Planning and Evaluation of The University Green Canteen Construction Development Project

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Abstract. The construction of a green concept canteen on campus is very important as a form of environmental protection and preservation. The construction planning of a green campus canteen includes four main activities: preparatory activities, structural work, architectural work, and mechanical work. So far, development projects executed by third parties often have delays from the schedule, therefore the construction needs to be carefully planned so the construction development can be executed efficiently, effectively, and finished on time. The delay of the project itself is a situation that should be avoided by all parties as much as possible. Therefore, this study will provide a planning concept and evaluation method for the development of a green canteen project using the Critical Part Method (CPM) and PERT (Project Evaluation and Review Technique) methods. CPM and PERT methods are used to get a realistic fastest time to finish a project. This research method is performed by processing the information derived from the project's schedule and seeking information from related workers and then processing the information using standard CPM and PERT methods. The results of the fastest construction project networks are A-B-C-D-E-F-G-M-U-V or A-B-C-D-E-F-H-M-U-V or A-B-C-D-E-N-O-R-U-V. The optimal time for completing the green canteen construction project is 195.76~196 days from the project target of 165.58~165 days. Whereas, Cost estimation can be can decrease or increase based on probability using the PERT method until Rp. 647,624,047.

Keywords: Green canten campus, CPM, PERT, project management

I. Background

The university green canteen is an eco-friendly canteen concept that provides hygienic food and drinks in a university. This project development concept supports the university's vision to become an excellent, smart, and green university in ASEAN 2030. The existence of a green canteen can boost the UI Green Metric index value of the university. The green university canteen also directly contributes to and influences the variables in UI's green metrics, including increasing the value of green arrangement and infrastructure, renewable energy management since it uses solar cells, manages the waste and manages rainwater so it can be recycled [1,2].

Given the large influence and benefits of a green canteen at a university, it is necessary to plan the construction so that its construction can be well executed. Careful planning plays an essential role in completing a construction project. With project planning, cost saving and project completion time itself will be achieved. Project management plays a vital role in the success of a project. Management is needed so it can control the project from the beginning to the end of the project. Project management is a science and art concerned with leading and coordinating human and material resources by using modern management techniques to achieve predetermined objectives such as scope, quality, schedule, and cost, as well as meeting the expectations of the stakeholder. Project management can be defined as the process of planning, monitoring, and controlling all aspects and the motivation of all involved, to achieve project objectives within the agreed time, cost, and performance criteria. The field of project management grows and develops to the needs of the modern industry in an attempt to coordinate and control more complex activities [2,4,5].

The success or failure of project implementation is often caused by poor planning projects and a lack of controls, so the project activities become inefficient. this problem may lead to delay, thus decreasing work quality, and increasing the cost budget. The delay of the project itself is a situation that should be avoided by all parties involved as much as possible. The existence of project management will show the limitations of the duties, authorities, and responsibilities of the parties involved, both direct and indirect so there are no simultaneous

tasks and responsibilities[10]. The purpose of project management is to be able to run each project effectively and efficiently and also provide maximum service to all customers [11]. Furthermore, project management aims for project implementation to be well executed, according to budget, time, and specifications which must comply with predetermined specifications [3]. To achieve the final result, project activities have a budget limit, schedule, and quality known as triple constraints [4,9].

Project planning is necessary to be used as a guide in project implementation, so the project can be executed with optimal time and cost based on the purposes. Project activity planning is the responsibility of management to optimally manage all available resources. We realize that the resources we have for the projects are very limited because in general projects have a deadline, which means that the project must be completed before or on schedule. However, in reality, a project does not always go according to the schedule. A lot of factors happen, one of them is rain. Raining causes the construction process to be delayed. Thus far, development projects performed by third parties often determine the scheduled time and cost only based on experience [12,13,14]. Working processes are often affected by time delays. It will have a negative impact on the third parties, such as the reputation of not being able to finish the project according to the contract. Furthermore, the project cost will go over budget [5,6,7].

