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Cost And Time Analysis Using Time Cost Trade Off (TCTO) In Order To Catch Up With Execution Time (Case Study: Jakarta Islamic Hospital Pondok Kopi Construction Project)

Thesa Nurshela[1], Nikko Rozy[2*)]
[1,2]Departement of Civil Engineering, Faculty of Engineering, Swadaya Gunung Jati University, Cirebon, West Java, Indonesia
[*)]Correspondence author (cheepers12@gmail.com)

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Abstract

In a construction project, there are three crucial aspects to consider, namely time, cost, and quality. The implementation of the Jakarta Islamic Hospital Pondok Kopi construction project faces several obstacles, especially at the stage of foundation structure and concrete structure work. Based on observations at the location, it is estimated that the completion of the construction of the Jakarta Islamic Hospital Pondok Kopi will be delayed or not in accordance with the planned schedule. There are several options that can be used to speed up project activities, including increasing working hours (overtime), adding manpower, adding or changing tools, adding more effective work methods, and other options. Of the several available alternatives, this study will apply two alternatives, namely increasing working hours (overtime) and increasing labor using the Time Cost Trade Off (TCTO) method. The optimization alternative that has the most optimal or efficient total cost and duration is by adding 5 workers because the project duration becomes faster, even though there is an increase in cost, the addition is more optimal or efficient compared to other alternatives, as indicated by a time efficiency of 51,36% and a cost efficiency of -20,02%. This optimization result can be used as an acceleration option for the project party.

Keywords: *Optimasi, Cost, Time Cost Trade Off, Time*

Abstrak

Dalam sebuah proyek konstruksi, ada tiga aspek penting yang perlu dipertimbangkan, yaitu waktu, biaya, dan kualitas. Pelaksanaan proyek pembangunan Pondok Kopi RSUD Jakarta menghadapi beberapa kendala, terutama pada tahap pengerjaan struktur pondasi dan struktur beton. Berdasarkan pengamatan di lokasi, diperkirakan penyelesaian pembangunan RSUD Islam Jakarta Pondok Kopi akan tertunda atau tidak sesuai jadwal yang direncanakan. Ada beberapa opsi yang dapat digunakan untuk mempercepat kegiatan proyek, antara lain menambah jam kerja (lembur), menambah tenaga kerja, menambah atau mengganti alat, menambahkan metode kerja yang lebih efektif, dan opsi lainnya. Dari beberapa alternatif yang tersedia, penelitian ini akan menerapkan dua alternatif, yaitu menambah jam kerja (lembur) dan meningkatkan tenaga kerja menggunakan metode Time Cost Trade Off (TCTO). Alternatif optimasi yang memiliki total biaya dan durasi yang paling optimal atau efisien adalah dengan menambahkan 5 pekerja karena durasi proyek menjadi lebih cepat, meskipun terjadi kenaikan biaya, penambahan tersebut lebih optimal atau efisien dibandingkan dengan alternatif lain, seperti yang ditunjukkan dengan efisiensi waktu sebesar 0,51% dan efisiensi biaya sebesar -0,20%. Hasil pengoptimalan ini dapat digunakan sebagai opsi akselerasi untuk pihak proyek.

Kata Kunci: *Optimasi, Biaya, Time Cost Trade Off, Waktu*

INTRODUCTION

A project can be defined as an activity that utilizes existing resources, is structured to achieve specific goals, objectives, and expectations, and must be completed within an agreed timeframe. In a construction project, there are three crucial aspects to consider, namely time, cost, and quality. In general, construction quality is the main foundation that must be maintained to keep it in accordance with the original plan. However, in practice, there are often unexpected increases in costs along with delays in the implementation schedule[1].

Various factors can arise during the execution of a construction project, which generally results in an extension of the duration of the work, so that the project exceeds the specified time limit[1]. The main causes of such delays include site conditions, design revisions, weather impacts, and shortages of labor, materials, or equipment, as well as errors in planning or technical specifications. To overcome these delays, acceleration measures can be implemented, although cost considerations must still be taken into account[2].

