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IMPACT ON FINANCIAL CAPABILITY OF CONSTRUCTION CONTRACTOR: CASE STUDY OF THAI GOVERNMENT PROJECT AFFECTED BY 2011 MAJOR FLOOD CRISIS

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ABSTRACT

The 2011 Thailand's flood crisis is one of the most severe unexpected events that occurred of the Central Plains of Thailand. This study proposes the extreme criteria for assessing the potential impact on the financial capability of a contractor who experiences a building construction of the government sector and is suffered from this disaster. The delays of the project consists of: (1) the delay causing by flooding for 48 days which resulted from the construction site cannot be accessed; (2) the delay causing by the period of time to solve the soil problems for 215 days and 261 days for the main and service buildings, respective; and (3) the contractor responsible delay obtained from analytical result is 22 days, which may cause by the shortage of some construction materials. The 55 percent of the construction budget is claimed as the extreme criteria for assessing the financial capability of a potential contractor for getting a job after such a serious natural disaster. Lesson learned from the rare disaster is finally presented into four categories.

1. INTRODUCTION

The flood crisis in Central Plains of Thailand in 2011 extensively impacts on the construction industries. Construction projects after the flood disaster face more difficult problems than the usual situation. Many unexpected events occur. Transportation system is damaged since many roads cannot be immediately repaired after the effects of the flood. Resources, which are needed for a construction project such as labor, materials, and equipment, become the crucial issues.

Regarding the labor situation, after the flood has subsided, some business temporarily suspends. Several construction companies continue to keep their employees and expect to achieve their original performance as soon as possible. However, some businesses need to speed up their performance

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during the period of reconstruction. This increases the labor demand especially for the experienced workers and technicians resulting in the awareness of the labor shortage.

The material manufacturers are affected by floods. Many construction contractors require the same material at the same time. This causes the material shortage and the material prices also rise up. As the flood has affected the construction industry, many contractors are increasingly bearing the burden of balancing the expanding financial, which lead some company to go into liquidation or bankruptcy.

This study intends to record the impact on a building construction of the selected project causing by the 2011 flood crisis in the Central Plain of Thailand. Construction resource management, such as project scheduling with time delays, financial impact, and human resource planning, are investigated. The extreme criteria for assessing the impact on the financial capability of a potential contractor who experiences a building construction of government project suffering from the flood are proposed. Lesson learn from this study, finally, are presented. Information created in this paper is based on the available contract document and the interview results obtained from the Consultants of this construction project.

2. CONSTRUCTION SCHEDULING DELAYS AND RESPONSE TO CRISIS

A construction schedule is complex and changeable in time. All activities need to be planned and well balanced to ensure building completion in the long period of the project. Scheduling delay can be considered as a result causing by one of the three parties; owner, contractor, and a third party or the unexpected events (Arcuri et al., 2007). These are defined as Owner Responsible Delay (ORD), Contractor Responsible Delay (CRD), and delay causing by an unexpected event or Excusable Delay (ED). In addition, when the delay impacts are taken into consideration, a construction schedule is sequentially presented as three different types; the As-planned, Adjusted, and As-built schedules (Alkass et al., 1996). The As-planned schedule is the first plan of the contractor, which are expected for driving the project to completion. The Adjusted schedule is created by a change of the As-planned schedule when the whole project or some original activities are modified. For example, the order of some activity is changed; some construction delays; or the project is sped up. The As-built schedule is the last schedule, which the actual sequence activities at the completion of the project is presented. At different stages of the construction schedule, including the As-built schedule, the different critical paths of the project can be obtained.

Braimah (2013) reviewed existing schedule delay analysis techniques (DATs) aiming to determine the degree of time and/or cost compensation by identifying the responsibility of each party involved in the delays of a construction project. Results show that different techniques applying to the same project provide the different degree of compensation, although the duration of each activity and delays is identical. Pisitpaibool and Suksomkullanan (2018) investigated the impact of schedule delays on a set of nine-building repair which had been damaged by the Thailand Flood Crisis in 2011. Completion of the actual project is 17 days after the finish date of the As-plan schedule. Results from five schedule impact analysis approaches using the retrospective technique were presented. Different time extensions were -8, 0, 0, 17 and 29 days. A time extension of 29 days was gained by the approach, which neglected time overlapping or the effect of concurrent delay. The negative time delay indicated that the delay caused by the contractors had dominated the whole project.

Many construction projects in several parts of the world have experienced the difficulty of some unpredictable and unavoidable crisis. The contractor companies need good plans and executing strategies for their survival to achieve the completion of the project under consideration. Lim et al. (2010) interview 34 senior executives of medium and large-sized construction companies to identify their survival strategies during the unexpected recession in the Singapore industry from 1997 to 2005. The strategies are classified into three types of actions; which relate to (1) contract, (2) cost-control, and (3) financial. Zuo et al. (2014) investigated the response of the Australian construction contractors to the economic downturn causing by the major impacts of the Global Financial Crisis (GFC) in 2008. The interviews were conducted with 35 senior managers from the Top 100 Australian construction companies. Results showed that the particularly large construction companies are not significantly affected; however, they performed certain actions to reduce the leading causes of financial problems in the forthcoming years. The strategies for relieving the negative impacts were classified into four types of actions; (1) human resource management, (2) cost control, (3) sustainability, and (4) business models.

A financial capability is one of the indicators to ensure the ability of a contractor to complete the construction project within the specified schedules and fulfill the quality requirement (Harris and McCaffer, 2013). This includes cash in hand, bank credit, overdraft, credit purchases, work-in-progress, invoiced amount, and etc. Akali and Sakaja (2018) investigated the influence of the financial capacity of contractors on the performance of road construction projects in Kakamega County, Kenya. Interviews and questionnaires are the procedure for data gathering. Results are presented based on the financial capability on the performance of road projects, which are rated by responders.

3. IMPACT ON SELECTED PROJECT DUE TO FLOOD CRISIS IN 2011

A higher educational project located in Pathum Thani, a province in Central Thailand, is selected as the representative of building construction of government project suffering from the flood crisis in 2011.

3.1 OVERVIEW OF SELECTED BUILDING

The selected project consists of two buildings, a main and service buildings. The main building has 5 floors with a total floor area of 15,000 square meters. The total construction cost is approximate THB 300 million within the contract period of 720 days. Some important characteristics of the building are as follows: (1) the structural components consist of the foundation system using concrete spun piles, the precast hollow core slab beam system in the first floor, and the post-tensioned floor system with one-way slab band for the 2nd floor to the flat roof; (2) architectural components consist of the rubber and granite tiles for flooring system, the glass curtain walls for most of the exterior wall system, concealed ceiling, and install aluminum composite panel (ACP) as exterior decoration; (3) air conditioning systems of this building uses a chiller system; and (4) a generator is installed for backup the power source.