To minimize delays in the green canteen construction project, this study will design a planning concept and evaluation method for the green university canteen construction that can provide analysis in optimizing the period time of the project so it can predict how long the project will take and explore the possibilities to speed up the period time. This study will use the Critical Part Method (CPM) and PERT (Project Evaluation and Review Technique) methods. CPM method is used to see in detail the connection of each project activity while the PERT method is used to analyze the acceleration and optimization of project implementation [6,8].

2. Method

2.1. Data Collecting

Data was collected through direct interviews with a project worker and 1 person as a project construction foreman staff. Based on the interview, information on the number of employees, field research/observations, and literature studies will be derived. The initial data information of the University Green Canteen development project was obtained as follows:

1. The number of Project Workers. There are ± 70 workers for the construction of a green canteen at the beginning of construction. But, at the end of the project, there were only 4 workers. 35 people work in the structural preparation, 25 people work in the steel construction, 6 people work in the Granite Installation, and 4 people work in the finishing and cleaning section. The green canteen project is estimated to take 1 1/2 months / 45 days and if there are some issues it will take ± 1 year / ± 365 days
2. Implementation progress. The preliminary process is the most important in the evaluation of project implementation. The implementation progress is generally reported as a percentage and presented in a graph. To find out each of the activities progress, usually, the realization of the activity is compared with the activity plan, from this comparison a deviation is obtained which can be evaluated as a job achievement. The construction of the canteen is planned to take 23 weeks. However, from week 13 to week 21 there was a very striking deviation. This means that there is a delay in the canteen construction process. Identification of the causes of delays in the work process will be used for Untirta's evaluation of the canteen construction project.

3. Project Activities. The construction schedule has been obtained, then the evaluation of the schedule will be conducted. The activities of the project in detail can be noticed in Table 1, and the flow of activities can be seen in Figure 2.

Table 1. Association between development activities

Activity Code		Activity	Preliminary Activity	Time scale, Days
I.	**LAND PREPARATION**			
	A	Land Preparation		36
II.	**STRUCTURAL WORK**			
	B	Bore Pile	A	24
	C	CAP Pile	B	12
	D	TIE BEAM	C	12
	E	2nd Floor Concrete	D	24
	F	Concrete Structure	E	18
III.	**1ST FLOOR ARCHITECTURE PREPARATION**			
	G	Floor	F	18
	H	Wall	F	18
	I	Window & Frame	F	6
	J	Concrete	F	6
	K	Toilet	F	6
	L	Plumbing & Sanitation	F	6
	M	Electricity	G,H,I,J,K,L	12
IV.	**2ND FLOOR ARCHITECTURE PREPARATION**			
	N	Floor	E	24
	O	Wall	N	18
	P	Window & Frame	N	6
	Q	Concrete	N,	6
	R	Roof	O,P,Q,S,T	6
	S	Toilet	N	6
	T	Plumbing & Sanitation	N	6
	U	Electricity	M,R	12
	V	Others	U	12
		Total		294

The data requirements in this study consist of primary data and secondary data. The primary data is the evaluation time on each activity being built as the time was set up, while the secondary data is the data obtained from the documentation by the third party. The method used in this study is the Critical Part Method (CPM) and data processing will be solved with the Project Evaluation and Review Technique (PERT) method. The Critical Part method is

used to describe the flow of project activities while the PERT method is used to optimize project time and costs [3,4,5].

3. Analysis and Discussion

3.1 Analysis With CPM Methode

Table 2. Critical Path with Slack (loose time)

ACTIVITY	TIME (Days)	ES	LS	EF	LF	SLACK	Critical Path
[1]	[2]	[3]	[4]=[6]-[2]	[5]=[3]+[2]	[6]	[7]	
Project	180						
A	36	0	0	36	36	0	YES
B	24	36	36	60	60	0	YES
C	12	60	60	72	72	0	YES
D	12	72	102	84	84	0	YES
E	24	102	84	126	102	0	YES
F	18	84	126	102	144	0	YES
G	18	126	126	144	144	0	YES
H	18	126	138	144	144	0	YES
I	6	126	138	132	144	12	NO
J	6	126	138	132	144	12	NO
K	6	126	138	132	144	12	NO
L	6	126	138	132	144	12	NO
M	12	126	144	156	156	0	YES
N	24	144	108	126	132	6	NO
O	18	126	132	144	150	6	NO
P	6	126	144	132	150	18	NO
Q	6	126	144	132	150	18	NO
R	6	144	150	144	156	6	NO
S	6	126	144	132	150	18	NO
T	6	126	144	132	150	18	NO
U	12	156	156	168	168	0	YES
V	12	168	168	180	180	0	YES

