EVALUATION OF CONSTRUCTION IMPLEMENTATION ON WAREHOUSE RECEIPT BUILDING USING TIME COST TRADE-OFF ANALYSIS METHOD
(Case Study of Warehouse Building Project at Tumpang, Indonesia)

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ABSTRACT: Planning is the most important thing in achieving a construction project's success. The effect of planning towards a construction project will impact on its revenue. It is underlined by numerous circumstances in construction projects stating that a good planning can save project costs up to ± 40 %, conversely, an ill-considered planning can cause budget leakage up to ± 40 %. Within the planning of a project, cost variable plays a crucial role apart from time variable and resource variable. Cost is one of the most essential aspect in management, where the costs that might arise must be controlled to be as low as possible. Cost management must also consider time factor, because there is a strong correlation between project completion time with the involved project costs. Often times, a project must be finished earlier than normal. In this case, the project leader is faced with a matter of accelerating the project completion time with a minimum budget. Therefore, the relationship between cost and time needs to be studied along with the Time Cost Trade Off Analysis. Based on the practice of Time Cost Trade Off method on this construction, it can optimally reduce the time duration by increasing human resources and project costs. The initial duration of this project which was 114 days turned to 93 days, cutting 21 days off from the normal schedule. The project cost of the normal schedule accounts to IDR 2.618.449.000,- whereas after the Time Cost Trade Off analysis is carried out with an additional direct cost of IDR 28.953.213,-, the total project cost is calculated to IDR 2.647.402.213,-.

Keywords: Time Acceleration; Construction Project

1. Introduction

The process of achieving a project activity's goal has three boundaries, which are essential parameters to measure a project's success. These three things are cost accuracy, time punctuality, performance/scope and quality (Soeharto, 2005). A problem still faced up to this day is the prolonging project construction duration which results to the increase of cost needed. Fact shows that 70% of constructions done in Malang Regency suffers from delays and cost swelling (Field survey, 2014). Factors that can influence project construction delays are: budget, material provisions, equipment provisions, human resources, project location, and weather condition. Critical Path Method is one of time management apparatus that can be used to analytically review the duration of a project's completion. Critical Path Method is very important for project execution because it shows the activities which, if are delayed, will impact on overall project delay (Ratna, 1999). Based on the explanations above, the problem formulations are as follows:

1. How to optimally implement the Time Cost Trade Off (TCTO) method so that time efficiency can be attained.
2. How long is the time duration upon implementing the Time Cost Trade Off (TCTO) method.

3. How much is the cost expended upon implementing the Time Cost Trade Off (TCTO) method.

2. Literature Review

2.1 Construction Project Definition

Differ with knowledge and technology transfer (Handoko et al, 2014; 2016; 2017; Handoko, 2017), a project is a one-time activity with limited duration and resources to achieve a specified target, for instance, goods or production facilities. Project activities can be defined as an individual, temporary activity that occurs on a limited time period, with definite resource allocations and is intended to yield products or deliverables having quality criteria that have been clearly outlined or defined (Soeharto, 2005). Construction projects can be classified into two building types that are related to each other but are generally planned and executed by different discipline of planners and executant. The two types are building and civil building, according to International Labour Organization in Maulana (1994).

As stated by Ervianto (2005), the stages of construction project activities consist of:

- Feasibility study stage, which aims to convince the project owner that the proposed construction project is suitable to carry out;
- Briefing stage, which aims to obtain explanations from the project owner regarding project function and detailing the allowed costs;
- Design stage, which aims to precisely design the project, comprising of site plan, design, construction method, and approximations;
- Bidding or Tender stage, which aims to appoint contractor or sub-contractor that will carry out the construction activities in the field;
- Execution or Construction stage, which aims to carry out the operation within the agreed financial and temporal boundary, as well as to specify qualities;
- Maintenance and Building Preparation stage, which aims to guarantee that the operation will be finished according to what is specified in the contract documents, and that all the facilities will operate as how they should.

2.2 Construction Project Delay

According to Ervianto (2005), factors that influence delays in the controlling process are:

- Monitoring manpower factor or inspectors that are not competent enough in their field of work which can cause ineffective and inaccurate project controls.
- Controlling system of information system application factor as well as supervising process that is too formal by disregarding human relationships may cause rigidity and compulsion.

