

# Crashing Analysis on the Construction of The First Its Tower Building Using Time Cost Trade Off Method

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## Abstract

A construction project is a series of activities carried out with a specific scope of work, time and expense according to the agreement between the project owners and the contractors. In the case of a project, it is necessary to file a task so that it can run smoothly and carry out according to plan times.

An optimum time and expense analysis of the job involved time cost trade off for case studies of the advanced construction of the tower's 1 (one) located on the campus of ITS Sukolilo - Surabaya. Analysis runs to speed up project time that is tardiness with minimal costs added and should be noted on the other hand that the emphasis on activities that are on critical trajectories and have the lowest cost slope on those tracks. Steps made in this acceleration are identifications of job activity, arranging network diagrams, specifying acceleration scenarios, crashing duration and crashing cost, calculating cost slope, and do the iteration phase. After a time cost trade off analysis, it would provide output with multiple time and cost alternatives to the new project. Of the many alternatives, selected the time and expense of the completion of the project optimum.

From the analysis, to complete the work at completion time according to plan, the cost increased by IDR 474.268.897,00 from IDR 9.919.982.348,00 to IDR 10.394.251.245,00 with a 32 day reduction from 180 days to 148 days so that the project could be completed as expected on March 2, 2021.

## Keywords:

Crashing Analysis, critical path, cost, time first tower of ITS Campus and Time Cost Trade Off.

## 1. Introduction

In building construction, the delay in completing the building construction project means that the implementing contractor must pay a penalty (penalty) for the delay in accordance with the contract agreement with the project owner which is not small in number. In addition, project delays also result in decreased confidence of project voters to cooperate again with implementing contractors in the future, especially if the project owner is a government agency. For this reason, it is necessary to have a planning and scheduling for building construction so that it is accepted by the project owner on time.(Chusnia Idawati, 2019)

It is inevitable that every implementation practice has various possibilities that can cause delays, for example delays in implementation, design changes, weather effects, delays in material supply, construction failures, and planning errors. If this happens, the supervisory consultant in the field must quickly and accurately provide a solution to the delay.

To do an acceleration, it is necessary to learn about the existing network and the relationship between time and cost in carrying out an acceleration. By utilizing the optimal time, the alternatives used to support the acceleration carried out are to increase working hours, increase labor force, or add construction equipment. One of the methods that can be used to analyze the project acceleration is Time and Cost Exchange Analysis.

The purpose of this method is to accelerate the time of project completion and to analyze the extent to which time can be shortened by adding minimum costs to activities that can be accelerated by the time of work. So that we can know the maximum acceleration and the minimum cost. This method provides an alternative solution for project planners to arrange the best planning so as to optimize the time and cost in project completion.

In the continued project of the construction of the ITS Tower 1 stage V located at the ITS Sukolilo Campus, Surabaya, East Java, this starts on September 4, 2020 with an implementation period of 6 months or is planned to be completed on March 2, 2021. However, until November 2020 the development progress is still running at around 10%, where the project should have been 27%. The continued project for the construction of the ITS Tower 1 Building experienced delays in architectural and mechanical electrical work.

There are several alternative ways to overcome this delay, namely by increasing the number of workers, working groups, having overtime hours, and adding work equipment. Therefore, the contractor needs to do a careful rescheduling so that the project can still be completed faster at optimum cost. Based on the literature and

problems that occur in the field, the author conducted research on the Analysis of the Acceleration of Further Work for the Construction of the ITS Tower Building 1 (One) with the Time Cost Trade Off Method.

## 2. Methodology

### 2.1 Research Concept

This type of research is a descriptive approach quantitative because this research is demanding use of numbers, starting from data collection, interpretation of these data, as well as appearance and the result. In this study, the type of non-test instrument was used because one of the data collection techniques used was using interviews, observation, and documentation to collect data.

### 2.2. Collecting data

Microsoft Excel Project schedule obtained from PT. Citra Mandiri Cipta as a Constructor. With the data obtained from the project implementation time, then determine the relationship between activities based on the sequence of work in the field and based on a predetermined project schedule. The relationship between these activities is adjusted to when this activity must be started and when it must be completed. The relationship between activities is obtained from the schedule in the field, which is then translated into sub-jobs. In determining the relationship between activities, it has been consulted with the implementer in the field so that the relationship between activities becomes more in line with the reality on the ground.

