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Analysis Of Scheduling Acceleration Of Worship Building Construction In Dili Timor-Leste Using Time Cost Trade Off (TCTO) Method

Jaime Ximenes Soares Maia, Lalu Mulyadi, Edi Hargono Dwi Putanto

Abstract: Planning is the most significant part to achieve success of construction project. The planning itself towards construction project has an impact on revenue in the project itself. Frequently, a project must be completed sooner than its normal time. In this case, the project leader is expected to issue how to accelerate the completion of the project with a minimum cost. The objectives that are expected to achieve from this research are: 1) analyzing the normal time scheduling?, 2) analyzing the scheduling acceleration of the development 3) analyzing changes in the cost increase in development. From the acceleration with time cost trade off (TCTO) method on a worship building project in Dili Timor-Leste, it is optimum to be able to reduce the time duration by adding resources/working groups, and having project cost increase. In the worship building construction project in Dili Timor-Leste, the initial duration of the project is 223 days and it is changed to 181 days, so that there are 34 days of difference from the normal schedule of the project. Where under normal schedule condition, the normal cost obtained is $377.552.868, thus after doing acceleration analysis with time cost trade off (TCTO) method on the project, there is an additional direct cost in the project of $1.123,08 so that the total project cost is $ 378.675,95.

Index Terms: acceleration, building, time cost trade

1. INTRODUCTION

The Government of the Democratic Republic of Timor-Leste has established a development plan in Timor-Leste, especially in Dili district as the capital city of the country which has the well-known name as an education city, so that many universities in this city are often found. Because it has many universities, so the city of Dili becomes one of the main destinations for those who are willing to study in college. The number of inhabitants which is increasing every year must be balanced with the growth or improvement of facilities to meet the needs of the increasing population, [1]. Public facilities, such as roads, houses for shelter, houses of worship and so forth, need to be considered in order to achieve the stability of a city in terms of service to the community, [2]. One of the public facilities that is not less important to support the growth of the population in the city is a place of worship, [3]. The existence of a worship place is very important. Especially in Dili with many people from inside and outside of the city with diverse religions, this city must be able to meet the needs of the population will be place of worship. With the better facilities of worship, then the needs of the community of worship place can be fulfilled. Timor-Leste Christian Church (GKTL) of Dili district is one of the institutions that sees the needs.

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The need for places of worship from the people of Dili is highly on demand, so that the services provided can be maximized. This is the Timor-Leste Christian Church (GKTL) foundation of Dili in undertaking the construction of additional facilities to meet the needs of the people of Dili in worshipping. The construction of a church building is generally same as that of a typical building [1,4]. Stages of work and methods of implementation are generally same as the usual project work. In terms of construction management, it is also the same, so the problems of scheduling, methods of implementation, estimation of cost, manpower or human resources have become mandatory in the construction [5]. Problems or constraints in the project are caused by the delay in the delivery of roofing materials such as steel, and also the shortage of manpower and experts, so that the delay occurs in the implementation. In Timor Leste, many people work not in line with their areas of expertise. The problems in the construction project of Christian church building in Dili Timor-Leste is caused by the delay in the delivery of materials sent from Surabaya. Therefore, it becomes a factor of delay. The author will conduct an analysis of the acceleration of the project completion by comparing the addition of working hours and the addition of labors as well as experts. The method used is the method of time and cost exchange (time cost trade off) and software that will be used is Microsoft Project. The purpose of this method is to accelerate the time of project implementation and to analyze the effect of time that can be shortened by the addition of cost to the activities that can be accelerated in the implementation period, [6]. Furthermore, the objectives that are willing to be achieved from this research are: 1) analyzing the normal time scheduling, 2) analyzing the scheduling acceleration of the project, and 3) analyzing changes in the cost increase in the project.

2. RESEARCH METHOD

This research uses quantitative method to analyze Time Cost Trade Off (TCTO). The analysis plan of the implementation at normal time is this analysis is conducted to determine the project time and normal cost as well as logical relationship between activities according to the plan schedule made by the contractor and the time acceleration is not done yet, [7]. Time and cost analysis with time acceleration is conducted by the

application of Time Cost Trade Off method, with the following provisions: 1) to accelerate the implementation time of Development Planning Agency at Sub-National Level (BAPPEDA) building of West Sumba, 2) to obtain the acceleration of project time, and 3) to obtain the cost of acceleration of project time. The optimal time and cost analysis of the project is done after the acceleration of time, the time acceleration of project implementation at the possible lowest cost is obtained, [8]. The steps of Data Analysis conducted in this study include: 1) identifying the remaining activity implementation plan, 2) identifying the remaining activity costs under the contract, 3) informing each working group, 4) making a normal scheduling of the remaining scheduling and identifying critical path, 5) analyzing cost slope for all activities, 6) compressing (accelerating) on a critical path that has the lowest cost slope value, 7) rearranging scheduling and new critical path time, 8) creating project duration with target time in the project, 9) re-analyzing step 5 and 8 to reach the target duration, 10) calculating the total cost = direct cost and indirect cost, 11) calculating the additional cost.

2 Result and Discussion

3.1 Project Scheduling Plan

3.1.1. Identification of Project Description

Activity details depend on the ability of a planner to reduce the variety of activities of a project that will be implemented. Details of this activity are presented in the description of the project activities in which the more detail arranged shows the more accurate an activity identified.