2.3 Arrow Diagram

This network first developed in America in 1957, which is known as the Critical Path Method (CPM) and in France in 1059 is also known as Metra Potential Method (MPM). On this diagram, activity status is potrayed and determined in a network while considering several inter-activities relationship, such as the end – start relationship. The order of activities shown inside the network describes the dependency of an activity to another activity, where each activity has a specified execution duration.

2.3.1 Real and Dummy Activity

Real activities are the actual implementation of an activity. This is usually depicted graphically as arrows on networks while its duration is sometimes stated (see Figure 1)

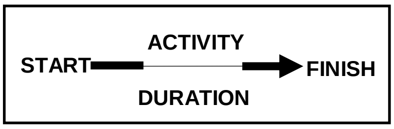

Figure 1 Real Activity (Source: Soeharto, 2005)

Dummy activities are depicted as dashed arrows and have a function to show the dependency between each activity (see Figure 2). Dummy activities have no activity duration.

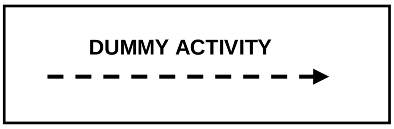

Figure 2 Dummy Activity (Source: Soeharto, 2005)

Event is the base point of the endpoint of an activity. An event doesn't require time or resources. Graphically, it can be depicted as a circle with a number in it (see Figure 3).

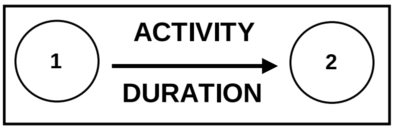

Figure 3 Event (Source: Soeharto, 2005)

2.3.2 Types of Inter-Activity Relationships

The diagram in Figure 4 shows consecutive activities (respective to the straight line), a work can only be done. It means that the end of activity A occurs at the same time with the beginning of activity B.

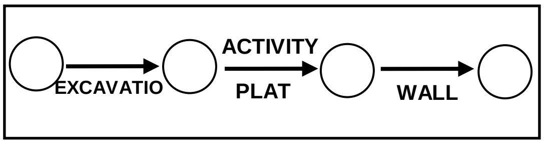

Figure 4 Consecutive Activity Diagram (Source: Soeharto, 2005)

If several activities must be completed first before the next activity, then the end of the activities occur simultaneously with the beginning of the next activity. Event number 30 is where activity A and activity B coincide, then it is continued by activity C. Event number 30 is called "merge event" (see Figure 5)

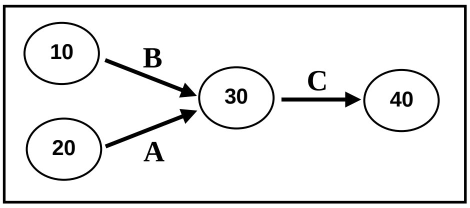

Figure 5 Merge Event Diagram (Source: Soeharto, 2005)

On the contrary, some activities can only be started after the completion of certain activities (precondition), shown on Figure 6 that event number 20 is an event that allows the splitting of excavation (B) and foundation plate (C). Event number 20 is called “burst” event. This figure can be interpreted that only after excavation 1 is completed, excavation 2 and foundation plate can be started. The end of activity 1 is the start of activity 2 and foundation plate.

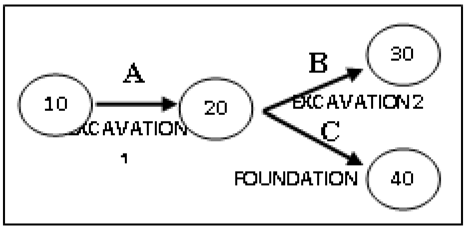

Figure 6. Burst Event Diagram (Source: Soeharto, 2005)

If two activities must be completed as a requirement before two other activities can be carried out, then the diagram can be drawn as shown in Figure 7; event number 30 is both merge event and burst event.

