

# Chapter 4

## Analysis and Discussion of Results

### 4.1 Introduction

In this chapter, the results of the study will be analysed and discussed for cost reduction and process improvement. In cost analysis, ABC supports cost reduction efforts in two ways. First, it helps us find opportunities that have the greatest potential for cost reduction. It helps us pick the biggest ones as cost reduction targets. Second, ABC is used to simulate the impact of cost reduction actions. This cost simulation helps us build commitment in advance and subsequently confirms positive results. In this study, the activity cost will be analysed to find the opportunity for cost reduction. Next, the cost reduction with activity-based improvement is performed. Finally, the cost simulation will be done to make advance commitment and confirm the results.

### 4.2 Cost Analysis

Analyse Cost Data is the last step of Activity Based Costing technique. In this stage, the activity model with its cost and time measurements will be reviewed and analysed to determine the appropriate point for improvement. Since the method of analysis is not specific, this study selects the Pareto analysis to be a tool for analysis.

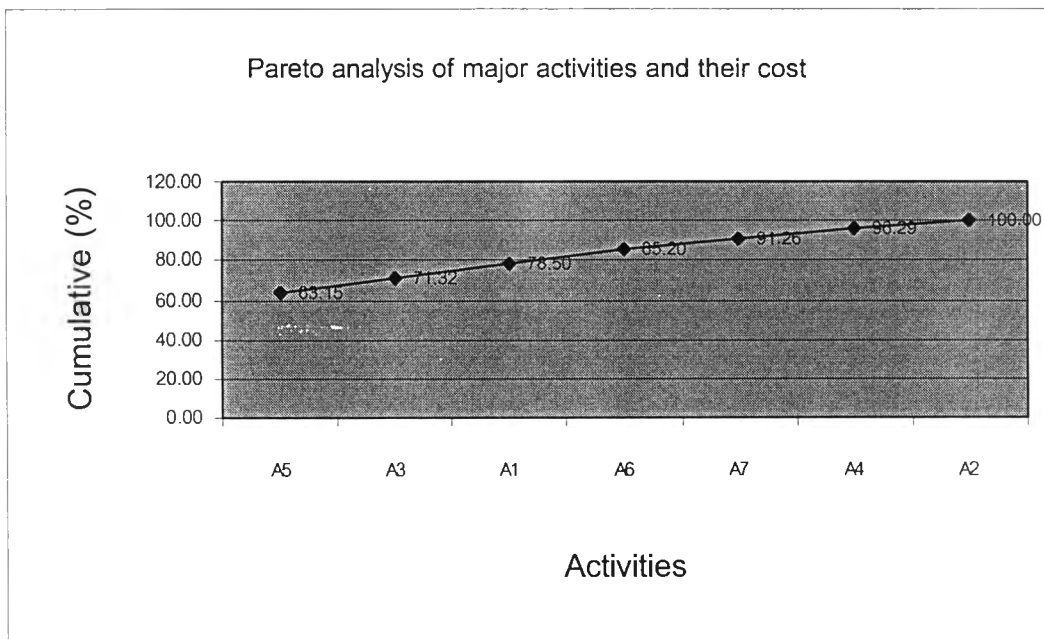
#### 4.2.1 Pareto Analysis

Pareto analysis is a simple ranking tool to assist in the selection of the largest or smallest component of cost. The concept of Pareto analysis is based on the theory that eighty percent of the total cost is normally generated by twenty percent of the activities. This tool allows several very quick conclusions to be reached. It can help us prioritise the application of reduced resources.

Using the Pareto analysis, the major activities of the project management of this project are ranked as shown in Table 4-1 and Figure 4-1.

**Table 4-1: Pareto analysis – Rank between major activities and their cost**

Activity	Activity Cost (Baht)	% of Total Cost	Cumulative (%)
A5	4,088,514	63.15	63.15
A3	528,704	8.17	71.32
A1	464,785	7.18	78.50
A6	433,503	6.70	85.20
A7	392,454	6.06	91.26
A4	325,693	5.03	96.29
A2	240,320	3.71	100.00



*Figure 4-1: Pareto analysis of major activities and their cost*

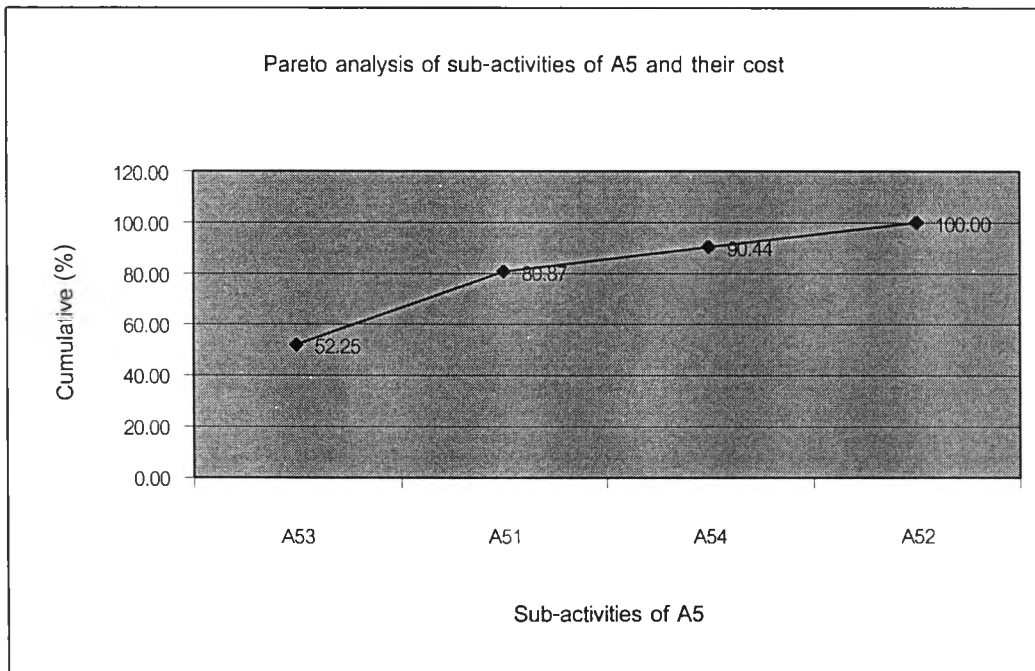
Based on Table 4-1 and Figure 4-1, the conclusion can be reached as follows:

1. Activities A5, A3, A1, and A7 are the sub-activities of all activities that generate 84 percent of the total cost.
2. Activity A5 (Supervise Construction Work) has the largest cost of all activities (4,085,353 Baht or 63.15% of total cost).

Using the Pareto analysis for Activities A5, A3, and A1, the sub-activities that caused the major cost of their parent activities are identified. This analysis are shown in Table 4-2 below:

**Table 4-2: Pareto analysis of sub-activities of Activities A5, A3, and A1**

Activity	Activity Cost	% of Total Cost	Cumulative (%)
A5			
A53	2,136,276	52.25	
A51	1,170,250	28.62	80.87
A54	3391,046	9.56	90.44
A52	390,942	9.56	100.00
A3			
A35	288,384	54.55	
A34	96,128	18.18	72.73
A33	96,128	18.18	90.91
A32	24,032	4.55	95.45
A31	24,032	4.55	100.00
A1			
A12	232,393	50.00	
A11	185,914	40.00	90.00
A13	46,479	10.00	100.00



*Figure 4-2: Pareto analysis of sub-activities of activity A5 and their cost*

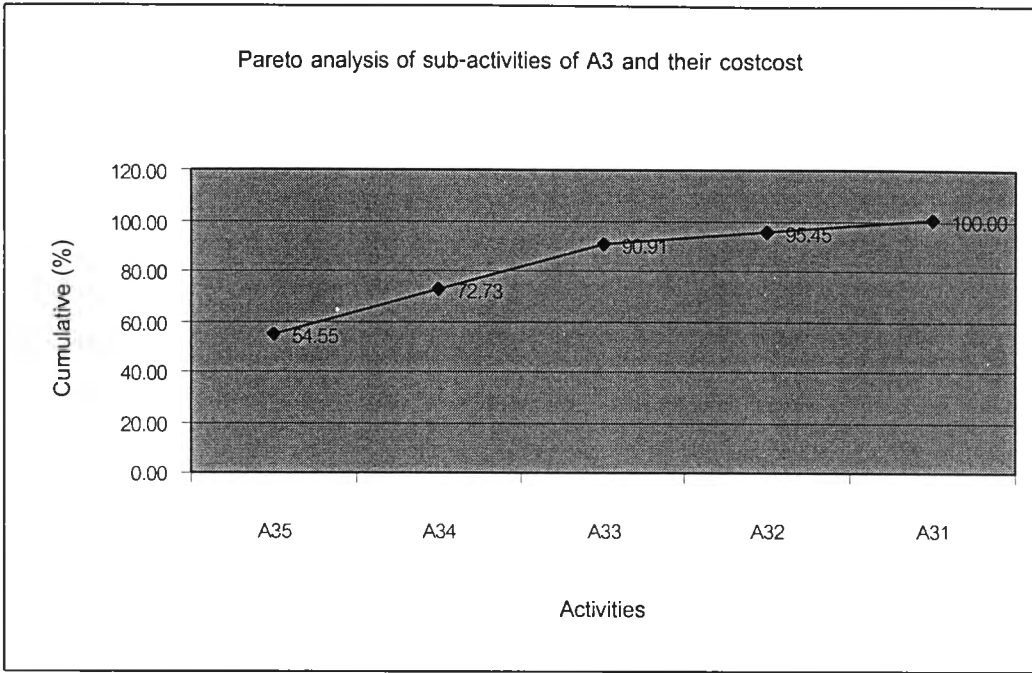


Figure 4-3: Pareto analysis of sub-activities of Activity A3 and their cost

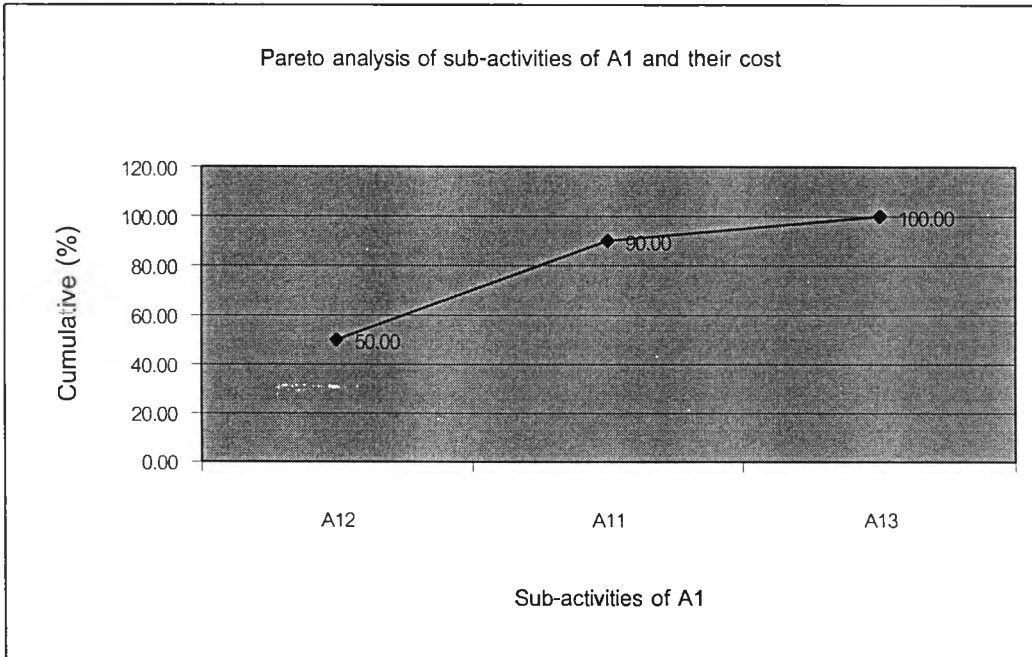


Figure 4-4: Pareto analysis of sub-activities of Activity A1 and their cost

Based on Table 4-2 and Figure 4-2, 4-3, and 4-4, the conclusion can be reached as follows:

1. Activities A53 and A51 are the sub-activities that generate 81 percent of the total cost of Activity A5.

2. Activities A35, A34, and A33 are the sub-activities that generate ninety one percent of the total cost of Activity A3.
3. Activities A12, and A11 are the sub-activities that generate ninety percent of the total cost of Activity A1.

