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ANALYSIS ON SCHEDULING ACCELERATION FOR CONSTRUCTION PROJECT OF WEST SUMBA BAPPEDA BUILDING USING TIME-COST TRADE-OFF METHOD

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ABSTRACT

The construction project of West Sumba BAPPEDA (Development Planning Agency at Sub-National Level) Building, in the fiscal year of 2016, is located at Weekarou Street in Loli Sub-District of Waikabubak City of West Sumba District (East Nusa Tenggara) and is according to construction agreement contract No 04/PPK-LELANG/BAPP/2016 dated June 24, 2016 with a contract value of IDR 3,415,700,000. The construction project of West Sumba BAPPEDA Building began on June 24, 2016 with a completion time limit of 180 days. The deadline for project completion is on December 20, 2016. Until the 5th week of the second month, the implementation of the project experiences delays that were caused by a lack of workforce. Due to the deadline for the scheduling plan, the construction project must complete all work. Therefore, the government issued an addendum for adding 50 days of project completion time. Based on these problems, the scheduling time acceleration plan needs to be reviewed. The scheduling acceleration of the construction project of West Sumba BAPPEDA Building is conducted by adding workforce to acceleration activities that have the lowest cost slope using the Time-Cost Trade-Off (TCTO) method. The scheduling is conducted using Gantt chart in the Microsoft Project scheduling application. The process of scheduling acceleration is carried out through 4 acceleration processes based on the types of activities that are on the critical path and have the lowest cost slope value. The results of scheduling acceleration are stopped in the fourth duration of the acceleration process because acceleration process has fulfilled the target with a total of 177 days $\leq$ 180 days and costs of IDR 7,034,600 from the normal duration of 201 days and costs of IDR 5,939,600. It obtained an additional acceleration cost from the normal duration as much as IDR 1,095,000. The scheduling acceleration using the Time-Cost Trade-Off (TCTO) method is carried out by adding a workforce of 24 days from the normal project schedule of the 201 to 177 calendar days. The total additional cost is IDR 14,871,462 from the planned cost according to the contract of IDR 3,105,189,408.66 to IDR 3,120,060,870.66.

KEY WORDS

Cost, critical path, scheduling, time acceleration.

Construction planning is the most basic stage in the management and implementation of construction projects. Success in its implementation is determined by several things, for example estimating good resources, determining the duration for each individual, choosing good technology, and identifying each interaction of various work tasks. Complete and appropriate planning and scheduling are the main keys to the successful implementation of the project on time (Whardana & Al Huda, 2017). In achieving its objectives, project activities have three constraints which are important parameters for measuring the success of a project which include the accurate budget (Cost), schedule (Time), performance and quality (Quality) (Suharto, 1995).

The larger the scale of a project, the more complex the management of scheduling. Scheduling is part of construction planning that can provide information about the schedule and progress of the project in terms of performance of resources in the form of costs, workforce, equipment, materials, project duration plans and time progress for project completion (Assaf & Al-Hejji, 2006). Scheduling is always referring to assumptions and

estimates when the plan and schedule are made. Thus, it results in problems of discrepancy between estimates or assumptions and the actual reality. The general impact that often occurs, in addition to increasing the cost of implementing the project, is the delay in project implementation time (Mondié & Michiels, 2003).

Project delays are often a source of disputes and demands between owners and contractors, so that delays become very expensive, both in terms of contractors and owners Kaliba, C., Muya, M., & Mumba, K. (2009).. Penalties will be given to contractors if the implementation time exceeds the contract and also additional overhead costs during the project. From the owner's side, project delays will have an impact on reduced income due to delays in the operation of facilities (Sambasivan & Soon, 2007).

Factors that can affect project development delays include: funds, material supply, equipment supply, human resources (HR), project location and weather. In addition, the current scheduling system is the conventional one, i.e. scheduling using the Bar Chart and S-curve methods in which the method does not describe dependencies and descriptions of activities where critical development activities are not revealed. Thus, the time for the most determining activities cannot be determined which results in a delay in project completion time (Doloi et. al., 2012).