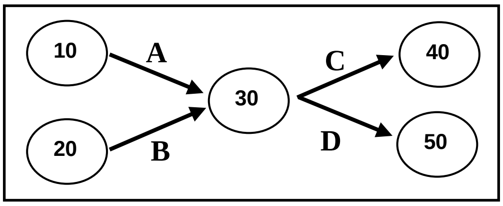

Figure 7 Merge and Burst Event Diagram (Source: Soeharto, 2005)

To display the relationship of one activity to the other, dummy activity can be used. Dummy is the flaw of arrow diagram network, because if forgotten, ambiguity between activities and changes in logic of network will happen. On the contrary, too much of dummy within the network will cause it to be abstruse or difficult to interpret, especially in terms of calculating the time. Another special characteristic of arrow diagrams which also complicates it, is that they have to be 100% completed first, then are connected with other activities. But the fact is that, in practice, it isn’t so. Most of the consequent works are already started even before the preceding work are 100% completed. To resolve this, these activities are broken down into two activities having name similar with index codes, for instances, activity A is broken down into A1, A2, and so on. Then it can be discovered that activity B (foundation plate 3) can be started without waiting activity A to be 100% completed, but after A1, which is a part of activity A’s completion (see Figure 8 and Figure 9)

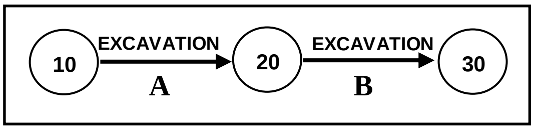

Figure 8 Activity B begins when activity A is done (Source: Soeharto, 2005)

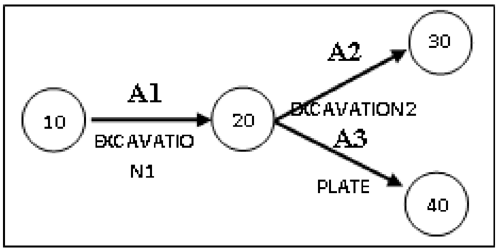

Figure 9 Activity A broken down into indexed code (Source: Soeharto, 2005)

2.4 Critical Path Method Decision

Within the process of time calculation, there are several notations, which are:

- d = Time needed to execute an activity, or duration.
- SA = TE = Earliest event occurrence time.
- SL = TL = Latest allowable event occurrence time.
- MA = ES = Earliest activity start time.
- BA = EF = Earliest activity finish time.
- ML = LS = Latest allowable activity start time.
- BL = LF = Latest allowable activity finish time.
- TF = S = Total actvity slack or float or total float, which is the amount of allowable time period of activity delay.
- SF = Free slack of an activity or activity free time.
- The equations to calculate the amount of total float (S) and free slack (SF) are: S = SL – BA = TL – EF and SF = SA – BA = TE – EF

2.5 Critical Path Calculation Stages

To determine the critical path of arrow diagrams, there are three ways, which are forward calculation, backward calculation, and float/stack. The explanation as well as the calculation for these ways in determining the critical path are as follows:

1. Forward Calculation
    a. The earliest moment for the first event of a network to occur is equal to zero (SA = 0)
    b. Each earliest activity starting time (MA) is equated to the earliest preceding event occurrence time (MA = SA). Hence, it can be formulated as:
    c. For merge event, the earliest activity occurrence time is equated with the largest cost of the earliest completion time of preceding activities.
2. Backward Calculation
    a. The latest allowable event occurrence time in a network is equal to the earliest preceding event occurrence time (SL = SA).
    b. The latest allowable activity starting time (ML) is equal to the latest allowable ending time for the succeeding activity (SL) subtracted with the duration of the activity (d).
    c. For burst event, the latest allowable event occurrence time is the same as the least cost of the latest allowed time for the succeeding activity to start.
3. Float/Slack Calculation

    An activity is considered to be critical if:

    ES = LS or MA = ML and

    EF = LF or BA = BL

    This means these activities can’t be shifted to left or right in the time scale. If these critical activities correlate with each other, critical path occurs.

2.6 Types of Costs on Construction Project

Total project cost needed in a construction comprises of direct costs and indirect costs. Total project cost has a strong connection with the duration of a project.

- Direct Cost, is the cost that arises and directly interacts with the ongoing project activities. Direct costs consist of material costs, salary, equipments, sub-contractors.
- Indirect Cost, is the cost needed in every project activity, but it does not correlate directly with the involved activities and is calculated from the beginning until the end of a project. If the end of the project is delayed from what was planned initially, then the indirect cost will grow larger. Due to the number of work and contract value staying the same, the contractor's profit will decrease over time, even to the point that they experience loss. Indirect costs consist of general overhead such as temporary operational facilities; security guard; occupational safety and health costs; employee wages, unanticipated expenses, recommended contractor's profit stated on work contract is generally 10%.

