the total duration using the Critical Chain Project Management (CCPM) method with the addition the project buffer is 169 calendar days.

Keywords: project scheduling, safety time, buffer time, critical chain project management

1 Introduction

Time as a resource viewed from a financial perspective (Time is Money or Time Value of Money) is the impact of the existence of other resources (Man, Method, Machine and Material). Time is qualified as a resource, considering that lost time cannot be recovered, so time must be managed well so that it can be used effectively. Time related to Project Scheduling is accommodated in the estimated activity duration (activity time). Scheduling in construction projects is a way to determine the time needed to complete an activity in a construction project [1]. In conventional time planning concepts, such as scheduling with the form; Bar Chart, Linear Balance Chart/Line of Balance, to the form of a Network, schedulers unconsciously, in estimating the duration of an activity, include safety time, taking into consideration the possibilities that will occur and hinder optimism in completing the activity. Unknowingly, this can lengthen the overall project completion time. Obstacles in estimating duration by schedulers who are used to taking safety time into account in the management method contained in Critical Chain Project Management (CCPM) in project management body of knowledge through an

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approach to increasing the confidence of schedulers are expected to be able to estimate the time/estimated duration of activities without safety time [2]. In other words, through the "CCPM" method, Safety Time can be eliminated and focused on completing the project as a whole by adding safety time in the form of buffer time on both the critical and non-critical paths [3].

2 Method

This research was conducted on the SMAN 2 Abiansemal Office Building construction project carried out by PT. Sanur Jaya Utama as the contractor. This project is located in Abiansemal Badung. The data used is secondary data obtained from PT. Sanur Jaya Utama as the contractor. The data obtained are: bill of quantity, time schedule, spesification, and worker resource data. The data that has been collected will then be processed using the Critical Chain Project Management (CCPM) method with steps that can be seen in the following flow diagram:

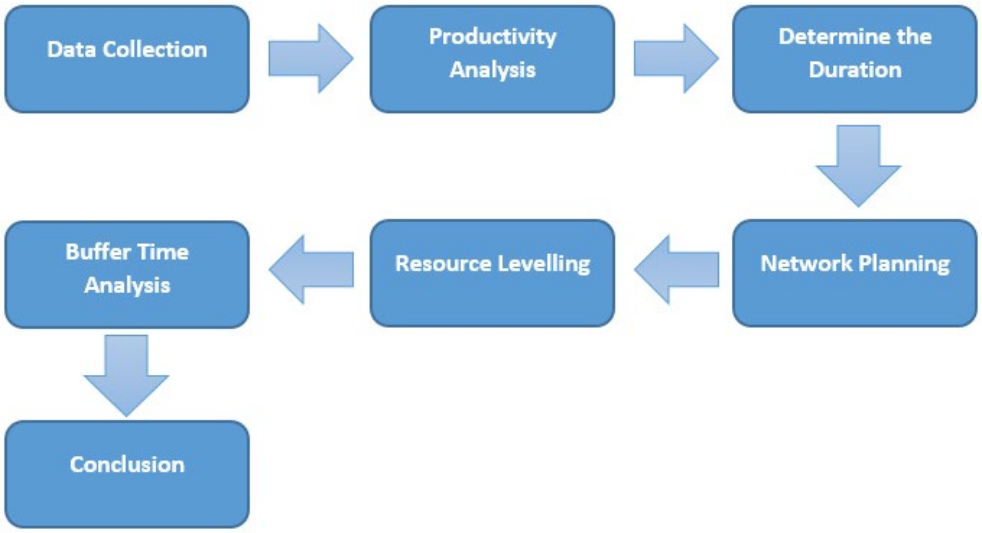

Fig. 1 Research Flow Chart

3 Result and Discussion

Based on the data that has been collected and the analysis that has been carried out, the Critical Chain Project Management (CCPM) method places more emphasis on labor productivity. Productivity can be calculated using the following formula [4]

$$Productivity = \frac{Unit\ Produced}{Man\ Hour}$$

The following calculation of worker productivity per day can be seen in table 1.

Table 1. CCPM Worker Productivity

No	Job Description	Volume Job		Based on Schedule				Based on Contractor Strength		
		Stn.	Vol.	Stn.	Koef.	Prod.	Kebutuhan	Kekuatan Kontraktor	Prod.	Koef.
I.	Structural Work									
I.1	Basement Work									
A	Land, Excavation And Foundation Work									
1	Bouwplank Measurement and Installation Work	m1	126.00							
	Worker			OH	0.030		6.00	1.00	33.333	0.030
	Carpenter			OH	0.040		8.00	1.00	25.000	0.040
	Chief Builder			OH	0.006		1.20	1.00	166.667	0.006
	Foreman			OH	0.005	200.000	1.00	1.00	200.000	0.005
2	Soil Excavation	m3	2,237.94							
	Operator			OH	0.019		2.00	2.00	107.568	0.019
	foreman			OH	0.009	107.568	1.00	1.00	107.568	0.009
3	Sand Finishing T = 5cm	m3	41.56							
	Worker			OH	0.730		73.00	2.00	2.740	0.730
	Foreman			OH	0.010	100.000	1.00	1.00	100.000	0.010
4	Stone-Casting Work Camp. 1 PC : 5 PS	m3	28.07							
	Worker			OH	1.280		17.07	2.00	1.563	1.280
	Mason			OH	1.260		16.80	2.00	1.587	1.260
	Chief Builder			OH	0.075		1.00	1.00	13.333	0.075
	Foreman			OH	0.075	13.333	1.00	1.00	13.333	0.075
5	Completion of Land Title	m3	30.00							
	Worker			OH	0.460		9.20	1.00	2.174	0.460
	foreman			OH	0.050	20.000	1.00	1.00	20.000	0.050