The construction project of West Sumba BAPPEDA (Development Planning Agency at Sub-National Level) Building, in the fiscal year of 2016, is located at Weekarou Street in Loli Sub-District of Waikabubak City of West Sumba District (East Nusa Tenggara) which is carried out by PT. Panji Cemerlang and is according to construction agreement contract No 04/PPK-LELANG/BAPP/2016 dated June 24, 2016 with a contract value of IDR 3,415,700,000. The construction project of West Sumba BAPPEDA Building began on June 24, 2016 with a completion time limit of 180 days. The deadline for project completion is on December 20, 2016. Until the 5th week of the second month, the implementation of the project experiences delays that were caused by a lack of workforce. Due to the deadline for the scheduling plan, the construction project must complete all work. Therefore, the government issued an addendum for adding 50 days of project completion time.

Based on the above problems, the scheduling time acceleration plan needs to be reviewed. The scheduling acceleration of the construction project of West Sumba BAPPEDA Building is conducted by adding workforce to acceleration activities that have the lowest cost slope using the Time-Cost Trade-Off (TCTO) method. The scheduling is conducted using Gantt chart in the Microsoft Project scheduling application.

Research Problems. Based on the above description, the formulation of the research problems is as follow:

- What is the normal scheduling for the construction project of the West Sumba BAPPEDA Building?
- How long does it take to schedule the construction project of the West Sumba BAPPEDA Building after time acceleration using the Time-Cost Trade-Off method?
- How much is the cost after time acceleration using the Time-Cost Trade-Off method?
- What is the difference between the time and cost of the project after time acceleration using the Time-Cost Trade-Off method compared to the original plan?

Research Objectives. Based on the above research problems, the formulation of the research objectives is as follow:

- Analyzing the normal scheduling for the construction project of the West Sumba BAPPEDA Building;
- Analyzing the length of time for scheduling the construction project of the West Sumba BAPPEDA Building after time acceleration using the Time-Cost Trade-Off method;
- Analyzing the amount of the cost after time acceleration using the Time-Cost Trade-Off method;
- Analyzing the difference between the time and cost of the project after time acceleration using the Time-Cost Trade-Off method compared to the original plan.

METHODS OF RESEARCH

The research object is the Analysis on the Scheduling Acceleration for the Construction Project of the West Sumba BAPPEDA Building in the fiscal year of 2016 which had been delayed. To overcome this delay, the Time-Cost Trade-Off method is used to accelerate activities that are on the critical path so that the delay in the construction of the project at week 5 of the second month until the end of the project completion can be overcome. The acceleration analysis ≤ 180 calendar days according to the target is determined by the amount of duration obtained. The duration of project acceleration is stopped if the duration of the project time is accelerated cepat 180 days, and if the duration of the duration after acceleration is greater than 180 days, then the acceleration of the project is carried out until the duration of ≤ 180 days.

Identification of plans for scheduling project activities is carried out to determine whether the planned project activities are carried out in accordance with conditions in the field. This analysis is carried out to determine project time, normal costs and logical relations between activities according to the schedule of plans made by the contractor in which the time acceleration has not been carried out. Analysis of time and costs as well as time acceleration (crashing) is carried out by using the Time-Cost Trade-Off method, i.e. adding workforce and making shifts in acceleration activities, with the following conditions:

- Getting time acceleration for the construction project of West Sumba BAPPEDA Building;
- Obtaining the amount of time acceleration of the construction project;
- Obtaining the amount of time accelerating cost of the construction project.

After the time acceleration is carried out, the time acceleration and the lowest possible cost of the project implementation can be determined so that it can be compared with the original plan.

RESULTS OF STUDY

Analyzing Schedule of Activity Implementation in Normal Time Equation of Work Volume. Furthermore, after the activities and costs are identified, each activity will be described again and the work volume will be equalized. The equalization is intended to reduce the number of activities in the project by combining activities that have relatively small costs into larger activities.