Using the Pareto analysis for Activities A53, A51, A35, A34, and A33, the sub-activities that caused the major cost of their parent activities are identified. This analysis are shown in Table 4-3 below:

**Table 4-3: Pareto analysis of sub-activities of Activities A53, A51, A35, and A33**

Activity	Activity Cost	% of Total Cost	Cumulative (%)
A53			
A531	884,990	41.43	
A534	508,312	23.79	65.22
A532	390,942	18.30	83.52
A533	352,032	16.48	100.00
A51			
A512	472,388	40.37	
A511	442,287	37.79	78.16
A513	255,576	21.84	100.00
A35			
A353	261,391	90.64	
A352	23,763	8.24	98.88
A351	3,230	1.12	100
A34			
A343	86,438	89.92	
A342	6,460	6.72	96.64
A341	3,230	3.36	100
A33			
A333	48,064	50	
A332	24,032	25	75
A331	24,032	25	100

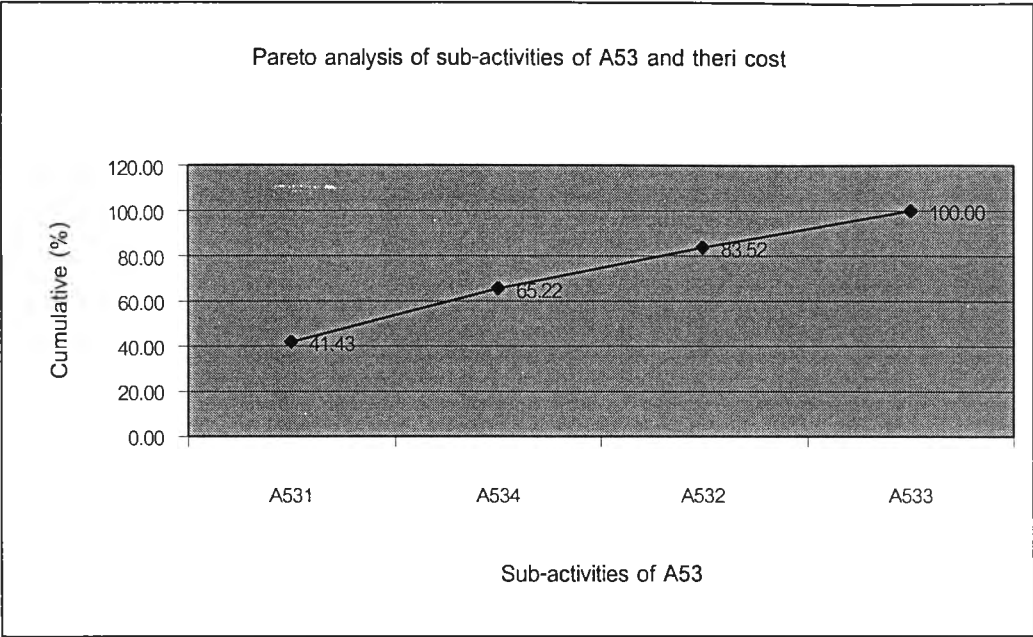


Figure 4-5: Pareto analysis of sub-activities of Activity A53 and their cost

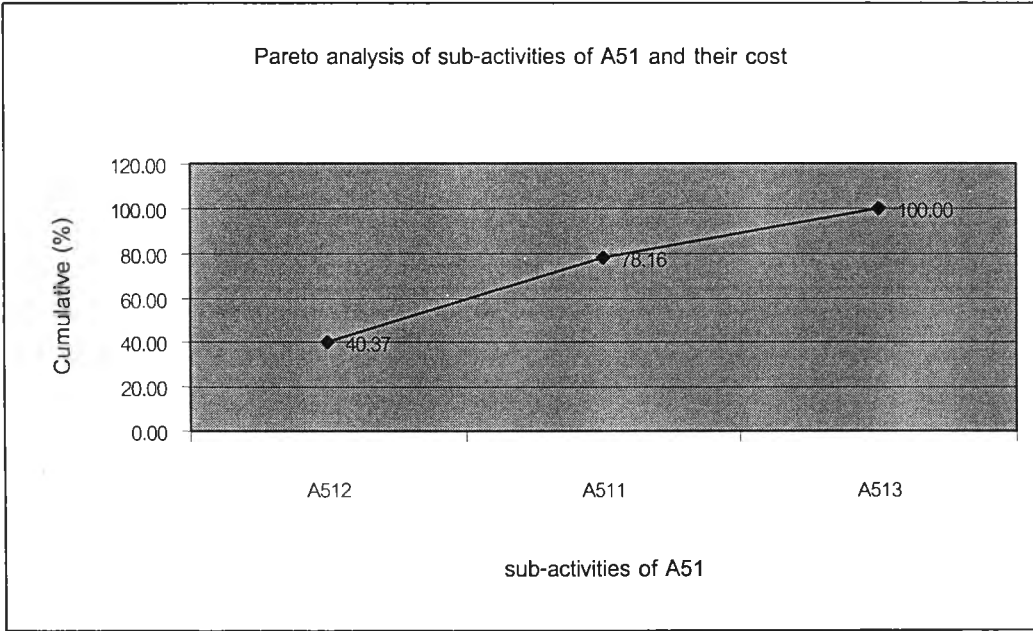


Figure 4-6: Pareto analysis of sub-activities of Activity A51 and their cost

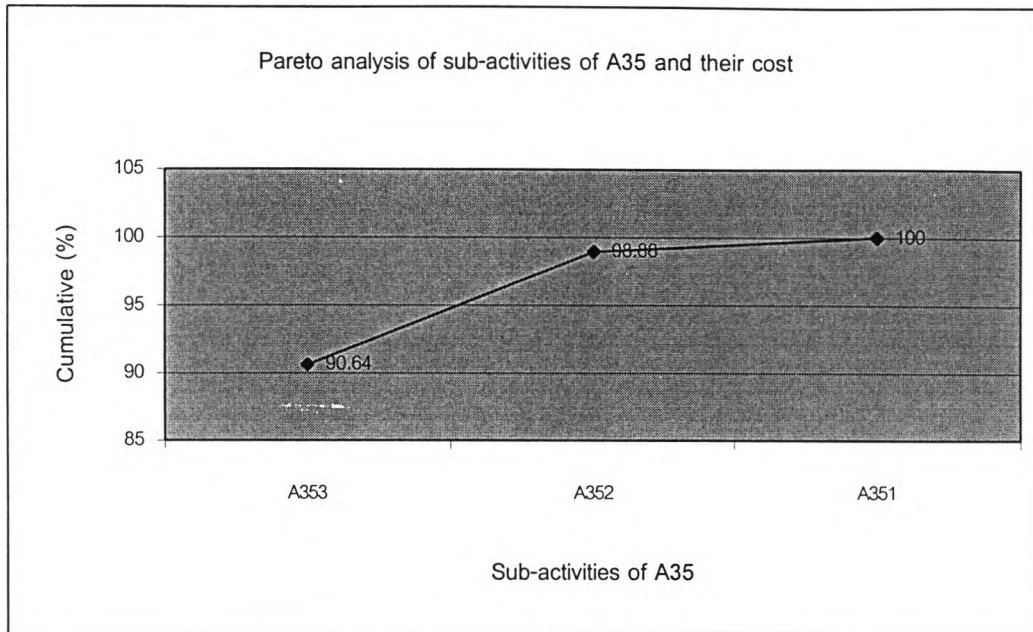


Figure 4-7: Pareto analysis of sub-activities of Activity A35 and their cost

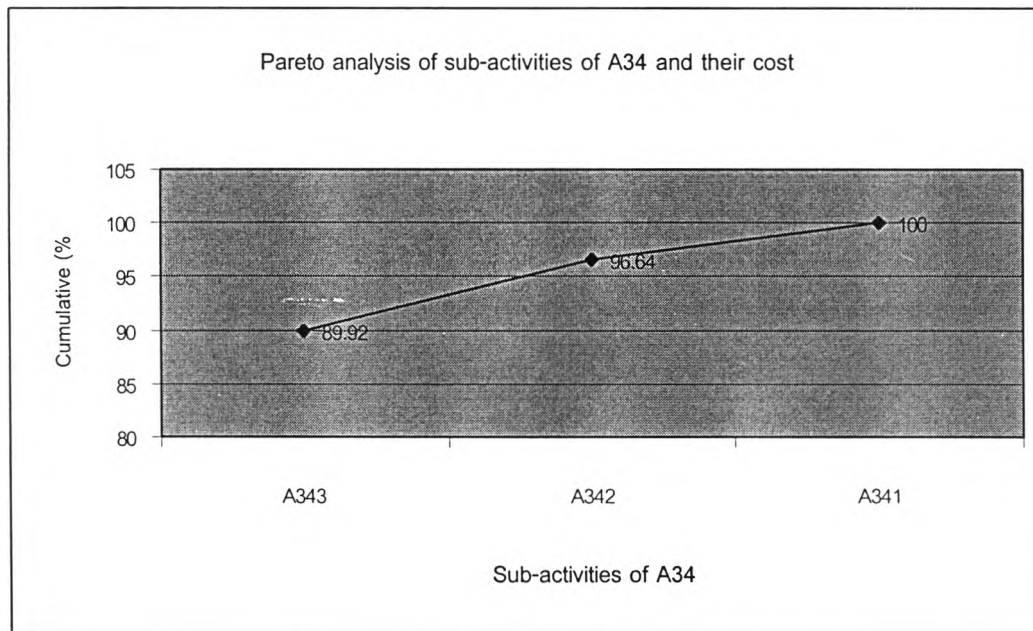


Figure 4-8: Pareto analysis of sub-activities of Activity A34 and their cost

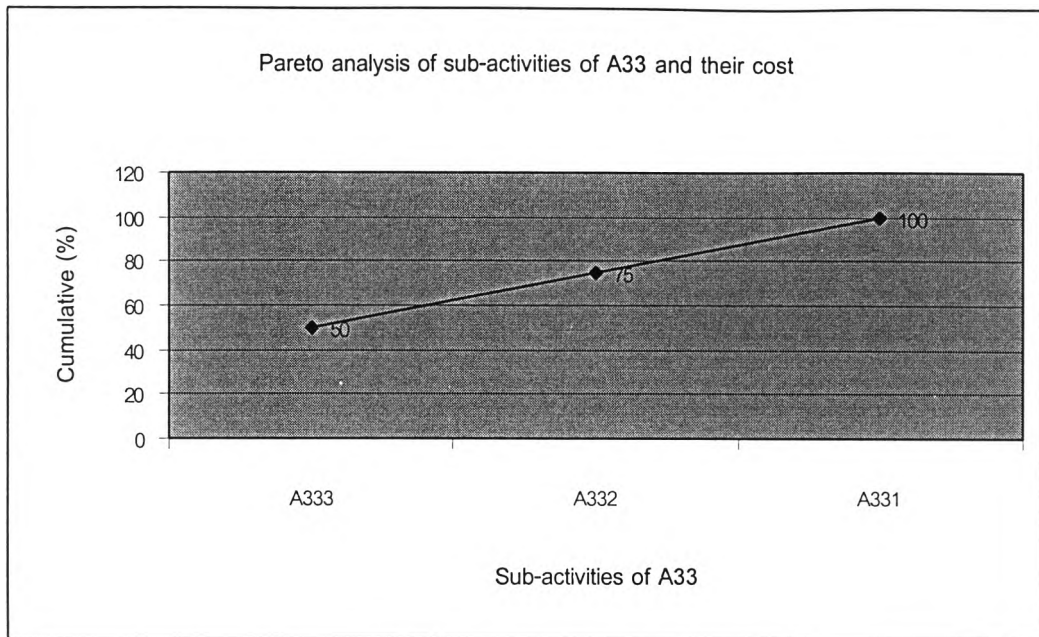


Figure 4-9: Pareto analysis of sub-activities of Activity A33 and their cost

Based on Table 4-3 and Figure F4-5, 4-6, 4-7, 4-8, and 4-9, the conclusion can be reached as follows:

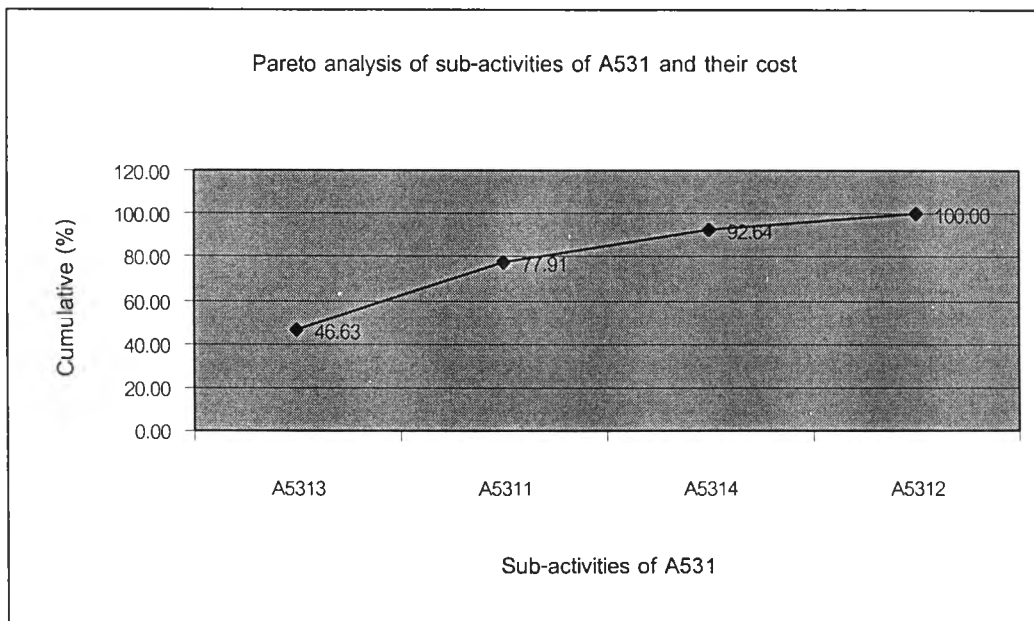
1. Activities A531, A534 and A532 are the sub-activities that generate 84 percent of the total cost of Activity A53.
2. Activities A512 and A511 are the sub-activities that generate 78 percent of the total cost of Activity A51.