The service building is comparatively small and used for installing the facility system to support the main building. This is a two-story building with a total floor area of 750 square meters. The construction cost of the service building is included in the overall project budget of the main building.

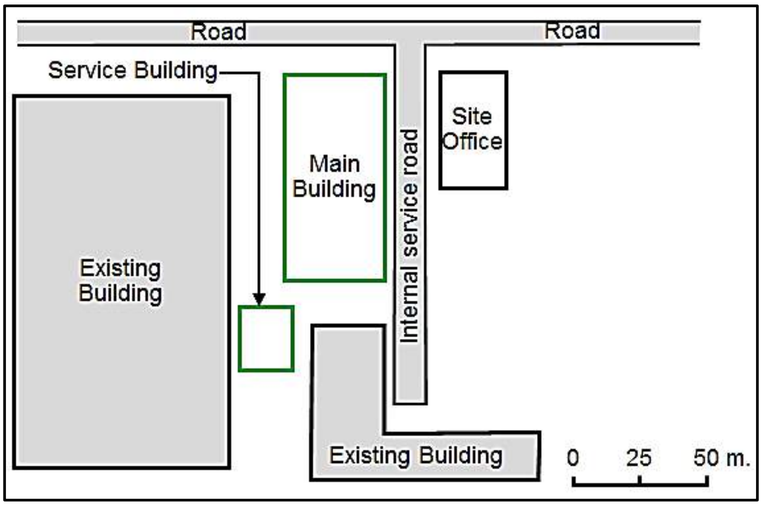


Figure 1: Site layout plan.

Figure 1 shows the top view of the case study with the location of the main and service buildings to be constructed. The construction site is adjacent to two existing buildings representing by dashed cells; one existing building is on the left-hand side and the other one is at the bottom. The site office is located on the opposite side of the internal service road. The minimum distances between the main and service buildings are approximately 10 meters.

3.2 COMPLETION OF SELECTED PROJECT WITH UNEXPECTED DELAYS

The project completion can be simply defined by the bar charts showing only the duration, start and finish dates of the As-planned and the As-built schedules, following by three delay durations as shown in Figure 3.2. The actual delay of the whole project is calculated by the time difference between the duration of the As-built and As-planned schedules, which is 983 – 720 = 263 days. These criteria are based on the Net Impact Approach (Brambee et al., 1990; Arcuri et al., 2007). There are two major unexpected events that occur throughout the project: (1) flooding which results in the construction site cannot be accessed; and (2) solving the soil problem, since most piles that are tested cannot resist the specified loads. However, these two major events cause three Excusable Delays (ED): (1) a delay of the Activity 1 or the surveying activity causing by flooding; (2) a delay of the Activity 4 or the foundation activity of the main building; and (3) a delay of the Activity 49 or the foundation activity of the service building. This is a concurrent delay with overlapping between these last two Excusable Delays, which cause by the period of time to solve the soil problem.

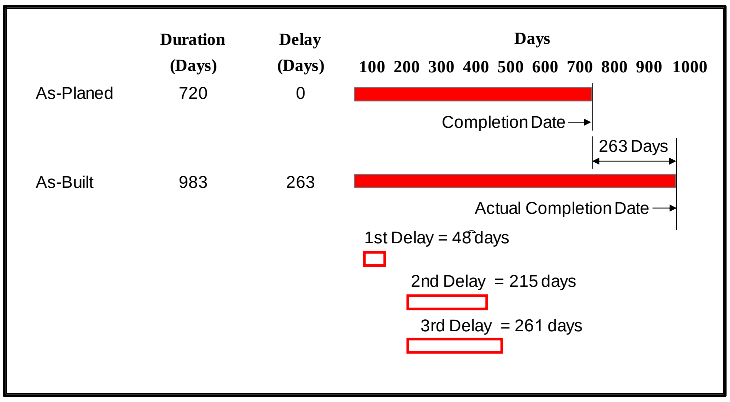


Figure 3: Bar chart of the whole project with Excusable Delays.

Table 1 presents the duration, start and finish dates of the three activities of Excusable Delay (ED) of the As-planed and As-built schedules. The end dates of each event causing the delay are also included in the As-built. The delay duration of the Activity 49 or the Foundation activity of the service building in the As-built schedule is 289 days, which is 14 days longer than that of the delay duration of Activity 4 of the main building (275 days), although its total floor area is comparatively smaller. This results by the building locations are separated and their operations for foundation activities are independent. In addition, the number of types of machinery for the foundation activity of the service building is significantly smaller than that of the main building.

Table 1: Three activities of ED affecting by the two major unexpected events

Activity	As-planned Start	As-planned Finish	Duration (Days)	As-built Start	As-built Event End	As-built Finish	Duration (Days)
1 Surveying	1	30	30	1	66	73	73
4 Foundation	30	90	60	141	371	416	275
49 Foundation	60	120	60	173	371	462	289

3.3 SELECTED PROJECT SCHEDULING WITH TIME DELAYS

Three different types of schedules of the selected building construction causing by the flood crisis in 2011 are presented to determine the impact of delay affecting the project completion. These include the As-planed, Adjusted, and As-built schedules.

The As-planned schedule shown in Figure 3.3 is created from the available contract document. The designer uses a payment method called the percentage of completion method. This method recognizes the revenue and expenses as a percentage of the project completed during several construction periods. The As-planed project duration is 720 days

The Adjusted schedule of this project shown in Figure 3.4 is obtained by inserting all Excusable Delays (ED) into the As-planned schedule. Activities are split by each delay. All Excusable Delay activities consist of a case causing by flooding and the other two cases causing by solving the soil problem. In addition, the contractor requests for swapping of the order and subdividing of some activities for receiving a faster payment. This reflects the change in start and finish dates including the duration of some activities in the Adjusted schedule. The Adjusted project duration becomes 961 days with three cases of the Excusable Delays.

