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The Evaluation of *Resi Gudang* (Warehouse Receipt) Building Implementation Project by Employing Time Cost Trade Off Analysis in Tumpang Subdistrict of Malang Regency – Indonesia

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Abstract— *Planning is the main important factor in attaining a successful construction project. The influence of planning activity to construction project will be affected on the project income. This impact is strengthened by report of many events inside the construction project that said a good/better planning construction is able to save the project cost in approximate number of 40 percents, whereas unsuccessful planning construction make a deficit (budget stretch) up to 40 percents. Aside from time variable and resources variable within a planning activity in a project, the cost variable in the management aspect also has a crucial role for a project, where its occurence must be controlled as minimum as it can. Hence, in creating a cost control for a project, a great concern should be given to the time factor because there is a close correlation between project completion time with the cost factor of the related project.*

Sometimes a construction project often must be finished ahead of the time than its normal time. When this accelerated activity must happen, Head of the project or Project Leader is put to the problem about how to accelerate the project completion time with a minimum cost. Therefore, it is necessary to study the relationship between the time variable and the cost variable first before running an analysis about the time variable to cost variable with a method known as Time Cost Trade Off Analysis (TCTO).

From the application of Time Cost Trade Off (TCTO) into a project, it is found that the analysis able to give an optimum reduction in time duration by adding the manpower (human resources) and increasing the project's cost. The time duration in this project which originally set up to 114 days is able to be shortened into 93 days and give a time diffence of 21 days ahead of the project normal time. Therefore, with a project normal cost amounted to Rp. 2.618.449.000,00. then after the application of TCTO into the project, an extra direct cost emerges amounted to Rp. 28.953.213,00. and make the project total cost becomes Rp. 2.647.402.213,00.

Keywords— *Construction management, construction, management application.*

I. INTRODUCTION

In attaining a completion of a project, the project activities have three limitations as the parameters for measuring the success of a project. The three parameters are: (a) right budget (a frugal cost), (b) right schedule (punctual on time), and (c) workperformance (scope and quality of work) (Soeharto, 2005). One problem keeps remaining today is the frequent increase in project development time which inaccordance to the initial plan and resulting in a cost overrun to the related project. The fact shows about 70% of project developments carried out in Malang Regency are experiencing time delays and cost overruns (Field Survey, 2014).

There are some factors that able to affect project development delays such as: material supplies, equipment provisions, manpower (human resources), location project and weather conditions. A Critical Path Network Method is one of the time control modelling technic used to analytically observe of how much time needed for the completion time of a certain project. The critical path becomes very important to project implementation because within these paths are lies activities that when those activities are delayed, those will be impacted on the delay of the overall project (Ratna, 1999).

From the description above then postulates three problem formulations which can be stated as:

1. How to put the Time Cost Trade Off (TCTO) application optimally so it able to produce time efficiency to the related project?
2. How much time that able to obtain by applying the Time Cost Trade Off (TCTO) method into the related project?
3. How much is the cost for applying The Time Cost Trade Off (TCTO) method into the related project?

II. LITERATURE REVIEW

A. The Definition of A Construction Project

A project is one-time-completion activity done with limited time and resources to achieve a predetermined end result, for example to finish a product or production facility. Project activity can be defined as a temporary activity that lasts for a limited period of time, with the allocation of certain resources and is intended to produce products or deliverable whose quality criteria have been clearly outlined (Soeharto, 2005).

Construction projects can be divided into two types of interrelated building groups but are generally planned and executed by different disciplines of planners and implementers. The two types of building groups are buildings and civil buildings as stated in the *International Labor Organization* in Maulana (1994).

According to Ervianto (2005) there are six stages in project construction activities:

1. A feasibility study stage, aims to convince the project owner that the proposed construction project is possible (feasible) to implement;
2. A briefing stage, aims to get an explanation from the project owner regarding the project's functions and details, also calculate the detailed costs that allowed;
3. A planned design stage, aims to design the work in detail including determining the layout, design, construction method, and estimations;
4. An auction or *tender* stage, aims to appoint a contractor or sub-contractor who will carry out construction work in the field;
5. An implementation or construction stage, aims to carry out the work within the agreed cost and time limits, also to make a detail quality (grade) agreement;
6. A building maintenance and preparation stage, aims to ensure the work completion as detailed as stated in the contract documents where all facilities are working in line as they should.