### 2.3. Network Diagram

After primary and secondary data are completed the next step is to develop a network diagram to identify the work and establish a critical path by using the MS. Project Application. This program can assist in setting up a network even with a large number of work items. From the results of scheduling carried out with Microsoft Project, it will be known the lists of activities that are included in critical activities.

Table 1. Critical Activities

Code	Activities	Duration
1	Preparation	31 days
2	Coloumn	5 days
3	Brick wall	6 days
5	Brickwall layering + finishing	4 days
13	Homogeneous Tile 60x60cm (HT1)	10 days
16	Gypsumboard 9mm (PG) + Hollow Galvalume frame	8 days
17	Acoustic Gypsum Tyle 600x1200 (PG1) + Acoustic Cross Tee Main Tee frame	5 days
19	Interior Painting	6 days
25	Clear Glass 12mm (KC1)	3 days
27	Clear Glass for partition	3 days
28	Doors and windows	10 days
39	Main stairs Railing	3 days
40	Void Railing	3 days
45	Floor Drain TX 1 AVIN + Closet, TOTO Type CW 421 J + Urinal Body, TOTO Type UW 447 JT1M	2 days
46	Shower Spray, TOTO Type TX 423 SMCRB	2 days

### 2.4. Time Cost Trade Off Analysis

In determining the acceleration of the work time of a project, a scenario is made by increasing the number of tools, the number of workers and the number of groups of workers so that the productivity of tools and labor increases. After the selected the scenario, calculate analysis is required to crash cost and crash duration. (Andi Maddepungeng, 2015)

For Example adding manpower :

Brickwall, 1 Pc : 2 Ps ; Citicon (PC2)

Volume : 655,373 m<sup>2</sup>

Unit Price : IDR. 239.195,00 x 655,373 m<sup>2</sup> = IDR. 156.762.181,00

Material Unit Price : IDR 83.065,00

Material Cost : IDR 83.065,00 x 655,373 m<sup>2</sup> = IDR 54.438.531,00 m<sup>2</sup>/day

Normal Duration : 6 days

Total Manpower : 10 Man Power

Normal Productivities := (655,373 m<sup>2</sup>)/(6 days) = 109,23 m<sup>2</sup>/day = (109,23 m<sup>2</sup>/day)/(10 man)

= 10,923 m<sup>2</sup>/day/man  
 Wage Unit Price : IDR 156.130,00  
 Normal wage per day : IDR 156.130,00 x 655,373 m<sup>2</sup> = IDR 102.323.650,00 /day  
 It is planned to add a workforce of 10 people with the same number of productivities at 10,923 m<sup>2</sup>/day/man which resulted in an additional fee of Rp. 500,000.00 / man.

So that productivity crashing : = (10,923 m<sup>2</sup>/day/man x 10 man) + (10,923 m<sup>2</sup>/day/man x 10 man)  
 = 218,458 m<sup>2</sup>/day

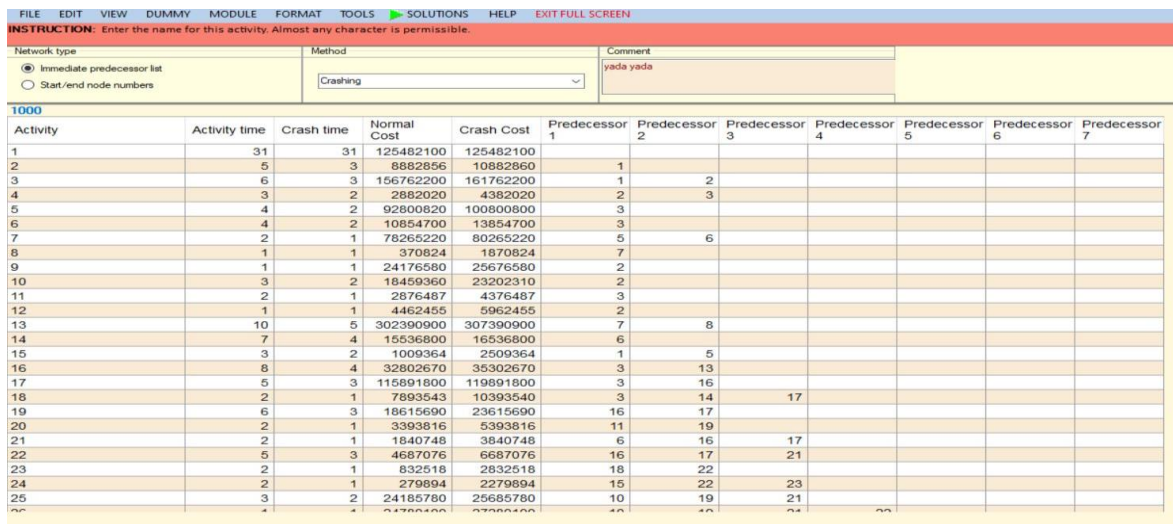
$$\text{Crash Duration} = \frac{\text{Volume}}{\text{Crashing Productivities}} = \frac{655,373 \text{ m}^2}{218,458 \text{ m}^2/\text{day}} = 3 \text{ days}$$