The principle of equality lies in the ratio of the lowest unit cost divided by the largest unit cost multiplied by the volume. The unit cost calculated here is only the unit cost of labor that is very influential in productivity, and will also affect the progress of the work, while the cost of material is considered to be fixed and not too influential on productivity; for instance, equalizing volume on land work:

$$\begin{aligned} 0.27 &= \text{IDR } 67.125.49 / 251.874.28 \\ 87.50 &= 328.32 \text{ m}^3 \times 0.27 \\ 429.18 &= 87.50 + 16.79 + 323.40 + 1.49 \end{aligned}$$

The unit price in bold is a divider from the price of the other units at each activity. The calculation results of other types of activities are the same as the example above. Based on the analysis, the equivalent volume of each work item can be determined, i.e. preparatory work of 85.25 m², land work of 429.18 m³, foundation work of 221.39 m³, structure work 274.74 m³, ceramic and covering work of 44.87 m³, wall work of 1,328.87 m², roof work of 1,941.67 m² and utility work of 22.22 m².

Calculating Workforce Productivity. After obtaining volume equalization, the productivity of each activity/unit/day can be determined. The productivity analysis uses the Indonesian National Standard 2013, which is calculated as 8 hours of work/day. Working hours on the construction project of the West Sumba BAPPEDA Building use 8 working hours/day. Thus, in 1 day (8 working hours of INS 2013) can obtain the productivity of work groups by:

$$\begin{aligned}
 1 \text{ day}/0.850 &= 1.18 \text{ m}^3, \text{ so for 1 day (8 hours of work in the field)} \\
 &= 8/8 \times 1.18 = 1.18 \text{ m}^3/\text{day needs (1 HM)}, \\
 &= 1.18 \times 3.400 = 4.02 \text{ m}^3/\text{day needs (4 WK)}, \\
 &= 1.18 \times 0.085 = 0.10 \text{ m}^3/\text{day needs (0.1 FM)}, \\
 &= 1.18 \times 0.170 = 0.20 \text{ m}^3/\text{day needs (0.2 SP)},
 \end{aligned}$$

The above calculation is used to find the productivity of other types of work, and the results of the productivity calculation can be seen in Table 1 below.

Table 1 – Calculation of Workforce Productivity

No	Work types	Equivalent volume	Ins productivity of workforce 2013 unit/day/group	Product of 8 working hours per day
I	Preparatory Work	85.25	3.00 m ²	28
			0.1 FM + 0.1 SP + 1 HM + 1 WK	
II	Land Work	429.18	2.00 m ³	215
			0.1 SP + 2 WK	
III	Foundation Work	221.39	1.18 m ³	188
			0.1 FM + 0.2 SP + 1 HM + 4 WK	
IV	Structure Work	274.74	8.15 m ³	34
			0.1 FM + 0.1 SP + 1 HM + 7 WK	
V	Ceramic and Covering Work	44.87	3.00 m ³	15
			0.1 FM + 0.3 SP + 1 HM + 6 WK	
VI	Wall Work	1,328.87	10.00 m ²	133
			0.1 FM + 0.2 SP + 1 HM + 6 WK	
VI I	Roof Work	1,941.67	16.67 m ²	116
			0.2 FM + 0.1 SP + 1 HM + 6 WK	
VI II	Utility Work	22.22	6.30 m	4
			0.1 FM + 0.03 SP + 1 HM + 1 WK	

Calculating the Duration and Workforce Group in a Normal Time. Determination of the duration of each work group must consider the experience, capabilities, and availability of existing human resources. In general, the formula used to search for duration is:

$$\text{duration} = \frac{\text{volume}}{\text{productivity}}$$

Example of calculating duration for foundation work: if the work is carried out by 1 working group consisting of 1 Handyman, 4 Workers, 0.1 Foreman and 0.2 Supervisor, then the productivity per day is 1.18 m³. To complete 221.39 m³, it takes duration: 221.39/ 1.18 = 188. If it uses 6 work groups the volume is 6 x 1.18 = 7.08 m³, the duration is 221.39 / 7.08 = 31.27; rounded up to 31 days.