3. Activity A353 is the sub-activity that generates 91 percent of the total cost of Activity A35.
4. Activity A343 is the sub-activity that generates 90 percent of the total cost of Activity A34.
5. Activity A333 is the sub-activity that generates 50 percent of the total cost of Activity A33.

Using the Pareto analysis for Activities A531, A534, and A533, the sub-activities that caused the major cost of their parent activities are identified. This analysis are shown in Table 4-4 below:



**Table 4-4: Pareto analysis of sub-activities of Activities A531, A534, and A533**

Activity	Activity Cost	% of Total Cost	Cumulative (%)
A531			
A5313	412,630	46.63	
A5311	276,882	31.29	77.91
A5314	130,315	14.73	92.64
A5312	65,162	7.36	100.00
A534			
A5342	394,916	77.69	
A5343	75,601	14.87	92.56
A5344	18,897	3.72	96.28
A5341	18,897	3.72	100.00
A533			
A5333	180,534	51.28	
A5332	144,425	41.03	92.31
A5334	18,049	5.13	97.44
A5331	9,025	2.56	100.00



*Figure 4-10: Pareto analysis of sub-activities of Activity A531 and their cost*

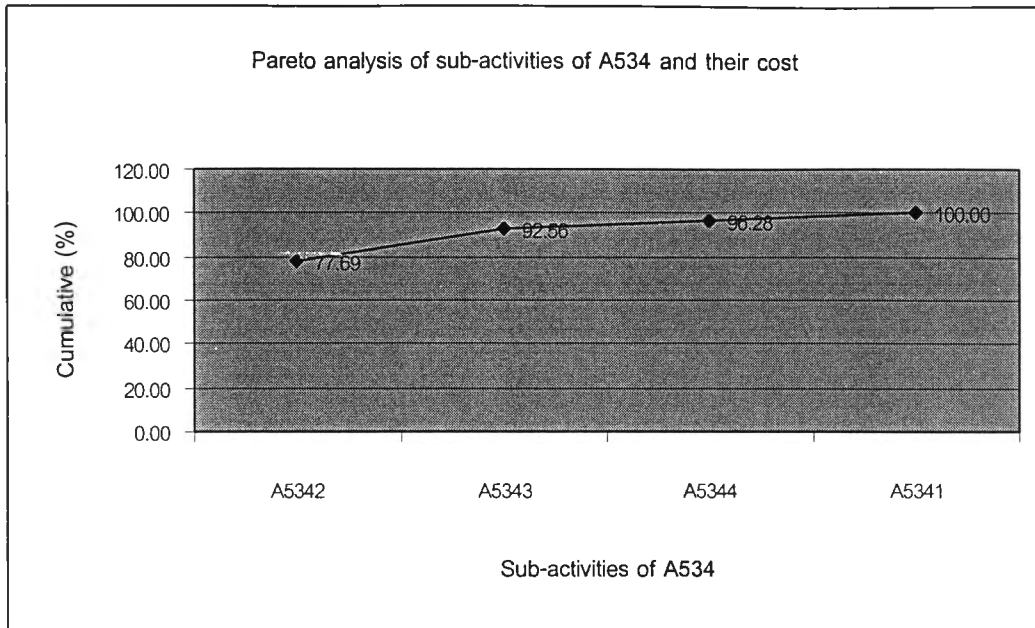


Figure 4-11: Pareto analysis of sub-activities of Activity A534 and their cost

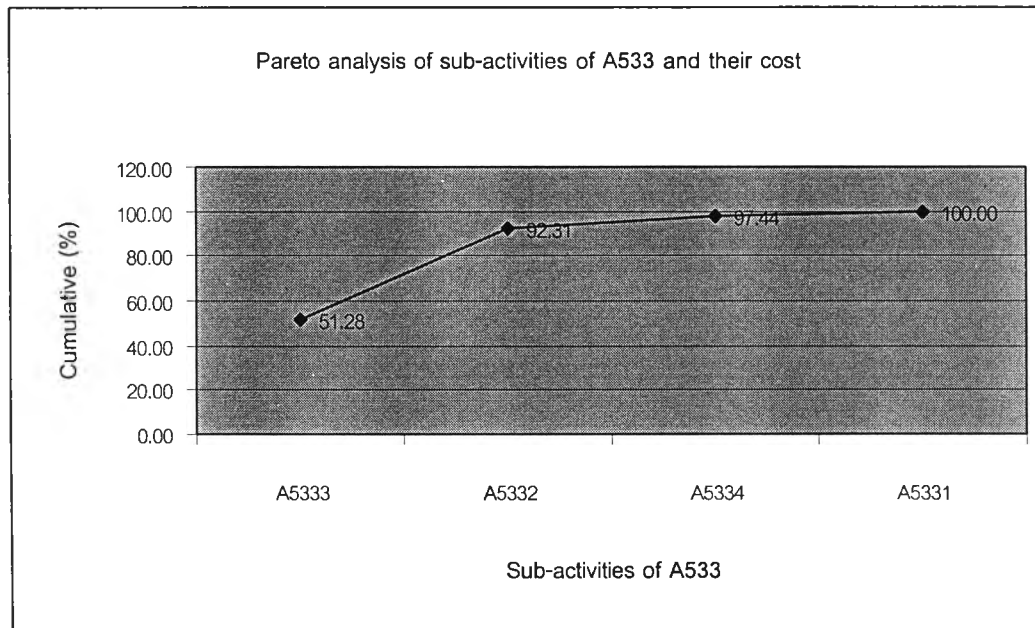


Figure 4-12: Pareto analysis of sub-activities Activity A533 and their cost

Based on Table 4-4 and Figure 4-10, 4-11, and 4-12, the conclusion can be reached as follows:

1. Activities A5313 and A5311 are the sub-activities that generate 78 percent of the total cost of Activity A531.

2. Activities A5342 and A5343 are the sub-activities that generate 93 percent of the total cost of Activity A534.
3. Activities A5333, and A5332 are the sub-activities that generate ninety two percent of the total cost of Activity A533.