Crash Cost = (Normal wage x total manpower x crash duration) + fee by adding manpower x material cost (IDR.102.323.650,00 x 10 man x 3 day) + (IDR.500.000,00 x 5 man) + Rp. 54.438.531,00,00 = Rp. 161.762.181,00/day

So that it can be summarized :

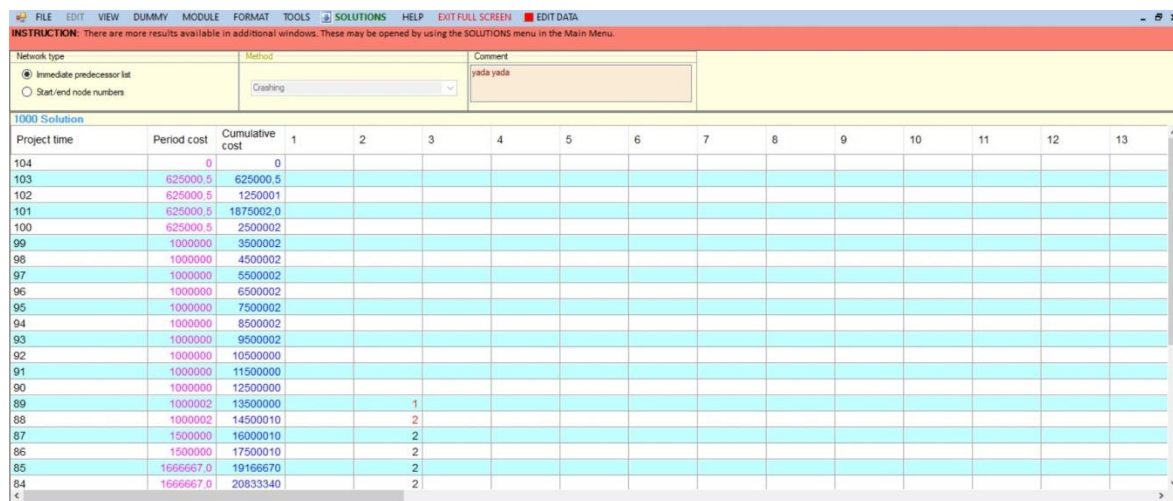
- Normal Cost = IDR. 156.762.181,00
- Crashing Cost = IDR. 161.762.181,00
- Normal Duration = 6 Days
- Crashing Duration = 3 Days

After calculating the duration and cost, the next step is to determine which activities will be accelerated along with the time and costs using the Quantitative Method For Windows Application. This application helps make it easier to analyze automatically by inputting the normal duration, crash duration, normal cost and crash cost of each activity into the Application. Normal duration and normal cost data are obtained directly from the project, so no more calculations are made to determine these costs. Output data from this analysis by using QM For Windows is total crash cost, crash duration and cost slope.



Activity	Activity time	Crash time	Normal Cost	Crash Cost	Predecessor 1	Predecessor 2	Predecessor 3	Predecessor 4	Predecessor 5	Predecessor 6	Predecessor 7
1	31	31	125482100	125482100							
2	5	3	8882856	10882856	1						
3	6	3	156762200	161762200	1	2					
4	3	2	2882020	4382020	2	3					
5	4	2	92800820	100800820	3						
6	4	2	10854700	13854700	3						
7	2	1	78265220	80265220	5	6					
8	1	1	370824	1870824	7						
9	1	1	24176580	25676580	2						
10	3	2	18459360	23202310	2						
11	2	1	2876487	4376487	3						
12	1	1	4462455	5962455	2						
13	10	5	302390900	307390900	7	8					
14	7	4	15536800	16536800	6						
15	3	2	1009364	2509364	1	5					
16	8	4	32802670	35302670	3	13					
17	5	3	115891800	119891800	3	16					
18	2	1	7893543	10393543	3	14	17				
19	6	3	18615690	23615690	16	17					
20	2	1	3393816	5393816	11	19					
21	2	1	1840748	3840748	6	16	17				
22	5	3	4687076	6687076	16	17	21				
23	2	1	832518	2832518	18	22					
24	2	1	279894	2279894	15	22	23				
25	3	2	24185780	25685780	10	19	21				
26	4	4	24786400	27286400	40	40	24	25			