As-Plan1 (Designer)	No.	Activities	Duration	Completion date
Surveying	1	Surveying	30	30
	2	Site office	30	45
Main building				
Foundation work	3	Piling work	45	60
	4	Foundation	60	90
1st Floor	5	Structure	60	135
	6	Ductwork	60	270
	7	Brickwork	39	240
	8	Tile finish and Interior wall plastering	60	300
	9	Ceiling	30	300
	10	Door and Window	30	330
2nd floor	11	Structure	55	150
	12	Ductwork	82	300
	13	Brickwork	39	270
	14	Tile finish and Interior wall plastering	60	330
	15	Ceiling	35	330
	16	Door and Window	57	360
3rd floor	17	Structure	55	180
	18	Ductwork	82	330
	19	Brickwork	39	300
	20	Tile finish and Interior wall plastering	60	360
	21	Ceiling	35	360
	22	Door and Window	57	390
4th floor	23	Structure	60	210
	24	Ductwork	82	360
	25	Brickwork	39	330
	26	Tile finish and Interior wall plastering	60	390
	27	Ceiling	35	390
	28	Door and Window	57	420
5th floor	29	Structure	55	240
	30	Ductwork	82	390
	31	Brickwork	39	360
	32	Tile finish and Interior wall plastering	60	420
	33	Ceiling	35	420
	34	Door and Window	57	450
Roof floor	35	Structure	85	270
Architecture, interior, and landscape	36	Decoration work	225	570
	37	Exterior painting	280	600
	38	Landscape	230	690
	39	Aluminium composite panel	80	600
	40	Exterior decoration	30	480
	41	Wiring	30	480
	42	Lamp	60	540
	43	Rubber tile finish	42	570
	44	Furniture	100	690
Facility system	45	Air Handling Unit	60	510
	46	Sanitary system	50	540
	47	Elevator	117	690
Service building				
Foundation work	48	Piling work	80	90
	49	Foundation	60	120
1st Floor	50	Structure	60	150
	51	Brickwork	39	450
2nd floor	52	Structure	55	180
	53	Brickwork	39	480
Roof floor	54	Structure	70	210
Architecture	55	Architecture and Facility management	30	720
Facility system	56	Transformer	80	630
	57	Pumping system	70	630
	58	Cooling tower	90	690
	59	Generator	50	660
Finish	60	Completeness check	30	720

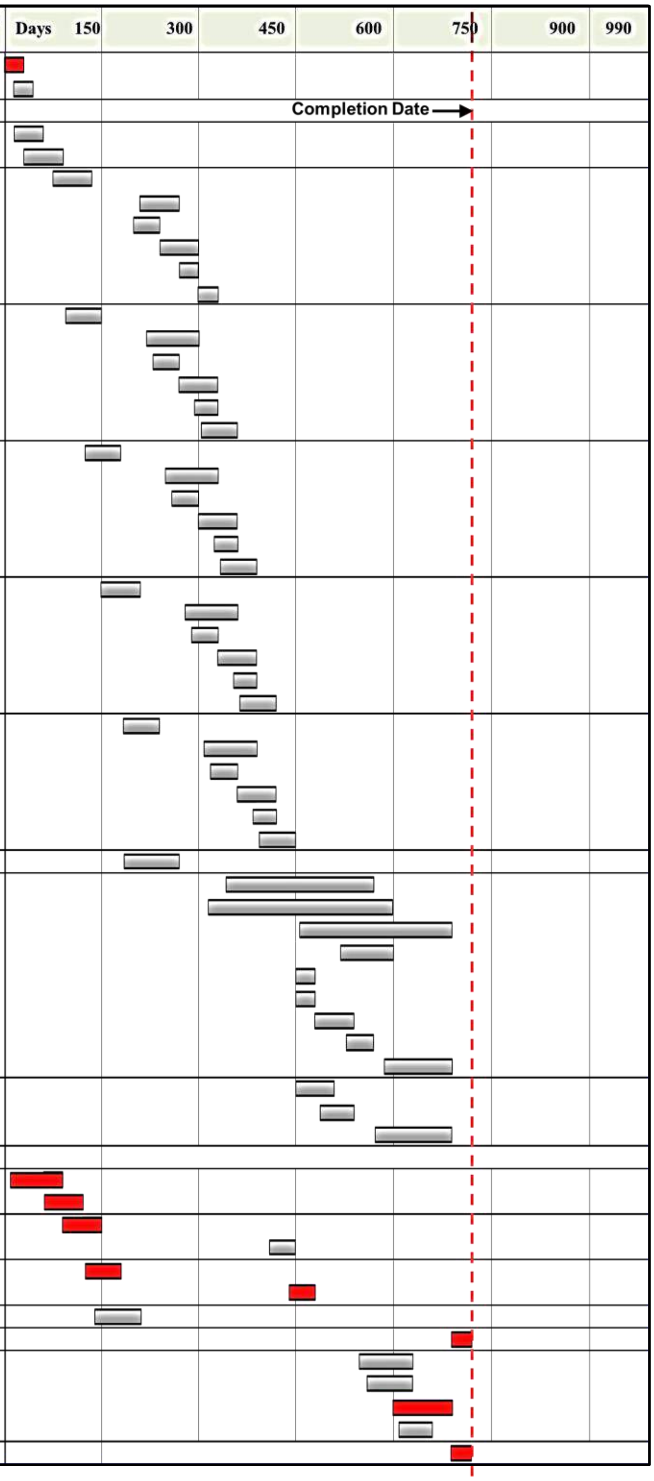


Figure 3: As-planned schedule.

The As-built schedule or the last schedule shown in Figure 5 expresses the sequence of all actual activities and delays at the completion of the project. Comparing with the Adjusted schedule, the start and finish dates including the durations of several activities of the As-built schedule are changed depending on the delays or the acceleration of the construction works. The As-built project duration is 983 days, which consists of three cases of the Excusable Delays (ED) and twenty-six cases of Contractor Responsible Delays (CRD).

