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COST AND TIME ANALYSIS OF FAST FOOD RESTAURANT BUILDING CONSTRUCTION PROJECT IN PONTIANAK USING CRASHING METHOD

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Abstract

The construction project of the McD Pontianak building encountered significant challenges due to a tight schedule of 110 calendar days and unforeseen delays arising from the existing building's foundation. These delays led to a setback in the construction progress, prompting the need for strategic measures to accelerate the project and mitigate the delays amounting to 11.48%, equivalent to 12.63 days. The potential financial consequences of this delay were estimated at IDR 228,366,605. In order to expedite the construction process, the chosen acceleration method was the crashing method, involving an increase in overtime ranging from 1 to 4 working hours, in accordance with relevant laws and regulations. This required a comprehensive analysis encompassing normal cost, normal duration, critical path, productivity, crashing cost, and crashing duration calculations. Upon thorough examination, it was determined that the optimal solution to overcome the delays was to implement an additional 2 hours of overtime. However, this decision came with associated costs, resulting in a necessary expenditure of IDR 93,651,965 to achieve a crashing time of 18.30 days. Despite the increased financial commitment, this strategic approach was deemed essential to meet the project's original schedule and avoid potential penalties. The findings and conclusions drawn from this analysis provide valuable insights into effective project management and decision-making in the face of unexpected challenges in the construction industry.

Keywords: *Cost, Time, Crashing method*

1. INTRODUCTION

The introduction briefly explains the research background, research gaps, and research objectives at the end of the introduction. The introduction should be written efficiently and supported by relevant references.

The *time cost trade off method* is an exchange of time and cost is a way used to accelerate the implementation time on a project by testing all activities in a project that are focused on activities that are on a deliberate and systematic critical path. In this study, it has been limited that project duration acceleration activities will be carried out by increasing working hours. The background of using this method can be caused by several things such as uncertainty in the project, time pressure, limited resources (Izzah, 2018)

In the case study, the construction of the McD Pontianak building was faced with a tight schedule with the work period of 110 calendar days and experienced delays caused by the foundation of the existing building that was still there, thus hampering the erection process and local rain, cost and time management was needed so that the results obtained were in accordance with the plan. in week 11 there was a delay with a

deviation of - 11.48% (minus eleven point forty-eight percent) with a total cumulative realization reaching 37.14% (thirty seven point fourteen percent). Therefore, it takes a proper cost and time analysis on construction projects, so as to minimize the risk of delays in project work which will be a case study is the construction of the Pontianak McD building.

The alternative taken in this method is to increase work time *(manhour)*, this alternative is done to accommodate work that is stopped due to rain during the day and with such conditions the addition of working hours is the most likely alternative for delays that occur in structural work. Increasing the number of workers is also an alternative to support work activities. The type and intensity of project activities change rapidly throughout the cycle, so the addition of the number of workers must include estimates of the type and when labor is needed by knowing the estimated numbers and schedules of needs, then the addition of labor both quality and quantity becomes better and more efficient. In planning a realistic increase in the number of workers, it is necessary to pay attention to various factors, namely labor productivity, limited resources, the number of construction workers in the field. However, the addition of manpower is not possible because structural and foundation work requires skilled workers in their fields and to find skilled workers takes time, so it is not recommended as an alternative to the time towards the end of the year and the deadline for work. As for the alternative of increasing the number of work tools, because, work tools affect the number of workers who are not added; This is because work tools and labor are directly proportional, so if no additional labor is made, it is not possible to add work tools. Therefore, increasing working hours is an efficient alternative that can be tested and analyzed, so that the right cost and time analysis on construction projects can minimize the risk of delays in project work.

2. LITERATURE REVIEW

One alternative that can be used to carry out project acceleration is to use overtime work. One method that can be used to analyze the effect of project acceleration on costs that must be incurred is by crashing analysis by converting schedules to get more profitable results in terms of time, cost and revenue

2.1. Project Management

Project management is a series of processes in a construction project from the initial stage to the end which includes planning, organizing, and controlling resources to achieve predetermined goals (Soeharto, 1999).