This calculation is also used to calculate the duration of other work types, the calculation results can be seen in the following Table 2:

Table 2 – Calculation of the Normal Duration and Workforce Group for the Construction Project of West Sumba BAPPEDA Building

No	Work types	Work group	Product	Volume	Equivalent volume	Duration (day)
I	Preparatory Work	1	3.00	3.00	85.25	28
II	Land Work	7	2.00	14.00	429.18	31
III	Foundation Work	6	1.18	7.08	221.39	31
IV	Structure Work	1	8.15	8.15	274.74	34
V	Ceramic and Covering Work	1	3.00	3.00	44.87	15
VI	Wall Work	4	10.00	40.00	1,328.87	33
VII	Roof Work	3	16.67	50.01	1,941.67	39
VIII	Utility Work	1	6.30	6.30	22.22	4

Normal duration of the construction of the West Sumba BAPPEDA Building based on the planned budget is 180 days. Meanwhile, the normal duration of the Gantt Chart scheduling analysis results in the Microsoft Project scheduling application is 201 days. From the analysis of the normal duration and workforce groups for each activity for the Construction Project of West Sumba BAPPEDA Building, the duration of each work item includes: 28 days of preparation work, 31 days of land work, 31 days of foundation work, 34 days of structure work, 15 days of ceramics and covering work, 33 days of wall work, 39 days of roof work, and 4 days of utility work.

Analysis of Scheduling Acceleration Using Time-Cost Trade-Off Method. Arranging work networks must be in accordance with the logical sequence of dependency relationships between activities. In addition, the sequence of work between activities with one another must be in accordance with the method of completion of the work, so that the technical logic in its preparation must be considered. For instance, the land work is done after the preparatory work is completed, or the foundation work is done after the earthwork is completed. The arrangement between activities is carried out using the Gantt Chart in the Microsoft Project scheduling application program.

Table 3 – Dependence Logic between the Activities

No	Work types	Codes	Predecessors	Duration (day)
I	Preparatory Work	A	--	28
II	Land Work	B	A	31
III	Foundation Work	C	B	31
IV	Structure Work	D	C	34
V	Ceramic and Covering Work	E	G	15
VI	Wall Work	F	D	33
VII	Roof Work	G	F	39
VIII	Utility Work	H	C	4

Determining critical trajectories using the Gantt Chart Microsoft Project scheduling application program results the critical trajectory of A-B-C-D-G-F-E. This process is done by filling in the work groups in the task name, filling in the duration of each job and filling in the predecessors as a sequence of logical dependencies between activities and as the determination of any work that is on the critical path.

Table 4 – Calculation of Cost Slope and Normal Duration

No	Work codes	Pracd works	Time (day)		Costs		Cost slope
			Product	Normal	Product	Normal	
I	A	--	28	28	IDR 125,500	IDR 125,500	IDR --
II	B	A	215	31	IDR 99,000	IDR 693,000	IDR 3,229
III	C	B	188	31	IDR 270,500	IDR 1,623,000	IDR 8,650
IV	D	C	34	34	IDR 401,500	IDR 401,500	IDR --
V	E	G	15	15	IDR 437,000	IDR 437,000	IDR --
VI	F	D	133	33	IDR 362,500	IDR 1,450,000	IDR 10,912
VII	G	F	116	39	IDR 363,000	IDR 1,089,000	IDR 9,350
VIII	H	C	4	4	IDR 120,600	IDR 120,600	IDR --
TOTAL					IDR 2,179,600	IDR 5,939,600	IDR 32,141

After knowing the critical path at normal time with a total duration of 201 days and exceeding the scheduling plan of 180 days, then the acceleration of the of the project was carried out for the Construction Project of the West Sumba Regency BAPPEDA Building. The selection of project duration acceleration activities is carried out step by step on the type of work that is on the critical path that has the lowest cost slope and a long duration. The results of calculating the Cost Slope at normal times ranging from the lowest value to the

highest value include: work B (Land Work) worth IDR 3,229, the lowest cost slope followed by work C (Foundation Work) worth IDR 8,650, work G (Roof Work) worth IDR 9,350, and work F (Wall Work) worth IDR 10,912 which is the highest cost slope. After knowing the lowest cost slope value on the work B (Land Work), the acceleration of the duration of the first stage is carried out.

