The Critical Path Method in Construction Project Rescheduling

IOP Conf. Series: Earth and Environmental Science **832** (2021) 012009 doi:10.1088/1755-1315/832/1/012009

The Critical Path Method in Construction Project Rescheduling

Zakia and Dian Febrianti
Department of Civil Engineering, Teuku Umar University, Indonesia
*Corresponding author: zakia.mrk@gmail.com

Abstract. Generally, Projects have a deadline, which means the completion of the project must be on time because the successful implementation of a project is an important goal for both the project owner. Management involvement is required for executing the project more effectively and efficiently from the beginning of the task, project completion time and cost. The program needed to project scheduling, project completion time and cost. The problem discussed in this study is the CPM calculation result using Microsoft Project, how to identify the critical path and float in each activity with the CPM. The purpose is to obtain the results of time scheduling calculations using Microsoft project-based CPM, to analyze the critical path of the CPM, and to find out activities that have a grace period. Based on shop drawing, SNI analysis is carried out which is the starter to make project schedules with duration calculated from SNI analysis. The calculation result and data input carried out in Microsoft Project create 180 workdays with 22 activities are on a critical trajectory which takes 20,635 hours. After the authors reschedule the project implementation lasted 172 working days, there were 7 activities on the critical trajectory, spending 18,339 hours.

1. Introduction

Management is an integrated process where individuals from the organization are involved in maintaining, developing, controlling, and running programs all, of which are directed at predetermined goals and continue over time. A project is an organized effort to achieve important goals, objectives, and expectations by using budget funds and available resources, which must be completed within a certain period.

2. Literature Review

2.1 Scheduling

Scheduling has a role in determining the success of the project. Good scheduling, shown through the activities in a project running smoothly. For example, the mobilization and demobilization of manpower and equipment can take place within the right time frame to avoid delays and waste. As the result, an optimal combination of implementation time, costs, and quality will be obtained.

Scheduling is the determination of when an activity will be started, postponed and completed [1]. So that the financing and use of resources can be adjusted according to predetermined needs. Scheduling is an absolute tool needed to complete a project [2]. For small-scale projects, which only have a few activities, generally scheduling is imagined so that scheduling is not necessary. However, the problem is different in large-scale projects, where the number of activities is very large and the relationship between activities is complicated so that it is no longer possible if only processed in mind. Scheduling and control is complicated and very important so that activities can be carried out efficiently. The main

element of scheduling is forecasting. It needs to be realized that changes can occur in the future so that it will affect the pattern of plans that have been made.

Scheduling is the allocation of time available to carry out work activities to complete a project to achieve optimal results by considering existing limitations [3]. In reality, project implementation, the problem of resource allocation is not an unlimited allocation, but a limited allocation of resources. Therefore, the limitation of these resources causes the planning of scarce resources such as manpower to be made as well as possible.

2.2 CPM (Critical Path Method)

According to Schroeder in the book Project Management by Hamdan Dimyati and Kadar Nurjaman [4], "Critical Path Method (CPM)" is a network-based method that uses a linear time-cost balance. Each activity can be completed faster than normal by cutting the activity for a certain amount of cost. Thus, if the project completion time is not satisfactory, certain activities can be cut short to complete the project in less time". In operation, the CPM (Critical Path Method) is a method using arrow diagrams to determine the critical path, so it is also called the critical path method. CPM uses a certain number of estimated activity duration.

A key advantage of network planning methods is the creation of schedule of project activities that will help manager achieve the objectives of the project [5]. Manager can (1) estimate the completion time of a project by finding the critical path, (2) identify the start and finish time for each activity for a project schedule, and (3) calculate the amount of slack time for each activity.

The following are the components contained in the Critical Path method: ES (earliest activity start time) The earliest time to start a job, EF (earliest activity finish time), The earliest completion time of a job, EF previous activity = ES next activity, LS (latest activity start time), The latest time to be allowed to start a job, LF (latest activity finish time, the slowest time to complete an activity without slowing down the completion of the project. T (activity duration time) Is the time required for an activity (days, weeks, months). S (activity slack) Is a grace time to start a job or a grace time to complete a job. Activities that have a slack of zero (0), then these activities are categorized as activities that have a critical path (are in the critical path).