Table 1. Project Activity Description

NO.	WORK DESCRIPTION	UNIT	VOLUME
I	PREPARATORY WORK		
1	Location Cleaning	m^2	652
2	Project Name Board	PIECE	1,00
3	Temporary Fence	m	85,00
4	Bouwplank Installation	m	106,00
5	1 M² Manufacture of cement warehouses and tools	m^2	18,00
6	Clean Water Availability	LS	1,00
II	LAND WORK		
1	Soil excavation	m^3	285
2	Sand Fill	m^3	101
3	Sand Backfill	m^3	12
4	Soil Compaction	m^3	378
III	FOOTING		
1	Skewers	m^3	21
2	Broken Stone Footing	m^3	62
IV	WALL WORK		
1	Brick Installation (1pc: 4ps)	m^2	683
2	Brick Installation (1pc: 2ps)	m^2	119
3	Glass Block Installation	m^2	8
4	Plastering (1pc: 4ps)	m^2	1641
5	Plastering (1pc: 2ps)	m^2	238
6.	Rendering	m^2	2358
V	CONCRETE AND STRUCTURE WORK		
1	Story Work	m^3	59
2	Footing Cast (150x150x40) - F'c 30 Mpa	m^3	24
3	Footing Cast (120x120x40) - F'c 30 Mpa	m^3	3,5
4	Middle Plate Footing Cast -f'c 30 Mpa	m^3	0,72
5	Column Cast 40x 40 cm (c-1) - f'c 30 MPa	m^3	26
6	Column Cast 30x30 Cm (C-2) -F'c 30Mpa	m^3	8,5
7	Circle Column Cast with Diameter 40 Cm (C-3) -F'c30 Mpa	m^3	6,57
8	Lintel Cast 10x10 Cm - F'c 30 Mpa	m^3	2,46
9	Lintel Cast 10x20 Cm - F'c 30 Mpa	m^3	0,35
10	Beam Cast 30x40 Cm GB-1) - F'c 25 Mpa	m^3	24,45
11	Beam Cast 15x 40 Cm (GB-2) - Fc 25 Mpa	m^3	0,88
12	Beam Cast 30x40 Cm (B-1) - F'c 30 Mpa	m^3	22,1
13	Beam Cast 20/30 Cm (B-2) F'c 30 Mpa	m^3	3,65
14	Beam Cast 20/30 Cm (B-3) F'c 30 Mpa	m^3	1,18
15	Plate and Beam Cast 83/30 Cm (SB) - F'c 30 Mpa	m^3	6,15
16	Upper Beam Cast 30/40 Cm (TB-1) -F'c 30 Mpa	m^3	13,02
17	Upper Beam Cast 25/35 Cm (TB-2) -F'c 30 Mpa	m^3	8,02
18	Upper Beam Cast 25/35 Cm (TB-3) -F'c 25 Mpa	m^3	0,21
19	Secondary Beam 10/20 Cm (PB) -F'c 30 Mpa	m^3	1,63
20	Story Plate Cast Height = 12 -F'c 30 Mpa	m^3	28,78
21	Upper Plate Cast Height = 12 - F'c 30Mpa	m^3	19,28
22	Middle Plate Cast Height = 15 Cm -F'c 30 MPa	m^3	7,12

23	Fascia Board Cast -F'c Mpa	m^3	13,92
VI	FLOORING		
1	Granite Story Installation (60x60cm)	m^2	590
2	Ceramic Story Installation (60x60 Cm)	m^2	156
4	Ceramic Installation (60x60 Cm)	m^2	16,92
5	Wall Ceramic Installation (20x25 Cm)	m^2	15,81
6	Granite Skirting Installation 10x60 Cm	m	221
7	Granite Skirting Installation 10x60 Cm	m	108
8	Stone Outboard Installation	m	36
VII	ROOFING		
1	Work of Main Building Roofing and Its Completeness Wr 250.175.8.12	kg	6400
2	Building Roofing Construction RHS 100.50.	kg	928
3	Girder Installation C150.75.5,5.10	kg	13188
4	Girder Installation C 100.50.20.4	kg	580
5	Strain Installation Ø 12 Mm	kg	95
6	Wind Bracing Installation Ø16 Mm	kg	373
7	Wire mesh Installation	m^2	606
8	Aluminum Foil Working	m^2	606
9	Anti-Corrosion from Aluminum Roof Installation 0.42 Mm	m^2	641
10	Ridge Roof from Aluminum Installation 0.42 Mm	m	41,25
11	Fascia Board Installing, Calsiplank 1x30 cm	m	26,59
VIII	CEILING		
1	Ceiling Board of Gypsum	m	433
2	Gypsum Ceiling Work And Wood Frame	m^2	956
3	Calsiboard Ceiling and Wood Frame	m^2	175
IX	INSTALLATION OF DOORS AND WINDOWS		
1	Making and Installation of Door Type D1	unit	2,00
2	Making and Installation of Door Type D2	unit	1,00
3	Making and Installation of Door Type D3	unit	1,00
4	Making and Installation of Door Type D4	unit	4,00
5	Making and Installation of Door Type D5	unit	5,00
6	Making and Installation of Window Type W1	unit	9,00
7	Making and Installation of Window Type W2	unit	10,00
8	Making and Installation of Window Type W3	unit	1,00
9	Making And Installation of Door and Window Type DW1	unit	1,00
10	Ventilation Work Type V1	unit	1,00
11	Ventilation Work Type V2	unit	10,00
X	PAINTING		
1	Anti-Corrosion Painting	m^2	497
2	Steel Painting	m^2	497
3	Melamine Painting	m^2	139
4	Wall Painting	m^2	2358
5	Ceiling Painting	m^2	1196
6	Waterproofing Painting	m^2	171
XI	PIPING		
1	Galvanized Pipe Installation	m	56,00
2	Pvc Pipe Installation	m	54,00
3	Pvc Pipe Installation	m	42,00
4	I Pvc Pipe Installation	m	28,00
5	Water Faucet Installation	pcs	5,00
6	Washbasin Water Faucet Installation	pcs	3,00
7	Hand-washing Faucet Installation	unit	5,00
8	Mirror Installation in Washbasin	unit	3,00
9	Floor Drain Installation	unit	5,00
10	Washbasin Installation	unit	3,00
11	Sitting Closet Installation	unit	5,00
12	Tissue Place Installation	unit	5,00
13	Soap Place Installation	unit	1,00
14	Reinforced Concrete Septic Tank and Infiltration Well	unit	1,00
15	Water Pump	unit	1,00
16	Stainless Steel Tank with 1600 Liters Capacity	unit	2,00
XII	ELECTRICITY WORK		
1	NYM Cable Point 3 x 2.5 mm2 Installation	point	68,00
2	Electrical Current Outlet and NYM Cable 3 x 2.5 mm2 Installation	point	21,00
3	Electrical Current Outlet for Ac NYY 3x4 mm2 Installation	point	5,00
4	Single Switch Installation	pcs	9,00
5	Multiple Switch Installation	pcs	11,00
6	Ex-Philips Light Point Installation	pcs	16,00
7	AC Installation	pcs	5,00
8	Mercury Lamp Installation	Unit	2,00

9	Neon Lamp Installation	Unit	30,00
10	Down Light Lamp Installation	Unit	2,00
11	Down Light Lamp Installation	Unit	26,00
12	Down Light Lamp Installation	Unit	6,00
13	Down Light Lamp Installation	Unit	9,00
14	Spotlight Installation	Unit	2,00
15	Fan Installation	Unit	3,00
16	Fan Installation	Unit	3,00
17	Ac 2Pk Installation	Unit	5,00
18	Exhaust Fan Installation	Unit	3,00
19	MCB Installation	Set	1,00
20	ARDE Installation	Pcs	1,00
21	Panel Board Installation	Unit	1,00
22	Electric Meters Installation	Unit	1,00