Figure 1. Input data QM For Windows



Project time	Period cost	Cumulative cost	1	2	3	4	5	6	7	8	9	10	11	12	13
104	0	0													
103	625000.5	625000.5													
102	625000.5	1250001													
101	625000.5	1875002.0													
100	625000.5	2500002													
99	1000000	3500002													
98	1000000	4500002													
97	1000000	5500002													
96	1000000	6500002													
95	1000000	7500002													
94	1000000	8500002													
93	1000000	9500002													
92	1000000	10500000													
91	1000000	11500000													
90	1000000	12500000													
89	1000002	13500000			1										
88	1000002	14500010			2										
87	1500000	16000010			2										
86	1500000	17500010			2										
85	1666667.0	19166670			2										
84	1666667.0	20833340			2										

Figure 2. Output data QM For Windows

## 2.5. Indirect Cost

A reduction in the duration of the project will result in an increase in direct costs, but the indirect costs of the project will be reduced. In this project, indirect costs consist of fixed costs and variable costs. Where the costs included in the fixed cost consist of the cost of temporary project facilities, the cost of risk of damage and others. Meanwhile, the costs included in the variable cost are office overhead costs and field overhead costs. Office overhead costs are all costs for planning and executing personnel consisting of project heads, site managers, civilians, architects, engineering staff, project administration staff, security staff, and others. Meanwhile, costs for field overhead consist of reporting costs to directors, cleaning costs for equipment maintenance, field meeting costs, and others. (Andi Maddepungeng, 2015)

## 3.Result

After obtaining all the required time and cost compression data from the QM For Windows program, the next step is to calculate the optimum time and cost of the crashing. To find out more about the results of crashing, one of the ways is to create a table with the following formula.

$$\text{Total Cost} = \text{Direct Cost} + \text{Indirect Crash Cost}$$

Table 2. Total Cost

Duration (day)	Direct Cost (IDR)	Indirect Cost (IDR)	Total Cost (IDR)
104	9.919.982.348	604.026.127	10.524.008.475
100	9.922.482.350	580.794.353	10.503.276.703
95	9.927.482.350	551.754.636	10.479.236.985
90	9.929.482.354	522.714.918	10.452.197.272
88	9.931.482.358	511.099.031	10.442.581.389
87	9.932.982.358	505.291.087	10.438.273.445
86	9.934.482.358	499.483.144	10.433.965.501
85	9.936.149.025	493.675.200	10.429.824.225
83	9.941.149.026	482.059.313	10.423.208.339
80	9.946.149.027	464.635.483	10.410.784.509
79	9.948.149.027	458.827.539	10.406.976.566
77	9.952.149.027	447.211.652	10.399.360.679
76	9.954.149.027	441.403.708	10.395.552.735
75	9.959.579.335	435.595.765	10.395.175.100
73	9.970.579.319	423.979.878	10.394.559.197
72	9.976.079.311	418.171.934	10.394.251.245
71	9.982.079.311	412.363.991	10.394.443.301

The charts between project completion time and total project cost is used to compare the alternative additional costs for the benefits. In general, this line can be considered as a straight line. If we know the shape of the time curve of an activity, meaning by knowing some o slopes or slope angles, it can be calculated how much it will cost to shorten the time and cost of one day

The result from the calculation by using Time Cost Trade Off Method.