B. The Delay of A Construction Project

From Ervianto's statement (2005), a delay in project completion is due to the presence of inhibiting factors at the control process which are:

1. A supervisory (of workforce) or inspector (of the construction) factor who less skilled or inexperienced in their workfield which can cause ineffective and less accurate project control.
2. A control system factor in application of information and supervision systems which is too formal until ignores human relation process that will lead to rigidity and compulsion for the construction team.

C. The Arrow Diagram

This networking method initially developed in America (early 1957) as the Critical Path Method or CPM while in France (1958) was called as Metra Potential Method or MPM. Within these diagrams, the activity statuses are described and determined in the network by considering several types of relations that occur between activities such as the end-start relation. The order (sequence) of activities that shown within the network will describe the dependence aspect of one activity to another activity where each of them have a predetermined duration of time (execution time).

1. Actual (real) activity and dummy activity

The Actual or real activity is the real implementation of any activity in the related project. These real activities mostly depicted in graph as unbroken dash line arrows within network with inclusion of the time duration.

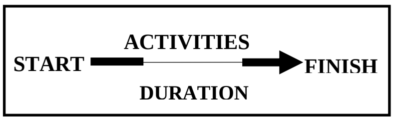

Fig. 1. Actual (real) activities. (Soeharto, 2005)

Meanwhile, there is a fake activity or called as Dummy activity. It is depicted in graph by dotted dash lines arrows function to show the dependencies between activities. This fake/dummy activities has no processing time (zero activity).

Fig. 2. The dummy activity. (Soeharto, 2005)

While the Event is the basepoint of the end point from the related activity. An event does not require time or resources. It can be graphically depicted as a circle with a number in it.

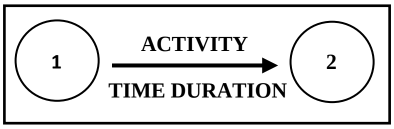

Fig. 3. The event. (Soeharto, 2005)

2. Types of relationship between activities

The diagram below is showing the sequencial activities (according to straight lines) where a new job can be implemented, then it can be explained that the end of 'A' activity occurs together with the beginning of 'B' activity.

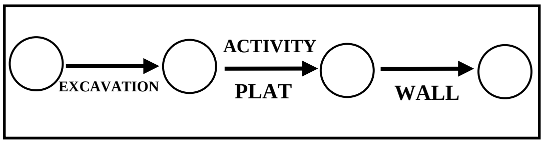

Fig. 4. The diagram of sequencial activities. (Soeharto, 2005)

When there are several activities that must be completed before starting the next activity, then the end of these activities will coincide with the beginning of the next activity. At event '30' there are gathered activities from 'A' and 'B' in which followed by the next activity, the 'C' activity. Thus, event number 30 is called as '*merge'* point.

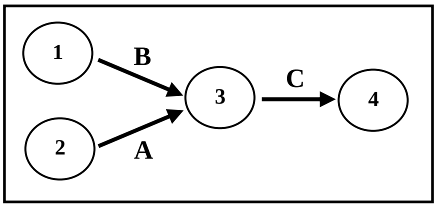

Fig. 5. The *merge* event diagram. (Soeharto, 2005)

In contrast, the opposite event can also happen such as the occurence of several new activities which can be started after one activity is completed (pre-requisite) where in the picture can be seen that event '20' is an event that allows dispersal of several activities such as excavation activity (B) and foundation plate activity (C). When it happens, the event number '20' said as the '*Burst'* event. Or, this diagram can be read as follow; when excavation activity 1 is finished, then the excavation 2 and a new foundation plate activities can be started. Hence, the end of activity 1 is the beginning of the event of excavation 2 and the foundation plate activities.