2.7 Time Cost Trade Off (TCTO) Analysis

In Time Cost Trade Off Analysis, as the project's completion duration changes, expenses or cost change as well. If the project's implementation duration changes, then the expenses or costs spent also change. If the implementation duration is accelerated, then the project's direct cost will increase while the indirect cost decreases. Several ways to accelerate the project duration are:

1. Increasing overtime hours, which can be done by increasing work hours per day without adding workers. What must be considered here, is that work hours are the time an individual works in a day. If an individual overworks during one day, the productivity will diminish due to fatigue.
2. Adding labors. Adding labors is meant by the increase the number of workers in one worker unit, to perform a specific activity without increasing the number of work hours. The increase of the number of workers must be balanced with the increase of supervisory personnels, because a crowded workspace and insufficient monitoring will decrease work productivity.
3. Replacing or adding equipments. Adding equipment is meant to increase productivity. However, the direct cost of mobilizing and demobilizing those equipments must be taken as consideration. The space that those equipment will occupy needs to be considered as well.
4. Selecting qualified human resources. Qualified human resources are labors with high productivity that produce ideal result.
5. Choosing effective construction methods. Construction method strongly correlates with work system and executant's level of expertise towards said method also with the availability of the necessary resources.

These ways can be performed separately or combinedly, for instance, the combination of increasing work hours with adding the number of labors, is usually called "shift".

2.8 The Element of Normal Time and Accelerated Time

If the duration of a project is accelerated, there is bound to be a change of value and time. There are two values of time shown by each activity in a network upon acceleration, which are:

- Normal time, is the time needed to complete a normal resource activity without additional extra cost in the project.

- Crash time, is the time needed for a project in its work to shorten the duration of a project, so that it is lower than the normal time.

2.9 The Element of Normal Cost and Accelerated Cost

Apart from the changes in the element of time, there are also changes in the element of cost upon the process of accelerating a project's completion, which are:

1. Normal Cost. This cost is related to the completion of a project on a normal time. This is the minimum cost from direct cost according to the estimator needed to carry out an activity during normal time. The estimation of this cost is located at planning and scheduling, simultaneously with the determining of normal time.
2. Crash Cost. It is the cost needed to execute an activity in the period of its crash time. This cost prompts the work to complete faster. Crash cost is going to be greater than normal cost, this is due to the time being faster. There is a relationship between project cost, both direct and indirect cost, with the time needed, which can be seen below. The increase of direct cost to accelerate an activity per unit of time is called "Cost Slope", which means:

   Cost slope : Cost per unit of time to shorten the activity completion time.

   Cost slope : Ratio of the price increase with the acceleration of completion time.

   The equation for Cost Slope is:

$$Cost\,Slope = \frac{Crash\,cost - Normal\,cost}{Normal\,duration - Crash\,duration} \tag{1}$$

3. Cost Slope. For example (see Figure 10), an activity with a normal duration of six days and crash duration of four days. Its normal cost is IDR 5,000,000 and its crash cost is 7,000,000 then

$$Cost\,Slope = \frac{7{,}000{,}000 - 5{,}00{,}000}{6-4} = IDR\ 1{,}000{,}000 / day$$

   Or to accelerate the operation by two days, then:

   2 x IDR 1,000,000 = IDR 2,000,000

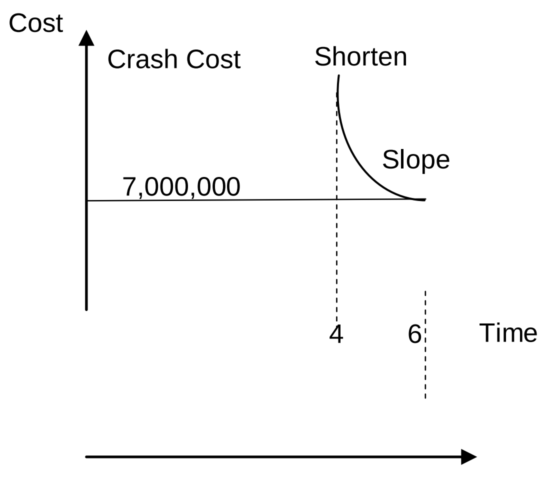

Figure 10 Crash Time and Crash Cost compared with Normal Time and Normal Cost (Source: Soeharto, 2005)

3. Research Method

3.1 Research Execution Stage

This research focuses on the analysis of the acceleration time of building construction using Time Cost Trade Off Analysis method with a study location of the construction of warehouse receipt building in Tumpang District, Malang Regency. Corresponding with the aims and the formulation of this research, the method carried out will be descriptive-quantitative research method.