If a project is delayed, it definitely indicates a delay in its completion time, so it is necessary to accelerate the implementation or known as project acceleration. This acceleration, of course, is based on various reasons, such as efforts to avoid weather conditions that can reduce labor productivity, requests from project owners, efforts to catch up behind schedule, and other factors. In this study, the discussion will focus on the problem of delays that occur in the construction of the Jakarta Islamic Hospital Pondok Kopi development project[3].

The implementation of the Jakarta Islamic Hospital Pondok Kopi construction project faced several obstacles, especially at the stage of concrete pondatin work. Based on observations at the location, it is estimated that the completion of the construction of the Jakarta Islamic Hospital Pondok Kopi will be delayed or not in accordance with the planned schedule[4].

The Time-Cost Trade-Off (TCTO) method was chosen because it is capable of analysing the relationship between project time acceleration and the resulting cost implications. This method is suitable for projects experiencing delays, as it can identify the most optimal acceleration alternatives in terms of both time and cost. There are several options that can be used to speed up project activities, including increasing working hours (overtime), adding manpower, adding or changing tools, adding more effective work methods, and other options.

Of the several available alternatives, this study will apply two alternatives, namely increasing working hours (overtime) and increasing the workforce[5]. According to the Great Dictionary of the Indonesian Language (KBBI), optimization can be defined as an effort to increase the efficiency of something that already exists to be more effective. Optimization is one of the strategies to prevent project delays or can be considered as an effort to speed up project implementation. To ensure the project goes as planned, accurate scheduling and efficient use of costs are required without sacrificing quality or standards. One of the calculation methods that can be used in optimization efforts is the Time Cost Trade Off (TCTO)[3].

Method Time Cost Trade Off is an analysis method designed to speed up the duration and manage costs in a project. This scheduling acceleration aims to determine the amount of time and cost required for the project to be completed according to the most efficient and ideal plan. This research is expected to provide efficiency in terms of cost and time in the development project of the Jakarta Islamic Hospital Pondok Kopi.

The novelty of this research lies in the use of the Time Cost Trade Off, techniques applied to optimize performance in terms of time and cost during the construction process, with approximately 75% of construction projects implementing this method successfully achieving time and cost efficiency. The benefits of this research for knowledge include understanding how to accelerate construction projects, calculating post-acceleration implementation costs, conveying information related to project completion time through the addition of working hours (overtime or optimal working hours), and understanding of optimal approaches to accelerate project completion time and costs.

THEORETICAL REVIEW

Projects and Project Management

A project can be defined as an activity that utilises available resources, organised in a structured manner to achieve specific goals, objectives and expectations, and which must be completed within an agreed timeframe. Generally

speaking, construction quality is the primary foundation that must be maintained to ensure it remains in line with the original plan. However, in practice, there are often unexpected cost increases and delays in the implementation schedule.

Increase in working hours

Overtime can be achieved by extending daily working hours without increasing the workforce. The aim of this extension is to increase daily output so that tasks can be completed more quickly.

Increase in the workforce

The aim of increasing the workforce is to boost the number of workers in a particular group in order to carry out specific activities without extending working hours. When increasing the workforce, attention must be paid to the condition of the workspace—whether it is too cramped or sufficiently spacious—as the addition of staff for one activity must not interfere with the deployment of staff for other activities taking place simultaneously[6].

METHODOLOGY

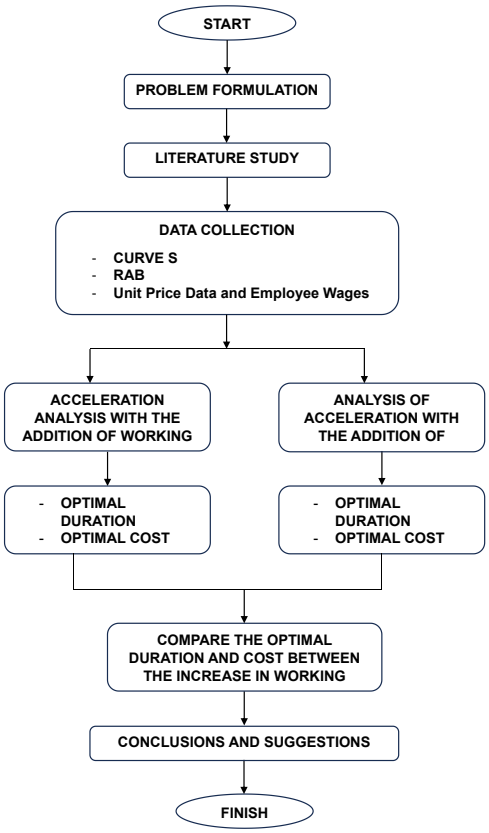
The research method used is descriptive analysis. Descriptive analysis is an approach to solving problems by collecting data, structuring the data obtained, describing the data, processing the data, and then analyzing it to achieve the final result.