As-Plan2 (Contractor)	No.	Activities	Duration	Completion date
Surveying	1	Surveying	30	30
		ED from flooding	48	73
	2	Site office	30	86
Main building				
Foundation work	3	Piling work	45	101
	4	Foundation	60	131
		ED from solving soil ploblems	215	331
1st Floor	5	Structure	60	376
	6	Ductwork and Wiring	172	571
	7	Brickwork	39	481
2nd Floor	11	Structure	55	391
	12	Ductwork and Wiring	142	571
	13	B2 Brickwork	39	511
	14	Tile finish and Interior wall plastering	42	571
	15	Ceiling and Lamp	125	691
	16	Door and Window	147	661
3rd floor	17	Structure	55	421
	18	Ductwork and Wiring	142	601
	19	Brickwork	39	511
	20	Tile finish and Interior wall plastering	60	601
	21	Ceiling and Lamp	125	721
	22	Door and Window	147	691
4th floor	23	Structure	60	451
	24	Ductwork and Wiring	142	631
	25	Brickwork	39	571
	26	Tile finish and Interior wall plastering	60	631
	27	Ceiling and Lamp	125	751
	28	Door and Window	147	721
5th floor	29	Structure	55	481
	30	Ductwork and Wiring	54	661
	31	Brickwork	39	541
	32	Tile finish and Interior wall plastering	60	661
	33	Ceiling and Lamp	125	781
	34	Door and Window	147	751
Rooftop floor	35	Structure	85	511
Architecture, interior, and landscape	36	Decoration work	225	751
	37	Exterior painting	280	871
	38	Landscape	230	901
	39	Aluminium composite panel	80	841
	40	Exterior decoration	80	841
	43	Rubber tile finish	42	811
	44	Furniture	100	931
Facility system	45	Air Handling Unit	48	571
	46	Sanitary system	50	781
	47	Elevator	81	871
	61	Treatment tank	70	781
Service building				
Foundation work	48	Piling work	80	133
	49	Foundation	60	203
		ED from solving soil ploblems	284	402
1st Floor	50	Structure	60	423
	51	Brickwork	39	543
2nd Floor	52	Structure	55	453
	53	Brickwork	39	543
Rooftop floor	54	Structure	70	483
Architecture	55	Architecture and Facility management	30	723
Facility	56	Transformer	80	573
	57	Pumping system	70	573
	58	Cooling tower	90	603
	59	Generator	50	573
Finish	60	Completeness check	30	961

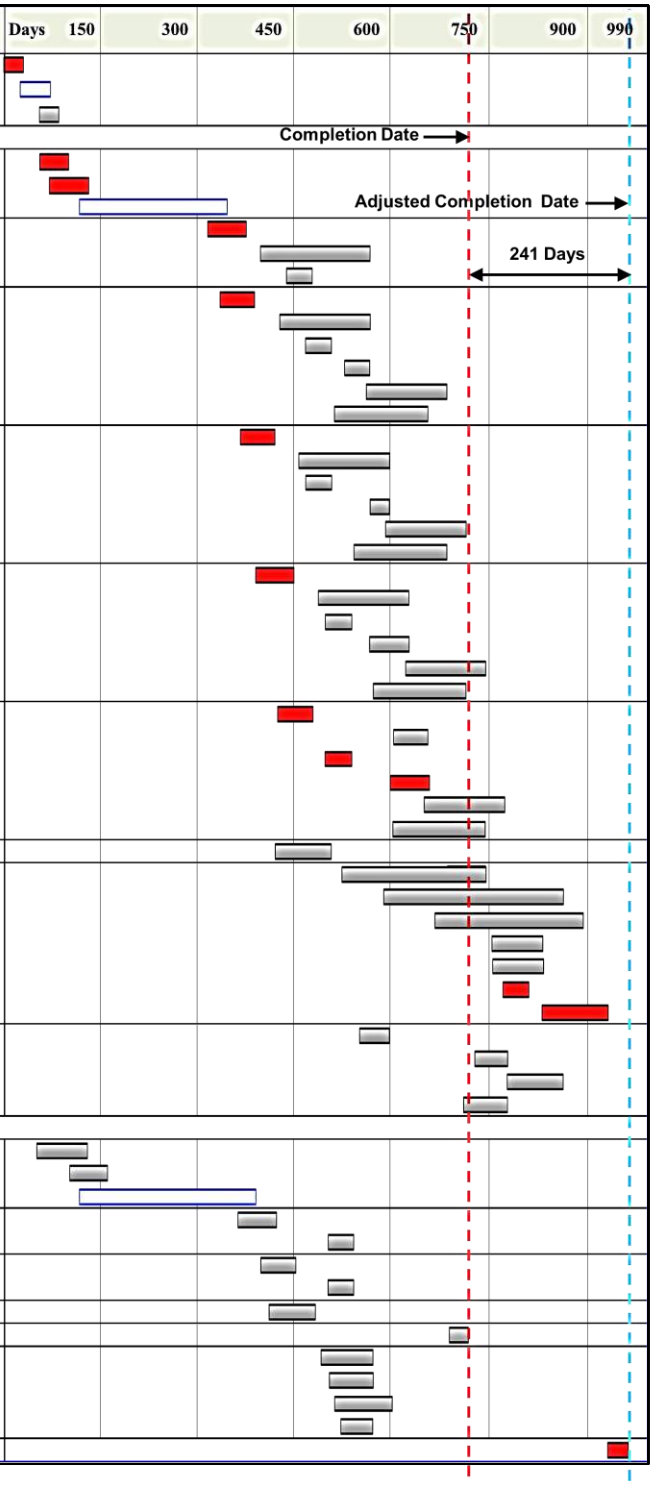


Figure 4: Adjusted schedule.

To determine the impact of delay affecting the overall project completion, the analysis is divided into three steps. In the first step, the modified time for Excusable Delay of the project is calculated by the time difference between the Adjusted project duration and the As-planned project durations, which is 961 – 720 = 241 days. In the second step, the actual delay of the whole project is calculated by the time difference between the As-built project duration and the As-planned project durations, which is 983 – 720 = 263 days. In the third or last step, the Contractor's Responsibility is determined by subtracting the result obtained from the second step by the one from the first step, which is 263 – 241 = 22 days.