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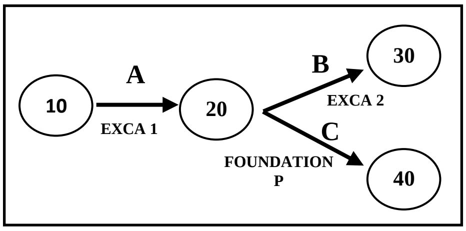

Fig. 6.The burst event diagram. (Soeharto, 2005)

Later, when two activities must be completed first as a condition/requirement to let the other two activities processing, then it can be described altogether as event '30' is a *merge* event and a *burst* event.

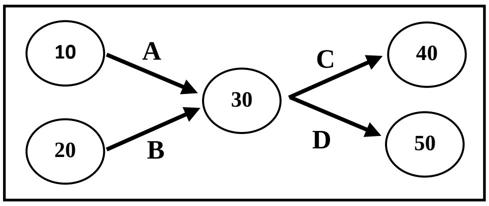

Fig. 7. The merge and burst events diagram. (Soeharto, 2005)

To perform the relationship of activities between one another, the dummy activities can be applied in it. Dummy activity is a weakness point in the arrow diagram network, because when it is forgotten then there will be obscurity (confusion) between one activity to another or worse it will change the logic of network. However, when you use too many dummy activities, then the network will be difficult to understand, particularly when it is time to calculate the time duration.

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There is one particular characteristic of arrow diagram which make workplan becomes difficult. An activity must be completed in a whole (100 %) before it will be connected to other activities, however, this is not the case during the work practices. In fact, the next job often started ahead of time before wait the previous work completed 100 %. As a solution, that type of activity was split into two activities which have the same index code name, for example, the related activity above is split into 'A1' activity and A2' activity and so on. Then it can be seen the 'B' activity (the foundation plate 3) can be started without waiting the full completion of 'A' activity but only has to wait 'A1" activity to complete (as the part of 'A' activity).

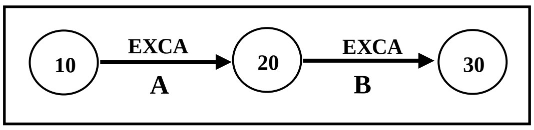

Fig. 8. B activity started after the A activity finished. (Soeharto, 2005)

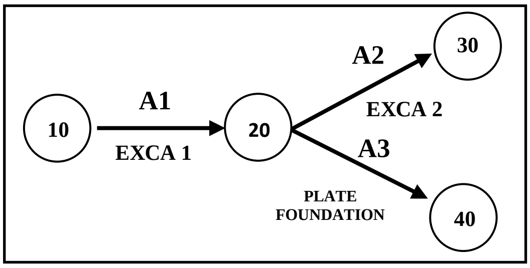

Fig. 9. The separation of 'A' activity into index code. (Soeharto, 2005)

D. The Determination of Critical Path Line

In the time calculation there are several notations to be known such as:

1. d = Time required to carry out an activity (duration).
2. SA = TE = Earliest event occurrence time.
3. SL = TL = The very last allowable event occurrence time.
4. MA = ES = Earliest activity start time.
5. BA = EF = Earliest activity finish time.
6. ML = LS = The very last allowable activity start time.
7. BL = LF = The very last allowable activity finish time.
8. TF = S = Total activity slack or float or total float, is the amount of time until the activity can be slowed down.
9. SF = Free slack of an activity or free activity time.
10. The formula to calculate the amount of total float S and free slack SF which can be written as:
    S = SL – BA = TL – EF and SF = SA – BA = TE – EF

E. The Step of Critical Path Calculation

There are three ways to determine the critical path of the arrow diagram, namely forward, backward, and float/slack calculations. Here are the following explanations and the calculations for each method in determining the critical path:

1. The forward calculation
   a. The earliest time for the first event of the network to occur is equal to zero (SA = 0)
   b. Each activity starting at the earliest time (MA) is equated with the earliest time of the previous event occurred (MA = SA). So, the formula can be written as follows:

      BA = MA + d = SA + d

   c. For merge events, the earliest start time of the activity is equated with the largest value from the earliest ending from the previous activities.
2. The Backward Equation
   a. The very last time allowed from the last event of the network is equated as the earliest time for that event which is obtained from the forward calculation method (SL = SA).
   b. The very last starting time that is still allowed for an activity (ML) is equated as the very last time ending (SL) that is allowed for the next event minus with the execution time of that activity (d).