The initial stage carried out in this research is the preparation stage, or conducting a literature study by reading journals or other sources that can be used as research references. Next, an observation is conducted on the research object by contacting the project party to request permission to conduct research. After obtaining permission from the project party, data is collected to support the research, with the data obtained from the project party including the time schedule, Budget Plan (RAB), unit labour costs (AHSP), and actual project duration.

The variables used in this study consist of time variables and cost variables. The time variables include the normal project duration and the crash duration, whilst the cost variables include the normal project cost and the crash cost. This study employs two acceleration alternatives: the addition of overtime hours and the addition of labour. These variables are analysed using the Time Cost Trade-Off (TCTO) method to determine the most optimal acceleration alternative in terms of time and cost.

The next step is data processing. The optimization calculation analysis uses the Time Cost Trade Off (TCTO) method with two alternatives, namely increasing working hours (overtime) and adding manpower. The systematic steps required include: identifying tasks that can be accelerated, calculating the normal duration, calculating the normal cost, calculating the crash duration, calculating the crash cost, calculating the cost slope, and finally comparing the acceleration alternatives. Next, an evaluation of the data processing results is carried out to ensure that the calculations have been performed correctly. After the data is processed and checked, conclusions are drawn from the calculation results and several suggestions are provided for further research.

The analysis was carried out using a comparative approach to assess the cost and time efficiency of each project acceleration option. Based on the theoretical studies that have been presented, in the preparation of the research, the author proposes the following framework:



Picture 1. Flowchart

RESULT AND DISCUSSION

The formulation of the problem obtained is that there is a delay in the foundation structure work caused by the PDA test that does not meet the standards.

Next, data processing is carried out, namely the optimal duration and cost after the addition of working hours (overtime) and labor using the Time Cost Trade Off (TCTO) method and the comparison of costs and optimal duration between the addition of working hours (overtime) and the addition of labor.

Table 1. work that will be accelerated

NO.	JOB ITEMS	VOLUME
I	**FOUNDATION STRUCTURE WORK**	
1	Bored Pile Foundation d.60 cm	1312,5
2	Procurement of Spun Pile Material D.50	784
II	**CONCRETE STRUCTURE WORK**	
1	1st floor (elv -0.050 to +3,400)	278,49
2	P1 Floor (elv +3,400 to +6,600)	330,43
3	P2 Floor (elv +6,600 to +9,800)	282,97
4	P3 Floor (elv +9,800 to +13,000)	283,85
5	P4 Floor (elv +13,000 to +16,200)	7,76
6	RAMP (elv -0.050 to +3.400)	19,9
7	RAMP (elv +3,400 to +19,400)	112,26
8	Ladder Work	11,71

The addition of labor is carried out by increasing the number of workers to carry out work activities without increasing working hours. In adding labor, several things need to be considered, such as paying attention to the available workspace so that it does not cause workers to be idle at the job site. The variations used in addition are by adding 1 and 2 workers.

The following is an example calculation by adding 1 hour of work (overtime) to the concrete structure work on the 1st Floor (elv -0.050 to +3.400).