Using the Pareto analysis for Activities A5313, A5311, A5342 and A5333, the sub-activities that caused the major cost of their parent activities are identified. This analysis are shown in Table 4-5 below:

**Table 4-5: Pareto analysis of sub-activities of Activities A5313, A5311, A5342 and A5333**

Activity	Activity Cost	% of Total Cost	Cumulative (%)
<b>A5313</b>			
A53132	287,752	69.74	
A53134	47,960	11.62	81.36
A53133	47,960	11.62	92.99
A53131	28,957	7.01	100.00
<b>A5311</b>			
A53113	239,754	86.59	
A53112	26,709	9.65	96.24
A53111	10,419	3.76	100.00
<b>A5342</b>			
A53421	200,885	50.87	
A53424	70,560	17.87	68.73
A53423	52,916	13.40	82.13
A53425	35,277	8.93	91.07
A53422	35,277	8.93	100.00
<b>A5333</b>			
A53331	141,542	78.40	
A53334	17,693	9.80	88.20
A53333	8,846	4.90	93.10
A53332	8,846	4.90	98.00
A53335	3,606	2.00	100.00

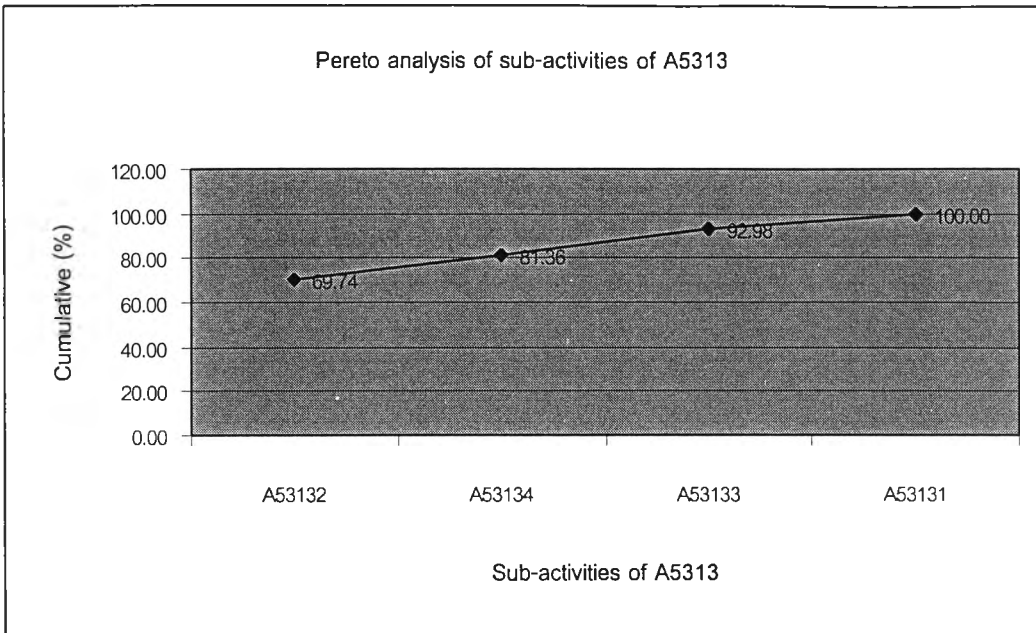


Figure 4-13: Pareto analysis of sub-activities of Activity A5313 and their cost

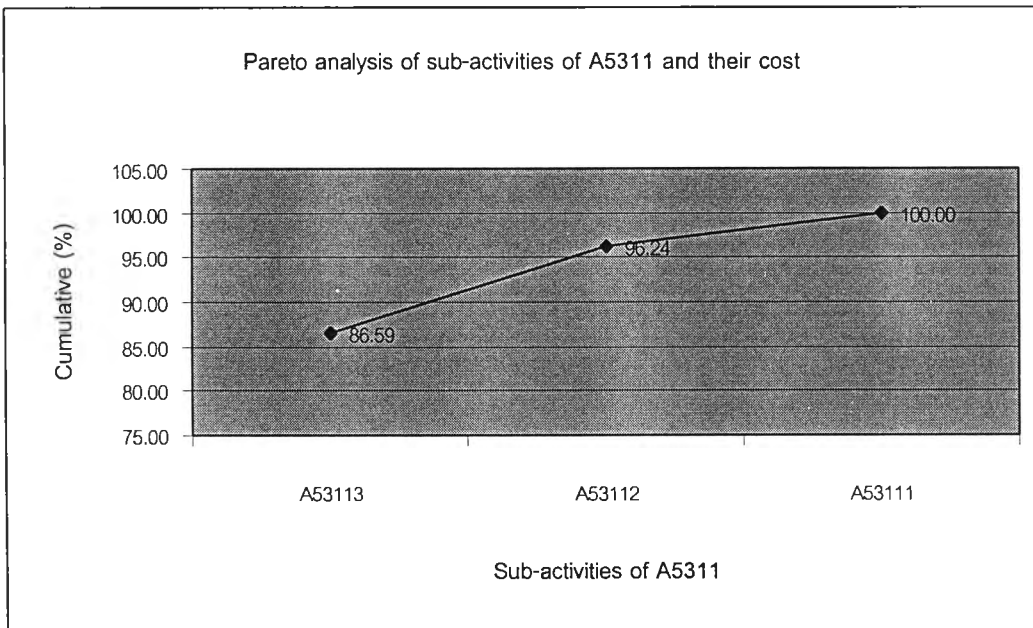


Figure 4-14: Pareto analysis of sub-activities of Activity A5311 and their cost

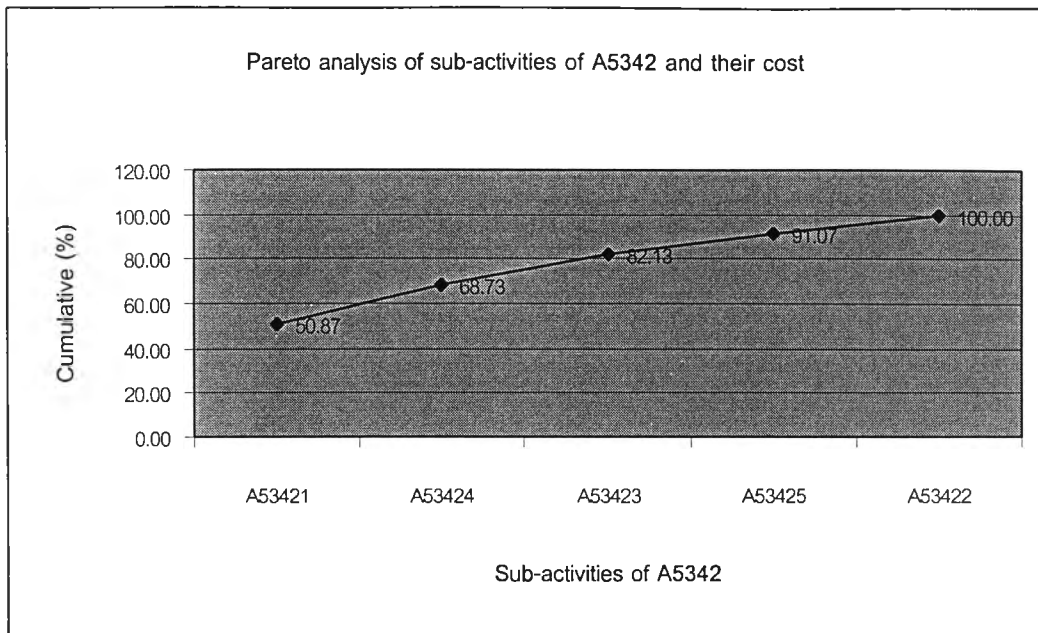


Figure 4-15: Pareto analysis of sub-activities of Activity A5342 and their cost

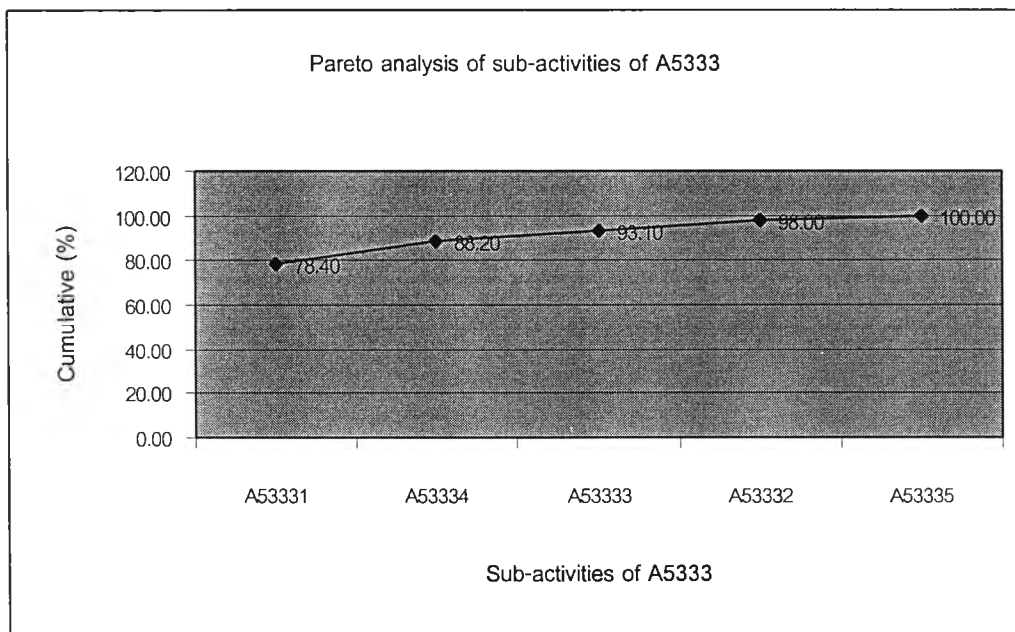


Figure 4-16: Pareto analysis of sub-activities of Activity A5333 and their cost

Based on Table 4-5 and Figure 4-13, 4-14, 4-15, and 4-16, the conclusion can be reached as follows:

1. Activity A53132 is the sub-activity that generates 70 percent of the total cost of Activity A5313.
2. Activities A53113 is the sub-activities that generates 87 percent of the total cost of Activity A5311.
3. Activities A53421, A53424 and A53423 are the sub-activities that generate 82 percent of the total cost of Activity A53142.
4. Activities A53331 is the sub-activities that generates 78 percent of the total cost of Activity A5333.

Using the Pareto analysis again, but cut off the parent activities that can be divided into sub-activities, the result is shown in Table 4-6.

**Table 4-6: Pareto analysis – Rank between activities and their cost**

Activity	Activity Cost (Baht)	% of Total Cost	Cumulative (%)
A512	472,388	7.30	
A511	442,287	6.83	14.13
A7	392,454	6.06	20.19
A54	391,046	6.04	26.23
A53132	287,752	4.44	30.67
A61	264,046	4.08	34.75
A353	261,391	4.04	38.79
A513	255,576	3.95	42.74
A53113	239,754	3.70	46.44
A12	232,393	3.59	50.03
A53421	200,885	3.10	53.13
A11	185,914	2.87	56.00
A45	162,864	2.52	58.52
A5332	144,425	2.23	60.75
A53331	141,542	2.19	62.94
A5325	111,705	1.73	64.66
A5323	111,705	1.73	66.39
A64	97,517	1.51	67.89
A522	86,872	1.34	69.24
A521	86,872	1.34	70.58
A343	86,438	1.34	71.91

Table 4-6 (Continued): Pareto analysis – Rank between activities and their cost

Activity	Activity Cost (Baht)	% of Total Cost	Cumulative (%)
A41	81,432	1.26	73.17
A23	80,117	1.24	74.41
A5343	75,601	1.17	75.58
A53424	70,560	1.09	76.67
A525	65,162	1.01	77.67
A524	65,162	1.01	78.68
A5324	55,844	0.86	79.54
A5322	55,844	0.86	80.40
A5321	55,844	0.86	81.27
A53143	54,299	0.84	82.10
A53423	52,916	0.82	82.92
A62	50,554	0.78	83.70
A333	48,064	0.74	84.45
A53134	47,960	0.74	85.19
A53133	47,960	0.74	85.93
A13	46,479	0.72	86.64
A53122	43,986	0.68	87.32
A526	43,436	0.67	87.99
A523	43,436	0.67	88.67
A25	40,051	0.62	89.28
A24	40,051	0.62	89.90
A22	40,051	0.62	90.52
A53425	35,277	0.54	91.07
A53422	35,277	0.54	91.61
A53131	28,957	0.45	92.06
A53145	27,149	0.42	92.48
A53142	27,149	0.42	92.90
A53112	26,709	0.41	93.31
A332	24,032	0.37	93.68
A331	24,032	0.37	94.05
A31	24,032	0.37	94.42
A352	23,763	0.37	94.79
A46	23,241	0.36	95.15
A44	23,241	0.36	95.51
A43	23,241	0.36	95.87