The planning function is the initial progress of the construction project process which aims at making decisions on managing selected data and information related to plans to be carried out on a project. The organizational function is aimed at organizing the flow of activities of project resources, both human and tools and materials; So that the scope of project activities can be interconnected and run according to the plan that has been designed. The implementation function aims to actualize all activities of organizational actors according to the target plan by prioritizing occupational safety and health. The control function aims to measure and maintain the quality of implementation work in accordance with planning data. All activities carried out in the

project must be organized and structured so that misactuacting does not occur and avoids delays in work progress. In this case, the preparation of Work Breakdown Structure (WBS) is carried out which is the basis of a grouping of work elements displayed in graphic form to organize and divide the scope of project work (Dimyati, A. Hamdan., Nurjaman, 2014).

2.2. Project Delays and Risks

Delay is the implementation of the realization schedule that does not reach the planned schedule that has been set due to several factors and reasons, then it can be said to experience delays; Delays can affect subsequent activities on a project, and will impact pre-established financial planning issues (Levis, 1996).

The impact of late work activity items will cause delays in project completion, extend the duration of project work, and can even have an impact on increasing costs incurred to meet targets, the causes of delay are:

Excusable non compensable delays, the cause of delays that most often affect the timing of project implementation, such as natural disturbances or unavoidable weather, riots, or demos, for examples are act of God, force majure, and weather

Excusable compenshable delays, the cause of these delays is that the project owner, contractor, is entitled to an extension of time and claims for delays. For example, delays in work details, for examples are late delivery of the total project site, late payment to the contractor, incorrect drawings and specifications, late detailing of the work

Non excusable delays, delays that are entirely the responsibility of the contractor, because the contractor extends the time of execution of work until it exceeds the planned deadline. Errors in coordinating work, materials and equipment, errors in project financial management, errors in hiring incompetent personnel. (Levis, 1996)

2.3. Crashing Programme

One alternative that can be used to carry out project acceleration is to use overtime work; one method that can be used to analyze the effect of project acceleration on costs that must be incurred is by crashing analysis.

A range of studies have explored the use of the crashing method to analyze the trade-off between time and cost in project management. (Karmaker & Halder, 2017) and (Sharma, S., Bedi, N., & Sukhwani, 2020) both developed linear programming models to optimize this trade-off, with Halder finding a 17% reduction in project duration with a 3.73% increase in cost, and Sharma noting a 15% reduction in duration with a 5% increase in cost. (Laksana, 2014) focused on the use of the crash program to shorten project implementation time, while (Bagherpour, M., Noori, S., & Sadjadi, 2006) adapted linear programming to solve cost time trade off problems in flow shop scheduling. These studies collectively highlight the potential of the crashing method in achieving cost and time efficiencies in project management.

The total cost of the project is equal to the sum of the direct costs and indirect costs. The total cost of the project depends largely on the completion time of the project. The relationship between cost and time can be seen in figure 2.1 Point A in the figure indicates normal conditions, while point B indicates accelerated conditions. The line

that connects these points is called the cost time curve. That the greater the increase in the number of working hours (overtime), the faster the project completion time, but as a consequence, there will be additional costs that must be incurred will be greater as in Figure 1. (Priyo & Aulia, 2016)

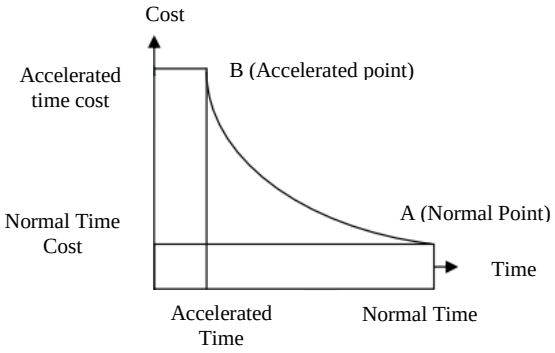

Figure 1. Graph of Normal and Accelerated Time - Cost Relationship
Source : Priyo & Aulia, 2016

2.4. Productivity

Productivity is a comparison between output and work output. In the field of construction, output can be seen from the quantity of work that has been done such as cubic meters of excavation or stockpiles, or square meters for plastering. While input is the amount of resources used such as labor, equipment and materials. Because equipment and materials are usually standardized, the skill level of the workforce is one of the determining factors of productivity. (Wowor et al., 2013)

According to productivity measures that are often observed are related to labor. The definition of labor according to Law of the Republic of Indonesia No. 13 of 2003 is everyone who is able to do work to produce goods and / or services both to meet their own needs and the community. Here are the functions and tasks of the workforce based on its expertise (KEMENPERIN, 2003), The head handyman is a person who has expertise in carpentry for a particular type of work and gives instructions to the craftsmen related to that type of work, Handymen are people who directly do work in the field in a particular field according to the instructions of the chief handyman.these people usually have little skills and a worker (laborer) is a person who helps a handyman or head handyman for all types of work without having to have expertise in a particular job.