Table 5 – Calculation of the Acceleration Duration and the First Stage of Workforce Group

No	Work types	Work groups		Productivity	Resulted volume		Equivalent volume	Duration
		Before	After		Before	After		
I	Preparatory Work	1	1	3.00	3.00	3.00	85.25	28
II	Land Work	7	8	2.00	14.00	16.00	429.18	27
III	Foundation Work	6	6	1.18	7.08	7.08	221.39	31
IV	Structure Work	1	1	8.15	8.15	8.15	274.74	34
V	Ceramic and Covering Work	1	1	3.00	3.00	3.00	44.87	15
VI	Wall Work	4	4	10.00	40.00	40.00	1,328.87	33
VII	Roof Work	3	3	16.67	50.01	50.01	1,941.67	39
VIII	Utility Work	1	1	6.30	6.30	6.30	22.22	4

Based on the results of the acceleration analysis of the duration in Table 5 using the Gantt Chart in the Microsoft Project scheduling application program, it obtains the critical path A-B-C-D-G-F-E. After accelerating the activities that are on the critical path and the lowest cost slope value, i.e. the land work with a normal duration of 31 days, the result in the first stage is 27 days. At this stage, the total duration of the project is 197 days and does not meet the target duration of ≤ 180 days. The results of the first accelerated cost slope can be seen in Table 6.

Table 6 – Results of Cost Slope Calculation and First Stage Duration

No	Work codes	Pracd works	Waktu (Day)		Costs		Cost slope
			Normal	Crash	Normal	Crash	
I	A	--	28	28	IDR 125,500	IDR 125,500	IDR --
II	B	A	31	27	IDR 693,000	IDR 792,000	IDR 25,835
III	C	B	31	31	IDR 1,623,000	IDR 1,623,000	IDR --
IV	D	C	34	34	IDR 401,500	IDR 401,500	IDR --
V	E	G	15	15	IDR 437,000	IDR 437,000	IDR --
VI	F	D	33	33	IDR 1,450,000	IDR 1,450,000	IDR --
VII	G	F	39	39	IDR 1,089,000	IDR 1,089,000	IDR --
VIII	H	C	4	4	IDR 120,600	IDR 120,600	IDR --
TOTAL					IDR 5,939,600	IDR 6,038,600	IDR 25,835

Table 7 – Calculation of the Duration Acceleration and the Workforce Groups of the Second Stage

No	Work types	Work groups		Productivity	Resulted volume		Equivalent volume	Duration
		Before	After		Before	After		
I	Preparatory Work	1	1	3.00	3.00	3.00	85.25	28
II	Land Work	7	8	2.00	14.00	16.00	429.18	27
III	Foundation Work	6	7	1.18	7.08	8.26	221.39	27
IV	Structure Work	1	1	8.15	8.15	8.15	274.74	34
V	Ceramic and Covering Work	1	1	3.00	3.00	3.00	44.87	15
VI	Wall Work	4	4	10.00	40.00	40.00	1,328.87	33
VII	Roof Work	3	3	16.67	50.01	50.01	1,941.67	39
VIII	Utility Work	1	1	6.30	6.30	6.30	22.22	4

Based on the results of the acceleration analysis of the duration in Table 6 using the Gantt Chart in the Microsoft Project scheduling application program, it obtains the critical path A-B-C-D-G-F-E. After accelerating the activities on the critical path and on the lowest cost slope value, i.e. on land work with a normal duration of 31 days with a value of IDR 3,229 cost slope, the acceleration duration of the first phase is 27 days with a value of IDR 25,835 cost slope.

Based on the results of the acceleration analysis of the duration in Table 7 using the Gantt Chart in the Microsoft Project scheduling application program, it obtains the critical path A-B-C-D-G-F-E. After accelerating the activities on the critical path and on the lowest cost slope value, i.e. on foundation work with a normal duration of 31 days, the result of the second stage is 27 days. the acceleration duration of the first phase is 27 days. At this stage the total duration of the project is 193 days and does not meet the target duration of ≤ 180 days. The result of the accelerated cost slope on the second stage can be seen in the following Table 8.

Table 8 – Result of Cost Slope Calculation and Duration Acceleration on the Second Stage

No	Work codes	Pracd works	Time (day)		Costs		Cost Slope
			Normal	Crash	Normal	Crash	
I	A	--	28	28	IDR 125,500	IDR 125,500	IDR --
II	B	A	31	27	IDR 693,000	IDR 792,000	IDR --
III	C	B	31	27	IDR 1,623,000	IDR 1,893,500	IDR 60,554
IV	D	C	34	34	IDR 401,500	IDR 401,500	IDR --
V	E	G	15	15	IDR 437,000	IDR 437,000	IDR --
VI	F	D	33	33	IDR 1,450,000	IDR 1,450,000	IDR --
VII	G	F	39	39	IDR 1,089,000	IDR 1,089,000	IDR --
VIII	H	C	4	4	IDR 120,600	IDR 120,600	IDR --
TOTAL					IDR 5,939,600	IDR 6,309,100	IDR 60,554

Based on Table 8, after accelerating to the lowest cost slope value, i.e. at the foundation work with a normal duration of 31 days with a value of IDR 8,650 cost slope, the acceleration duration in the second stage is 27 days with a cost slope of IDR 60,554.