**Table 4-6 (Continued): Pareto analysis – Rank between activities and their cost**

Activity	Activity Cost (Baht)	% of Total Cost	Cumulative (%)
A63	21,713	0.34	96.20
A5344	18,897	0.29	96.49
A5341	18,897	0.29	96.79
A214	18,687	0.29	97.08
A213	18,687	0.29	97.36
A5334	18,049	0.28	97.64
A53334	17,693	0.27	97.92
A53123	14,657	0.23	98.14
A42	11,673	0.18	98.32
A53144	10,859	0.17	98.49
A53141	10,859	0.17	98.66
A53111	10,419	0.16	98.82
A322	9,613	0.15	98.97
A321	9,613	0.15	99.12
A5331	9,025	0.14	99.26
A53333	8,846	0.14	99.39
A53332	8,846	0.14	99.53
A53121	6,519	0.10	99.63
A342	6,460	0.10	99.73
A323	4,806	0.07	99.80
A53335	3,606	0.06	99.86
A351	3,230	0.05	99.91
A341	3,230	0.05	99.96
A212	1,338	0.02	99.98
A211	1,338	0.02	100.00

Based on Table 4-6, the following conclusions may be drawn from Pareto diagram:

- Activity A512 has the largest cost of all activities.
- Activities A512, A511, A7, A54, a53132, A61, A353, A513, A5113, A12, A53113, A12, A53421, A11, A45, A5332, A53331, a5325, A5323, A64, A522, A521, A343, A41, A23, A5343, A53424,



A525, A524, A5324, and A5322 are the twenty percent of all activities that generate 80 percent of the total cost.

- The group of sub-activities of Activity A5 is the large group that generates the major cost in this process. The sub-activities of Activity A5 that made the major cost are Activities A512, A511, A54, A53132, A5113, A53113, A53421, A5332, A53331, A5325, A5323, A5343, A522, A521, A5343, A53424, A525, A524, A5324, and A5322.
- Except the Sub-activity of Activities A5, A3, A1, and A7, there are some sub-activities of other major activities that are the members of twenty percent of all activities that generate eighty percent of the total cost. They are Activities A61, A45, A64, A41, and A23.

To see the order of cost of major activities and sub-activities when compare with each others, all of the activities are ranked by their cost as shown in Table 4-7.

**Table 4-7: Ranking of all activities by their cost**

Activity	Activity Cost (Baht)	% of Total Cost
A5	4,088,514	63.15
A53	2,136,276	33.00
A51	1,170,250	18.08
A531	884,990	13.67
A3	528,704	8.17
A534	508,312	7.85
A512	472,388	7.30
A1	464,785	7.18
A511	442,287	6.83
A6	433,830	6.70
A5313	412,630	6.37
A5342	394,916	6.10
A7	392,454	6.06
A54	391,046	6.04
A532	390,942	6.04
A52	390,942	6.04
A533	352,032	5.44
A4	325,693	5.03
A35	288,384	4.45
A53132	287,752	4.44

Table 4-7 (Continued): Ranking of all activities by their cost

Activity	Activity Cost (Baht)	% of Total Cost
A5311	276,882	4.28
A61	264,046	4.08
A353	261,391	4.04
A513	255,576	3.95
A2	240,320	3.71
A53113	239,754	3.70
A12	232,393	3.59
A53421	200,885	3.10
A11	185,914	2.87
A5333	180,534	2.79
A45	162,864	2.52
A5332	144,425	2.23
A53331	141,542	2.19
A5314	130,315	2.01
A5325	111,705	1.73
A5323	111,705	1.73
A64	97,517	1.51
A34	96,128	1.48
A33	96,128	1.48
A522	86,872	1.34
A521	86,872	1.34
A343	86,438	1.34
A41	81,432	1.26
A23	80,117	1.24
A5343	75,601	1.17
A53424	70,560	1.09
A5312	65,162	1.01
A525	65,162	1.01
A524	65,162	1.01
A5324	55,844	0.86
A5322	55,844	0.86
A5321	55,844	0.86
A53143	54,299	0.84
A53423	52,916	0.82
A62	50,554	0.78
A333	48,064	0.74
A53134	47,960	0.74
A53133	47,960	0.74
A13	46,479	0.72

Table 4-7 (Continued): Ranking of all activities by their cost

Activity	Activity Cost (Baht)	% of Total Cost
A53122	43,986	0.68
A526	43,436	0.67
A523	43,436	0.67
A25	40,051	0.62
A24	40,051	0.62
A22	40,051	0.62
A21	40,051	0.62
A53425	35,277	0.54
A53422	35,277	0.54
A53131	28,957	0.45
A53145	27,149	0.42
A53142	27,149	0.42
A53112	26,709	0.41
A332	24,032	0.37
A331	24,032	0.37
A32	24,032	0.37
A31	24,032	0.37
A352	23,763	0.37
A46	23,241	0.36
A44	23,241	0.36
A43	23,241	0.36
A63	21,713	0.34
A5344	18,897	0.29
A5341	18,897	0.29
A214	18,687	0.29
A213	18,687	0.29
A5334	18,049	0.28
A53334	17,693	0.27
A53123	14,657	0.23
A42	11,673	0.18
A53144	10,859	0.17
A53141	10,859	0.17
A53111	10,419	0.16
A322	9,613	0.15
A321	9,613	0.15
A5331	9,025	0.14
A53333	8,846	0.14
A53332	8,846	0.14
A53121	6,519	0.10

**Table 4-7 (Continued): Ranking of all activities by their cost**

Activity	Activity Cost (Baht)	% of Total Cost
A342	6,460	0.10
A323	4,806	0.07
A53335	3,606	0.06
A351	3,230	0.05
A341	3,230	0.05
A212	1,338	0.02
A211	1,338	0.02

Based on Table 4-1 through Table 4-7, the activities that have the greatest potential of cost reduction can be listed in Table 4-8 as follows:

**Table 4-8: The activities that have the greatest potential of cost reduction**

Activities	Activities Description	Activities Cost (Baht)
A5	Supervise Construction Work	4,088,514
A53	Supervise Main Construction Work	2,136,276
A531	Supervise Tank Work	884,990
A5313	Supervise Tank Erection Work	412,630
A53132	Supervise Shell Plate Installation & Welding	287,752
A5311	Supervise Pre-erection Work	276,882
A53113	Supervise Pre fabrication Work	239,754
A534	Supervise Electrical & Instrument Work	508,312
A5342	Supervise Electrical & Instrument Installation	394,916
A53421	Supervise Trench Work	200,885
A53424	Supervise Tank Grounding System Work	70,560
A5343	Supervise Control Panel Modification	75,601
A532	Supervise Civil Work	390,942
A5325	Supervise Spillwall / Bundwall	111,705
A5323	Supervise Pipe Support Work	111,705
A533	Supervise Mechanical Work	352,032
A5333	Supervise Pipeline Installation	180,534
A53331	Supervise Pipeline Erection	141,425
A5332	Supervise Spool Piece Work	144,425
A51	Approve Documents	1,170,250

**Table 4-8 (Continued): The activities that have the greatest potential of cost reduction**

Activities	Activities Description	Activities Cost (Baht)
A512	Approve Mechanical Documents	472,388
A511	Approve Civil Documents	442,287
A513	Approve Electrical Documents	255,576
A54	Supervise Final Commissioning Work	391,046
A52	Supervise Warehouse Work	390,942
A522	Supervise Structure Work	86,872
A521	Supervise Demolish Work	86,872
A525	Supervise Finishing Work	65,162
A524	Supervise Concrete Work	65,162
A3	Perform Bidding Work	528,704
A35	Bid Negotiation	288,384
A353	Negotiate the Bid	261,391
A34	Bid Package Evaluation	96,128
A343	Evaluate the Bid Package	86,438
A33	Perform Bidder Site Survey & Bid Clarifying	96,128
A333	Clarify the Bid Questions	48,064
A1	Project Planning & Control	464,785
A12	Project Monitoring	232,393
A11	Project Planning	185,914
A7	Perform Payment Work	392,454
A6	Supervise Hand-over Work	433,830
A61	Supervise One Month of Operation	264,046
A64	Approve As-built Document	97,517
A4	Perform Contract Work	325,693
A45	Produce the Construction Contract	162,864
A41	Request the Permission to Award Contract	81,432
A2	Perform Basic Design, Scope of Work, and TOR Work	240,320
A23	Produce Basic Design & Scope of Work	80,117

#### 4.2.2 Cost & time Analysis

The cost-time table of the major activities of this study is shown in Table 4-9 as follows:

**Table 4-9: Cost and time of major activities**

Activity	Cost (Baht)	Time (Month)
A1	464,785	2.5
A2	240,320	2.5
A3	528,704	5.5
A4	325,693	1
A5	4,085,353	20
A6	433,503	2
A7	392,454	0.5

Based on Table 4-9, the Activity A5 (supervise Construction Work) consumes the most cost and time.

So, Activity A5 is the first priority to reduce cost and time, and improve the process.

The cost-time table of all activities of this study is shown in Table 4-10 as follows:

**Table 4-10: Cost and time of all activities**

Activity	Cost (Baht)	Time (Month)
A1	464,785	2.5
A11	185,914	2.5
A12	232,393	2.5
A13	46,479	2.5
A2	240,320	2.5
A21	40,051	0.5
A211	1,338	0.03
A212	1,338	0.03
A213	18,687	0.25
A214	18,687	0.25
A22	40,051	0.5
A23	80,117	1
A24	40,051	0.5
A25	40,051	0.5
A3	528,704	5.5
A31	24,032	0.25
A32	24,032	0.25
A321	9,613	0.06
A322	9,613	0.03
A323	4,806	0.03
A33	96,128	1
A331	24,032	0.25
A332	24,032	0.25
A333	48,064	0.5
A34	96,128	1
A341	3,230	0.03
A342	6,460	0.06
A343	86,438	1
A35	288,384	3
A351	3,230	0.03
A352	23,763	0.25

Table 4-10 (Continued): Cost and time of all activities

Activity	Cost (Baht)	Time (Month)
A353	261,391	2.75
A4	325,693	1
A41	81,432	0.25
A42	11,673	0.03
A43	23,241	0.06
A44	23,241	0.06
A45	162,864	0.5
A46	23,241	0.06
A5	4,088,514	20
A51	1,170,250	6
A511	442,287	6
A512	472,388	6
A513	255,576	6
A52	390,942	4
A521	86,872	1
A522	86,872	1
A523	43,436	0.5
A524	65,162	0.75
A525	65,162	0.75
A526	43,436	0.5
A53	2,136,276	9.5
A531	884,990	9.5
A5311	276,882	6
A53111	10,419	0.25
A53112	26,709	0.25
A53113	239,754	5.75
A5312	65,162	1
A53121	6,519	0.1
A53122	43,986	0.75
A53123	14,657	0.25
A5313	412,630	4
A53131	28,957	0.5
A53132	287,752	3
A53133	47,960	0.5
A53134	47,960	0.5
A5314	130,315	1.5
A53141	10,859	0.25
A53142	27,149	0.25
A53143	54,299	0.5
A53144	10,859	0.25
A53145	27,149	0.25
A532	390,942	6
A5321	55,844	1
A5322	55,844	1
A5323	111,705	2
A5324	55,844	1
A5325	111,705	2
A533	352,032	7
A5331	9,025	0.25
A5332	144,425	4
A5333	180,534	5
A53331	141,542	4
A53332	8,846	0.25
A53333	8,846	0.25
A53334	17,693	0.5
A53335	3,606	0.1