One strategy to speed up project completion time is to increase working hours (overtime). Overtime can be done by adding 1 hour, 2 hours, 3 hours, and 4 hours according to the desired addition time. The greater the increase in overtime hours can cause a decrease in productivity, an indication of a decrease in worker productivity against the increase in working hours (overtime) (Priyo & Aulia, 2016)

Tabel 1. The Relationship of the Effect of Overtime Hours on Work Performance (%)

Overtime Hour/s	Decline in Productivity Index	Work Performance (%)
1 hour	0,1	90
2 hours	0,2	80
3 hours	0,3	70
4 hours	0,4	60

Source : Priyo & Aulia, 2016

3. RESEARCH METHODS

Research method is a plan or framework used to organize all the sequences of a research. The research method is also a guide that assists researchers in designing, implementing, and analyzing research. The following are the design stages of the implementation of this research.

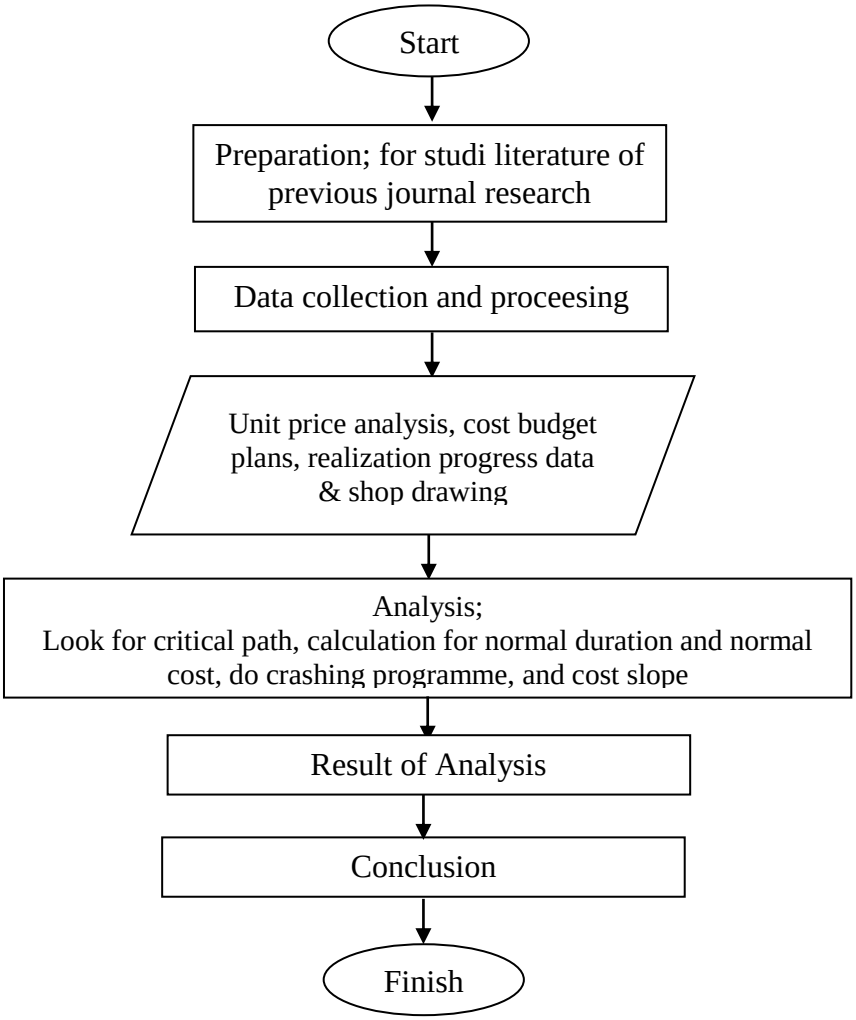

Figure 2. Workflow of Research
Source : Processed Researcher, 2023

3.1. Preparation

Problem identification and field studies are carried out to identify problems to be used in this research and conduct literature studies to deepen knowledge and support the completion of research.