Source: Project Data of 2016

3.1.2 Project Cost Identification under the Contract

Table 2. Recapitulation of Christian Church Project Construction Budget in Dili Timor-Leste

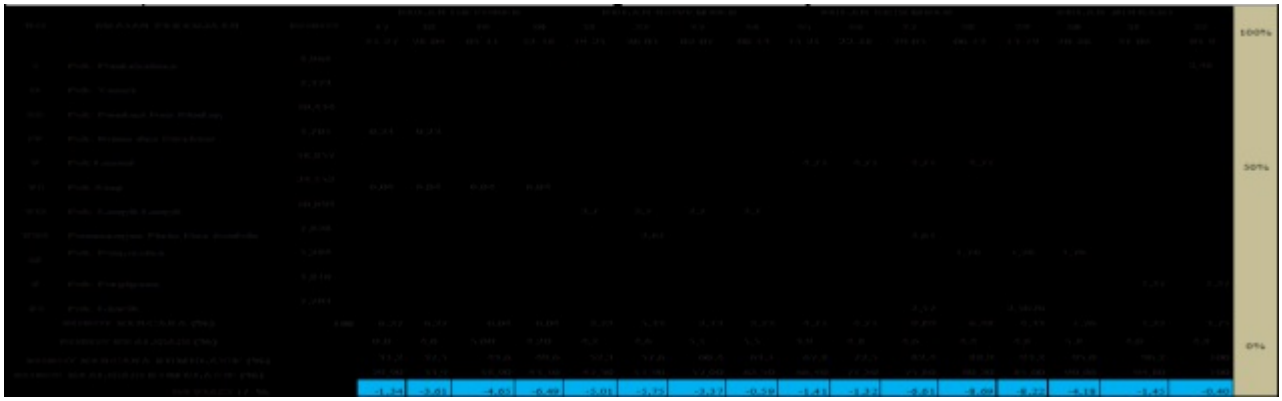
No.	Work Description	Cost Total
1	Preparatory Work	$ 6.809,88
2	Land Work	$ 4.719,2
3	Footing	$ 5.558,4
4	Wall	$ 25.081,9
5	Concrete and Structural Work	$ 123.428
6	Flooring	$ 54.621,5
7	Roofing	$ 63.860,08
8	Ceiling	$ 13.709,9
9	Installation of Doors and Windows	$ 23.878,5
10	Painting	$ 24.973,9
11	Piping	$ 11.708,1
12	Electricity Work	$ 19.097,6
GREAT AMOUNT OF COST		$ 377.552,868

The plan and realization of the work are done by using Bar Chart method on the Christian Worshipping Building Project in Dili with the budget year of 2016. It is completed by MAIDALO I CONSULTANT, LDA dated on June 1, 2016 with contract value of IDR $ 377.552,868

3.1.3. Identification of Existing Condition Project Scheduling

Based on the data and the progress report obtained show that the implementation of the construction of the Worship Building in Dili Timor Leste, up to the 17th week of the 5th month, the new implementation progress reaches 1,34% of the plan of 31,24%, and it has deviation increase in the 18th week of the 5th month, progress of new implementation reaches 33,9% from plan that is 37,5 and it has deviation decrease from the 15th week of the 5th month to the additional time for completion of project implementation provided by the government.

Table 3. Time Schedule



3.2 Analyzing Scheduling Implementation of Activity at Normal Time

3.2.1 Equalizing Work Volume

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0. 15 = $ 2,40/ $ 16,00
960 = 6400 m3 x 0.15
3991 = 960 + 139,2 + 1978 + 87 + 28 +14+ 56 + 83 + 148 + 461 +38+27

Table 4. Work Volume Equalization

NO.	WORK DESCRIPTION	UNIT	Volume	Unit Price	Equivalent Volume
1	2	3	4	5	c
I	PREPARATORY WORK				
1	Location Cleaning	m^2	652	1,10	67
2	Project Name Board	piece	1,00	2,17	
3	Temporary Fence	m	85,00	38,33	
4	Bouwplank Installation	m	106,00	7,27	
5	1 M² Manufacture of cement warehouses and tools.	m^2	18,00	102,40	
6	Clean Water Availability	ls	1,00	218,20	
II	LAND WORK				
1	Soil excavation	m^3	285	5,380	241
2	Sand Fill	m^3	101	19,60	
3	Sand Backfill	m^3	12	2,000	
4	Soil Compaction	m^3	378	3,100	
III	FOOTING				
1	Skewers	m^3	21	35,33	72
2	Broken Stone Footing	m^3	62	79,08	
IV	WALL WORK				
1	Brick Installation (1pc: 4ps)	m^2	683	12,00	250
2	Brick Installation (1pc: 2ps)	m^2	119	12,40	
3	Glass Block Installation	m^2	8	100,50	
4	Plastering (1pc: 4ps)	m^2	1641	6,82	
5	Plastering (1pc: 2ps)	m^2	238	6,43	
6	Rendering	m^2	2358	0,78	
V	CONCRETE AND STRUCTURE WORK				
1	Story Work	m^3	59	110,90	67
2	Footing Cast (150x150x40) - F'c 30 Mpa	m^3	24	224,00	
3	Footing Cast (120x120x40) - F'c 30 Mpa	m^3	3,5	315,00	
4	Middle Plate Footing Cast -f'c 30 Mpa	m^3	0,72	358,00	
5	Column Cast 40x 40 cm (c-1) - f'c 30 MPa	m^3	26	448,80	
6	Column Cast 30x30 Cm (C-2) -F'c 30Mpa	m^3	8,5	1.084,56	
7	Circle Column Cast with Diameter 40 Cm (C-3) -F'c30 Mpa	m^3	6,57	434,00	
8	Lintel Cast 10x10 Cm - F'c 30 Mpa	m^3	2,46	1.024,30	
9	Lintel Cast 10x20 Cm - F'c 30 Mpa	m^3	0,35	1.088,62	
10	Beam Cast 30x40 Cm GB-1) - F'c 25 Mpa	m^3	24,45	274,98	
11	Beam Cast 15x 40 Cm (GB-2) - Fc 25 Mpa	m^3	0,88	$ 486,88	
12	Beam Cast 30x40 Cm (B-1) - F'c 30 Mpa	m^3	22,1	486,89	