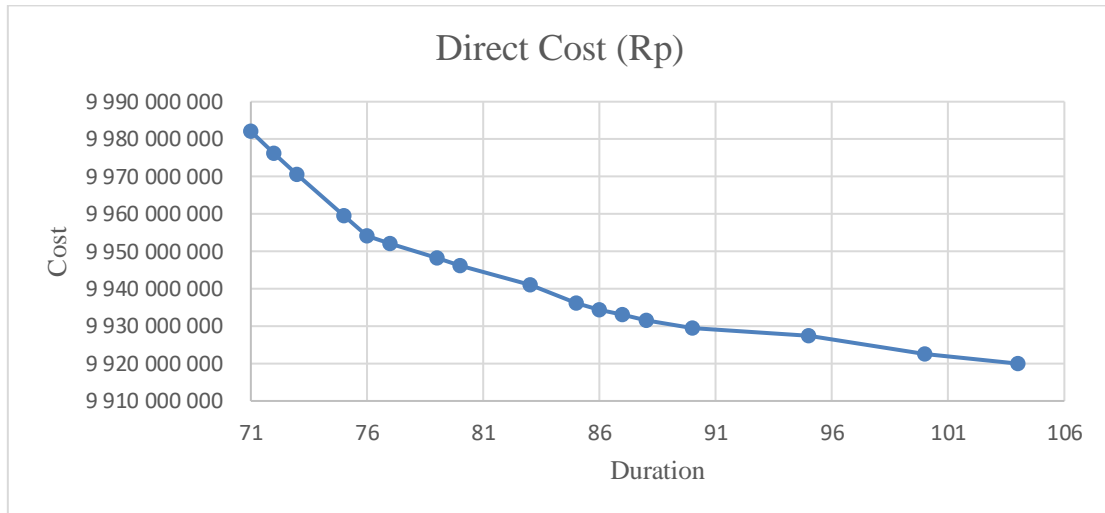


Figure 3. Direct Cost Curve

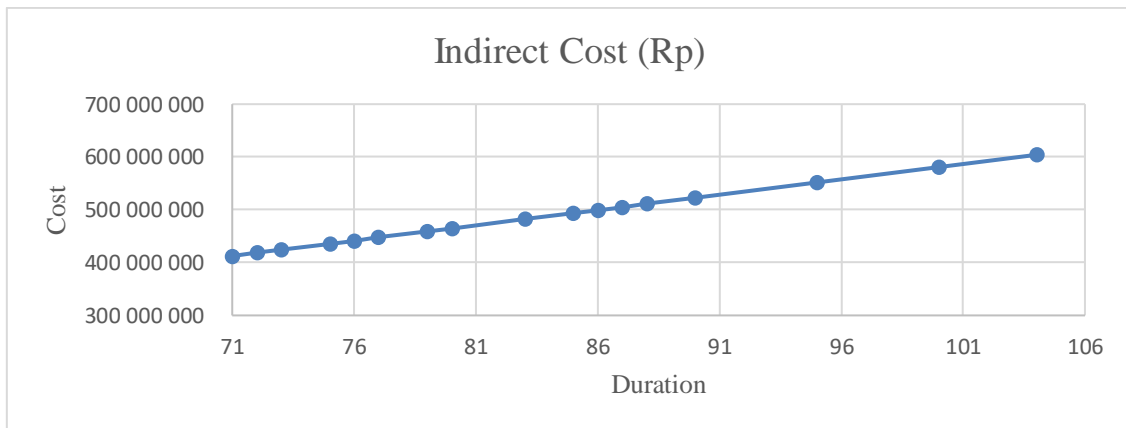


Figure 4. Indirect Cost Curve

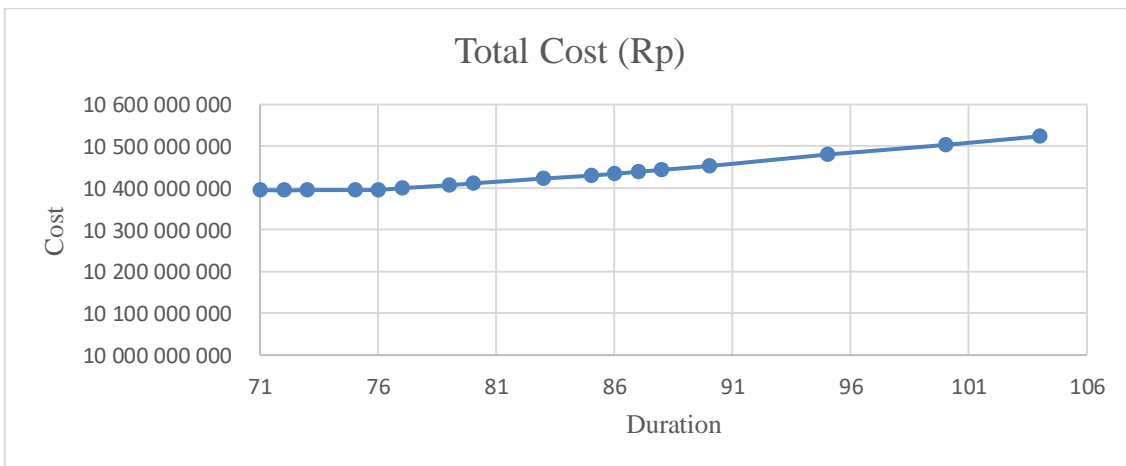


Figure 5. Total Cost Curve

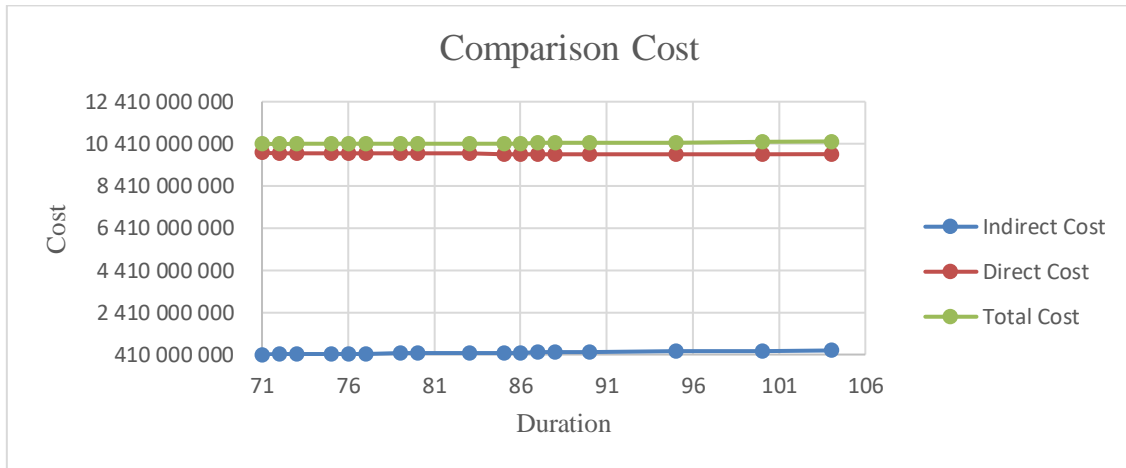


Figure 6. Comparison Cost Curve

### 3.1. Duration

Based on the table 7. Total Cost the optimum time is taken by the optimum cost which is the duration which have minimum cost at 72 days. The total normal duration of the Continuation work of the ITS Tower 1 (First) Building is 180 days and the duration after acceleration is 148 days. Then the total acceleration duration of the Continuation work of the ITS Tower 1 (One) Building is 32 days. (Andi Maddepungeng, 2015)

### 3.2. Cost

Based on the table 7. Total Cost the normal cost of the Continuation work of the ITS Tower Building 1 (First) is Rp. 9,919,982,348.00 and the cost after acceleration is Rp. 10,394,251,245.00. Then it can be determined for the total acceleration price of the Continuation work of the ITS Tower Building 1 (First) is Rp. 474,268,897.00.(Andi Maddepungeng, 2015)

## 4. Conclusions

Based on the analysis of the calculations that have been carried out in the discussion, then the things that can be concluded from this final project include :

The work that will be carried out is accelerated by applying the Time Cost Trade Off method, namely architectural work. Critical works on this research are :

Table 3. conclusion

Code	Activities
1	Preparation