3.2. Data Collection and Processing

At this stage, secondary data collection is carried out in the form of cost budget plans, realization progress data, unit price analysis of work, and shop drawing, so that the data can be the basis for acceleration analysis using the crashing method.

3.3. Analysis

In this third stage, analysis is carried out by the crashing method with the initial stage is to find the critical path of work from secondary data that has been obtained, then the analysis is continued by finding the duration and normal costs, then accelerating the duration of work and calculating costs due to acceleration. In the next stage, the cost slope calculation is carried out to see the time and cost of effective work resulting from the acceleration calculation.

3.4. Conslusion

At this stage, a conclusion is made on the discussion that has been carried out in the previous stage, so that an effective acceleration time is obtained to overcome the delay compared to the amount of the predetermined fine.

4. RESULTS AND DISCUSSION

Cost and Time Analysis of Mcdonald's Pontianak construction project work using crashing method, project overview when case study analysis is carried out and the duration of acceleration of project work duration will also be explained in this chapter. Activities that are on critical lines with a high risk of delay will be identified, and the determination of crashing will be further reviewed. The data used in this case study comes from actual secondary project data in the form of cost budget plans, work drawings, unit prices of work, and progress data.

4.1. Cost Budget Plan

The overall budget plan for the construction of McDonald's Pontianak Ahmad Yani no 5, Pontianak is Rp 8,146,012,042 (eight billion one hundred forty three six million twelve thousand forty two rupiah), with a special budget plan for concrete structure work is Rp 839,227,822 (eight hundred thirty nine million two hundred twenty seven thousand eight hundred twenty two rupiah) consisting of ground beam work, Formwork, ironing and concreting of beams, columns, floor slabs. The weather condition in Pontianak, West Kalimantan according to the project manager's report is entering the rainy season; in week 11 there was a delay with a deviation of - 11.48% (minus eleven point forty-eight percent) with a total cumulative realization reaching 37.14% (thirty seven point fourteen percent).

4.2. Normal Duration & Normal Cost

Analysis of the calculation of the total normal duration is obtained from the normal duration of each work item. Here is an example of calculating the normal duration of each work item.

Calculation example 1, Beam Formwork +3,770

1. Volume of work : 265,27 m2
2. Coefficient of worker : 0,100
3. Quantity of worker : 10 men
4. Work per day productivity : (1/ Coefficient of worker x quantity of worker)
   = 1/0,100 x 10
   = 100
5. Normal Duration : Volume of Work / Work per day productivity
   = 265,27 / 100
   = 2,65 days.

Normal cost is the direct cost incurred during the completion of project activities in accordance with normal time. To get the normal cost data needed is the volume of work and the unit price of each sequences.

Calculation example 1, Beam Formwork +3,770

1. Volume of Work : 265,27 m2
2. Material unit price : IDR 120.745
3. Unit price of workers : IDR 40.248
4. Normal price : Volume x (unit price of material + unit price of workers)
   = 265,27 x (Rp 120.745 + Rp 40.248)
   = IDR 42.706.061,-

Table 2. Normal Cost and Duration

Information	Summary of Normal Cost all items	Summary of Normal Duration all items
Normal	IDR 839,227,822	109.79 days

(Source : Processed Researcher, 2023)

In the results of every sequences of calculation, the total normal price of structural work is IDR 839,227,822 and total normal duration of structural work is 109.79 days.

4.3. Critical Path

In concrete structure work, critical path items were work of elevation beams + 3,770, elevation beams +7,200, canopy slab floors, guttering work el 7,200, stair structure work. For looking for critical path, Microsoft project is recommended.