NO.	WORK DESCRIPTION	UNIT	Volume	Unit Price	Equivalent Volume
13	Beam Cast 20/30 Cm (B-2) F'c 30 Mpa	m^3	3,65	998,86	
14	Beam Cast 20/30 Cm (B-3) F'c 30 Mpa	m^3	1,18	879,89	
15	Plate and Beam Cast 83/30 Cm (SB) - F'c 30 Mpa	m^3	6,15	345,80	
16	Upper Beam Cast 30/40 Cm (TB-1) -F'c 30 Mpa	m^3	13,02	456,89	
17	Upper Beam Cast 25/35 Cm (TB-2) -F'c 30 Mpa	m^3	8,02	1.832,44	
18	Upper Beam Cast 25/35 Cm (TB-3) -F'c 25 Mpa	m^3	0,21	924,48	
19	Secondary Beam 10/20 Cm (PB) -F'c 30 Mpa	m^3	1,63	1.498,21	
20	Story Plate Cast Height = 12 -F'c 30 Mpa	m^3	28,78	540,86	
21	Upper Plate Cast Height = 12 - F'c 30Mpa	m^3	19,28	632,20	
22	Middle Plate Cast Height = 15 Cm -F'c 30 MPa	m^3	7,12	768,48	
23	Fascia Board Cast -F'c Mpa	m^3	13,92	149,44	
	TOTAL CONCRETE WORK				
VI	FLOORING				
1	Granite Story Installation (60x60cm)	m^2	590	78,90	692
2	Ceramic Story Installation (60x60 Cm)	m^2	156	24,57	
3	Ceramic Installation (60x60 Cm)	m^2	16,92	33,28	
4	Wall Ceramic Installation (20x25 Cm)	m^2	15,81	25,31	
5	Granite Skirting Installation 10x60 Cm	m	221	6,97	
6	Granite Skirting Installation 10x60 Cm	m	108	6,53	
7	Stone Outboard Installation	m	36	28,56	
VII	ROOFING				
1	Work of Main Building Roofing and Its Completeness Wr 250.175.8.12	kg	6400	2,40	3991
2	Building Roofing Construction RHS 100.50.	kg	928	2,40	
3	Girder Installation C150.75.5,5.10	kg	13188	2,40	
4	Girder Installation C 100.50.20.4	kg	580	2,40	
5	Strain Installation Ø 12 Mm	kg	95	2,40	
6.	Wind Bracing Installation Ø16 Mm	kg	373	2,40	
7.	Wire mesh Installation	m^2	606	2,20	
8	Aluminum Foil Working	m^2	606	3,90	
9	Anti-Corrosion from Aluminum Roof Installation 0.42 Mm	m^2	641	11,50	
10	Ridge Roof from Aluminum Installation 0.42 Mm	m	41,25	14,85	
11	Fascia Board Installing, Calsiplank 1x30 cm	m	26,59	16,00	
VIII	CEILING				
1	Ceiling Board of Gypsum	m	433	2,64	754
2	Gypsum Ceiling Work And Wood Frame	m^2	956	9,81	
3	Calsiboard Ceiling and Wood Frame	m^2	175	18,19	
IX	INSTALLATION OF DOORS AND WINDOWS				
1	Making and Installation of Door Type D1	unit	2,00	1.224,09	20
2	Making and Installation of Door Type D2	unit	1,00	1.098,70	
3	Making and Installation of Door Type D3	unit	1,00	643,00	
4	Making and Installation of Door Type D4	unit	4,00	755,32	
5	Making and Installation of Door Type D5	unit	5,00	479,58	
6	Making and Installation of Window Type W1	unit	9,00	657,98	
7	Making and Installation of Window Type W2	unit	10,00	439,87	

NO.	WORK DESCRIPTION	UNIT	Volume	Unit Price	Equivalent Volume
8	Making and Installation of Window Type W3	unit	1,00	480,08	
9	Making And Installation of Door and Window Type DW1	unit	1,00	990,08	
10	Ventilation Work Type V1	unit	1,00	223,89	
11	Ventilation Work Type V2	unit	10,00	225,49	
X	PAINTING				
1	Anti-Corrosion Painting	m^2	497	2,43	2317
2	Steel Painting	m^2	497	5,67	
3	Melamine Painting	m^2	139	10,78	
4	Wall Painting	m^2	2358	5,27	
5	Ceiling Painting	m^2	1196	5,27	
6	Waterproofing Painting	m^2	171	4,20	
XI	PIPING				
1	Galvanized Pipe Installation	m	56,00	8,35	548
2	Pvc Pipe Installation	m	54,00	6,89	
3	Pvc Pipe Installation	m	42,00	10,93	
4	I Pvc Pipe Installation	m	28,00	21,38	
5	Water Faucet Installation	pcs	5,00	24,67	
6	Washbasin Water Faucet Installation	pcs	3,00	24,56	
7	Hand-washing Faucet Installation	unit	5,00	40,98	
8	Mirror Installation in Washbasin	unit	3,00	46,25	
9	Floor Drain Installation	unit	5,00	18,95	
10	Washbasin Installation	unit	3,00	218,98	
11	Sitting Closet Installation	unit	5,00	542,98	
12	Tissue Place Installation	unit	5,00	28,98	
13	Soap Place Installation	unit	1,00	42,78	
14	Reinforced Concrete Septic Tank and Infiltration Well	unit	1,00	2.176,98	
15	Water Pump	unit	1,00	2.276,98	
16	Stainless Steel Tank with 1600 Liters Capacity	unit	2,00	580,90	
XII	ELECTRICITY WORK				
1	NYM Cable Point 3 x 2.5 mm2 Installation	point	68,00	80,90	16
2	Electrical Current Outlet and NYM Cable 3 x 2.5 mm2 Installation	point	21,00	52,50	
3	Electrical Current Outlet for Ac NYY 3x4 mm2 Installation	point	5,00	80,40	
4	Single Switch Installation	pcs	9,00	10,86	
5	Multiple Switch Installation	pcs	11,00	14,86	
6	Ex-Philips Light Point Installation	pcs	16,00	8,88	
7	AC Installation	pcs	5,00	8,88	
8	Mercury Lamp Installation	unit	2,00	84,60	
9	Neon Lamp Installation	unit	30,00	48,95	
10	Down Light Lamp Installation	unit	2,00	34,80	
11	Down Light Lamp Installation	unit	26,00	24,65	
12	Down Light Lamp Installation	unit	6,00	21,75	
13	Down Light Lamp Installation	unit	9,00	18,50	
14	Spotlight Installation	unit	2,00	88,00	
15	Fan Installation	unit	3,00	448,00	