Increase in Working Hours (Overtime)

1. Normal Cost
   a. Vol. of work = 278.49 m³
      Coeficin = 1.6315
      Productivity = 1/Coeficin
      = 1/1.6315
      = 0.6129
      Prod. Workers =Prod. x Worker
      = 0.6129 x 20
      = 12.2585
   b. Wages of labor units
      = IDR 126.775
   c. Normal duration
      $= \frac{\text{Volume}}{\text{Prod.Worker}}$
      $= \frac{278,49}{12,2585}$
      = 22.72 ≈ 23 days
   d. Normal cost
      = (a x b)
      = 278.49 x IDR 126,775
      = IDR 35,305,570
   e. Normal cost/day
      = (d/c)
      = IDR 35,305,570/23 days
      = IDR 1,535,025
   f. Normal cost/hours = (e/9 hours)
      = IDR 1,535,025/9 hours
      = IDR 170,558
2. Crash Duration
   g. Daily Productivity
      = (a/c)
      = 278.49/23
      = 12.11 m³/day
   h. Hourly productivity
      = (g/9jam)
      = 12,11/9
      = 1.35 m³/jam
   i. Crash
      =12.11+(1 x h x overtime efficiency)
      = (12,11 + (1 x 1,35 x 0,9))
      = 13.32 m³/day
   j. Crash Duration
      $= \frac{a}{i}$
      $= \frac{278,49}{13,32}$
      = 20.91 ≈ 21 days
3. Calculating the Index of Workers Who Work Overtime
   Volume of Work when Overtime
   = Prod. per Jam x Crash Duration
   = 1.35 x 21 days
   = 28.25 m³
   Calculating the Index of Workers Who Work Overtime
   Labor Index during Overtime
   = Volume of Work when Overtime x Labor Coefficient
   The following is for the calculation of each workforce
   Employees = 278,49 x 0,4
   = 111.40 OH
   Builder = 278,49 x 0,1
   = 27.85 OH

Head builder = 278,49 x 0,01
= 2.78 OH
Foreman = 278,49 x 0,04
= 11,14 OH

4. Crash Cost
   k. Normal cost/hour
      = (bxh)
      = IDR 126,775 x 1,35
      = IDR 170,558
   l. 1 Hour Overtime cost
      = (1.5 x k)
      = 1.5 x IDR 170,558
      = IDR 255,837
   m. Total overtime pay
      = (j x l)
      = 21 x IDR 255,837
      = IDR 5,372,587
   n. Crash Cost
      = (d+m)
      = IDR 35,305,570 + IDR 5,372,587
      = IDR 40,678,156

5. Cost Slope
   $= \frac{n-d}{c-j}$
   $= \frac{\text{IDR } 40{,}678{,}156 - \text{IDR } 35{,}305{,}570}{23-21}$
   = IDR 43,435,583

The following is an example of a calculation with the addition of 3 worker to the concrete structure work on the 1st Floor (elv -0.050 to +3.400).

Workforce Enhancement

1. Work volume = 278.49 m³
   Coeficient = 1.6315
   Productivity = 1/Coeficient
   = 1/1.6315
   = 0.6129
   Worker Productivity
   = Productivity x Workers
   = 0.6129 x 20
   = 12.2585
2. Normal Duration
   =Volume/(Prod. Worker)
   = 278.49/12.2585
   = 22.72 ≈ 23 days
3. Labor coefficient
   Employees = 0.66
   Builder = 0.33
   Head builder = 0.03
   Foreman = 0.11
4. Labor wage price per day
   Employees = IDR 100,000
   Builder = IDR 150,000
   Head builder = IDR 175,000
   Foreman = IDR 200,000

5. Calculating the working capacity of the workforce per day
   Calculating working capacity for workers
   Working capacity = 1/Koef. Workforce
   = 1/0.66
   = 1.5 m³/day

6. Calculating the labor index per day (OH)
   Calculate the employee index
   Employee Index
   = (Volume of work)/(work capacity x duration of work)
   = 278.49/(1.5 x 23)
   = 7.99 OH
   Calculating Normal Cost
   Normal cost = labor coefficient x unit normal cost
   Employees = 0.66 x IDR100,000
   = IDR 66,000
   Builder = 0.33 x IDR 150,000
   = IDR 49,000
   Handyman's head = 0.03 x IDR 175,000
   = IDR 5,250
   Foreman = 0.11 x IDR 200,000
   = IDR 22,000
   Total Normal Cost = IDR 142,750
   Normal Cost
   = Total Normal cost x work volume
   = IDR 142,750 x 278,49
   = IDR 39,754,448
7. Calculating Crash Duration
   Adding 3 Employee