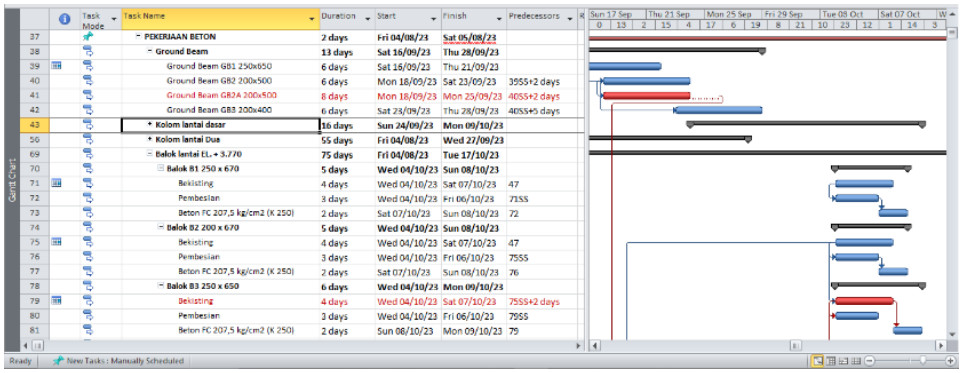

Figure 3. Looking For Critical Path Using Microsoft Project
Source : Capture of Microsoft Project Processing, 2023

Work items that pass through the critical path will be red in Microsoft project, in which case indicating that the item has a cost slope equal to 0; So it requires acceleration on the predecessors.

4.4. Crash Duration & Crash Cost

In the calculation of *crash duration* , the data needed is the worker coefficient in the analysis of the unit price of work and the volume of work. The duration of this acceleration is obtained by calculating hourly productivity and overtime productivity for 1 to 4 hours of work.

Acceleration Duration for beam formwork at +3,770 elevation

1. Volume = 265,27 m^2
2. Coefficient of worker = 0,100
3. Quantity of worker = 10 men
4. Work per day productivity : (1/ Coefficient of worker x quantity of worker)
   = 1/0,100 x 10
   = 100
6. Normal Duration : Volume of Work / Work per day productivity
   = 265,27 / 100
   = 2,65 days.
7. Hourly productivity as a team
   = Work per day productivity / normal working hours
   = 100 / 8 hours = 12,5 per hours
5. Produktivitas saat lembur (4 jam)
   = 4 x Hourly productivity as a team x Coefficient of Productivity Reduction
   = 4 hours x 12,5 per hours x 0,60 = 30
6. Produktivitas setelah crashing
   = normal productivity + Overtime productivity
   = 100 + 30 = 130 m2/days
7. Durasi Crashing
   = Volume / Productivity after *crashing*

= 265,27 m2 / 130 m2/days = 2,04 days

In the summary of the overall crash *duration work* , the following results are obtained

1. With the addition of overtime for 1 hour, total duration of work becomes 98.69 days
2. With the addition of overtime for 2 hours, total duration of work becomes 91.49 days
3. With the addition of overtime for 3 hours, total duration of work becomes 86.96 days.
4. With the addition of overtime for 4 hours, total duration of work becomes 84.45 days.

In this *crash duration calculation*, it can be concluded that the addition of overtime hours is inversely proportional to the total time of work.

In normal cost calculation, processing of datas analysis of the unit price of work, unit price and volume of work. The first thing to get is normal productivity and productivity during overtime. For costs due to overtime working hours, it is obtained by multiplying twice the normal hourly working hour wage.

The following is an example of calculating crash cost for overtime duration for 4 hours in the calculation of acceleration cost on elevation beam + 3,770.

1. Volume = 265,27 m2
2. Unit price of materials = IDR 120.745
3. Unit price of workers = IDR 40.248
4. Number of workers = 10 men
5. Normal cost
   = volume x (unit price of workers + unit price of materials)
   = 265,27 m2 x (IDR 40.248 + IDR 120.745)
   = IDR 42.706.061
6. Hourly Worker Wages
   = Unit price Worker / normal working hours
   = IDR 40.248 / 8 hours
   = IDR 5.031,-
7. Workers' Wages During Overtime
   = (2 x 4 hours x Hourly Worker Wages)
   = 2 x 4 hours x IDR 5.031,-
   = IDR 40.248,-
8. Per-day Wages
   = Employee wages + Workers' Wages During Overtime
   = IDR 40.248 + IDR 40.248
   = IDR 80.496,-
9. Productivity after *crashing* = 130 m2/days
10. Duration after *crashing* = 2,041 days
11. Acceleration Cost
    = (unit price of materials + unit price of workers after overtime) x productivity after crashing *x duration of crashing*