Table 9 – Calculation of the Duration Acceleration and the Workforce Group on the Third Stage

No	Work types	Work groups		Productivity	Resulted volume		Equivalent volume	Duration
		Before	After		Before	After		
I	Preparatory Work	1	1	3.00	3.00	3.00	85.25	28
II	Land Work	7	8	2.00	14.00	16.00	429.18	27
III	Foundation Work	6	7	1.18	7.08	8.26	221.39	27
IV	Structure Work	1	1	8.15	8.15	8.15	274.74	34
V	Ceramic and Covering Work	1	1	3.00	3.00	3.00	44.87	15
VI	Wall Work	4	4	10.00	40.00	40.00	1,328.87	33
VII	Roof Work	3	4	16.67	50.01	66.68	1,941.67	29
VIII	Utility Work	1	1	6.30	6.30	6.30	22.22	4

Based on the results of the acceleration analysis of the duration in Table 9 using the Gantt Chart in the Microsoft Project scheduling application program, it obtains the critical path A-B-C-D-G-F-E. After accelerating the activities that are on the critical path and at the lowest cost slope value, i.e. on the roof work with a normal duration of 39 days, the result in the third stage is 29 days. At this stage, the total duration of the project is 183 days and has not met the target duration of ≤ 180 days. The third stage of the accelerated cost slope can be seen in the following Table 10.

Based on Table 10, after accelerating to the lowest cost slope value, which i.e. the roof work with a normal duration of 39 days with a cost slope of IDR 9,350, it obtains the acceleration duration in the second stage of 29 days with a cost slope value of IDR 37,398.

Table 10 – Results of Cost Slope Calculation and the Duration Acceleration on the Third Stage

No	Work codes	Pracd works	Time (day)		Costs		Cost Slope
			Normal	Crash	Normal	Crash	
I	A	--	28	28	IDR 125,500	IDR 125,500	IDR --
II	B	A	31	27	IDR 693,000	IDR 792,000	IDR --
III	C	B	31	27	IDR 1,623,000	IDR 1,893,500	IDR --
IV	D	C	34	34	IDR 401,500	IDR 401,500	IDR --
V	E	G	15	15	IDR 437,000	IDR 437,000	IDR --
VI	F	D	33	33	IDR 1,450,000	IDR 1,450,000	IDR --
VII	G	F	39	29	IDR 1,089,000	IDR 1,452,000	IDR 37,398
VIII	H	C	4	4	IDR 120,600	IDR 120,600	IDR --
TOTAL					IDR 5,939,600	IDR 6,672,100	IDR 37,398

Table 11 – Calculation of the Duration Acceleration and the Workforce Group on the Fourth Stage

No	Work types	Work groups		Productivity	Resulted volume		Equivalent volume	Duration
		Before	After		Before	After		
I	Preparatory Work	1	1	3.00	3.00	3.00	85.25	28
II	Land Work	7	8	2.00	14.00	16.00	429.18	27
III	Foundation Work	6	7	1.18	7.08	8.26	221.39	27
IV	Structure Work	1	1	8.15	8.15	8.15	274.74	34
V	Ceramic and Covering Work	1	1	3.00	3.00	3.00	44.87	15
VI	Wall Work	4	5	10.00	40.00	50.00	1,328.87	27
VII	Roof Work	3	4	16.67	50.01	66.68	1,941.67	29
VIII	Utility Work	1	1	6.30	6.30	6.30	22.22	4

Based on the analysis results of the duration acceleration in Table 11 using the Gantt Chart in the Microsoft Project scheduling application program, it obtains the critical path A-B-C-D-G-F-E. After accelerating the activities that are on the critical path and at the lowest cost slope value i.e. on the wall work with a normal duration of 33 days, the result in the fourth stage is 27 days. At this stage, the total duration of the project is 177 days and meets the target duration of ≤ 180 days. The results of the acceleration cost slope in the fourth stage can be seen in the following Table 12.