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c. For burst events, the slowest time allowed for an event to occur is equal to the smallest value from the slowest start time allowed for subsequent activities.

3. The Float/Slack Equation
An activity be called as critical when:
ES = LS or MA = ML and
EF = LF or BA = BL
This definition has a meaning that the activity can not be shifted or swipe to the left or right in its time scale, when these critical activities are interconnected, then a 'critical path' will happen.

F. Type of Cost in A Construction Project

There are three ways to determine the critical path of the arrow diagram, namely forward, backward, and float/slack calculations. Here are the following explanations and the calculations for each method in determining the critical path:

The total project costs required for a construction are consisted of direct cost and indirect cost. The total project cost has a close relationship with the time duration of the implementation of a project.

1. *Direct cost* are any expenses arise and directly related to ongoing project activities. Direct costs include all costs of any materials, wages, tools and sub contractors.
2. *Indirect cost* are any expenses required for every activity within a project but not directly related to the field activities and calculated from the beginning of the project to the end of the project. When the implementation of the final project is delayed from the predetermined time, these indirect costs will increase, while the number of works and the contract value remains the same, thus, the contractor's profit will be reduced and worse, in some certain conditions will suffer some losses. These indirect costs are include general overhead costs such as temporary operational facilities; security guard; costs for K3 (Occupational Health and Safety), employee salaries, unexpected costs, contractor benefits that recommended in the employment contract where generally the amount is 10%.

G. The Analysis of Time Cost Trade Off (TCTO)

The analysis of Time Cost Trade Off (TCTO) with some changes in the project completion time will make the costs also changes. If the project implementation time changes then the costs will also change. If the implementation time is accelerated, the project's direct cost will increase while the indirect cost will decrease.

There are some methods to accelerate a project implementation time:

1. Increasing the number of working overtime hours by adding working hours per day without employing more workers. The consideration aspect when adding working hours is the length of time for a person works in a day. When the workers work too long in one day then the worker's productivity will decrease because they are too tired of working.
2. Addition of manpower. The addition of manpower is intended as an increase in the number of workers in one unit to carry out a certain activity without adding working hours. The addition of workers number must be equal/balanced with the addition of supervisory staff because when the work space is crowded and it is lack of supervision then this condition will reduce the work productivity.
3. Replacement or addition of equipment. Equipment addition is intended to increase productivity. However, it should be put into consideration that some additional direct costs will appear for activity of mobility and demobility of the device, also finding a land area to place the equipment.
4. Selection of quality manpower or human resources (HR). A qualified manpower is a worker who has high productivity with competent results.
5. The application of effective construction method. Construction methods are closely related to the work system and mastery level of the implementers of these methods as well as the availability of the required resources.

These methods can be carried out separately or put in combination, for example a combination of adding working hours together with adding number of workers which commonly called as a shift.

H. Normal Time and Accelerated Time Elements

When duration of a project is accelerating then there will be changes in time and value aspects. There are two time values that emerge for each activities inside the network when an acceleration occurs which are:

1. *Normal time* is the time required to complete an existing normal resource activity without any additional costs in the project.
2. *Crash time* is the time that will be needed by a project in its effort to shorten the time for a project so that its duration is shorter than normal time.

I. Normal Time and Accelerated Cost Elements

Aside from changes in the element of time, there is also a change to element of cost when the project completion is accelerated, these costs are:

1. *Normal cost.* This is a cost related to the completion of a project in a normal time. It is the minimum cost from the direct cost that required to carry out an activity during normal time according to the estimator. This cost estimation is calculated at planning and scheduling time along with the determination of the normal time of the related project.
2. *Crash cost.* Crash cost of a project activity is the cost used to implement/carry out the activity within period (as big as) the duration of the crash. This cost accelerate the work to be completed faster. The crash cost will be greater than the original normal costs due to faster time completion than normal, and the relationship between project costs (direct and indirect costs) with time required in that related project can be seen as follow. The increase of direct cost to speed up an activity per-unit time is known as *Cost Slope,* therefore:

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

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Cost slope : The ratio between additional costs and the acceleration of completion time.