NO.	WORK DESCRIPTION	UNIT	Volume	Unit Price	Equivalent Volume
16	Fan Installation	unit	3,00	182,00	
17	Ac 2Pk Installation	unit	5,00	650,00	
18	Exhaust Fan Installation	unit	3,00	285,00	
19	MCB Installation	set	1,00	1.200,00	
20	ARDE Installation	pcs	1,00	25,00	
21	Panel Board Installation	unit	1,00	823,00	
22	Electric Meters Installation	unit	1,00	780,00	

Source: Analysis Result of 2017

3.2.2 Calculating Labor Productivity

After equalizing the volume obtained, then each activity/unit/day can be determined. The analysis uses Indonesian National Standard 2013 with working hours calculated 8 hours of work/day. In addition, working hours on the building construction project in Dili Timor-Leste uses 8 hours of work/day. For example, productivity calculation for footing is presented below:

Table 5. Coefficient of Labor Productivity

RESOURCE	COEFFICIENT	
Workers	3.400	OH
Bricklayers	0.850	OH
Head of the Bricklayers	0.085	OH
Foreman	0.170	OH

Therefore, in 1 day (8 working hours based on Indonesian National Standard 2013), productivity per working group can be obtained of:

1 day / 0.850 BRICKLAYER = 1.18 m3, so for,
1 day (8 hours working in field)
= 8/8 x 1.18 = 1.18 m3. It needs (1 Labor),
= 1.18 x 3.400 = 4.02m3. It needs (4 Workers),
= 1.18 x 0.085 = 0.10m3. It needs (0.1 Head of Bricklayer),
= 1.18 x 0.170 = 0.20 m3. It needs (0.2 Foreman),

The above calculation is used to find productivity from other types of work and the productivity calculation result can be seen in the table below.

Table 6. Calculation of Labor Productivity

No.	TYPE OF WORK	EQUIVALENT VOLUME	PRODUCTIVITY OF LABOR BASED ON INDONESIAN NATIONAL STANDARD 2013 ONE/DAY/GROUP	PRODUCT OF 8 WORKING HOURS PER DAY
1	Preparatory work	67	6,25 0,1 Foreman+0,1 Head of Labor+1 Labor+2 Workers	11
2	Land Work	241	3,33 0,1 Foreman+1 Worker	72
3	Footing	69	2,78 0,1 Foreman+0,1 Head of Labor+1 Head of Labor + 2 Workers	25
4	Wall Work	250	4,46 0,1 Foreman + 0,1 Head of Labor+1 Labor+ 3 Workers	56
5	Concrete and Structure Work	67	0,71 0,1 Foreman+ 0,1 Head of Labor+ 1 Labor + 2 Workers	96
6	Flooring	692	11,11 0,1 Foreman+0,1 Foreman 1 Head of Labor + 2 Workers	62
7	Roofing	7815	166,67 0,1 Foreman + 0,1 Head of Labor+1 Labor+10 Workers	24
8	Ceiling	754	24,05 1 Labor +0,5 Foreman +10 Head of Labor+10 Workers	31
9	Door & Window Work	20	6,25 0,1 Foreman+6 Workers	3
10	Painting	1389	23,81 0,1 Foreman+0,1 Head of Labor+1 Labor+2 Workers	58
11	Piping	285	10,00	28

			0,1 Foreman+0,1 Head of Labor +1 Labor+2 Workers	
12	Electricity Work	16	5,00 0,1 Foreman + 0,1 Head of Labor+ 1 Labor+ 4 Workers	3

Source: Analysis Result of 2017

3.2.3. Calculating Duration and Labor Group at Normal Time

To determine the duration of each group of work, it should pay attention on the experience, capability, and availability of human resources used.

Table 7. Calculation of Normal Duration and Labor Group Building of Worship Place in Dili Timor-Leste

Type of work	Labor Group	Productivity	Volume Generated	Volume Equalized	Duration
a	b	c	d	e	f
Preparatory work	1	6,25	6,25	66,50	11
Land Work	2	4,33	8,66	241	28
Footing	2	2,78	2,78	72	`30
Wall work	2	4,46	8,92	250	28
Concrete work	2	0,70	0,70	67	56
Flooring	2	11,00	22,00	692	31
Roofing	2	166,67	333,34	3.991	12
Ceiling	3	10,00	20,00	754	25
Door & Window Works	1	6,25	6,25	20	3
Painting	3	23,81	71,43	1.389	24
Piping	3	10,00	30,00	285	14
Electricity Work	1	5,00	5,00	16	3

Source: Analysis Result of 2017

3.3. Analysis of Scheduling Acceleration Using Time Cost Trade Off

3.3.1 Interdependence Logic of Activities

Arranging the working network in accordance with the sequence of interdependence logic relationship between activities and work between activities with each other must be in line with the method of project completion, so that reasonable technical logic is taken into account in the arrangement.

Table 8. Interdependence Logic of Activities

No.	Work	Code	Preceding	Duration
1	Preparatory work	A	-	11
2	Land Work	B	A	28
3	Footing	C	B	`30
4	Wall work	D	E	28
5	Concrete and Structure Work	E	C	56
6	Flooring	F	H	31
7	Roofing	G	D	12
8	Ceiling	H	G	25
9	Door & Window Works	I	F	3
10	Painting	J	D	24
11	Piping	K	C	14
12	Electricity Work	L	H	3

Source: Analysis Result of 2017

3.3.2. Determining the Critical Path

Determination of critical path using Gantt Chart Microsoft Project scheduling application program, critical paths are obtained which are A-B-C-D-E-H-J

3.3.3. Calculation of Cost Slope and Acceleration of Project Duration

After knowing the critical path in the normal time with a total duration of 223 days and exceeding the scheduling plan of

180 days, then acceleration of the project duration on the Construction of Worship Building in Dili Timor-Leste is done.