   Crash duration
   $= \frac{\text{Work Volume}}{\text{Work Capacity x (OH+3)}}$
   $= \frac{278{,}49}{1{,}5 \text{ Xx } (7{,}99+3)}$
   = 16.72 ≈ 17 days
   It was obtained for an accelerated duration of 17 days.
8. Crash Labor Index
   = (OH + increments) x Crash duration
   = (7.99 + 1) x 17
   = 153 OH

9. Calculating Crash Cost
   Additional worker wages + Materials
   = HSU x (OH + 3) x Crash duration
   = IDR 100,000x (7.99 + 3) x 17
   = IDR 18,685,469
10. Calculating the total Crash Cost
   = normal cost + additional employee wages
   = IDR 39,754,448 + IDR 18,685,469
   = IDR 58,439,916
11. Calculating the Cost Slope

$$= \frac{\text{Crash Cost} - \text{Normal Crash}}{\text{Normal Duration} - \text{Crash Duration}}$$

$$= \frac{\text{IDR } 58{,}439{,}916 - \text{IDR } 39{,}754{,}448}{23-17}$$

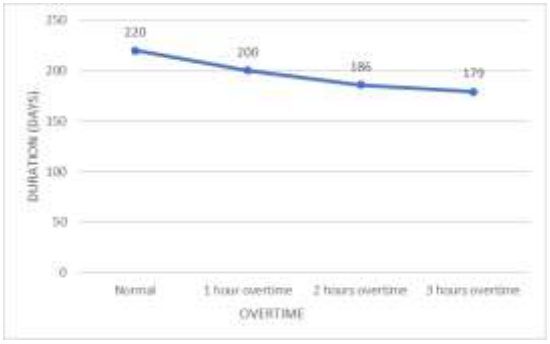
   = IDR 51,814,175

The following is a recapitulation of the results of the calculation (foundation structure and concrete structure work), acceleration duration and total cost with other additions variations.

Table 2. Results of Total Cost Calculation in

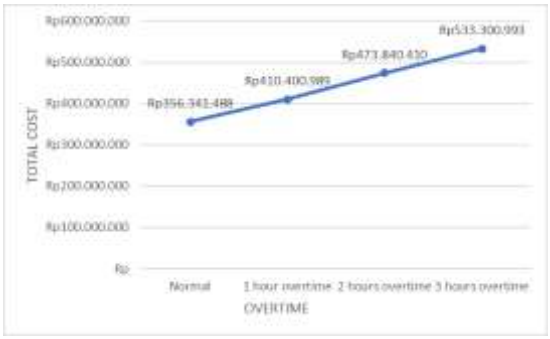
NO	CONDITIONS	TOTAL DURATION (DAYS)	TOTAL COST
1	Normal	220	IDR 356,341,488
2	1 hour overtime	200	IDR 410,400,989
3	2 hours overtime	186	IDR 473,840,410
4	3 hours overtime	179	IDR 533,300,993
5	Add 3 employees	134	IDR 430,793,781
6	Add 5 employees	107	IDR 427,691,346
7	Difference 1 and 2	20	IDR 54.059.501
8	Difference 1 and 3	34	IDR 117.498.922
9	Differences 1 and 4	41	IDR 176,959,505
10	Difference 1 and 5	86	IDR 74,452,293
11	Difference 1 and 6	113	IDR 71,349,858

A graph of the relationship between cost and time to alternative use, can be seen in the following figure. Figure 1 shows that the increase in working hours resulted in a shorter project duration.



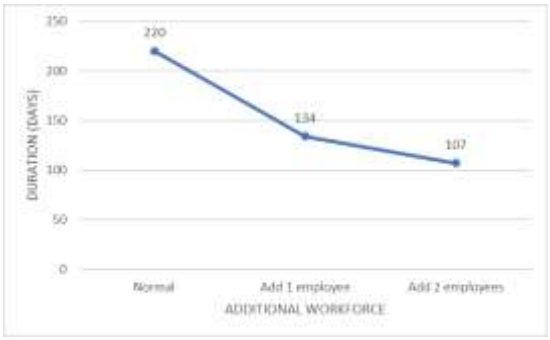
Picture 2. Relationship of Total Duration to

Graph 2 shows that total costs are increasing due to overtime.