= (IDR 120.745 + IDR 80.496) x 130 m2/days x 2,041 days
= IDR 53.382.577,-

The summary of *crash cost* , the following results are obtained:

1. With the addition of overtime for 1 hour, the work cost becomes IDR 901,185,006.
2. With the addition of overtime for 2 hours, the work cost becomes IDR 932,879,787.
3. With the addition of overtime hours for 3 hours, the work cost becomes IDR 964,574,568.
4. With the addition of overtime hours for 4 hours, the cost of work becomes IDR 996,269,349.

In this calculation, it can be concluded that the addition of overtime hours is directly proportional to *crashing* costs so that along with the addition of working time, acceleration time also increases costs.

4.5. Discussion

The analysis of direct *cost* results on normal duration, acceleration duration, normal costs, and McDonald's Pontianak work acceleration costs comparison of additional working hours of 2 hours, 3 hours, and 4 hours is as follows;

Table 3. Comparison of *Normal Cost, Normal Duration, Crash Cost and Crash Duration* for Direct Cost

Descriptions	Direct Cost	Durasi	Deviase of Direct Cost	Deviase of Direct Duration
	(IDR)	(days)	(IDR)	(days)
Normal duration	839.227.822	109,79	nihil	nihil
Additional overtime hours for 1 hour	901.185.006	98,69	+ 61.957.184	+11,10
Additional overtime hours for 2 hours	932.879.787	91,49	+ 93.651.965	+18,30
Additional overtime hours for 3 hours	964.574.568	86,96	+ 125.346.746	+22,83
Additional overtime hours for 4 hours	996.269.349	84,45	+ 157.041.526	+25,34

Source: Processed by researchers, 2023

Based on the comparison table of normal cost, normal duration, crash cost and crash duration for direct costs, the following results are obtained;

1. With the addition of overtime for 1 hour, the direct cost of work becomes IDR 901,185,006.31, - with a duration of work acceleration of + 11.10.
2. With the addition of overtime for 2 hours, the direct cost of work becomes IDR 932,879,787, - with a duration of work acceleration of + 18.30.
3. With the addition of overtime for 3 hours, the direct cost of work becomes IDR 964,574,567, - with a duration of work acceleration of + 22.83.

4. With the addition of overtime for 4 hours, the direct work cost becomes IDR 996,269,348, with a duration of work acceleration of + 25.34.

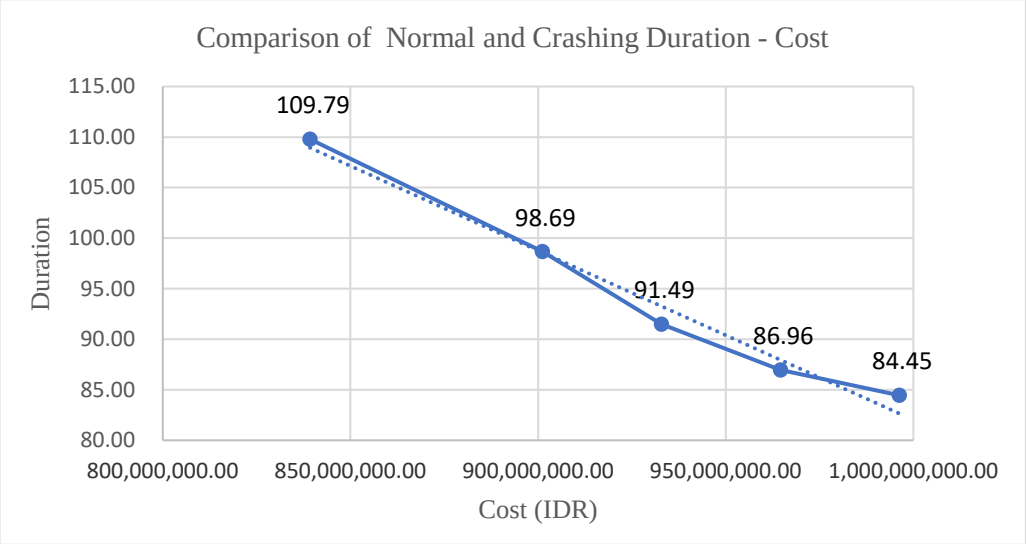

Figure 4. Comparison Diagram of Normal and Crashing Duration – Cost
Source : Processed by researchers, 2023