Table 4 and Figure 2 show that the project implementation can be carried out based on the normal time of 180 days. By using the Critical Method, it can be seen that the critical path where activities that cannot be delayed are through the A-B-C-D-E-F-G-M-U-V or A-B-C-D-E-F-H-M-U-V or A-B-C-D-E-N-O-R-U-V.

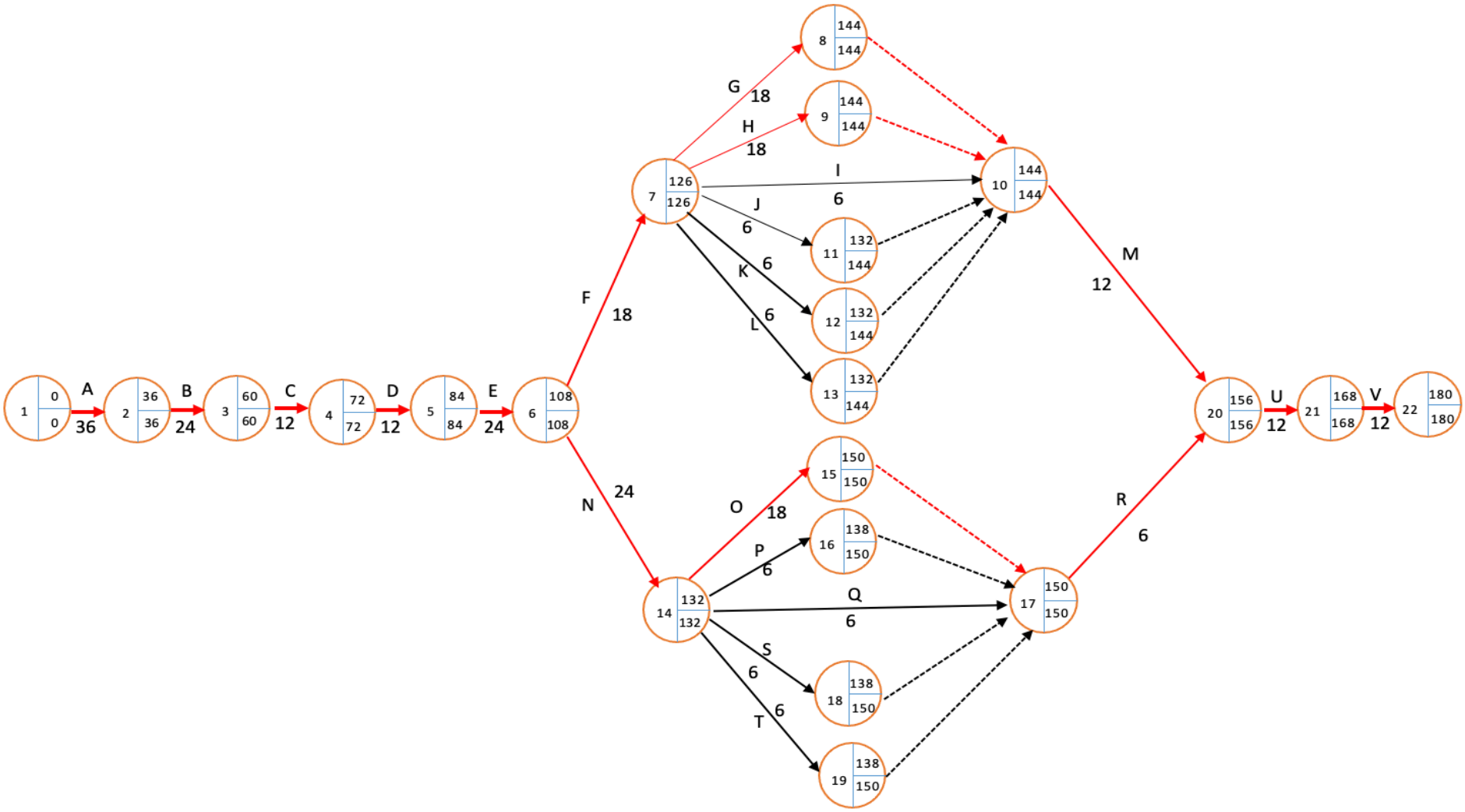

Figure 2. Green Canteen Project Activity Flow

3.2. Analysis With PERT Methode

The project time for each activity is a required time to finish the activity. By defining This time activity, it can help reduce the uncertainty in the implementation of the project. In this study, the activity time was obtained from direct interviews with the project contractor was also the initial planner for the implementation of the green canteen construction. This time also has a standard time for each activity. Furthermore, it can be calculated the optimistic time, normal time, and pessimistic time using the PERT method. The calculation is shown in table 2 regarding the estimated project time [4,5].

Table 3. Time Estimation for PERT Method

Activity Code	Activity	Preliminary	Time (days)		
			Optimistic Time	Normal Time	Pessimistic Time
			(a)	(m)	(b)
A	Land Preparation		36	36	40
B	Bore Pile	A	20	24	28
C	CAP Pile	B	8	12	16
D	TIE BEAM	C	8	12	16
E	2nd Floor Concrete	E	20	24	28
F	Steel Structure	F	15	18	21
G	Floor	F	15	18	21
H	Wall	F	15	18	21
I	Window & Frame	F	4	6	8
J	Concrete	F	4	6	8
K	Toilet	F	4	6	8
L	Plumbing & Sanitation	F	3	6	9
M	Electricity	G,H,I,J,K,L	10	12	14
N	Floor	E	21	24	27
O	Wall	N	16	18	20
P	Window & Frame	N	4	6	8
Q	Conncrete	N,	4	6	8
R	Roof	O,P,Q,S,T	4	6	8
S	Toilet	N	4	6	8
T	Plumbing & Sanitation	N	3	6	9
U	Electricity	M,R	10	12	14
V	Others	U	9	12	15