Table 9. Calculation of Cost Slope and Normal Duration

No.	CODE OF WORK	PRECEDING WORK	TIME (DAY)		COST		COST
			PRODUCT	NORMAL	PRODUCT	NORMAL	SLOPE
1	A		11	11	$ 22,20	$ 22,20	--
2	B	A	72	19	$ 31,20	$ 62,40	$ 34,17
3	C	B	60	26	$ 22,44	$ 22,44	$ 14,4
4	D	E	56	28	$ 29,28	$ 58,56	$ 30,1
5	E	C	112	56	$ 66,20	$ 66,20	$ 75,6
6	F	H	63	31	$ 16,20	$ 32,40	$ 0,7
7	G	D	24	12	$ 79,00	$ 158,00	$ 142,7
8	H	G	75	25	$ 22,20	$ 66,60	$ 41,2
9	I	F	3	3	$ 39,00	$ 39,00	--
10	J	D	97	24	$ 28,20	$ 84,60	$ 88,2
11	K	C	55	14	$ 40,20	$ 160,80	$ 146,4
12	L	H	3	3	$ 34,20	$ 34,20	
					$ 430,32	$ 785,20	$ 573,4

Source: Analysis Result of 2017

Table 10. Calculation Result of Cost Slope and Duration Acceleration in the First Phase

No.	Code of Work	Preceding Work	Time (Day)		Cost		Cost Slope
			Normal	Crash	Normal	Crash	
1	A		11	11	$ 22,20	$ 22,20	
2	B	A	28	19	$ 62,40	$ 93,60	$ 72,4
3	C	B	30	30	$ 44,88	$ 44,88	
4	D	E	28	28	$ 58,56	$ 58,56	
5	E	C	56	56	$ 132,40	$ 132,40	
6	F	H	31	31	$ 32,40	$ 32,40	
7	G	D	12	12	$ 158,00	$ 158,00	
8	H	G	25	25	$ 66,60	$ 66,60	
9	I	F	3	3	$ 39,00	$ 39,00	
10	J	D	24	24	$ 112,80	$ 112,80	
11	K	C	14	14	$ 160,80	$ 160,80	
12	L	H	3	3	$ 34,20	$ 34,20	
					$ 924,24	$ 933,24	$ 72,4

Source: Analysis Result of 2017

Table 11. Calculation of Duration Acceleration and Working Group in the Second Phase

№	Type of work	Working Group		Product	Volume Generated		Equivalent Volume	Duration	Duration
		Before	After		Before	After			
1	Preparatory work	1	1	6,25	6,25	6,25	67	10,64	11
2	Land Work	2	3	4,33	12,99	12,99	241	18,54	19
3	Footing	2	2	2,78	2,78	5,56	72	12,88	20
4	Wall work	2	2	4,46	8,92	8,92	250	27,98	28
5	Concrete and Structure Work	2	2	0,60	1,20	1,20	67	56,21	56
6	Flooring	2	2	11,00	22,00	22,00	692	31,47	31
7	Roofing	2	2	166,67	333,34	333,34	3991	11,97	12
8	Ceiling	3	3	10,00	30,00	30,00	754	25,12	25
9	Door & Window Works	1	1	6,25	6,25	6,25	20	3,12	3
10	Painting	4	4	23,81	95,24	95,24	2317	24,32	24
11	Piping	4	4	10,00	40,00	40,00	548	13,69	14
12	Electricity Work	1	1	5,00	5,00	5,00	16	3,18	3

Source: Analysis Result of 2017

Table 12. Calculation Result of Cost Slope and Duration Acceleration Duration in the Second Phase

No.	Code of Work	Preceding Work	Time (Day)		Cost		Cost Slope
			Normal	Crash	Normal	Crash	
1	A		11	11	$ 22,20	$ 22,20	
2	B	A	28	19	$ 62,40	$ 93,60	$ 72,4
3	C	B	30	20	$ 44,88	$ 44,88	$ 45,8
4	D	E	28	28	$ 58,56	$ 58,56	
5	E	C	56	56	$ 132,40	$ 132,40	
6	F	H	31	31	$ 32,40	$ 32,40	
7	G	D	12	12	$ 158,00	$ 158,00	
8	H	G	25	25	$ 66,60	$ 66,60	
9	I	F	3	3	$ 39,00	$ 39,00	
10	J	D	24	24	$ 112,80	$ 112,80	
11	K	C	14	14	$ 160,80	$ 160,80	
12	L	H	3	3	$ 34,20	$ 34,20	
13					$ 924,24	$ 955,68	$ 118,2

Source: Analysis Result of 2017

Table 13. Calculation of Duration Acceleration and Labor Group in the Third Phase

№	Type of work	Working Group		Product	Volume Generated		Equivalent Volume	Duration	Duration
		Before	After		Before	After			
A	B		C	D		E	F	G	H
1	Preparatory work	1	1	6,25	6,25	6,25	67	10,64	11
2	Land Work	2	3	4,33	86,99	12,99	241	18,54	19
3	Footing	2	3	1,19	2,38	3,57	72	20,06	20
4	Wall work	2	2	4,46	8,92	8,92	250	27,98	28
5	Concrete and Structure Work	2	3	0,60	1,20	180	67	37,47	37
6	Flooring	2	2	11,00	22,00	22,00	692	31,47	31
7	Roofing	2	2	166,67	333,34	333,34	3991	11,97	12
8	Ceiling	3	3	10,00	30,00	30,00	754	25,12	25
9	Door & Window Work	1	1	6,25	6,25	6,25	20	3,12	3
10	Painting	4	4	23,81	95,24	95,24	2317	24,32	24
11	Piping	4	4	10,00	40,00	40,00	548	13,69	14
12	Electricity Work	1	1	5,00	5,00	5,00	16	3,18	3

Source: Analysis Result of 2017

Table 14. Calculation Result of Cost Slope and Duration Acceleration in the Third Phase

No.	Code of Work	Preceding Work	Time (Day)		Cost		Cost Slope
			Normal	Crash	Normal	Crash	
1	A		11	11	$ 22,20	$ 22,20	
2	B	A	28	19	$ 62,40	$ 93,60	$ 72,4
3	C	B	30	20	$ 44,88	$ 67,32	$ 45,8
4	D	E	28	28	$ 58,56	$ 58,56	
5	E	C	56	37	$ 132,40	$ 198,60	$159,2
6.	F	H	31	31	$ 32,40	$ 32,40	
7.	G	D	12	12	$ 158,00	$ 158,00	
8	H	G	25	25	$ 66,60	$ 66,60	
9	I	F	3	3	$ 39,00	$ 39,00	
10	J	D	24	24	$ 112,80	$ 112,80	
11	K	C	14	14	$ 160,80	$ 160,80	
12	L	H	3	3	$ 34,20	$ 34,20	
					$ 924,24	$ 1.021,88	$ 262,9

Source: Analysis Result of 2017

Table 15. Calculation of Duration Acceleration and Labor Group in the Fourth Phase

№.	Type of work	Working Group		Product	Volume Generated		Equivalent Vol	Duration	Duration
		Before	After		Before	After			
1	Preparatory work	1	1	6,25	6,25	6,25	67	10,64	11
2	Land Work	2	3	4,33	86,99	12,99	241	18,54	19
3	Footing	2	3	1,19	2,38	3,57	72	20,06	20