As-Built	No.	Activities	Duration	Completion date
Surveying	1	Surveying	30	30
		ED from flooding	48	73
	2	Site office	30	86
Main building				
Foundation work	3	Piling work	45	131
		CRD	78	186
	4	Foundation	60	201
		ED from solving soil ploblems	215	416
1st Floor	5	Structure	60	446
		CRD	46	462
	6	Ductwork and Wiring	172	672
		CRD	189	775
	7	Brickwork	39	591
		CRD	46	618
2nd Floor	11	Structure	55	492
		CRD	60	525
	12	Ductwork and Wiring	142	705
		CRD	141	775
	13	Brickwork	39	645
		CRD	104	730
	14	Tile finish and Interior wall plastering	40	775
	15	Ceiling and Lamp	55	825
	16	Door and Window	82	820
3rd floor	17	Structure	55	550
		CRD	31	553
	18	Ductwork and Wiring	142	733
		CRD	143	805
	19	Brickwork	39	643
		CRD	136	760
	20	Tile finish and Interior wall plastering	60	805
	21	Ceiling and Lamp	56	841
	22	Door and Window	57	825
4th floor	23	Structure	60	583
		CRD	35	588
	24	Ductwork and Wiring	142	768
		CRD	93	790
	25	Brickwork	39	708
		CRD	56	745
	26	Tile finish and Interior wall plastering	40	805
	27	Ceiling and Lamp	108	893
	28	Door and Window	76	841
5th floor	29	Structure	40	618
	30	Ductwork and Wiring	54	798
		CRD	49	820
	31	Brickwork	39	678
		CRD	116	775
	32	Tile finish and Interior wall plastering	40	820
	33	Ceiling and Lamp	103	893
	34	Door and Window	80	863
Rooftop floor	35	Structure	85	663
		CRD	180	801
Architecture, interior, and landscape	36	Decoration work	225	893
	37	Exterior painting	285	924
	38	Landscape	230	924
	39	Aluminium composite panel	80	893
	40	Exterior decoration	80	893
	43	Rubber tile finish	40	893
	44	Furniture	100	927
Facility system	45	Air Handling Unit	48	805
	46	Sanitary system	50	835
	47	Elevator	81	924
	61	Treatment tank	70	781
		CRD	89	835
Service building				
Foundation work	48	Piling work	80	133
		CRD	110	203
	49	Foundation	60	233
		ED from solving soil ploblems	261	462
1st Floor	50	Structure	60	492
		CRD	63	525
	51	Brickwork	39	645
		CRD	175	801
2nd Floor	52	Structure	45	553
	53	Brickwork	39	645
		CRD	175	801
Rooftop floor	54	Structure	70	585
		CRD	38	588
Architecture	55	Completeness check	30	825
Facility	56	Transformer	80	642
		CRD	199	801
	57	Pumping system	70	676
		CRD	160	801
	58	Cooling tower	90	805
	59	Generator	50	676
		CRD	150	801
Finish	60	Completeness check	30	953
		CRD	41	983

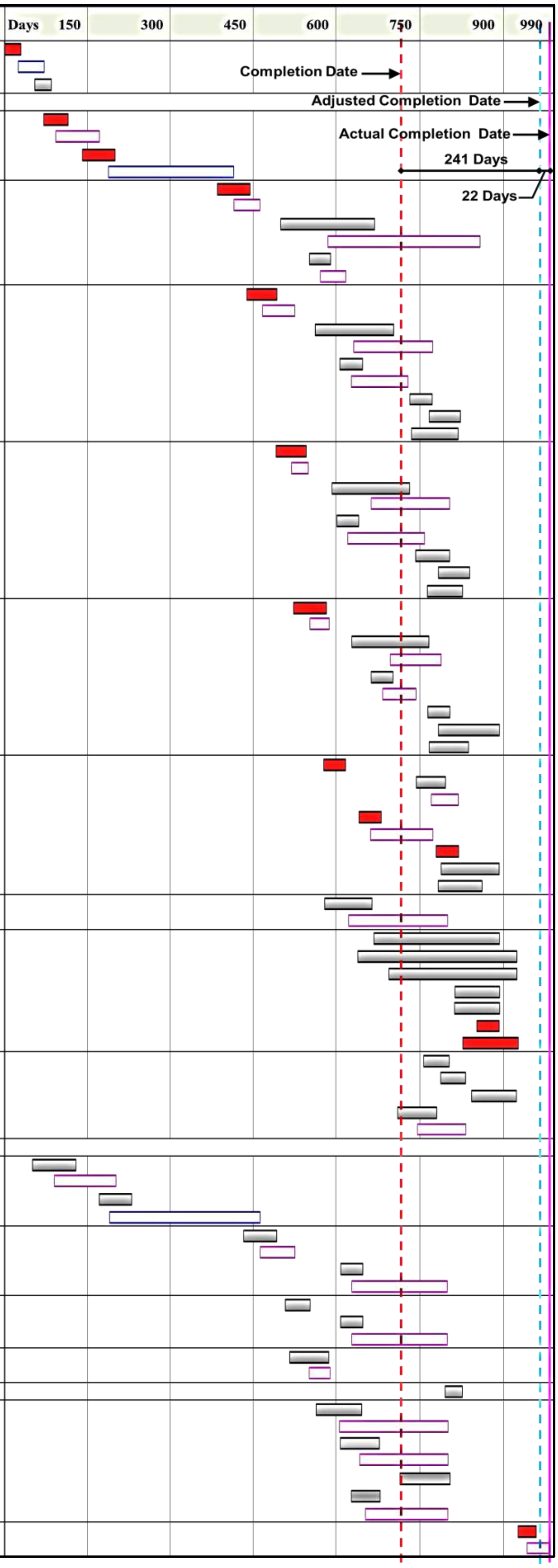


Figure 5: As-built schedule.

4. CONSTRUCTION RESOURCE MANAGEMENT AFTER FLOOD CRISIS IN 2011

The contractor, who experiences a building construction project in this area, suffers from the unexpected flood crisis in 2011. When the floodwater has subsided, it leaves extensive damage to homes, property, and the environment. Various control approaches are performed to expect the project completion on time within the available budget. Construction resource management of the selected project is presented in the following keywords; financial impact, workforce planning, and proposed financial capability.

4.1 FINANCIAL IMPACT

Financial situations of the selected project can be classified into three phases as shown by a step line chart in Figure 6. Each line represents the accumulated amount of the construction cost at several defined phase of the construction project.

The green line (the first line) represents the payment schedule of the original plan (the As-plan), which is set up by the designer. The contractor is expected to receive the payment from the owner following the terms of the contract between them.

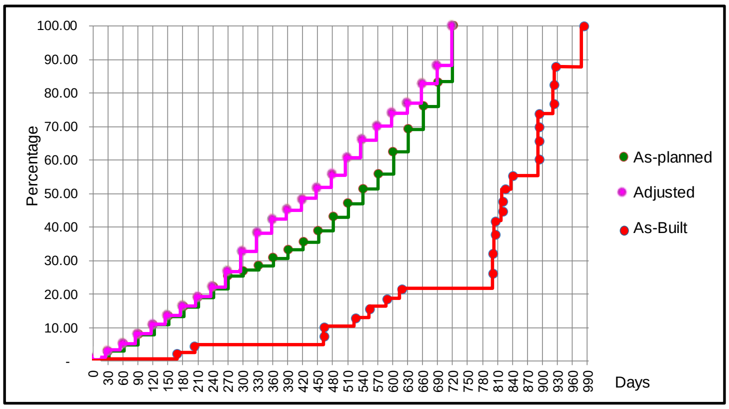


Figure 6: Financial situations of the selected project.