The results of the time analysis of the addition of manhours to the work of the Pontianak McD development project are as follows

1. With the addition of 1 hour of overtime work with a productivity index of 90%, the results of accelerating the project duration by days or structural work were carried out for 98.69 days.
2. With the addition of 2 hours of overtime work with a productivity index of 80%, the results of accelerating the project duration by 18.30 days or structural work were carried out for 91.49 days.
3. With the addition of 3 hours of overtime work with a productivity index of 70%, the results of accelerating the project duration by 22.83 days or structural work were carried out for 86.96 days.
4. With the addition of 4 hours of overtime work with a productivity index of 60%, the results of accelerating the project duration by 25.34 days or structural work were carried out for 84.45 days.

The results of the cost analysis of the addition of manhours to the work of the Pontianak McD development project was obtained

1. With the addition of 1 hour of overtime work with a productivity index of 90%, the result of additional costs of Rp 61,957,184,-
2. With the addition of 2 hours of overtime work with a productivity index of 80%, the results of additional costs of Rp 93,651,965 were obtained
3. With the addition of 3 hours of overtime work with a productivity index of 70%, the result of additional costs of Rp 125,346,746,-

4. With the addition of 4 hours of overtime work with a productivity index of 60%, the result of additional costs of Rp 157,041,526

5. CONCLUSION

Summary of the results of the analysis, it was found that the optimal working hours was for 2 hours of overtime with an additional cost of IDR 93,651,965 or totals of all costs are 932,879,787 and could save time for 18.30 days. Thus, this is the optimum result of the project fine imposed in the event of a delay of IDR 228,366,605 for a delay time of 12.63 days.

REFERENCES

Bagherpour, M., Noori, S., & Sadjadi, S. . (2006). Cost Time Trade Off Models Application to Crashing Flow Shop Scheduling Problems. *Communication Systems and Applications*.

Dimyati, A. Hamdan., Nurjaman, K. (2014). *Manajemen Proyek* (cet. 1). CV. Pustaka Setia.

Izzah, N. (2018). Analisis Pertukaran Waktu dan Biaya Menggunakan Metode Time Cost Trade Off (TCTO) pada Proyek Pembangunan Perumahan di PT. X. *Rekayasa*, *10*(1), 51. https://doi.org/10.21107/rys.v10i1.3604

Karmaker, C. L., & Halder, P. (2017). Scheduling Project Crashing Time Using Linear Programming Approach: Case Study. *International Journal of Research in Industrial Engineering*, *Vol. 6*, *No*(November), 283–292. https://doi.org/10.22105/riej.2017.96572.1010

KEMENPERIN. (2003). Undang - Undang RI No 13 tahun 2003. *Ketenagakerjaan*, *1*.

Laksana. (2014). *Optimalisasi Waktu dan Biaya Proyek Dengan Analisa Crash Program*.

Levis, A. (1996). *Delay Construction*. Cahner Books Internasional.

Priyo, M., & Aulia, M. R. (2016). Aplikasi Metode Time Cost Trade Off Pada Proyek Konstruksi: Studi Kasus Proyek Pembangunan Gedung Indonesia. *Semesta Teknika*, *18*(1), 30–43. https://doi.org/10.18196/st.v18i1.703

Sharma, S., Bedi, N., & Sukhwani, V. (2020). Optimization of Time and Cost for a Research Project by Project Crashing Method. *IOP Conference Series: Materials Science and Engineering*, *998*.

Soeharto, I. (1999). Manajemen Proyek. In *Erlangga* (Edisi Kedu).

Wowor, F. N., Sompie, B. F., Walangitan, D. R. O., Malingkas, G. Y., Teknik, F., Teknik, J., Universitas, S., Ratulangi, S., Masalah, P., & Masalah, B. (2013). Aplikasi Microsoft Project Dalam Pengendalian. *Jurnal Teknik Sipil*, *1*(8), 543–548.

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