2	Coloumn
3	Brick wall
5	Brickwall layering + finishing
13	Homogeneous Tile 60x60cm (HT1)
16	Gypsumboard 9mm (PG) + Hollow Galvalume frame
17	Acoustic Gypsum Tyle 600x1200 (PG1) + Acoustic Cross Tee Main Tee frame
19	Interior Painting
25	Clear Glass 12mm (KC1)
27	Clear Glass for partition
28	Doors and windows
39	Main stairs Railling
40	Void Railling
45	Floor Drain TX 1 AV1N + Closet, TOTO Type CW 421 J + Urinal Body, TOTO Type UW 447 JT1M
46	Shower Spray, TOTO Type TX 423 SMCRB

From the results of the rescheduling of the Continuation Work for the Construction of the ITS Tower 1 (One) Building with the Time Cost Trade Off (TCTO) method, it was found that the completion time due to acceleration was 148 days from the duration of completion of 180 days, so 32 days of acceleration was needed so that the project could be completed according to the planned target.

The total cost due to acceleration is Rp. 10,394,251,245.00 from the previous cost of Rp. 9,919,982,348.00, there is an additional cost of Rp. 474,268,897.00

## 5. Suggestions

1. In the Continuation Work of the ITS Tower 1 (One) Building, the progress of the work is delayed by 17%, it is necessary to accelerate the time so that the completion time of the work can be completed as planned, namely on March 2, 2021
2. By analyzing the acceleration of work using the time cost trade off method, it can produce the optimum acceleration time and cost of a job.

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