The magenta line (the second line) refers to the payment schedule of the Adjusted plan, which is requested by the contractor once the water subsides. The contractor requests to swap the order of some activities within the construction period and the payment schedule for survival project management. The cumulative amount of construction cost of the Adjusted schedule plan increases faster than the original plan (the As-plan schedule) starting from the 9th period to the 11th period (or from the 270th to 330th days). For the 9th, 10th, and 11th work periods, the payment increases by 1.33%, 4.42% and increased by 4.12%, respectively. Therefore, the difference between the cumulative payment of the original plan (the As-plan schedule) and the Adjusted schedule from the 9th period to the 11th period is 9.87 percent.

The red line (the third line) refers to the payment schedule of the plan created based on the project completion (the As-built). The contractor fails to keep the construction project as expected on the Adjusted schedule plan. According to the actual construction (the As-built), the major late withdrawal on the construction project representing by the flat straight line of the payment schedule of the As-built plan (the red line) may be classified into three periods. The first period of late withdrawal occurs on days 1 to 168. The second period of late withdrawal occurs on days 203 to 462.

The third period of late withdrawal occurs on days 618 to 800. Therefore, the duration of the three late withdrawal is 168, 260, and 183 days, respectively.

The first period of late withdrawal suffers from flooding and restoration of the construction site after the flood. The activities occurring during this period are a site layout survey, construction of the temporary office and the installation of the piling work of the main building. In this period, it is requested to install the piles more than 50 percent of the piling work installation. The contractor, fortunately, meets this requirement.

The second period of late withdrawal suffers from the unexpected soil problem since the soil strength is reduced caused by the flood. Most of the piles that are tested cannot resist the specified load. The contractor solves the problem by using the Shaft Grouting method. The cement is injected into the soil in the project area in order to increase the capabilities of the soil strength.

It is not completely clear what causes the late withdrawal in the third period. Based on the interview results obtained from the Consultants of this construction project, it appears that the Contractor seems to have problems with the shortage and delay in material supply. The shortage material, which mainly affects the delay, is supposed to be the bricks since it is the main material of the brickwork activity. The start dates of subsequent activities are then delayed.

Although there are three periods of major late withdrawal on the actual construction (the red line or the As-built), some activities are speeded up so that the contractor can submit multiple tasks three times after the third period.

In the first period (days 801 to 841), the contractor has a late withdrawal that starts on the 9th of the payment schedule and ends on the 16th of the payment schedule. In the second period (days 893), the contractor has a late withdrawal that starts on the 17th of the payment schedule and ends on the 20th of the payment schedule. In the third period (days 924 to 927), the contractor has a late withdrawal that starts on the 21st of the payment schedule and ends on the 23rd of the payment schedule.

4.2 WORKFORCE PLANNING WITH FINANCIAL PERFORMANCE

To investigate the plan for speeding up the work so that the multiple tasks can be submitted after the periods of late withdrawal, workforce planning is discussed. The variation in numbers of people in the workforce that are employed over the whole project is presented using a vertical bar graph in the lower part of Figure 7. This part includes the graphs of the cumulative percentage of completion of actual work (the blue line) and the accumulative percentage of the actual payment schedule from the project completion (the red line or the As-built).

The workforce data in the lower part of Figure 4.2 is presented as the average of numbers of people in every 10 days. The workforce is divided into 4 groups. The first three groups are woodworker, steelworker, and labor. The fourth group or the last group consists of the remainders, which include the machine operator, bricklayer, plasterer, tile technician, ceiling technician, welder, painter, furniture technician, elevator technician, aluminum technician, glass technician, plumber, mechanical technician, electrician, sprinkle technician, air conditioning technician, and cleaner.

In Figure 7, flooding occurs on day 26 to day 66. After the floods subsided, the number of people in every group of the workforce is increased. The contractor aware of the labor shortage and starts to collect human resources in order to keep the specialty resources so that the project can be accelerated as soon as possible. Then, since the soil strength is reduced caused by the flood, the time is required for solving this soil problem. The contractor then decides to reduce the number of people in every group of the workforce during the soil problem. Then, the contractor again starts to collect people in every group of the workforce approximately after the soil problem has been solved. However, in the beginning, the contractor emphasis mainly on people in the first three groups of the workforce; who work at structural components.

From day 619 to day 800, the flat line of the accumulative percentage of the actual payment schedule (the red line or the As-built) represents that the contractor cannot withdraw. It is expected to be caused by the shortage of some construction materials such as brick, duct, and wire. However, the graphs of the cumulative percentage of completion of actual work (the blue line) appears a line with a positive slope. It represents that, during this period, the contractor is also worked in other activities. From the beginning of this period, the number of people in the first three groups of the workforce is reduced. In contrast, the number of people in the fourth group of the workforce is largely employed. This supports the contractor strategy for survival management by a request to swap the order of activities within the construction period and the payment schedule

After the problem of material shortage has been solved, the contractor can submit multiple tasks three times from day 801 to day 927. The construction project finally reaches completion on the day 983. The relationship between the average number of people in the workforce and the activities in the As-built schedule of this construction project can be seen in Figure 7.