Determining the duration of an activity is based on the volume of work and productivity of the worker group in completing an activity [5]. The productivity of the dominant workforce working on each work item which has been calculated above is used, for further details, see table 2.

Table 2. CCPM Duration Calculation

No	Job Description	Unit	Volume	Productivity (Days)	Duration (Days)	Duration (Days)
I	Structural Work					
I.1	Basement Wordk					
A	Land, Excavation And Foundation Work					
1	Bouwplank Measurement and Installation Work	m1	126.00	33.33	3.78	4.00
2	Soil Excavation	m3	2,237.94	752.98	2.97	3.00
3	Sand Excavation Work T = 5 cm	m3	41.56	2.74	15.17	16.00
4	Stone-Casting Work 1PC : 5PS	m3	28.07	1.56	17.96	18.00
5	Sand Excavation Work Again	m3	30.00	2.17	13.80	14.00

Planning CCPM network planning using the PDM method carries out forward and backward calculations with the help of the Microsoft Project application which can be seen in Figure 2.

Fig. 2. CCPM Network Planning

The graph of human resource requirements that has been leveled for jobs that do not cross the critical path in the network can be seen as in Figure 3.

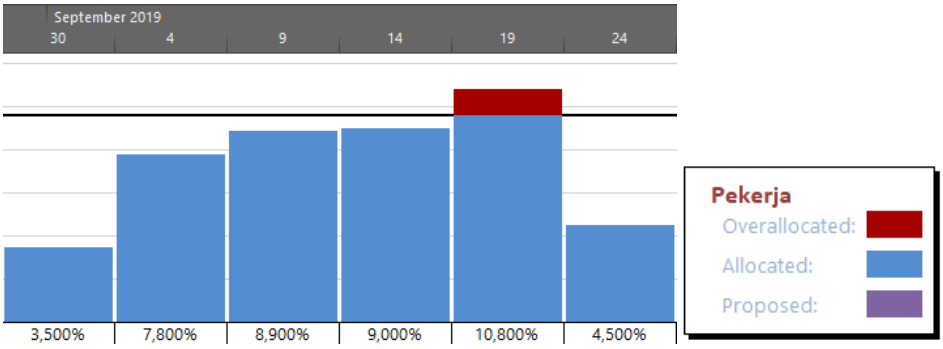

Fig. 3 Worker Resource Graph

Due to resource conflicts that exist on all critical paths, a Project Buffer is added. This Buffer is added at the end of the project to protect the final completion time. Next, the buffer size can be seen in table 3.

Table 3. Project Buffer

NO	Job Description	Duration CCPM S-A	S-A/2	(S-A/2)^2
I.2	First Floor Work			
A4	Concrete Work			
	1st Floor Concrete Plate Work T = 12 cm, K-250 Floor Deck, T=0.75 mm	7	3.5	12.25
I.4	Second Floor Work			
A4	Concrete Work			
	2nd Floor Concrete Plate Work T = 12 cm, K-250 Floor Deck, T=0.75 mm	7	3.5	12.25
I.5	Third Floor Work			
A4	Concrete Work			
	3rd Floor Concrete Plate Work T = 12 cm, K-250 Floor Deck, T=0.75 mm	7	3.5	12.25
			TOTAL (S-A/2)^2	36.75
			2*√(S-A/2)^2	12.12
			Project Buffer =	12.00

$$\text{Project buffer} = \mathbf{2} \times \sqrt{(\frac{S_1 - A_1}{2})^2 + (\frac{S_2 - A_2}{2})^2 + \cdots + (\frac{S_n - A_n}{2})^2}$$

$$\text{Project buffer} = \mathbf{2} \times \sqrt{\mathbf{36,75}} = 12{,}12 \text{ days} \approx 12 \text{ days}$$

After eliminating the safety time by calculating the duration using labor productivity, then make a scheduling plan for the implementation time with the duration that has been removed from the safety time by using network planning and entering the buffer results for the work required. So the total duration using the Critical Chain Project Management (CCPM) method with the addition the project buffer is 169 calendar days.

4 Conclusion

Based on the results of the analysis that has been carried out, there are several things that can be concluded that the buffer time value obtained using the Critical Chain Project Management (CCPM) method to cover safety time in the conventional method is 12 days. And then the total duration using the Critical Chain Project Management (CCPM) method with the addition the project buffer is 169 calendar days.

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