Thus, the formulation of Cost slope becomes :

$$Cost\ Slope = \frac{Crashcost - Normal\ Cost}{Normalduration - CrashDuration}$$

For example, there is an activity with a normal duration of six days and a crash duration of four days, while the normal cost is Rp. 5.000.000,00 and the crash cost is Rp. 7.000.000,00 then

$$Cost\ Slope = \frac{Rp.7.000.000 - Rp.5.000.000}{6-4} = Rp.\ 1.000.000,00/day$$

Or, to speed up the operation by two days, then the calculation will be:

2 x Rp. 1.000.000,00 = Rp 2.000.000,00

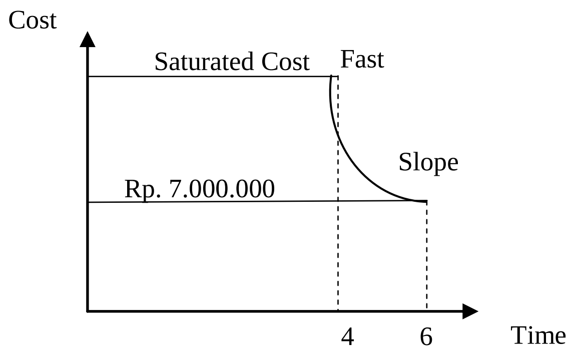

Fig. 10. Time and saturated cost/ crash cost in comparation with time and normal cost. (Soeharto, 2005)

III. Method

A. The Stages of Research Implementation

This study focuses on analysis of acceleration building construction time by applying the Time Cost Trade Off Analysis (TCTO) method to study location on Construction site of *Resi Gudang (*A Warehouse Building) in Tumpang Subdistrict of Malang Regency. According to the research objectives and problem formulation of this study then the most appropriate type of research is descriptive and quantitative research.

B. Data Analysis

1. The project schedulling method
   a. Activity weighting

   An activity weight is the percentage value of the project which generated from the price of the activity divided by the total price of the activity on a percentage scale. (Lynna, 2005). The formula is:

$$\text{Activity weight} = \frac{\text{Price of the activity}}{\text{Total price of the activity}} \times 100\%$$

   b. Time determination

   After the implementation time from each activity has been determined then it will continue with time determination of how much time/how long for the project to complete.

   The forward calculation. The procedure of this calculation are:

- Determine the initial event of the project at t = 0. When the first event is marked as 1, then it is written by: $SPA_1 = 0$
  Where SPA= *Saat Paling Awal* (The Earliest Time)
- Determine the earliest start time of all activities. It is assumed that all activities that precede it must also be completed as quickly as possible, so that it can be written: SPAxy = SPLmaximum of activities that precede activity x- y.
  Where SPL = *Saat Paling Lambat* (The Very Last Time)
- Determine the earliest completion time of an activity. The fastest ending time is the fastest start time plus the time it takes to complete the activity, so it can be written:
  $FPA_{xy} = SPA_{xy} + L_{xy}$,
  Where FPA= *Finish Paling Awal* (The Earliest Finish) ; L = Time

The backward calculation. The goal is to determine the slowest possible time for the start and end of an activity.

- Determine the very last event at the last ending that allow to happen, which is the same with the project completion time that has been scheduled in the forward calculation, so the formula can be written as : $SPL_t = T_s$ or SPA_t
- Determine the very last ending time of the completion of an activity which has the same value with the smallest price of the very last start (which allowed to happen) from the activity that follows, so the formula can be written as:
  FPA_{xy}= FPL minumum from activity that directly follows the x-y activity
- The very last starting time (that allowed to happen) for an activity is the very last ending time (that allowed to happen) minus time needed for completing the activity, so the formula can be written as:
  $SPL_{xy} = FPL_{xy} - L_{xy}$

Determination of the critical path. An activity is called critical when SPA = SPL (The Earliest Time = The Very Last Time) or FPA = FPL (earliest finish = slowest finish) which means these activities cannot be postponed, and if there is a delay then it will make an overall affect to the project completion time.