4	Wall work	2	2	4,46	8,92	8,92	250	27,98	28
5	Concrete and Structure Work	2	3	0,60	1,20	180	67	37,47	37
6	Flooring	2	2	11,00	22,00	22,00	692	31,47	31
7	Roofing	2	3	166,67	333,34	500,01	3991	7,98	8
8	Ceiling	3	3	10,00	30,00	30,00	754	25,12	25
9	Door & Window Work	1	1	6,25	6,25	6,25	20	3,12	3
10	Painting	4	4	23,81	95,24	95,24	2317	24,32	24
11	Piping	4	4	10,00	40,00	40,00	548	13,69	14
12	Electricity Work	1	1	5,00	5,00	5,00	16	3,18	3

Source: Analysis Result of 2017

Table 16. Calculation Result of Cost Slope and Duration Acceleration in the Fourth Phase

No.	Code of Work	Preceding Work	Time (Day)		Cost		Cost Slope
			Normal	Crash	Normal	Crash	
1	A		11	11	$ 22,20	$ 22,20	
2	B	A	28	19	$ 62,40	$ 93,60	$ 72,4
3	C	B	30	20	$ 44,88	$ 67,32	$ 45,8
4	D	E	28	28	$ 58,56	$ 58,56	
5	E	C	56	37	$ 132,40	$ 198,60	159,2
6	F	H	31	31	$ 32,40	$ 32,40	
7	G	D	12	8	$ 158,00	$ 23,00	215,8
8	H	G	25	25	$ 66,60	$ 66,60	
9	I	F	3	3	$ 39,00	$ 39,00	
10	J	D	24	24	$ 112,80	$ 112,80	
11	K	C	14	14	$ 160,80	$ 160,80	
12	L	H	3	3	$ 34,20	$ 34,20	
					$ 924,24	$ 1.100,88	$ 478,8

Source: Analysis Result of 2017

4.3.4. Calculating the Cost of Acceleration Time

From the calculation analysis of the building scheduling time acceleration above, then direct costs and indirect costs are obtained with the steps as follows:

Table 17. Cost Per Day of Labor of Worship Building Project in Dili Timor Leste

No.	Type of work	Unit of Labor Costs		Labor Productivity	Total Cost / day
1	Preparatory work	Foreman	$ 12,00	6,25	$ 22,2
		Head of Labor	$ 10,00		
		Labor	$ 8,00	0,1 Foreman+0,1 Head of Labor + 1 Labor+ 2 Workers	
		Worker	$ 6,00		
2	Land Work	Foreman	12,00	3,33	$ 31,2
		Head of Labor	$ 10,00		
		Labor	$ 8,00	0,1 Foreman + 5 Workers	
		Worker	$ 6,00		
3	Footing	Foreman	$ 12,00	1,19	$ 22,44
		Head of Labor	$ 10,00	0,12 Foreman+0,1 Head of Labor + 1 Labor+ 2 Workers	
		Labor	$ 8,00		
		Worker	$ 6,00		
4	Wall work	Foreman	$ 12,00	4,46	$ 29,28
		Head of Labor	$ 10,00	0,19 Foreman + 0,1 Head of Labor+ 1 Labor + 3 Workers	
		Labor	$ 8,00		
		Worker	$ 6,00		
5	Concrete and Structure Work	Foreman	$ 12,00	0,6	$ 66,2
		Head of Labor	$ 10,00		
		Carpenter	$ 8,00	0,1 Foreman + 0,1 Head of Labor + 1 Carpenter + Bricklayer + Blacksmith 6 Workers	
		Bricklayer	$ 8,00		
		Blacksmith	$ 8,00		
		Worker	$ 6,00		
6	Flooring	Foreman	$ 12,00	11,11	

		Head of Labor	$ 10,00	0,1 Foreman +0,1 Head of Labor + 0,1 Labor + 1 Worker	$ 16,2
		Labor	$ 8,00		
		Worker	$ 6,00		
7	Roofing	Foreman	$ 12,00	166,67	$ 79
		Head of Labor	$ 10,00	0,5 Foreman + 0, 1 Head of Labor + 0,5 Labor+ 10 Workers	
		Labor	$ 8,00		
		Worker	$ 6,00		
8	Ceiling	Foreman	$ 12,00	20,00	$ 22,2
		Head of Labor	$ 10,00	0,1 Foreman + 0,1 Head of Labor+ 1 Labor + 2 Workers	
		Labor	$ 8,00		
		Worker	$ 6,00		
9	Door and Window Work	Foreman	$ 12,00	6,25	
		Head of Labor			
		Labor	$ 8,00	0,25 Foreman + 6 Workers	
		Worker	$ 6,00		
10	Painting	Foreman	$ 12,00	23,81	$ 28,2
		Head of Labor	$ 10,00	0,6 Foreman +01 Head of Labor + 1 Labor + 2 Workers	
		Labor	$ 8,00		
		Worker	$ 6,00		
11	Piping	Foreman	$ 12,00	10,00	$ 40,2
		Head of Labor	$ 10,00	0,1 Foreman + 0,1 Head of Labor + 1 Labor + 5 Workers	
		Labor	$ 8,00		
		Worker	$ 6,00		
12	Electricity Work	Foreman	$ 12,00	5,00	$ 34,2
		Head of Labor	$ 10,00	1 Foreman + 1 Head of Labor + 1 Labor + 4 Workers	
		Labor	$ 8,00		
		Worker	$ 6,00		

Source: Analysis Result of 2017

Table 18: Cost of Labor Group at Normal Time and Acceleration Time in the First Phase

No.	TYPE OF WORK	COST OF LABOR GROUP PER DAY	COST OF LABOR GROUP PER NORMAL DAY OF 233 DAYS		COST OF LABOR GROUP PER CRASH DAY OF 214 DAYS	
			GROUP TOTAL	COST TOTAL	GROUP TOTAL	COST TOTAL
1	Preparatory work	$ 22,20	1	$ 22,20	1	$ 22,20
2	Land Work	$ 31,20	2	$ 62,40	3	$ 93,60
3	Footing	$ 22,44	2	$ 44,88	2	$ 67,32
4	Wall work	$ 29,28	2	$ 58,56	2	$ 58,56
5	Concrete and Structure Work	$ 66,20	2	$ 132,40	2	$ 132,40
6	Flooring	$ 16,20	2	$ 32,40	2	$ 32,40
7	Roofing	$ 79,00	2	$ 158,00	2	$ 237,00
8	Ceiling	$ 22,20	3	$ 66,60	3	$ 66,60
9	Door and Window Work	$ 39,00	1	$ 39,00	1	$ 39,00
10	Painting	$ 28,20	4	$ 84,60	4	$ 112,80
11	Piping	$ 40,20	4	$ 120,60	4	$ 160,80
12	Electricity Work	$ 34,20	1	$ 34,20	1	$ 34,20
				$ 924,24		$ 924,24