	Total		237	294	347

After making a time estimation, so the normal time, the pessimistic time, and the optimistic time are also bein known. Furthermore, calculations are given to determine the expected time value (t(e)) and the variance value of each activity. the time expectation calculation value can be seen in table bellow:

Table 4. Overall Time Expectation Calculation Value

Activity	Preliminary Activity	Time (days)			Expectation Time	Variance
		Optimistic Time	Normal Time	Pessimistic Time	t (e) =(a+4m+b)/6	((b-a)/6)^2
		(a)	(m)	(b)		
A		36	36	40	37	0,44
B	A	20	24	28	24	1,78
C	B	8	12	16	12	1,78
D	C	8	12	16	12	1,78
E	E	20	24	28	24	1,78
F	F	15	18	21	18	1
G	F	15	18	21	18	1
H	F	15	18	21	18	1
I	F	4	6	8	6	0,44
J	F	4	6	8	6	0,44
K	F	4	6	8	6	0,44
L	F	3	6	9	6	1
M	G,H,I,J,K,L	10	12	14	12	0,44
N	E	21	24	27	24	1
O	N	16	18	20	18	0,44
P	N	4	6	8	6	0,44
Q	N,	4	6	8	6	0,44
R	O,P,Q,S,T	4	6	8	6	0,44
S	N	4	6	8	6	0,44
T	N	3	6	9	6	1
U	M,R	10	12	14	12	0,44
V	U	9	12	15	12	1
TOTAL		237	294	355	295	19

From table 3, it is known that the Expected Time (t(e)) is 294.67 ~ 295 days. After knowing the results of the Expected Time (t(e)), the next step is to calculate the critical path using the results of the estimated time (te) and the calculation of the critical path same as in table 2. So, From the results of the scheduling analysis using the PERT method with the Expected Time (t(e)) value as the duration used in the calculation, it is known that the project completion time (TE) is 294.67 ~ 295 days and the critical path is obtained on the network diagram for activities expected 180.67 ~181 days. These two variables can be interpreted in the form of tables and distribution curves as shown in Table 5 and Figure 3.