2. Cost calculation

An extra cost tabulation required for every activities project displays below:

TABLE 1. The Analysis of Normal Cost and Accelerated Cost

Event	Normal Time	Normal Cost	Accelerated Time	Accelerated Cost	Activities that 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	$a_2 - b_2$	$d_2 - c_2$
.....	.....	.....	.....	.....	.....	.....

Where a_1 is the normal time for activity 1 and b_1 is the acceleration time for activity 1. Thus, the acceleration time is written as $a_1 - b_1$. To speed up the project completion time, obviously there are additional costs needed that can be written as follows:

$$d_1 = c_1 + \frac{a_1 - b_1}{a_1} \text{ x } 0,5 \text{ x } c_1$$

From the normal cost of c_1 then it will be obtained the calculation of the cost for acceleration of d_1 Thus, accelerating time requires an additional cost of $d_1 - c_1$.

IV. RESULT

A. Estimation Time and Resources Requirements Planning

From the result analysis about the work quantity that has been obtained, the next step is making a time estimation for schedule planning and resource requirements according to the required quantity analysis.

The estimated planning time in the schedule project is carried out by observing the required productivity/worker's capacity that related to analysis that has been stated in the SNI. There is one example of planning time analysis on Bowplank Installation Work:

TABLE 2. SNI Analysis of Blowplank Installation

Volume	Unit	Description
0,012	m^3	Wood 5/7
0,02	kgs	Ordinary nails
0,007	m^3	Wooden plank
0,01	oh	The chief carpenter
0,1	oh	The carpenter
0,1	oh	Workers
0,005	oh	Foreman

The SNI analysis can produce the calculation of resource requirements for installation of a bowplank for one m' and also can calculate the requirement of manpower that used to complete this bowplank installation in one day. Based on these result, then, it can be estimated the planning time for constructing a bowplank installation (for one day) is needed of 0.01 Chief Carpenter; 0.1 carpenter; 10.28 workers and 0.514 foreman to complete the 102 m' bowplank work. While the analysis of required materials as input for the project is aided by the MS-Project sofware, to complete the 102 m' bowplank installation requires 0.012 m^3 of 5/7 wood; 0.02 ordinary nails and 0.007 m^3 of plank wood, and so on. These are the estimation planning and input of material data for each activity.

B. Arranging The Sequence of Work

Arranging work sequences or developing the relationship of one activity to another within the process of creating a network is based on the logic of dependencies between these activities. As an example, *kerja pasangan (*installation/couple work) activity is conducted after finishing the foundation making activity while the concrete work after *kerja pasangan* (installation/couple work), and so on. The logic of this dependency based on technical sequence of work execution or the implementation method that will be applied (later) in the execution of work. This is a basic rule in setting up a network which able to encourage the planner to take a systematic approach by his/her analytical thinking. The longer the time a person get experience in setting up a network, the more skillfull the person is in determining the relationship between activities, thus more optimum schedule of work plans is possible to acquire.

The application of dependence between activities on the site of *Resi Gudang* (Warehouse Receipt) Building Construction Project on Tumpang Subdistrict on one activity project called as the river stone foundation work has a dependence with the previous activity of *aanstamping (*make arrangement of bare stones to dry the soil) work.

C. Project Completion Time and Critical Path

After all activities had been inputted and the required estimated duration together with estimated resources needed for completing each activity has been conducted, as well as the dependencies between activities, then the schedule plan is almost complete. This is the stage where the obtained schedule can be asked to display the results needed for the project evaluation process that related to cost of time and overall quality of work.

The first result that can be displayed is the total project completion time and project activities that indicated as critical activities. Critical activities are activities in the project that must be carried out in accordance with the schedule, where if there is a delay, it will affect the total time of project completion.

While the result from scheduling plan of *Resi Gudang* (Warehouse Receipt) Building Project in Tumpang Subdistrict of Malang Regency shows total time for project completion is 114 working days with several critical activities which include of site cleaning, project nameplates installation, IMB permit, bowplanks installation, *poer* soil foundation excavation, backfillingfoundations and *galam* wood piling (stake) activities.