3.2 Data Analysis

3.2.1 Project Scheduling Method

a. Activity Weighting

Activity weight is the project percentage value generated from activity price divided with the total activity price in percentage scale (Lynna, 2005), expressed below.

$$Activity\cos t = \frac{Activity\cos t}{Total\,activity\cos t} \times 100\% \tag{2}$$

b. Duration Determination

After the execution time of each activity has been decided, the duration for the project completion is then determined.

1. Forward Computation

The procedures are:

i. Determine the initial event of project at t = 0. If first event is marked as 1, then it can be written as: $SPA_1 = 0$, where SPA= Earliest point of event

ii. Determine the earliest initial point of all activities. The assumption is that the preceding activities have to be completed as early as possible, thus can be noted as: SPA_{xy} = SPL maximum of the activity preceding activity x- y, where SPL: The latest point.

iii. Determine the earliest possible an activity will complete. The earliest completion time is the earliest starting time added with the time needed to complete said activity, it can be written as:

$$FPA_{xy} = SPA_{xy} + L_{xy}, \tag{3}$$

where FPA = Earliest Completion Time; L = Time.

2. Backward Computation

The purpose of this computation is to determine the latest allowable time for an activity to start and to end.

i. Determine the latest allowable event completion time, which is the same as the scheduled project completion time in the forward computation, thus it can be said: $SPL_t = T_s$ or SPA_t

ii. Determine the latest allowable activity completion time, which is the same as the lowest price of the latest allowable starting time of the succeeding activity, which can be written as:

FPA_{xy}= minimum FPL of the activity that is directly following/succeeding activity x – y

iii. The latest allowable activity starting time is the latest allowable activity completion time subtracted with the time needed to complete said activity, hence noted as:

$$SPL_{xy} = FPL_{xy} - L_{xy} \tag{4}$$

3. Determining the Critical Path

   An activity is considered to be critical if SPA = SPL (Endmost time = Latest time) or FPA = FPL (Earliest Finist/Completion = Latest Finish/Completion) which means that these activities can't be delayed, and if there is a delay, then it will affect the overall project completion time.

3.2.2 Cost Calculation

The tabulation of the extra cost needed for each project activity is given in Table 1. Notation a_1 is the normal time of activity 1, while b_1 is the accelerated time of activity 1. Hence, time acceleration is $a_1 - b_1$.

Table 1 Normal Cost and Acceleration Analysis

Event	Normal Time	Normal Cost	Accelerated Time	Accelerated Cost	Activities Experiencing Acceleration	
					Time	Cost
1	a_1	c_1	b_1	d_1	$a_1 - b_1$	$d_1 - c_1$
2	a_2	c_2	b_2	d_2	$a_2 - b_2$	$d_2 - c_2$
.....	.....	.....	.....	.....	.....	.....

4. Data Analysis and Discussion

4.1 Time and Resource Estimation Planning

Based on the analysis of work quantity that has been obtained, the next stage is to perform scheduling planning and resource need estimations according to the quantitative analysis needed. Time planning estimation in the schedule is done by observing the require worker capacity/productivity based on the analysis stated within National Standards of Indonesia (SNI). One example of time planning analysis on a bowplank installation work, which is given in Table 2.

Table 2 SNI Analysis of Bowplank Installation

Quantity	Unit	Remark
0.012	m^3	5/7 Wood
0.02	kg	Regular Nails
0.007	m^3	Wood Planks
0.01	man/day	Head Carpenter
0.1	man/day	Carpenter
0.1	man/day	Worker
0.005	man/day	Foreman

According to the SNI analysis, it can be discovered that the resources needed are materials for the installation of bowplanks in 1 m^3 as well as the required human resource employed to complete the bowplank installation in one day. Based on this result, a time planning estimation can be done; if within a day, 0.01 head carpenter; 0.1 carpenter; 10.28 worker and 0.514 foreman, are needed to complete a bowplank work of 102 m^3. Meanwhile, the analysis for material needs will be done through MS – Project software. In order to complete a 102 m^3 bowplank installation, 0.012 m^3 5/7 wood; 0.02 regular nail and 0.007 m^3 wood plank. And so on for the planning and material data input estimation for each activity.