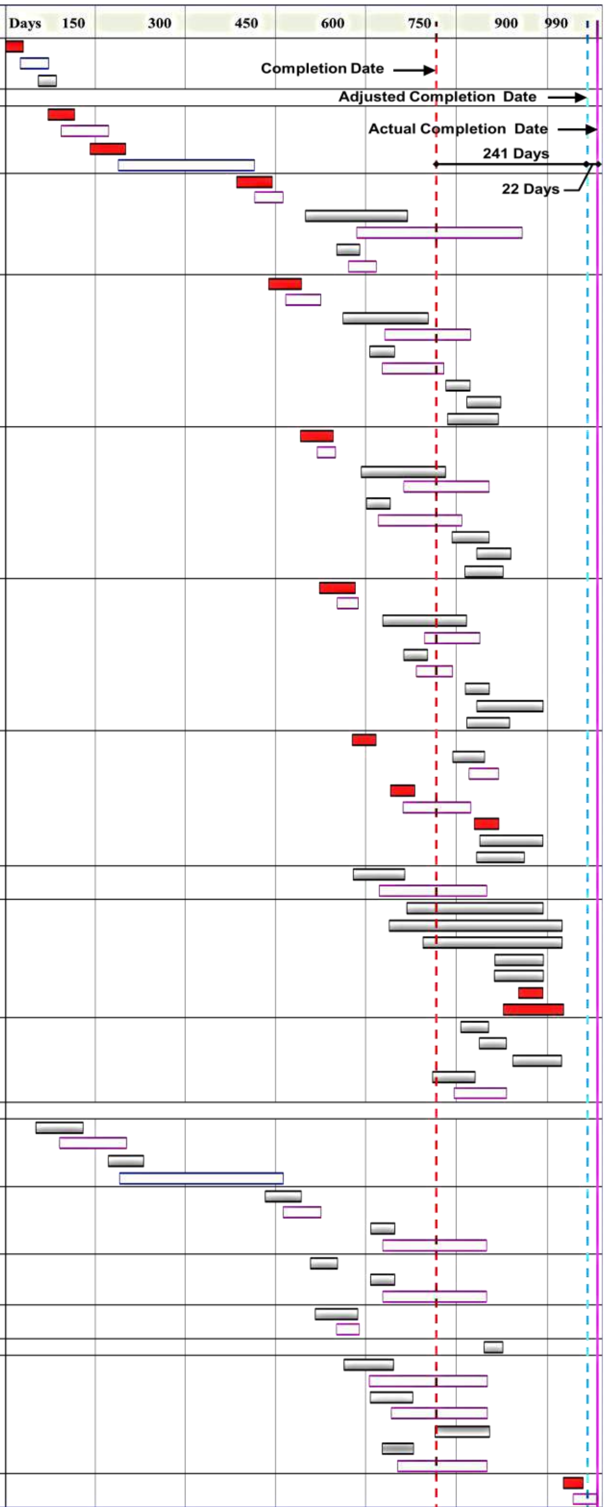
4.3 PROPOSED FINANCIAL CAPABILITY FOR POTENTIAL CONTRACTOR

During the construction, the contractor has to bear the expenses of the project that have already been done but cannot withdraw. The contractor may use the external sources of finance to manage this project for survival, since the contractor may lack his own sufficient financial liquidity to continue construction work. In order to analyze the difference between the actual construction progress and the construction cost that withdrew, the percentage chart of the cumulative percentage of complete of actual work is compared with the accumulative percentage of the actual payment schedule from the project completion as shown in Figure 8.

From Figure 8, it is found that during the 90th day until the 630th day of construction, the contractor had to bear small expenses amounts of the project that have already been done but cannot withdraw. However, during the period between 630th and 800th day of construction, the contractor had to bear a larger amount of the expenses of the project that have already been done but cannot withdraw. The maximum difference occurs on the 800th day of construction approximately 55.62 percent of the construction cost.

It is found that the 800th day of construction is a critical date for the financial survival of this project. The contractor has to bear the highest burden of all expenses for activities that have already been done but cannot withdraw. Therefore, 55 percent of the construction projects is claimed as the extreme criteria for assessing the financial capability of a potential contractor for getting a job after such a serious natural disaster.

As-Built	No.	Activities	Duration	Completion date
Surveying	1	Surveying	30	30
		ED from flooding	48	73
	2	Site office	30	86
Main building				
Foundation work	3	Piling work	45	131
		CRD	78	186
	4	Foundation	60	201
		ED from solving soil ploblems	215	416
1st Floor	5	Structure	60	446
		CRD	46	462
	6	Ductwork and Wiring	172	672
		CRD	189	775
	7	Brickwork	39	591
		CRD	46	618
2nd Floor	11	Structure	55	492
		CRD	60	525
	12	Ductwork and Wiring	142	705
		CRD	141	775
	13	Brickwork	39	645
		CRD	104	730
	14	Tile finish and Interior wall plastering	40	775
	15	Ceiling and Lamp	55	825
	16	Door and Window	82	820
3rd floor	17	Structure	55	550
		CRD	31	553
	18	Ductwork and Wiring	142	733
		CRD	143	805
	19	Brickwork	39	643
		CRD	136	760
	20	Tile finish and Interior wall plastering	60	805
	21	Ceiling and Lamp	56	841
	22	Door and Window	57	825
4th floor	23	Structure	60	583
		CRD	35	588
	24	Ductwork and Wiring	142	768
		CRD	93	790
	25	Brickwork	39	708
		CRD	56	745
	26	Tile finish and Interior wall plastering	40	805
	27	Ceiling and Lamp	108	893
	28	Door and Window	76	841
5th floor	29	Structure	40	618
	30	Ductwork and Wiring	54	798
		CRD	49	820
	31	Brickwork	39	678
		CRD	116	775
	32	Tile finish and Interior wall plastering	40	820
	33	Ceiling and Lamp	103	893
	34	Door and Window	80	863
Rooftop floor	35	Structure	85	663
		CRD	180	801
Architecture, interior, and landscape	36	Decoration work	225	893
	37	Exterior painting	285	924
	38	Landscape	230	924
	39	Aluminium composite panel	80	893
	40	Exterior decoration	80	893
	43	Rubber tile finish	40	893
	44	Furniture	100	927
Facility system	45	Air Handling Unit	48	805
	46	Sanitary system	50	835
	47	Elevator	81	924
	61	Treatment tank	70	781
		CRD	89	835
Service building				
Foundation work	48	Piling work	80	133
		CRD	110	203
	49	Foundation	60	233
		ED from solving soil ploblems	261	462
1st Floor	50	Structure	60	492
		CRD	63	525
	51	Brickwork	39	645
		CRD	175	801
2nd Floor	52	Structure	45	553
	53	Brickwork	39	645
		CRD	175	801
Rooftop floor	54	Structure	70	585
		CRD	38	588
Architecture	55	Completeness check	30	825
Facility	56	Transformer	80	642
		CRD	199	801
	57	Pumping system	70	676
		CRD	160	801
	58	Cooling tower	90	805
	59	Generator	50	676
		CRD	150	801
Finish	60	Completeness check	30	953
		CRD	41	983



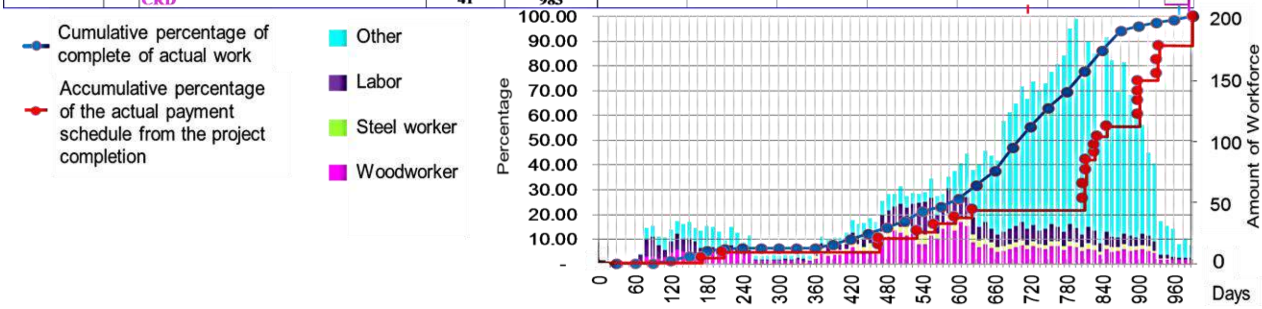


Figure 7: The relationship between the As-built schedule, financial and workforce planning.