D. Project Plan Cosh

A project cost consists of direct and indirect costs. For a direct cost can be interpreted as costs that directly able to affect project implementation time or project completion time, meanwhile, the indirect cost only affect on the total project budget.

The input process for resources, both in the form of materials and in the form of human labor, has consequences for the expenditure of costs for the payment of each resource that is planned to be used. In accordance with the quantity required for each activity, a budget plan for each activity and a total cost budget plan for the project is obtained. The schedule result will provide a report on the total direct costs that must be incurred for planning the *Resi Gudang* (Warehouse Receipt) building construction of the Tumpang Subdistrict with amount of Rp. 4.243.139.000,00.

E. Analysis of Time Cost Trade Off (TCTO)

From the result of scheduling process that has been done, the critical and non-critical activities can be identified. Critical activities are those activities that do not have a slack time and must be really observed to make them not late and affected on the total project completion time. While non-critical activities are those that still have a slack (grace period) time where there is still enough room to arrange the layout of the predetermined network plan or shortening the completion time of the project.

Based on the list of critical and non-critical activities above then the accelerated activities can be determined. The process in accelerating the activity time depends on project activities that can be carried out by adding working time (overtime hours) with a fixed number of workers or by adding essential workers according to the reduced duration as its consequence. For *Resi Gudang* (Warehouse Receipt) Building construction in Tumpang Subdistrict of Malang Regency, there was an analysis carried out, by exchanging the time used against the costs incurred. With the TCTO analysis, the crash cost is obtained by considering the addition of number of workers, therefore, there is cost increase for accelerated labor wages. The application of TCTO can only be implemented when factors related to the activity has been studied or observed (such as the materials, work, equipment available on site and sufficient finances to be used in the field) The final result of this analysis is expected to show a saturated project duration which cannot be compressed anymore.

From the scheduling result that has been arranged and the selection of accelerated activities, the time limitation of each activity description has reached saturation time and unable to be accelerated no more. However, there only few activities as shown in Table 3 that able to have accelerated duration.

TABLE 3. The Analysis of Normal Cost and Acceleration Cost

Type of Works	Total Normal Cost	Total Cost After Accereleation
	Rp.	Rp.
Warehouse 1000 m^2	2.355.859.000,00	2.144.988.334,00
Office 54 m^2	173.616.000,00	106.899.240,00
Security worker house 36 m^2	88.974.000,00	76.742.019,00
Total cost	2.618.449.000,00	2.328.629.593,00

The accelerated activities carried out for *Resi Gudang* (Warehouse Receipt) Building Construction project in Tumpang Subdistrict are adding the necessary resources to speed up the duration of project activities. The increase in number of resources has an implication to the increase of wages cost for each accelerated activity. By these acceleration models, it requires some trial and error to the resulted schedule so it will produce a saturated accelerated duration.

TABLE 4. The Result of Analysis of Normal Cost and Accerelation Cost

Type of Works	Total Normal Cost	Normal Wages Cost	Normal Duration	Crash Wages Cost
	Rp.	Rp.		Rp.
Warehouse 1000 m^2	2.355.859.000,00	2.144.988.334,00	93	23.064.300,00
Office 54 m^2	173.616.000,00	106.899.240,00	30	3.563.308,00
Security Worker House 36 m^2	88.974.000,00	76.742.018,00	33	2.325.515,00

From the calculation result in Table 4 shown that in the beginning of all works that will be accelerated have given total result normal cost for each work whether in the form of manpower or material resources that needed for the project. It also can be sorted, based on the result from MS-project software application in form of costs incurred only for the work labour. Then, based on the duration of normal activities and labor costs, the required acceleration costs for this project can be obtained if the activity selected in this project is adding the necessary workers. While the result from the required crash labour cost is to divide the normal labor cost by the normal duration of the related activity.

$$\frac{\text{Rp. } 2.144.988.334{,}00}{93} = \text{Rp } 23.064.390{,}00$$

And so on, an analysis is carried out for each accelerated activity as listed in table 4 above. In the TCTO, it is necessary to identify the cost of acceleration and the duration of the acceleration so it is able to generate a cost slope.