4.2 Composing the Sequence of Work

Composing the sequence of work or the relationship of one activity with another in the process of creating network, is based on the dependency logic among the activities. For instance, the installing work is done after creating the foundation, concrete work after installation work, and so on. This dependency logic is based on the technical order of work execution or the execution method which will be implemented in the execution of further works. This is one of the basic rule in creating a network that will encourage a planner to embed systematic approaches and analytical thinking. The more experienced an individual in creating networks, the more skillful he/she is in determining relationships among the activities, so that the work planning made will be optimal. Dependency implementation among activities in the contration project of a warehouse receipt building in Tumpang District on one of its activity, the river stone foundation work, has a dependency with its prior activity, which is the *aanstamping* work.

4.3 Project Completion Time and Critical Path

After the input of each activity, the duration estimation that is required and the resources used to complete each activity, as well as the dependency among activities are done, then schedule planning can be considered done. Obtained schedule can be inquired to present the necessary results for the sake of project evaluation regarding the overall time and work quality cost. The first result that can be presented is the total completion time of projects and activities indicated as critical activity. Critical activities are activities in a project that must be completed on time or according to the schedule, lest it will affect the total project completion time or duration. Schedule result on the construction project of the warehouse receipt building in Tumpang District indicates that the total project completion time are 152 work days with several critical activities such as; location cleaning, project name board installation, building permit (IMB), bowplank installation, excavation for pile cap foundation soil, piling back the foundation soil, and staking *gelam* wood.

4.4 Project Planning Cost

Project cost consists of direct and indirect cost. Direct cost can be defined as costs that directly influence a project's execution or completion time. While indirect cost only affects the total project budget. The process of resource input, both material and human resource, lead to the consequence of expenses for each planned resource that will be use. Corresponding to the required quantities for each activity, cost budget planning for each activity and total planned cost budget needed for the project will be made. Schedule result done gives a total direct cost report that must be expended by the planner for the construction of warehouse receipt building in Tumpang, as many as IDR 4,243,139,000.

4.5 Time Cost Trade Off Analysis

Based on the schedule result done, critical and non-critical activities can be identified. Critical activities are activities that have no slack time, which means that it is crucial to keep an eye on them so that they won't be delayed, resulting in the delay of the total project completion time. Non-critical activities are activities that still have slack time, where their layout can be readjusted in the planned network and their completion duration can be shortened. According to the critical and non-critical activity list, it can be determined which activities can be accelerated. The process of accelerating the activities' time depends on the condition that they are accelerated by increasing the work hours (overtime) with the number of labor being the same, or by adding the necessary labors according to the shortened duration as a consequence. In the warehouse receipt building construction in Tumpang District, Malang Regency, an analysis is carried out relating to the compensation of cost expended in order to shorten the duration. Through TCTO analysis, crash cost is obtained by considering the increase of labors, which results in the increase of cost in the form of wage for its acceleration. The implementation of TCTO can only be done if study regarding factor of the activities have been done; such as materials, works, available and present equipments, and sufficient finance to be used on the field. The result of this analysis is expected to give a compact project duration that can no further be condensed again. Based on the composed scheduling result and from the selected activities that are accelerated, resulted the time limitation for each activity's descriptions which are considered to be time-saturated and can not be accelerated. So, there are only a few activities selected which can be accelerated. The acceleration done towards the construction project of warehouse receipt building in Tumpang District is to add the necessary resources to speed up the project activity's duration. This increase of resources will lead to the rise of wage cost for each of the accelerated activity. Through this acceleration model, numerous trials and errors must be performed on the produced schedule in order to come up with a saturated accelerated duration.

The computation result shows that initially, all the works that are going to be accelerated present total normal costs of each work, both consisting human resources and materials needed. Then they are sorted according to the result of their MS-project of the amount of cost expended only on labors. Based on the normal activity duration and this labor cost, necessary acceleration cost can be discovered if the acceleration done only spans to adding the number of labors. The amount of necessary crash labor cost can be found by dividing normal labor cost with normal activity duration, i.e. IDR 2,144,988,334 / 93 = IDR 23,064,390. This analysis is done for every accelerated activity.