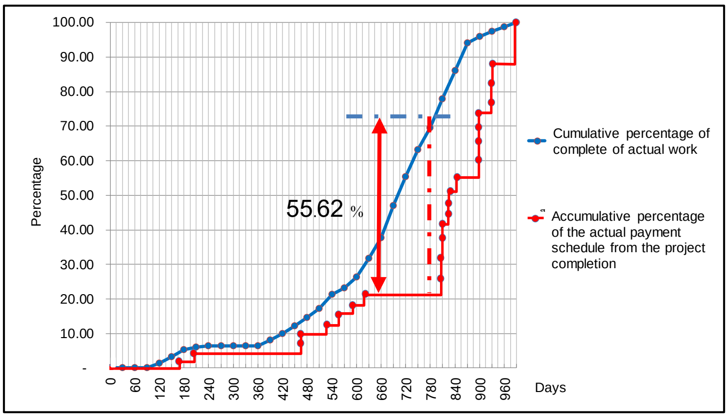


Figure 8: The cumulative percentage of complete actual work and the accumulative percentage of the actual payment schedule from the project completion.

5. LESSON LEARNED

Lesson learned from this study is finally presented into 4 categories: {1} strength properties of soil is decreased; {2} an available government assistance is the time extension causing by flooding and labor shortage; {3} the survival project management is requested for receiving a faster payment, and {4} conceptual design in this area is changed for preventing or reducing the future damage.

{1} the unexpected problem caused by the flooding is the decrease in soil strength in this area. Most piles that are tested cannot resist the specified loads. The time required for solving this soil problem is 170 days, which is 23.61 percentage of construction.

{2} the government is aware of these situations. Assistance is the time extensions causing by flooding and labor shortage, which are 180 days, and 150 days, respectively. This project can, therefore, combined these time extension and requests as the Excusable Delay of 180 + 150 = 330 days. However, the actual delay of the project consists of : (1) the delay causing by flooding which resulted in the construction site cannot be accessed for 48 days; (2) the concurrent delays causing by the time period for solving soil problems, which are 215 days and 261 days for main and service buildings, respectively. However, the shorter delay, 215 days, for the main building is taken into account since it is the critical path of the As-built schedule; and (3) the delay due to contractor responsibility obtained by the analytical result is 22 days, which may cause by the shortage of some construction materials. Finally, the expected time extension of the project is 48 +215 + 22 = 285 days. This is smaller than the available time extension, 330 days, which is provided by government assistance.

{3} the main strategy for survival of the project management is the swapping the order and subdividing some activities within the construction period and the payment schedule for receiving a faster payment.

{4} the conceptual design in this area is changed for preventing or reducing future damage. For example, a water tank, which was originally installed underground, is changed to a ground floor. The system work, which was originally installed on the first floor, is changed to the second floor.

6. CONCLUSIONS

A set of two buildings of a higher education project located in Pathum Thani, which is a province in central Thailand, is selected as a case study. There are two major events occurring throughout the construction process. The first event begins on the 26th days; the construction site is flooded causing the construction delayed for 48 days. The government assists the construction contractors who suffering from the floods by granting extensions of time 180 days. The second event is found when most of the piles are unable to bear the specified load. The long enough period of flooding changes the soil strength in this area. The contractor solves this problem by using the Shaft Grouting method. This soil problem causes the construction delayed for 215 days, and 261 days for the main and service buildings, respectively. During this time, the government has adjusted the minimum wage to 300 Thai Baht. However, the government assists the construction contractors who suffering from the labor shortage by granting extensions of time 150 days. In addition, by combining the interview result and the determination of a relationship between three schedules (the As-planned, the Adjusted, and the As-built), it is indicated that the contractor faced a shortage of construction materials such as bricks, pipes, and wires. This material shortage problem can analytically reflect on the delay due to the Contractor Responsibility for 22 days. Duration for completion of the whole project or the As-built project duration is 983 days. Moreover, the swapping of the order and subdividing of activities within the construction period seems to be the survival project management.

The highest burden of all expenses that have already been done but cannot withdraw of the contractor is 55.62 percent, on the 800th day of construction. Therefore, 55 percent of the total cost of construction projects is claimed as the extreme criteria for assessing the financial capability of a potential contractor for getting a job after such a serious natural disaster.

Lesson learned from this unexpected flooding, can be divided into 4 categories: (1) strength capability in soil properties is decreased, (2) the government assistance is the time extensions of 180 days and 150 days for flooding and labor shortage, respectively. These are considered as the Excusable Delays. (3) survival management is the swapping of the order of activities within the construction period and the payment schedule, and (4) conceptual design in this area is changed for preventing or reducing future damage. For example, the location for a water tank installation is changed from underground to a ground floor. The location for installation of the system work is changed from the first floor to the second floor.

7. SUGGESTION

Experience from the case study can be applied to any construction project that suffering from the flood crisis in the future as follows:

(1) According to the construction area of this study, the flood duration for 41 days has changed the strength capability of soil. Therefore, if the duration of any future flood crisis in an area of the Central Plains of Thailand is more than 30 days, it is suggested that soil test or the piles test for the load capacity of the foundation shall be repeated after the flood.

(2) The time extensions provided by the government assists causing just only by flooding, which is 180 days, is insufficient for the contractor survival since the actual delay of the whole project or the expected time extension is 263 days or 285 days, respectively. For future reference, it is suggested

that if the flood duration in this area is 40 day, the overall duration from government assists should be not smaller than 300 days.

8. AVAILABILITY OF DATA AND MATERIAL

Used or generated data from this study can be requested to the corresponding author.

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