In the realization of the critical path method, there are techniques in its use. According to Arifudin in his journal, he states that the calculation of the critical path includes two stages. The first stage is called the forward pass, where the computation starts from the "start" node and moves to the "end" node. At each node, a number is computed which represents the fastest time for the corresponding event. The second stage, called the backward pass, starts the calculation from the "end" node and moves to the "start" node.

There is a technique for calculating the critical path method: Forward Pass, the forward count starts at the start point (Start) and finishes at the end point (Finish), and has components of ES (fastest time to start an activity) and EF (fastest time to complete an activity).

There are the rules in forward count: (1) The initial activity starts when the previous activity has been completed (except the earliest activity) The earliest completion time is the same as the earliest start time after adding the length of the previous activity If an activity has two or more previous activities joined, then the earliest start time (ES) of the activity is the same as the largest completion time (EF) of the previous activity, (2) Backward Pass The countdown starts at the end point (Finish) to the starting point (Start) which is used to identify the slowest time of a job, and has components in the form of LF (the slowest time to complete the activity and the LS (the slowest time to complete the activity). starting work).

There are the rules for counting down: (1) The last start time is the same as the last finish time minus the duration of the activity, (2) If an activity is split into two or more activities, then the last time (LF) of the activity is the same as the last start time (LS) of the next smallest activity, (3) After getting the two calculations above, the Slack and Float values will be obtained which are the amount of time leeway on a network.

2.3 CPM method for activity duration

The duration of activities in the network method is the length of time required to carry out activities from start to finish [6]. This time period is usually expressed in hours of days or weeks. The calculation of duration in the CPM method is used to estimate the time for completion of activities, namely by means of single, duration, estimate. This method is done when the duration can be determined accurately and does not fluctuate too much.

2.4 Critical path

In conducting critical path analysis, two-pass processes are used, consisting of a forword pass and a backword pass [7]. In the CPM method, there is a critical path, which is a path that has a series of activity components with the longest total amount of time. The benefits of knowing critical path are (1) delay of work on critical path causes all project work to be delayed completion and (2) The completion of the project can be accelerated if the existing works on the critical path can be accelerated.

2.5 Previous Researchers

M. Jamal (2013), Title "Rescheduling of Construction Projects using the PDM Method (Precedent Diagram Method) case study: Cimahi Tax Office", with PDM method, research result is After rescuduling on normal activities, the new activities become 169 days from 180 days. Suartono (2015). Title "Rescheduling of Construction Projects using the CPM (Critical Path Method) method case study: Construction of the homestead mother Bandung" with CPM method, research result is After rescuduling on normal activities, the new activities become 190 days from 210 days

3. Research Methods

3.1 Research Location

The location of the research was carried out in the construction project of the PUPR Service Laboratory of West Aceh Regency, which is located on the Sisingamangaraja road, Drien Rampak Village, Johan Pahlawan District, West Aceh Regency. The maps of Aceh Regency can be seen on Figure 1. The construction project map and the existing condition of the building can be seen on Figure 2 and Figure 3.

3.2 Method of collecting data

This research is an effort to increase the efficiency of the use of labor in the implementation of construction projects. To simplify the analysis required data directly related to the project. The data in this study is secondary data obtained from related parties or the project implementing party, namely the supervisory consultant CV. Joint Structure Design. The data include the list of the Budget Plan (RAB) for implementation; time schedule and drawing of project implementation plan; and list of wage price analysis and materials.

Figure 1. Aceh maps

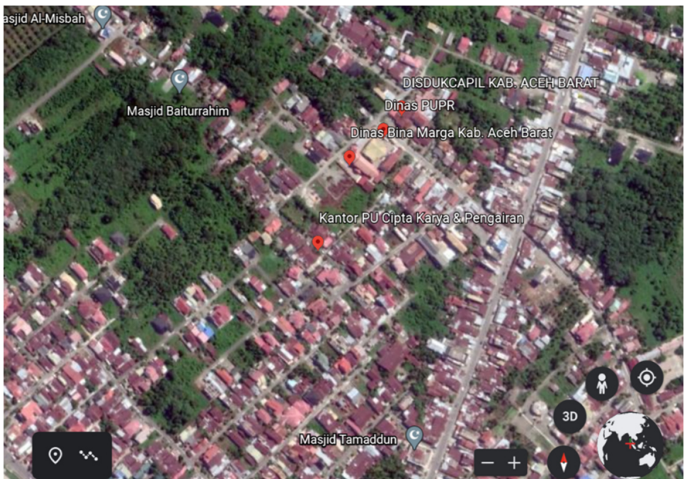

Figure 2. The construction project location map of the government Office PUPR Laboratory of West Aceh Regency