Tabel 5. Standard Deviation and Variance of each Activity using PERT Method

Activity	Symbol	a (days)	b (days)	S	V(te)
I. Land Preparation	A	36	40	0,05	00.45
II. Structural Work	B, C, D, E, F	71	109	01.52	07.12
III. 1st Floor Architecture Work	G, H, I, J, K, L, M	55	89	01.15	07.27
IV. 2nd Floor Architecture Work	N, O, P, Q, R, S, T, U, V	75	117	0,09	0,25
Σ V(te)	20.48				
Standard Deviation	05.03				

Table 5 shows that the total variance (∑V(te)) = 20.48 and the standard deviation (S) is 5.03. From the behavior of the normal distribution curve where 99% of the area is in the interval (te

– 3S) and (te + 3S), the 3S range is 3 x 5.03 = 15.09. So the project completion period is 180.67 ± 15.09 days. The fastest estimated project completion time is 180.67 – 15.09 = 165.58 days ~ 166 days. While the estimated project completion at the latest is 180.67 + 15.09 = 195.76 ~ 196 days. If in this case, the target to be achieved is the fastest timeframe, then the value of t(d) = 165.58 ~ 165 days.

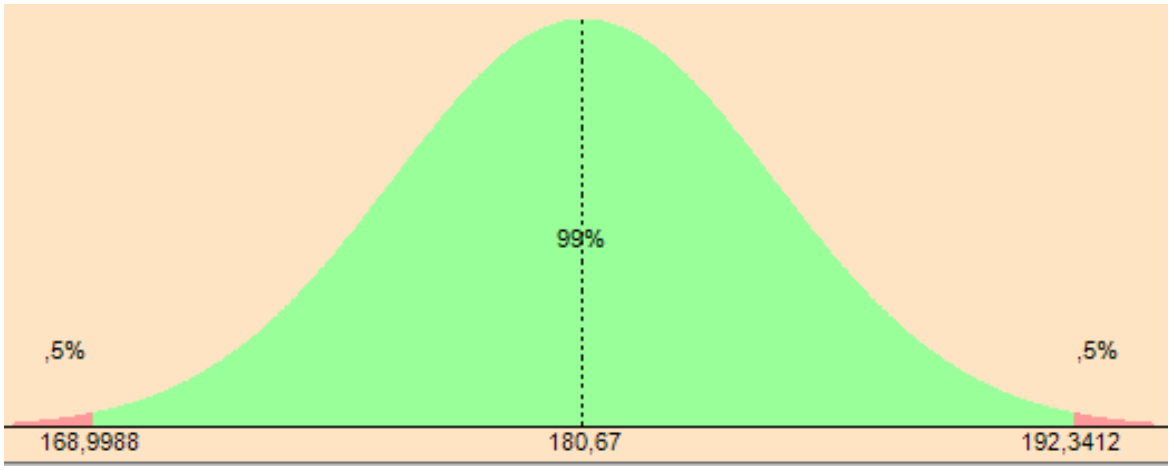

Figure 3. Normal Distribution for Canteen Project

3.3. Determine project completion time probability

To find out the probability of achieving the target schedule, can be done by connecting the expected time (TE) with the target T(d) which is expressed by:

$$z = \frac{T\,(d) - TE}{s}$$

With :
Z = The probability of hitting the target
T(d) = Schedule target
TE = Total time of Critical Path
S = Standard Deviation

given :
T(d) = 165.58 days
TE = 180.67 days
S = 5.03

$$z = \frac{T\,(d) - TE}{s}$$

$$z = \frac{165.58 - 180.67}{5.03}$$

$$z = -3$$

The results of the Z value confirmed are normally distributed with T(d) 165.58 and standard deviation of 5.03 through the QM for windows application, the probability of the possibility of completion project is shown in table 6.