Table 4-10 (Continued): Cost and time of all activities

Activity	Cost (Baht)	Time (Month)
A5334	18,049	0.5
A534	508,312	5
A5341	18,897	0.25
A5342	394,916	3.5
A53421	200,885	2
A53422	35,277	1
A53423	52,916	1.5
A53424	70,560	2
A53425	35,277	1
A5343	75,601	1
A5344	18,897	0.25
A54	391,046	1.5
A6	433,830	2
A61	264,046	1
A62	50,554	0.5
A63	21,713	0.06
A64	97,517	0.5
A7	392,454	0.5

### 4.2.3 Resource of Cost Analysis

To perform cost reduction, the information is required on the type of element (operational, support or managerial element) that causes the large portion of cost of each activity. So, the resource analysis is required to identify the element that causes the large portion of cost in each activity. The resource of cost analysis of this study is shown as follows:

#### Initial & Support Cost vs. Managerial Cost

The percentage of initial & support cost that compares with the percentage of managerial cost is shown in Table 4-11 below:

Table 4-11: The portion of initial &amp; support cost and managerial cost allocation

Elements	Initial & Support Cost (Baht)	Managerial Cost (Baht)	PD Cost (Baht)	PM Cost (Baht)	EM Cost (Baht)
Planning & Control (PD)	94,027 (20.23%)	370,758 (79.77%)	93,975.52 (20.22%)	276,962.4 (59.55%)	-
Budget & Accounting (BA)	50,215 (12.80%)	342,238 (87.20%)	86,580.48 (22.06%)	255,657.6 (65.14%)	-
TOR & Bidding (TB)	341,227 (44.37%)	427,798 (55.63%)	108,225.6 (14.07%)	319,572 (41.56%)	-
Contract Management (CM)	62,207 (17.91%)	285,198 (82.09%)	72,150.4 (20.77%)	213,048 (61.32%)	-



**Table 4-11 (Continued): The portion of initial & support cost and managerial cost allocation**

Elements	Initial & Support Cost (Baht)	Managerial Cost (Baht)	PD Cost (Baht)	PM Cost (Baht)	EM Cost (Baht)
Civil Construction (CC)	1,236,336 (76.42%)	381,399 (23.58%)	168,351.2 (10.41%)	-	213,048 (13.17%)
Mechanical Construction (MC)	666,752 (63.61%)	381,399 (36.39%)	168,351.2 (16.06%)	-	213,048 (20.33%)
Electrical & Instrument Construction (EC)	376,278 (66.37%)	190,700 (33.63%)	84,157.6 (14.84%)	-	106,524 (18.79%)
Civil Engineering (CE)	97,743 (20.40%)	381,399 (79.60%)	168,351.2 (53.14%)	-	213,048 (26.46%)
Mechanical Engineering (ME)	130,352 (25.47%)	381,399 (74.53%)	168,351.2 (32.90%)	-	213,048 (41.63%)
Electrical & Instrumental Engineering (EE)	86,173 (31.12%)	190,700 (68.88%)	84,157.6 (30.40%)	-	106,524 (38.48%)

Table 4-11 shows the large portion of cost of each operational element that requires cost reduction and process improvement as follows:

- Initial & support cost is the major portion of cost of Civil, Mechanical, and Electrical & Instrument Construction element.
- Managerial cost is the major portion of Planning & Control, Budget & Accounting, TOR & Bidding, Contract Management, Civil Engineering, Mechanical Engineering, and Electrical & Instrument Engineering element.
- Project director cost is the major portion of managerial cost of Civil Engineering element.
- Project management cost is the major portion of managerial cost of Planning & Control, Budget & Accounting, TOR & Bidding, and Contract Management element.
- Engineering & Construction Management is the major portion of managerial cost of Mechanical Engineering and Electrical & Instrument Engineering element.

### Support Cost

The percentage of initial cost that compares with the percentage of support cost is shown in Table 4-12 below:

Table 4-12: The portion of initial cost and support cost allocation

Elements	Initial Cost (Baht)	Administration Cost (Baht)	Safety Cost (Baht)	Legal Cost (Baht)
Project Director (PD)	1,148,290 (95.49%)	54,218 (4.51%)	0	0
Project Management (PM)	1,011,022 (94.01%)	54,281 (5.09%)	0	0
Engineering & Construction Management (EM)	1,011,022 (94.01%)	54,281 (5.09%)	0	0
Planning & Control (PC)	39,809 (42.34%)	54,218 (5.09%)	0	0
Budget & Accounting (BA)	6,841 (13.62%)	43,375 (86.38%)	0	0
TOR & Bidding (TB)	265,272 (77.74%)	65,062 (19.07%)	0	10,893 (3.19%)
Contract Management (CM)	13,263 (21.32%)	16,266 (26.15%)	0	32,679 (52.53%)
Civil Construction (CC)	1,155,450 (93.45%)	16,266 (1.32%)	53,727 (4.35%)	10,893 (0.88%)
Mechanical Construction (MC)	628,966 (94.34%)	16,266 (2.44%)	21,491 (3.22%)	0
Electrical Construction (EC)	356,480 (94.74%)	10,844 (2.88%)	8,955 (2.38%)	0
Civil Engineering (CE)	47,156 (48.25%)	48,797 (49.92%)	1,791 (1.83%)	0
Mechanical Engineering (MC)	79,765 (61.20%)	48,797 (37.43%)	1,791 (1.37%)	0
Electrical Engineering (EE)	35,586 (41.3%)	48,797 (56.62%)	1,791 (2.08%)	0

Table 4-12 shows that the major portion of Civil, Mechanical, and Electrical & Instrument Construction element is initial cost. So, these initial costs require cost reduction and process improvement.

### 4.3 Cost Reduction and Process Improvement

The cost reduction and process improvement of this study can be performed as follows:

#### 1. Process Cycle-time Reduction

The example of process cycle-time reducing of this project are described as follows:

### 1.1) Serial Versus Parallel Activities

In activity A23, it took one month to produce the basic design & scope of work, and this activity must be completed before starting Activity A24 and then Activity A25, estimate construction cost, and produce the terms of reference respectively. In fact, production of the basic design & scope of work, estimation of construction cost and production of the term of reference can be started and worked in parallel with some overlapping. So, shifting the starting time of estimate construction cost and production of terms of reference, can reduce the time by 0.5 month.

In Activity A525, it took 0.75 month to supervise finishing work of warehouse, and this activity must be completed before starting Activity A526, supervise painting work of warehouse. In fact, painting work of warehouse can be started when finishing work of warehouse is 0.5 month performed. So, shifting the starting time of supervise painting work of warehouse to work in parallel with supervise finishing work of warehouse, can reduce time by 0.5 months.

In Activity A53122, it took 0.75 month to supervise firewall erection, and this activity must be completed before starting Activity A53123, supervise firewall equipment installation. In fact, firewall equipment installation can be started when supervise firewall erection is two-third performed. So, shifting the starting time of supervise firewall equipment installation to work in parallel with supervise firewall erection, can reduce the time by 0.25 month.

All sub-activities of Activity A532 (supervise civil work) can be worked in parallel together. If they are started at the same time, the process cycle-time of Activity A532 can be reduced from six months to 2 months. However, civil work was designed to be performed in parallel with tank construction work that consumed more time and was supervised by the same civil construction team. So, it is not necessary to perform all of sub-activities of Activity A532 in parallel because it will make the workload in that short parallel period time.

In Activity A53423, it took 1.5 month to supervise cable laying & wiring work, and this activity was designed to complete before starting Activity A5343, supervise control panel modification. In fact, control panel modification can be worked in parallel with supervise cable laying & wiring work. So,

shifting the starting time of supervise control panel modification to work parallel with supervise cable laying & wiring work, can reduce the time by one month.

For Activity A62, it took 0.5 month to supervise site cleaning & demolish work, and this activity was designed to be performed as the last activity. In fact the site cleaning & demolish work can be worked in parallel with Activity A64 (Approve As-built Document). So, shifting the starting time of site cleaning & demolish work to work parallel with approve as-built document, can reduce the time by 0.5 month.

### **1.2) Remove Down Time, Waiting Time**

Waiting time in Activity A33 can be reduced by reducing processing time and waiting time of Activity A331- inform site survey information, and Activity A332- coordinate site survey. To perform Activity A331, the bidding team prepared the information of site survey (date and time) and then informed all bidders. To perform Activity A332, the bidding team performed coordinating of the site survey and site survey meeting for bidders. Actual processing time in preparing the document is only 1 day; the rest was wasted time waiting for site survey day. So, reducing processing time of Activity A331 from 1 week to half week, and reducing processing time of Activity A332 from 1 week to half week can reduce total processing time by 0.25 month. In addition, waiting time was also automatically reduced.

In Activity A353 (Negotiate the bid), there are long waiting time in each negotiation. So, the bidding team should set the negotiation meeting with shorter waiting time.

All sub-activity of Activity A51 (Approve document) had long waiting time in preparing, correcting, printing, and sending of contractor. Moreover, in approval process, it required the Engineering & Construction manager to sign for approval after the engineer checked and approved those documents. This process has waiting time in case of the Engineering & Construction manager is not available at that time. So, it needs the improvement in procedure and method of this process. For example, use the electronic files instead of paper documents, and sending via email in stead of mail or sending by hand. Moreover, it needs to indicate the time of preparing and correcting the document of contractor should be specified to be a short time in the contract.

For conclusion, the waiting time can be minimised by combining operation, balancing workloads, or automation.

### **1.3) Remove Rework**

There are lots of rework in Activity A353 due to the re-negotiation. Preventing re-negotiation can be done by adding the rule of negotiation in TOR. That is, negotiation must be performed not more than twice, and the results that come out from the second negotiation are the final result of the bid negotiation. This can directly reduced rework, processing time, and cost spent in this activity.

### **1.4) Set Priorities**

Management must set proper priorities to the personnel to approve and sign some kinds of the document instead of the management level in the case that management level is not available. So, this priority will reduce the waiting time of activities that face delay in document approval. The activities that can be given priority to approve and sign are such as Activities A11, A12, A13, A23, A24, A25, A321, A343, A41, A42, A45, A46, A511, A512, A513, A63, A64, A7, etc.

### **1.5) Improve Timing**

Each activity should be done in proper timing and resource. The timing should be set not too short nor too long but should be set proper depending the resources and time available. The activity that is set too short in the timing will cause overload work and waiting time. The activity that is set too long will waste time and resources.