Inside TCTO, the accelerated cost and accelerated duration must be identified in order to create cost slope, which is expressed as

$$\Delta C = \frac{CC - NC}{ND - CD} \qquad \text{(IDR/time)} \qquad (5)$$

where:

Normal cost (NC) : The direct cost to complete a project in a normal time.

Crash cost (CC) : The direct cost to complete a project in the shortest amount of time.
Normal duration (ND) : The normal project completion time.
Crash duration (CD) : The shortest amount of project completion time
ΔC : Cost slope

Based on the given data, an example shows that a construction work of warehouse takes a normal cost (NC) of IDR 2,355,859,000 with a normal duration (ND) of 93 days, if the duration is accelerated by 21 days (CD) then the total accelerated cost is: normal cost + (acceleration duration x crash labor cost) = IDR 2,355,859,000 + (21 x IDR 23,064,390) = IDR 2,840,211,190, then the cost difference as a result of acceleration can be discovered with respect to the normal cost = NC-CC = IDR 23,064,390 and the cost slope value of this work will be IDR 1,098,304/ day.

The project execution with normal time and normal cost are compared with the accelerated time and the cost according to the accelerated time. Based on trial and error done regarding project acceleration, rescheduling with accelerated duration has been obtained therefore a new total project completion time can be discovered in the construction of Warehouse Receipt Building in Tumpang District, Malang Regency. It can be seen that the project acceleration will require additional cost. The difference of total accelerated cost respective to the normal cost (NC - CC) results the necessary total accelerated cost as an additional fund that must be expended as a direct cost of the project.

The result of acceleration done in the project leads to the consequence of additional cost where on the normal schedule shows a normal project cost of IDR 2,618,449,000, then after TCTO analysis is done to the project, there is an increase of direct cost on the total project to IDR 28,953,213, which sums the total project cost up to IDR 2,647,402,213. Corresponding to the acceleration done in the project, a new overall schedule result has been established where the existing works have been sped up. The previous project schedule of 114 days changes to 93 days, effectively cutting 21 days off the normal project schedule.

5. Conclusion

Based on Time Cost Trade Off (TCTO) computation analysis on the construction project of Warehouse Receipt Building in Tumpang District, Malang Regency presents a result as follows:

- The implementation of Time Cost Trade off (TCTO) method on the construction of Warehouse Receipt Building in Tumpang District, Malang Regency optimally reduce project duration through increasing human resouces, which requires an additional direct cost of the project.
- The construction project’s time of Warehouse Receipt Building in Tumpang District, Malang Regency of 114 days changes to 93 days, cutting 21 days off from the normal project schedule.
- The amount of direct cost on a normal schedule observed on the construction project of Warehouse Receipt Building in Tumpang District, Malang Regency shown to be IDR 2,618,449,000, after the project is analysed using Time Cost Trade off (TCTO), an additional direct cost of IDR 28,953,213 is discovered, which sums up to a total project cost of IDR 2,647,402,213.

References

Ervianto, Wulfram, I. 2005. Construction Project Management. Andi, Yogyakarta.

Handoko, F. 2017. Constructing Knowledge and Technology Transfer Model for SMEs Technology Development in Emerging Economies. International Journal of Pedagogy and Teacher Education. Vol 1, No. 2. pp. 93.

Handoko, F, Alan, S, and Burvill, C. 2014. The Role of Government, Universities, and Business in Advancing Technology for SMEs' innovation. Journal of Chinese Economic and Business Studies. Vol 12, No. 2. pp. 171.

Handoko, F., Nursanti,E., Harmanto, D and Sutriyono. 2016. Technology Transfer For Metal Based Smes In Central Java, Indonesia. ARPN Journal of Engineering and Applied Sciences, Vol.11, No. 8.

Handoko, F., Smith, A., Indriani, S. 2017. Technology Transfer for Metal Based SMEs in Central Java Indonesia. International Journal of Engineering and Management, Vol. 1, No. 1, p. 35-41.

Lynna. 2005. M Project Application for Work Scheduling Civil Engineering Project. Andi Publisher, Yogyakarta.

Maulana, A. 1994. International Labour Organization, Pustaka Binaman Pressindo, Jakarta.

Ratna S.A. 1999. "What If" Analysis, As Method of Anticipating Project Delay Duration, Journal of Civil Engineering Dimensions Vo.1.No2.

Soeharto, I. 2005. Project Management: from Konseptual to Operational, Erlangga Publishers, Jakarta.