Figure 3. Existing conditions

3.3 Data analysis

The stages in data analysis are a sequence of steps that are carried out systematically according to the theoretical basis and problems so that they can be analyzed accurately to achieve the purpose of writing. Data can be obtained from related parties then processed and analyzed with the following stages:

1. Review and identify work on a project by breaking it down into activities or groups of activities that are components of a project.
2. After the sequencing of work activities is carried out, the dependency of each job is carried out between one job and another to become a network planning using the CPM method. By using the Microsof Project 2013 application, then provide an estimated time for each activity.
3. Float analysis of ES (Early Start), EF (Early Finish), LS (Late Start), FF (Free Float) and TF (Total Float) values, by filling in the fields (task sheet).
4. Identification of the critical path based on the analysis table free float (free slack) and total float (total slack).
5. Make a rescheduling using the CPM method, using a network (network planning).
6. Identify the critical path based on the free float (free slack) and total float (total slack) analysis table.

4.Results and Discussions

4.1 Type of Work and Duration

The type of works and its duration can be seen in Table 1. Types of work and duration of project data for existing work, here are the types of work and length of time for completion, based on planning data from the project implementer, namely 180 working days.

4.2 Dependency relationship

The dependency relationships between the jobs on this project are not all the same. There are jobs that start or finish together. There is also work that starts after another few days of work have been completed. So that this job dependency relationship is called, namely the relationship to previous activities. The dependency relationship of activities can be seen on Table 2.

4.3 Project rescheduling

In this study, project rescheduling was carried out using the microsoft project software. So that after rescheduling the PUPR Service Laboratory construction project the resulting time acceleration is 7 days. Then the normal timeframe becomes 172 working days. The activity duration after rescheduling show in Table 3.

Table 1. Activity duration

Activities	Duration (days)
Preparatory work	26
Floor Work I	
Earthworks	33
Concrete works	147
Reinforced concrete work	175
Floor job	70
Window Door and Ventilation Works	
- Almunium work	49
- Door jobs	3
- Window work and ventilation	35
Painting Work	18
Electrical Works	35
Water Sanitation Works	56
Floor Work 2	
Couples work and plastering	57
Reinforced concrete work	42
Floor job	19
Roof and Ceiling Work	35
Window Door and Ventilation Works	
- Almunium work	25
- Door jobs	10
- Window work and ventilation	15
Painting Work	10
Electrical Works	14
Water Sanitation Works	20
Final Work	10

4.4 Work on a critical cross on project rescheduling

Based on the calculation of CPM using the Microsoft Project software, then it is depicted in the form of a network diagram that has been adjusted according to the results obtained. So, the normal time to complete this project is 180 days and has 22 activities which are cross critical. The activity on critical path can be seen on Table 4.

Table 2. Activities that have a dependency relationship

Activities	Duration (days)	Prodecesor
Floor Work 1		
Preparatory work		
- Installation of Safety Fence	5	2 SS
- Bowpalnk measurements	3	3SS
- Project Nameplate	5	4SS, 3SS
- Administration	2	6 SF
Concrete works		
- Column brackets and beam rings	21	75 FF
- Square motif wall relief	5	82 FF
- Concrete listplank relay	35	84 SS
Floor job		
- Cast the floor in and the terrace T = 5 cm	7	53 FS + 1 day
- Floor tile work	8	66 ss + 3 day
Door and window work		
- Almunium boarding work	21	75 FF
- Door work	5	82 FF
- Window work and ventilation	35	84 SS
Floor Work 2		
Install and stucco work		
- Pair of 1Pc Bricks; 1pc (traseram)	7	61FF
- Pair of Bricks 1 pc: 4 Ps	7	125 SS
- Brick Plastera	8	127 SS
Floor job		
- Ceramic Wall uk 20x25cm	5	147 FF
- Installation of Ceramic Bon Bonuses	4	148 FF
Water Sanitation Works		
- Install the pipe installation	5	176 SF
- WC water tub	3	178 SS

Table 3. Activity duration after rescheduling

Activity	Duration (days)
Preparatory work	18
Floor Work 1	
Earthworks	28
Concrete works	133
Reinforced concrete work	140
Floor job	45
Window Door and Ventilation Works	
- Almunium work	14
- Door jobs	2
- Window work and ventilation	28
Painting Work	5
Electrical Works	25
Water Sanitation Works	45

Table 3. Activity duration after rescheduling (cont.)