$$\Delta C = \frac{\Delta C}{\Delta T} = \frac{CC - NC}{ND - CD} \text{ (rupiah/time)}$$

Where:

Normal cost (NC) : Direct cost in finishing the project under normal time
Crash cost (CC) : Direct cost in finishing the project under the shortest time
Normal duration (ND): Normal project completion time
Crash duration (CD) : Shortest time which allowable in finishing the activities
ΔC : *Cost* slope

From the data shown in table 4, the warehouse construction work can be put as an example, where in a normal cost (NC) is Rp. 2.355.859.000,00 with 93 days of work as the normal duration (ND), when this work is decided to be accelerated by 21 days (CD), then the total acceleration cost will resulted as: normal costs + (duration of acceleration x crash labor costs) = Rp. 2.144.988.334,00-2.355.859.000,00 + (21 x Rp. 23.064.390,00) = Rp. 2.840.211.190,00 . Hence, the difference between costs due to acceleration also can be calculated against normal costs = NC-CC = Rp. 23.064.390,00 and the value of the *cost slope* of the work is Rp. 1.098.304,00/day.

The project implementation with normal time and costs when compared to project implementation with accelerated time and costs according to accelerated time. Based on trial and error which carried out in relation to project acceleration, a new rescheduling plan with an accelerated duration to make the (new) total completion time of *Resi Gudang* building construction project in Tumpang Subdistrict of Malang Regency can be obtained. The results of scheduling with time acceleration are attached in Appendix 3. Based on table 4, it can also be seen that project acceleration requires additional costs. The difference from the total acceleration costs to normal costs (NC – CC) resulting in the total acceleration costs that required as additional funds which must be removed from the direct costs of the project.

The resulted acceleration carried out within the project brings consequence of an additional cost where under normal schedule conditions, the normal project cost is Rp. 2.618.449.000,00. Then after the TCTO analysis put on the

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project, an additional direct cost emerge within the project amounted of Rp. 28.953.213,00 so that the total project cost becomes Rp. 2.647.402.213,00

According to acceleration process that has been conducted in the project, a new overall scheduling result is obtained where there have been several works that have previously been accelerated. The new schedule result has obtained, the project completion time from original completion time of 114 days to 93 days, so there was a difference of 21 days from the normal project schedule.

V. CONCLUTION

According to the analysis of Time Cost Trade Off (TCTO) in the implementation of *Resi Gudang* building construction in Tumpang Subdistrict of Malang Regency, the results of this study are stated as follow:

1. The application of Time Cost Trade Off (TCTO) method on the *Resi Gudang* building construction in Tumpang Subdistrict of Malang Regency is able to provide an optimum reduction in the time duration by adding the human labour with consequences of experiencing additional costs in the direct costs of the project.
2. The completion time which obtained from the implementation of *Resi Gudang* building construction in Tumpang Subdisctrict of Malang Regency from 114 days as the original time can be shortened to be 93 days of completion time, thus, there is a difference of 21 days from the normal project schedule.
3. The obtained direct costs for the *Resi Gudang* building construction project in Tumpang Subdistrict of Malang Regency under a normal schedule condition is Rp. 2.618.449.000,00 Later, after being analyzed with the Time Cost Trade off (TCTO) method on the project, there are additional direct costs emerge in the project amounted to Rp. 28.953.213,00 so that the total cost of the project became Rp. 2.647.402.213,00

According to the conclutions above, there are several suggestions conveyed in this study which hopefully might be useful for futher research that takes the same method as the material for accelerating time of a project.

1. During work implementation of a project in the field, it is necessary for giving focused attention to the implementation of the critical activities, because when these activities are late in their completion time then will resulted in the delay of other activities implementation.
2. For the future research, it is better to do the work in more detail when related to more detailed activities in the project completion, so these works will give better assist in the model design, determine the relationship between activities and time estimation of the project.
3. For a policy making, a better planning and supervision of project activities are needed to avoid delays to occur during the implementation of the project activities.

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