Source: Analysis Result of 2017

Table 19. Cost of Labor Group at Normal Time and Acceleration Time in the Second Phase

No.	TYPE OF WORK	COST OF LABOR GROUP PER DAY	COST OF LABOR GROUP PER NORMAL DAY OF 233 DAYS		COST OF LABOR GROUP PER CRASH DAY OF 204 DAYS	
			GROUP TOTAL	COST TOTAL	GROUP TOTAL	COST TOTAL
1	Preparatory work	$ 22,20	1	$ 22,20	1	$ 22,20
2	Land Work	$ 31,20	2	$ 62,40	3	$ 93,60
3	Footing	$ 22,44	2	$ 44,88	3	$ 67,32
4	Wall work	$ 29,28	2	$ 58,56	2	$ 58,56
5	Concrete and Structure Work	$ 66,20	2	$ 132,40	2	$ 132,40
6	Flooring	$ 16,20	2	$ 32,40	2	$ 32,40
7	Roofing	$ 79,00	2	$ 158,00	2	$ 237,00
8	Ceiling	$ 22,20	3	$ 66,60	3	$ 66,60
9	Door and Window Work	$ 39,00	1	$ 39,00	1	$ 39,00
10	Painting	$ 28,20	4	$ 84,60	4	$ 112,80
11	Piping	$ 40,20	4	$ 120,60	4	$ 160,80
12	Electricity Work	$ 34,20	1	$ 34,20	1	$ 34,20
				$ 924,24		$ 977,88

Source: Analysis Result of 2017

Table 20. Cost of Labor Group at Normal Time and Acceleration Time in the Third Phase

No.	TYPE OF WORK	COST OF LABOR GROUP PER DAY	COST OF LABOR GROUP PER NORMAL DAY OF 233 DAYS		COST OF LABOR GROUP PER CRASH DAY OF 185 DAYS	
			GROUP TOTAL	COST TOTAL	GROUP TOTAL	COST TOTAL
1	Preparatory work	$ 22,20	1	$ 22,20	1	$ 22,20
2	Land Work	$ 31,20	2	$ 62,40	3	$ 93,60
3	Footing	$ 22,44	2	$ 44,88	3	$ 67,32
4	Wall work	$ 29,28	2	$ 58,56	2	$ 58,56
5	Concrete and Structure Work	$ 66,20	2	$ 132,40	3	$ 198,60
6	Flooring	$ 16,20	2	$ 32,40	2	$ 32,40
7	Roofing	$ 79,00	2	$ 158,00	2	$ 237,00
8	Ceiling	$ 22,20	3	$ 66,60	3	$ 66,60
9	Door and Window Work	$ 39,00	1	$ 39,00	1	$ 39,00
10	Painting	$ 28,20	4	$ 84,60	4	$ 112,80
11	Piping	$ 40,20	4	$ 120,60	4	$ 160,80
12	Electricity Work	$ 34,20	1	$ 34,20	1	$ 34,20
				$ 924,24		$ 1.044,08

Source: Analysis Result of 2017

Table 21. Cost of Labor Group at Normal Time and Acceleration Time in the Fourth Phase

No.	Type of Work	Cost of Labor Group Per Day	Cost of Labor Group Per Normal Day of 233 Days		Cost of Labor Group Per Crash Day of 181 Days	
			Group Total	Cost Total	Group Total	Cost Total
1	Preparatory work	$ 22,20	1	$ 22,20	1	$ 22,20
2	Land Work	$ 31,20	2	$ 62,40	3	$ 93,60
3	Footing	$ 22,44	2	$ 44,88	3	$ 67,32
4	Wall work	$ 29,28	2	$ 58,56	2	$ 58,56
5	Concrete and Structure Work	$ 66,20	2	$ 132,40	3	$ 198,60
6	Flooring	$ 16,20	2	$ 32,40	2	$ 32,40
7	Roofing	$ 79,00	2	$ 158,00	3	$ 237,00

8	Ceiling	$ 22,20	3	$ 66,60	3	$ 66,60
9	Door and Window Work	$ 39,00	1	$ 39,00	1	$ 39,00
10	Painting	$ 28,20	4	$ 84,60	4	$ 112,80
11	Piping	$ 40,20	4	$ 120,60	4	$ 160,80
12	Electricity Work	$ 34,20	1	$ 34,20	1	$ 34,20
				$ 924,24		$ 1.123,08

Source: Analysis Result of 2017

The acceleration result done in the project provides consequence of additional costs in which under normal schedule condition, the project normal cost is obtained of $ 377.552,868, - thus, after doing TCTO analysis in the project, there is an additional direct cost in the project of $ 1.123,08 so that the total cost of the project becomes $ 378.675,95 in which it is in accordance with the acceleration that has been done in the project; then the overall results of new schedule have activities that have been accelerated. It is based on the data of acceleration duration on activity B, C, E, G Table 4.21 in acceleration scheduling. New scheduling results obtain the project completion time which is previously 233 days and it becomes to 181 days, therefore, there is a time difference of 34 days from the project normal schedule.

5. Conclusion

From the scheduling acceleration analysis of the worship building construction in Dili Timor-Leste by using time cost trade off (TCTO) method, the following results are obtained:

1. The result of normal time scheduling obtained in the project completion in the initial time of 223 days.
2. The time that can be obtained on the implementation of Christian church building construction in Dili which is originally 223 days changed to 181 days, so that there is a time difference of 42 days from the normal schedule of the project.
3. The direct cost of the Christian church building project in Dili under normal project schedule condition is $ 377.552,868, then after (TCTO) is done in the project, there is an additional direct cost in the project of 1.123,08, thus, the total cost of the project is $ 378.675,95.

6. Suggestion

Based on the above conclusion, some suggestions may be useful for further researches that take the same method as material for the acceleration of time on the project:

1. In the implementation of project in the field, it should be noted the critical activities because if the activity's completion time is late, then it leads to the delay of other activities.
2. Further researches should be more detailed regarding to the more detailed activities in project completion, hence, it will assist in the model design, the interrelation determination between the activity and the time estimation.
3. In terms of policy making, it needs better planning and supervision of project activities, so that the delay does not occur during project implementation.

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