Table 12 – Results of Cost Slope Calculation and Acceleration Duration on the Fourth Phase

No	Work codes	Pracd works	Time (day)		Costs		Cost Slope
			Normal	Crash	Normal	Crash	
I	A	--	28	28	IDR 125,500	IDR 125,500	IDR --
II	B	A	31	27	IDR 693,000	IDR 792,000	IDR --
III	C	B	31	27	IDR 1,623,000	IDR 1,893,500	IDR --
IV	D	C	34	34	IDR 401,500	IDR 401,500	IDR --
V	E	G	15	15	IDR 437,000	IDR 437,000	IDR --
VI	F	D	33	27	IDR 1,450,000	IDR 1,812,500	IDR 60,417
VII	G	F	39	29	IDR 1,089,000	IDR 1,452,000	IDR --
VIII	H	C	4	4	IDR 120,600	IDR 120,600	IDR --
TOTAL					IDR 5,939,600	IDR 7,034,600	IDR 60,417

Based on Table 12, after accelerating the lowest value of the cost slope, i.e. the wall work with a normal duration of 33 days with the value of the cost slope of IDR 10,912, the acceleration duration of the fourth stage is 27 days with a cost slope value of IDR 60,417.

The process of accelerating the duration is stopped in the fourth duration of acceleration process, because the acceleration process has fulfilled the target with a total duration of 177 days $\leq$ 180 days, in which the duration of each activity is: preparation work of 28 days, land work of 27 days, foundation work of 27 days, structure work of 34 days, ceramic and covering work of 15 days, wall work of 27 days, roof work of 29 days, and utility work of 4 days.

Calculating the Amount of Time Acceleration Costs. Based on the analysis results on the calculation of the amount of time acceleration for the construction project of building scheduling above, the amount of direct and indirect costs is obtained by the following steps:

Direct Cost

- Calculating handyman and worker groups needed for the duration of each work on the normal time of the building construction;
- Calculate the handymans and worker groups needed for the duration of each work on the time acceleration of building scheduling;
- Calculating the worker cost per day for the construction project of West Sumba BAPPEDA Building.

Based on the calculation of direct and indirect costs, it produces a chart of the total project costs as follows:

Figure 1 – Chart of Total Project Costs

Based on the above chart of the total project costs, the result of acceleration with each total duration has a total cost that includes: acceleration with a total duration of 177 days amounting to IDR 9,293,600, acceleration with a total duration of 183 days amounting to IDR 8,953,100, acceleration with a total duration of 193 days amounting to IDR 8,623,100, accelerating with a total duration of 197 days amounting to IDR 8,374,100, and normal duration with a total duration of 201 days amounting to IDR 8,286,600.

Calculating Cost Savings. The use of the Time-Cost Trade-Off (TCTO) method results in cost savings, i.e. indirect costs minus direct costs = IDR 15,966,462 - IDR 1,095,000 = IDR 14,881,462 or 0.48% of the agreed contract costs IDR 3,105,189,408, 66.

Due to the delay in the implementation of the project by 21 days from the planned time of 180 days, the additional costs obtained are IDR 13,970,649.

If project cost savings is carried out, it amounts to IDR 13,970,649 + IDR 14,781,462 = IDR 28,842,111 or 0.93% of the agreed contract costs IDR 3,105,189,408.66.

CONCLUSION

Based on the analysis on scheduling acceleration for construction project of West Sumba BAPPEDA Building using Time-Cost Trade-Off Method, it obtains the following results:

- Normal scheduling for the construction project of West Sumba BAPPEDA Building is 201 days;
- Based on the results of the acceleration analysis by adding workforce for the construction project of West Sumba BAPPEDA Building, the normal calendar of 201 days is accelerated to 177 calendar days according to the target time;
- After the acceleration is carried out, it obtains a total cost of IDR 3,120,060,870.66 from the total planned cost of IDR 3,105,189,408.66;
- Based on the results of the analysis of the time acceleration by adding workforce, it has an acceleration of 24 days with an additional cost of IDR 14,871,462.

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