The timing of Activity A5 and its sub-activities should be improved because the timing in the construction phase is longer than it should be. At that time, the government helped the construction contractors in economic crisis by adding the contract time. So, if the project team needs to perform the new project that has the scope like this project, they should improve the activity time in the construction phase for cost reduction and process improving. However, the time or reduction should be realistic and not result in excess workload or waiting time. Examples of the activity timing of this study that should be improved are list edas follows:

- The timing of Activity A51 (Approve Documents) and its sub-activities should be improved by reducing from 6 months to 4 months.
- The timing of Activity A521 (Supervise Demolish Work of Warehouse Construction) and Activity A522 (Supervise structure work of Warehouse Construction) should be improved by reducing from 1 month to 0.5 month.
- The timing of Activity A524 (Supervise Concrete Work of Warehouse Construction) should be improved by reducing from 0.75 month to 0.5 month.
- The timing Activity A53113 (Supervise Pre-fabrication work of Tank Work) should be improved by reducing from 5.75 months to 3.75 months.
- The timing of Activity A53122 (Supervise Firewall Installation) should be improves by reducing from 0.75 month to 0.5 month.
- The timing of Activity A53132 (Supervise Shell Plate Installation & Welding) should be improved by reducing from 3 months to 2.5 months.
- The timing of Activity A5323 (Supervise Pipe Support Work) and Activity A5325 (Supervise Spillwall/Bundwall Work) should be improved by reducing from 2 months to 1.5 months.
- The timing of Activity A5332 (Supervise Spoon Piece Work) should be improved by reducing from 4 months to 3 months.
- The timing of Activity A53331 (Supervise Pipeline Erection) should be improved by reducing from 4 months to 3 months.
- The timing of Activity A53421(Supervise Trench Work) and Activity A53424 (Supervise Tank Grounding System Work) should be improved by reducing from 2 months to 1.5 months.
- The timing of Activity A5343 (Supervise Control Panel Modification) should be improved by reducing from 1 month to 0.75 month.

- The timing of Activity A54 (Supervise Final Commissioning) should be improved by reducing from 1.5 months to 1 month.

The timing improvement will result in reducing process cycle time and time allocation of personnel.

## **2. Eliminate Unnecessary Activities**

### **2.1) Eliminate Bureaucracy Activities**

Eliminate bureaucracy activities are such as removing unnecessary administrative task, approvals, and paperwork. In this study, the reduction of unnecessary administration task of administration element will reduce the administration cost that is charged to other support elements, managerial elements and operational elements that they support. Moreover, other activities or sub-activities that consist of bureaucracy tasks such as unnecessary approvals or paperwork should be improved by cutting of these bureaucracy tasks. The eliminated bureaucracy activities will result in the reduction of resource and time consumed.

### **2.2) Value-added Assessment**

Value –added assessment is an essential principle in the streamlining process (Harrington, 1991). It is an analysis of every activity in the process to determine the contribution to meet end-customer expectation. In value-added assessment, there are three type of activities, they are as follows:

- Real-value added activities – they are activities that are required to provide the output that the customer is expecting.
- Business-value added activities – they are activities that are required by the business but that added no value from the customer’s point of view.
- Non-value-added activities – they are activities that do not contribute to meet customer requirements, and could be eliminated without degrading the product or service functionality. There are two kinds of non-value-added activities. They are described as follows:

- Activities that exist because the process is inadequately designed or the process is not functioning as designed. These activities would be unnecessary to produce the produce the output of the process but occur because of poor process design.
- Activities not required by the customer or the process and activity that could be eliminated without affecting the output to the customer.

Figure 4-17 shows how the value-added assessment is evaluated.

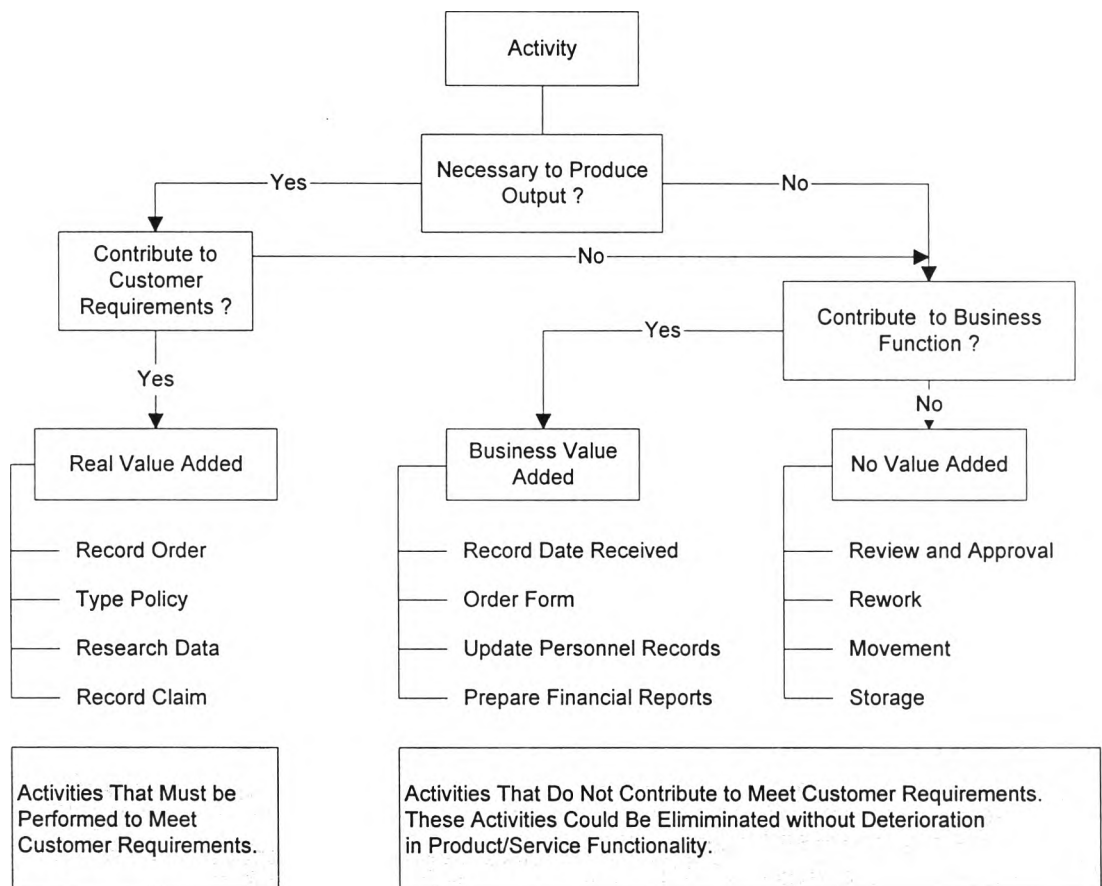


Figure 4-17: Value-added assessment (Source: Harrington, 1991)

Most of the activities that are listed in this study contributed the customer requirement (Spherical tank) but there are some business-value-added such as the bid guarantee work, performance security bond work, budget and payment work, etc. In addition, there are many business-value-added performed by the administration element that supports this project such as document receiving & register, document filing, personnel allowance work, supply management, etc. Moreover, there are many non-value-added



tasks or activities that should be eliminated such as unnecessary review and approval of management, rework, perform storage the documents, perform movement of document, etc. So, the project team should optimise business-value-added activities and minimise or eliminate non-value-added activities.

### **3. Work Simplification**

The objective of work simplification is reducing complexity wherever feasible. It leads to fewer tasks, fewer interdependencies and aim to make everything easier to learn, do, or understand. All of the activities of this project should follow the applications for simplification as follows:

- Identifying duplication and fragmentation that occur during various part of the process and then combining related task and eliminating redundancies.
- Simplifies the complex flows and bottlenecks by changing the order of task, combining or separating task, and balance the workload.
- Simplifies the memos and other correspondences by making them shorter, more direct, better formatted, more readable. This leads to time saving.
- Simplifies the meeting by using meeting agenda, fewer meeting, less time spent in each meeting.
- Reduce amount of handling by combining responsibilities.
- Eliminated unused data.
- Eliminate copies of documents.

The work simplification will result in the reduction of process cycle time and reducing of time allocation of personnel.

### **4. Match Resources with Activity**

Each activity requires the proper resources to perform the work and establish the output. Too many resources such as manpower or supplies will cause the high cost. Less resource will waste timing. Moreover, using the over or under specification resources will cause high cost or waste timing too. In

this project, the cost of project management is directly effect by cost of resource. Cost Reduction by changing in manpower cost and time allocation in each activity should be done. There was some manpower whose appointment does not match with the activities and need to be improved as follows:

- The TOR & Bidding element that performed Activity A2 (Produce Basic Design, Scope of work, Estimated Construction Cost, and Term of Reference) consists of three engineers (2 mechanical engineers and 1 electrical engineer) and one senior engineer. This team can be reduced from two mechanical engineers to one engineer.
- The Contract Management Element consists of two engineers to do the contract work (Activity A4). This work is not too big to use two engineers to perform the work. So, this element can be reduced from two engineers to one engineer.
- The Activity A7 (Perform Budget and Accounting Work) uses two engineers to perform the work. This work should be reduced the personnel from two persons to one person.
- In supervision construction work, There are three operational elements involved. They are Civil Construction Team, Mechanical Construction Team, and Electrical Construction Team. The Civil Team consists of a senior civil engineer that has experiences in tank construction and a civil technician. If the senior engineer is assigned to be work full time, it will not be necessary to assign the technician to work full time. So, the technician manpower should be cut off or assigned to work as part time work. The mechanical team that consists of two engineers should be reduced to one full time engineer.
- In review and approve the mechanical document activity, Each document was reviewed by two engineers and finally reviewed and approved by one senior engineer. It seems to assign too many personnel to do this work and do redundancy work. So, only one engineer is enough to be assigned to do this work.

Cost reduction and process improvement of this study can be concluded in Table 4-13 as follows:

Table 4-13: Cost reduction and process improvement of this study

Activity	Personnel Cost Reduction		Process Cycle Time Reduction				Reduction Cost (Baht)	
	Reduce Personnel / Assign Low Cost Personnel	Reduce Time Allocation	Assign Parallel activities Instead of Serial Activities	Remove Waiting Time	Remove Rework	Set Priority		Improve Timing
A1		✓					146,289	
A11		✓				✓	58,516	
A12		✓				✓	73,145	
A13		✓				✓	14,629	
A2	✓	✓					77,461	
A21	✓	✓					12,909	
A211	✓	✓					431	
A212	✓	✓					431	
A213	✓	✓					6,023	
A214	✓	✓					6,023	
A22	✓	✓					12,909	
A23	✓	✓	✓			✓	25,824	
A24	✓	✓	✓			✓	12,909	
A25	✓	✓	✓			✓	12,909	
A3	✓	✓					170,414	
A31	✓	✓					7,746	
A32	✓	✓					7,746	
A321	✓	✓				✓	3,098	
A322	✓	✓					3,098	
A323	✓	✓					1,549	
A33	✓	✓					30,984	
A331	✓	✓		✓			7,746	
A332	✓	✓		✓			7,746	
A333	✓	✓					15,492	
A34	✓	✓					30,984	
A341	✓	✓					1,041	
A342	✓	✓					2,082	
A343	✓	✓				✓	27,861	
A35	✓	✓					92,953	
A351	✓	✓					1,041	
A352	✓	✓					7,659	
A353	✓	✓		✓	✓		84,253	
A4	✓	✓					103,058	
A41	✓	✓				✓	25,767	
A42	✓	✓				✓	3,694	
A43	✓	✓					7,354	
A44	✓	✓					7,354	
A45	✓	✓				✓	51,534	
A46	✓	✓				✓	7,354	
A5	✓	✓					1,227,539	
A51	✓	✓					✓	400,332
A511		✓		✓		✓		142,270
A512	✓	✓		✓		✓		174,824
A513		✓		✓		✓		83,238
A52	✓	✓						120,612
A521	✓	✓					✓	26,802
A522	✓	✓						26,802
A523	✓	✓						13,401
A524	✓	✓					✓	20,104
A525	✓	✓	✓					20,104
A526	✓	✓	✓					13,401
A53	✓	✓						599,676