Table 6. Project Completion Targets

No	Compeltion Target (days)	Deviation (z)	Cumulative Normal Distribution	Probability of Project 100% completed
1	165	-3	0,5753	57,53
2	166	-2,916	0,6141	61,41
3	167	-2,717	0,6517	65,17
4	168	-2,518	0,6879	68,79
5	169	-2,32	0,7224	72,24
7	170	-2,121	0,7549	75,49
8	171	-1,922	0,7852	78,52
9	172	-1,723	0,8133	81,33
10	173	-1,524	0,8389	83,89
11	174	-1,326	0,8621	86,21
12	175	-1,127	0,883	88,3
13	176	-0,922	0,9015	90,15
14	177	-0,729	0,9177	91,77
15	178	-0,53	0,9319	93,19
16	179	-0,332	0,9441	94,41
17	180	-0,133	0,9545	95,45
18	181	0,065	0,9633	96,33
19	182	0,264	0,9706	97,06
20	183	0,463	0,9767	97,67
21	184	0,662	0,9817	98,17
22	185	0,86	0,9857	98,57
23	186	1,059	0,989	98,9
24	187	1,258	0,9916	99,16
25	188	1,457	0,9936	99,36
26	189	1,656	0,9952	99,52
27	190	1,854	0,9964	99,64
28	191	2,053	0,9974	99,74
29	192	2,252	0,9981	99,81
30	193	2,451	0,9986	99,86
31	194	2,65	0,999	99,9
32	195	2,848	0,9993	99,93

From the results of the analysis in table 6 above, it can be seen as follows:
• The probability that the acceleration project can be completed within 165 days is 57.53%.
• The probability that a normal project can be completed in 181 days is 96.33%.
• The probability that a pessimistic project can be completed within 195 days is 99.93%.

3.4. Cost Analysis

The cost analysis in this study only provides an overview of the cost requirements needed in construction. The need for the cost of building is obtained from the results of direct interviews with the executor of the green canteen development activity so the requirement cost

is an estimation from the executor of each activity. Cost analysis is being made with consideration of the project time either normal, optimal, or when the project is accelerated. So, in the cost slope, it is necessary to know in advance the shortened time and the nominal costs incurred when the shortening time happens. In this project, there are some activities whose time is shortened, including land preparation work, bore pile work, pile cap work, tie beam work, 2nd-floor concrete work, steel structure work, floor work, electrical work, and others. The slope costs for each activity can be calculated in table 7.

Table 7. Canteen Construction Cost Analysis

Activity		Time Scale (days)		Cost (Rp)		Slope Cost
	Symbol	Optimistic	Normal	accelerated	Normal	
I. Land Preparation	A	36	36	Rp 200,000,000	Rp 200,000,000	-
II. Structural Work	B, C, D, E, F	71	90	Rp1.960.350,000	Rp 1.546.498,333	Rp413.851.666,67
III and IV 1st and 2nd Floor Architecture	G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V	130	168	Rp1,033,520,000	Rp 799.747.619,05	Rp233.772.380,95
Total		237	294	Rp3,193,870,0000	Rp 2.546.245.952,38	Rp 647.624.047

The results of the evaluation of the green cantin campus development project process in the study can be described in table 8 below

Table 8. Evaluation of The Green Canteen Construction Project Process

No	Component	Evaluation	Note
1	The critical path in the construction of the canteen using CPM method	The critical path using CPM method is the path with slack time = 0, i.e. activity A-B-C-D-E-F-G-M-U-V or A-B-C-D-E-F-H-M-U-V or A-B-C-D-E-N-O-R-U-V	A critical path had been defined where each project activity path is related to each other
2	Time for the Green Canteen Project	The probability of work is 99% using PERT method acquired 237 days	the probability of successful construction of Green canteen using PERT method is given
3	Accelerated reduction of cost estimation	The amount could be added in the construction is Rp. 647,624,047 with an accelerated work period of 237 days.	Cost estimation can be can decrease or increase based on probability using PERT method.

4. Conclusion

The final results are the sequence of the fastest green canteen construction project network is A-B-C-D-E-F-G-M-U-V or A-B-C-D-E-F-H-M-U-V or A-B-C-D-E-N-O-R-U-V. The probability that the acceleration project can be completed within 165 days is 57.53%, a normal project can be completed in 181 days is 96.33%, and the probability that a pessimistic project can be completed within 195 days is 99.93%. The optimal time for completing the green canteen construction project is 195.76~196 days from the project target of 165.58~165 days. Whereas, Cost estimation can be can decrease or increase based on probability using The PERT method until Rp. 647,624,047.

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