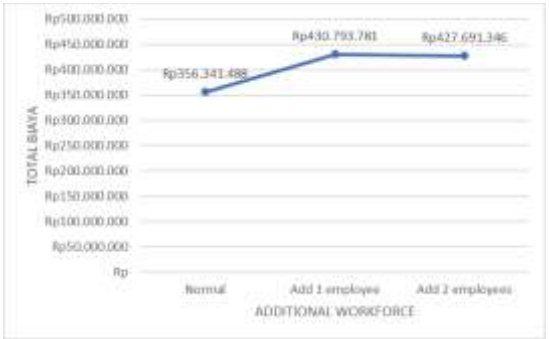
Picture 3. Relationship of Total Costs to

Then Graph 3 shows that the duration of the project has become shorter due to the addition of labor.



Picture 4. Relationship of Total Duration to Labor

Figure 4 shows the results of the optimization calculation by increasing working hours and increasing labor, it turns out that the duration and cost of the project have changed when compared to the normal duration and cost where there is an acceleration of the project duration, but there is an increase in the total project cost.



Picture 5. The Relationship of Total Costs to

Next, an efficiency calculation is carried out on costs and time to choose which alternative is the most optimal. The following is an example of calculating the total cost efficiency and time (duration) of the project by adding 1 hour of work (overtime).

Normal duration = 220 days
Crash duration = 200 days
Normal Fee = IDR 356,341,488
Crash cost = IDR 410,400,989

1. Total Project Cost Efficiency (Ec)

$$Ec = \frac{\text{Normal Cost} - \text{Crash Cost}}{\text{Normal Cost}} x\ 100$$

$$Ec = \frac{\text{IDR 356,341,488} - \text{IDR 410,400,989}}{\text{IDR 356,341,488}} x\ 100$$

EC = -15,17%

2. Time Efficiency (Et)

$$Et = \frac{\text{Normal Duration} - \text{Crash Duration}}{\text{Normal Duration}} x\ 100$$

$$Et = \frac{220 - 200}{220} x\ 100$$

Et = 9,09%

Calculations of cost and time efficiency in other alternatives are presented in the following table.

NO	CONDITIONS	COST EFFICIENCY	TIME EFFICIENCY
1	1 hour overtime	-15,17%	9,09%
2	2 hours overtime	-32,97%	15,45%
3	3 hours overtime	-49,66%	18,64%
4	Add 3 employees	-20,89%	39,09%
5	Add 5 employees	-20,02%	51,36%
6	Difference 1 and 2	84,83%	90,91%
7	Difference 1 and 3	67,03%	84,55%
8	Differences 1 and 4	50,34%	81,36%
9	Difference 1 and 5	79,11%	60,91%
10	Difference 1 and 6	79,98%	48,64%

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of data collection, data analysis, and discussion of data analysis, the following conclusions can be drawn:

1. Optimization by increasing working hours and workers makes the project duration shorter when compared to the initial conditions. After optimizing by adding 1 hour of work (overtime), the duration was obtained to 200 days. Optimization by adding 2 hours of work (overtime), the project duration is 186 days. Optimization by adding 3 hours of work (overtime), the project duration is 179 days. Optimization by adding 3 worker, the project duration is 134 days. Then, optimization by adding 5 workers, the project duration is 107 days.
2. Optimization by increasing man-hours and workers makes the total project cost greater or increased when compared to the total initial cost. After optimization by adding 1 hour of work (overtime), the total cost is IDR 410,400,989. Optimization by adding 2 hours of work (overtime), the total project cost is IDR 473,840,410. Optimization by adding 3 hours of work (overtime), the total project cost is IDR 533,300,993. Optimization by adding 3 worker gets the total project cost to IDR 430,793,781. Then, optimization by adding 5 workers, The total project cost was IDR 427,691,346.
3. The most optimal acceleration alternative is the addition of 5 workers, as this results in the shortest project duration of 107 days with a time efficiency of 51.36%, as well as a relatively lower increase in costs compared to other acceleration alternatives, namely -20.02%.

Further research is suggested to be able to try with other analyses such as the addition of tool capacity, the addition of work sifts, and changes in the construction method of work (using precasts) and this research is only carried out on building construction, for further research can be expected on road projects, bridge construction, dams or other civil work projects.

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