Table 4-13 (Continued) : Cost reduction and process improvement of this study

Activity	Personnel Cost Reduction		Process Cycle Time Reduction				Reduction Cost (Baht)
	Reduce Personnel / Assign Low Cost Personnel	Reduce Time Allocation	Assign Parallel activities Instead of Serial Activities	Remove Waiting Time	Remove Rework	Set Priority	
A531	✓	✓					256,446
A5311	✓	✓					76,375
A53111	✓	✓					2,853
A53112	✓	✓					7,879
A53113	✓	✓				✓	65,644
A5312	✓	✓					20,104
A53121	✓	✓					2,011
A53122	✓	✓	✓			✓	13,571
A53123	✓	✓	✓				4,522
A5313	✓	✓					122,025
A53131	✓	✓					8,934
A53132	✓	✓				✓	84,818
A53133	✓	✓					14,137
A53134	✓	✓					14,137
A5314	✓	✓					37,942
A53141	✓	✓					2,973
A53142	✓	✓					7,999
A53143	✓	✓					15,998
A53144	✓	✓					2,973
A53145	✓	✓					7,999
A532	✓	✓					120,612
A5321	✓	✓					17,229
A5322	✓	✓					17,229
A5323	✓	✓				✓	34,463
A5324	✓	✓					17,229
A5325	✓	✓				✓	34,463
A533	✓	✓					96,385
A5331	✓	✓					2,471
A5332	✓	✓				✓	39,543
A5333	✓	✓					49,429
A53331	✓	✓				✓	38,754
A53332	✓	✓					2,422
A53333	✓	✓					2,422
A53334	✓	✓					4,844
A53335	✓	✓					987
A5334	✓	✓					4,942
A534	✓	✓					126,233
A5341		✓					4,301
A5342	✓	✓					100,425
A53421	✓	✓				✓	56,266
A53422		✓					8,029
A53423		✓	✓				12,043
A53424		✓				✓	16,059
A53425		✓					8,029
A5343		✓	✓			✓	17,206
A5344		✓					4,301
A54	✓	✓				✓	106,918
A6	✓	✓					128,139
A61		✓					72,312
A62		✓	✓				15,597
A63	✓	✓				✓	6,871
A64	✓	✓	✓			✓	33,360
A7	✓	✓				✓	125,478

In Table 4-13, it can be noted that eliminating of unnecessary activities, work simplification, and matching resource with activity can be applied to every activities for cost reduction and process improvement.

#### **4.4 Cost Simulation**

Activity Based Costing can be used as an economic and performance model of the process or business. It provides the ability for simulating the impact of change in operating a process or business. The cost of each alternative can be computed using the ABC model. So, the ability to simulate the cost impact of improvement action has benefits in addition to identifying the lowest cost alternative. In this study, the cost simulation can be performed by following the cost reduction and process improvement that was stated earlier.

The improvement can be concluded as the input for simulation as follows:

1. The percentage of time allocation of this project of each personnel in each functional element should be improved by reduction of waste time and match the suitable manpower with function of work.
2. The total working time of each functional element should be improved by parallel working, removing waiting time, removing rework, setting priority, improving activity timing, eliminating unnecessary activities, etc. Following the time improvement, the total working time of this project will be reduced from 31 months to 23 months. The time of design and bidding phase will be reduced from 9 months to 7 months and the time of construction phase will be reduced from 22 months to 16 months.
3. The supplies cost and copy machine rental cost is assumed to be reduced by 10% due to the result of cost reduction.
4. The reduction of time allocation of each personnel in each functional element and reduction of total working time of each function element will result the reduction of manpower cost, and other resources cost.

More detailed of calculations of the cost simulation are shown in Appendix C The result of the cost simulation is shown in Table 4-14.

Table 4-14: Result of cost simulation

Activity	Cost (Baht)
A1	318,496
A11	127,399
A12	159,248
A13	31,850
A2	162,859
A21	27,141
A211	907
A212	907
A213	12,664
A214	12,664
A22	27,141
A23	54,293
A24	27,141
A25	27,141
A3	358,291
A31	16,286
A32	16,286
A321	6,514
A322	6,514
A323	3,257
A33	65,144
A331	16,286
A332	16,286
A333	32,572
A34	65,144
A341	2,189
A342	4,378
A343	58,577
A35	195,431
A351	2,189
A352	16,104
A353	177,139
A4	222,635
A41	55,665
A42	7,979
A43	15,887
A44	15,887
A45	111,329
A46	15,887
A5	2,860,975
A51	769,918
A511	300,016
A512	297,564
A513	172,338
A52	270,330
A521	60,071
A522	60,071
A523	30,035
A524	45,059
A525	45,059
A526	30,035
A53	1,536,600
A531	628,544
A5311	200,507
A53111	7,566

Table 4-14 (Continued): Result of cost simulation

Activity	Cost (Baht)
A53112	18,831
A53113	174,110
A5312	45,059
A53121	4,508
A53122	30,416
A53123	10,135
A5313	290,605
A53131	20,024
A53132	202,934
A53133	33,824
A53134	33,824
A5314	92,373
A53141	7,886
A53142	19,150
A53143	38,301
A53144	7,886
A53145	19,150
A532	270,330
A5321	38,615
A5322	38,615
A5323	77,242
A5324	38,615
A5325	77,242
A533	255,647
A5331	6,554
A5332	104,882
A5333	131,104
A53331	102,789
A53332	6,424
A53333	6,424
A53334	12,849
A53335	2,618
A5334	13,107
A534	382,079
A5341	14,597
A5342	294,491
A53421	144,619
A53422	27,249
A53423	40,873
A53424	54,502
A53425	27,249
A5343	58,395
A5344	14,597
A54	284,128
A6	305,690
A61	191,734
A62	34,957
A63	14,842
A64	64,157
A7	266,976

Table 4-14 shows that each activity cost is reduced, especially the activities that have high potential for cost reduction. For example, activity cost and time consumption of activity A5 and its sub-activities that have the greatest potential of cost reduction is reduced as shown in Table 4-15.

**Table 4-15: Cost and time reduction of Activity A5 and its sub-activities that have the greatest potential of cost reduction.**

Activity	Cost (Baht)		Time Consuming (Months)	
	Existing	Simulation	Existing	Simulation
A5	4,088,514	2,596,671	20	14.5
A53	2,136,276	1,338,613	9.5	8
A531	884,990	546,720	9.5	8
A5313	412,630	249,071	4	3.5
A53132	287,752	174,353	3	2.5
A5311	276,882	180,221	6	4
A53113	239,754	157,219	5.75	3.75
A534	508,312	336,957	5	3.5
A5342	394,916	258,281	3.5	3
A53421	200,885	123,659	2	1.5
A53424	70,560	24,476	2	1.5
A5343	75,601	52,453	1	0.75
A532	390,942	224,092	6	6
A5325	111,705	64,030	2	1.5
A5323	111,705	64,030	2	1.5
A533	352,032	230,845	7	6
A5333	180,534	118,385	5	4.5
A53331	141,425	92,816	4	3
A5332	144,425	94,706	5	3
A51	1,170,250	785,324	6	4
A512	472,388	303,152	6	4
A511	442,287	305,605	6	4
A513	255,576	176,566	6	4
A54	391,046	248,642	1.5	1
A52	390,942	224,092	4	2.5
A522	86,872	49,796	1	0.5
A521	86,872	49,796	1	0.5
A525	65,162	37,352	0.75	0.5
A524	65,162	37,352	0.75	0.5



## Comparison of Existing Process and Simulation Process

### 1. Comparison of Total Working Time of Existing Process and Simulation Process

The comparison result of total working time of existing process and simulation process shows that the total working time of each functional element of the simulation process is less than the total working time of the existing process. For example, in PD element, the total working time of existing process was 31 months while the total working time of simulation process is 23 months. In other words, the total working time spent in PD element in the simulation process is less than the time spent in existing process by 8 months or 25.8 %. The total working time of each functional element of the existing process compared with simulation process is shown in table 4-16.

**Table 4-16: Comparison of total working time**

Functional Element	Existing Total Working Time (months)	Simulation Total Working Time (months)	Difference (months)
PD	31	23	8
PM	31	23	8
PC	2.5	2	0.5
BA	0.5	0.5	-
TB	7.5	6	1.5
CM	1	1	-
EM	31	23	8
CC	13.75	10	3.75
MC	11.75	9.75	2
EC	7.5	6.25	1.25
CE	6.5	4.5	2
ME	6.5	4.5	2
EE	6.5	4.5	2
ST	17	14.5	2.5
LG	8.5	7	1.5
AM	31	23	8

### 2. Comparison of Schedule, before and after the Process Improvement

The schedule of the process before the process improvement is shown in Appendix B. The schedule of the process after the process improvement is shown in Appendix C.

### 3. Comparison of Personnel's Time Allocation

After improving the process, the time allocation of all personnel can be approximately reduced by 10 percent, except the person who worked in the Civil Construction, Mechanical Construction, and Electrical Construction element as these persons must work full time to complete these jobs. In addition, some person will not be assigned to work in the element that he or she had worked before. For example, after process improvement, PS will not be assigned to work in Budget & Accounting element, Contract Management, and Mechanical Construction. This action can definitely reduce costs. The detail of comparison of personnel's time allocation is shown in table 4-17.

**Table 4-17: Comparison of Personnel's Time Allocation**

Functional Element	Personnel	Existing Time Allocation (%)	Simulation Time Allocation (%)	Remark
Project Director (PD)	K.P.	30	27	
Project Management (PM)	N.W.	30	27	
Planning & Control (PC)	D.K.	10	9	
	P.S.	10	9	
	J.B.	10	9	
Budgeting & Accounting (BA)	P.S.	10	-	Reduce personnel
	W.S.	10	9	
TOR & Bidding (TB)	D.K.	30	27	Reduce personnel
	P.S.	10	9	
	W.S.	10	-	
	J.B.	20	18	
Contract Management (CM)	P.S.	10	-	Reduce personnel
	W.S.	10	9	
Engineering & Construction Management (EM)	K.W.	30	27	
Civil Construction (CC)	K.D.	100	100	Reduce personnel
	N.S.	100	-	
Mechanical Construction (MC)	P.S.	20	-	Reduce personnel and use low cost personnel instead of high cost personnel
	W.S.	80	100	
Electrical Construction (EC)	J.B.	100	100	
Civil Engineering (CE)	K.D.	10	9	
Mechanical Engineering (ME)	D.K.	5	-	Reduce personnel
	P.S.	10	9	
	W.S.	10	-	

**Table 4-17 (Continued): Comparison of Personnel's Time Allocation**

Functional Element	Personnel	Existing Time Allocation (%)	Simulation Time Allocation (%)	Remark
Electrical & Instrumental Engineering (EE)	J.B.	10	9	
Safety (ST)	I.N.	10	9	
Legal (LG)	P.R.	10	9	
Administration (AM)	K.T.	20	18	
	R.K.	30	27	
	N.I.	30	27	

### **Conclusion on Cost Simulation**

By applying the ABC modeling and cost simulation in this study, the total cost of the project management can be reduced from 6,474,300 Baht to 4,495,922 Baht or approximately 30%. The total time of this project can be reduced by 8 months.