Floor Work 2	
Couples work and plastering	52
Reinforced concrete work	25
Floor job	10
Roof and Ceiling Work	22
Window Door and Ventilation Works	
- Almunium work	20
- Door jobs	4
- Window work and ventilation	15
Painting Work	15
Electrical Works	14
Water Sanitation Works	20
Final Work	10 days

Table 4. Activity on critical path.

Activity	ES	EF	LS	LF	Slack
Preparatory work					
- Board of Directors Kit	0	5	0	5	0
- Project Nameplate	0	5	0	5	0
- Administration	2	4	2	4	0
Window Door and Ventilation Works					
Almunium work					
- Door jobs Ceiling Work	68	75	68	75	0
- Light Steel Horses	78	84	78	84	0
Ceiling Work					
- Light Steel Horses	138	145	138	145	0
Door, Window, and Ventilation Work					
- Installation of Aluminum Frames	151	156	151	156	0
- Installation of Glass Doors	163	168	163	168	0
- Installation of aluminum doors	163	168	163	168	0
- Installation of Aluminum Frames	151	156	151	156	0
- Installation of Window-sill Glass	163	168	163	168	0
- Cross glass vent	168	171	168	171	0
Painting Work					
- Wall paint	172	180	172	180	0
Electrical Works					
- Installation of lighting points	172	180	172	180	0
Water Sanitation Works					
- Install pipe instls, splicing connections and accessories	128	133	128	133	
- Installation of sinks and tiles					
- Drain DOP	168	171	168	171	
- Fiber glass water tank	168	171	168	171	
	177	180	177	180	
Final Work					
- Finishing Job	168	180	168	180	0
- P3 K and Security	0	180	0	180	0
- Project Documentation	0	180	0	180	0

Based on the calculation of CPM using the Microsof Project software, then it is depicted in the form of a network diagram that has been adjusted according to the results obtained. So the rescheduling time to complete this project is 172 days and the cross-critical activities obtained are only 7 activities, can be seen in the Table 5.

Tabel.5 Activities critical cross

Activity	ES	EF	LS	LF	Slack
Preparatory work					
- Board of Directors Kit	0	5	0	5	0
Floor job					
- Cast the basement floor and water tub T = 5cm	53	63	53	63	0
- Rough floor of the hallway	64	69	64	69	0
- Ceramic Wall 20x25	65	71	65	71	0
Door, Window, and Ventilation Work					
- Installation of Glass Sill Windows	84	88	84	88	0
- Cross Glass Vents	87	89	87	89	0
Electrical Works					
- Installation of lighting points	172	179	172	179	0

5. Conclusions and suggestions

From the analysis of the rescheduling project for the Construction of the PUPR Service Laboratory of West Aceh Regency, conclusions can be drawn.

1. After rescheduling the normal project activity duration, the rescheduling duration is 172 from 180 days of normal time.
2. Prior to rescheduling, 22 critical activities were obtained. After rescheduling with a duration of 172 days, 7 activities were obtained.

As for the suggestions of this study, monitoring and evaluation is very necessary to maintain project performance in accordance with the planning schedule and can anticipate delays that occur in the field.

6. References

[1] I G N O Suputra 2011 Penjadwalan Proyek Dengan Precedence Diagram Method (PDM) Dan Ranked Position Weight Method (RPWM) *Jurnal Ilmu. Tek. Sipil* 15(1) 18-28
[2] R M Eskandrani 2007 *Optimalisasi Penggunaan Sumber Daya Manusia dengan Metode Resources Leveling Menggunakan Bantuan Microsoft Project* (Surakarta: Universitas Sebelas Maret)
[3] W Ervianto 2006 *Manajemen Proyek Konstruksi-Edisi Revisi* (Yogyakarta: Andi Offset)
[4] H A Dimyati, K Hamdan and Nurjaman 2014 Manajemen Proyek (Bandung: Pustaka Setia)
[5] D Caesaron and A Thio 2015 Analisa Penjadwalan Waktu Dengan Metode Jalur Kritis Dan Pert Pada Proyek Pembangunan Ruko (Jl. Pasar Lama No.20, Glodok) *J. Industri Eng. Man. Syst.* 8(2) 59-82
[6] I Soeharto 1999 *Manajemen Proyek (Dari Konseptual sampai Operasional)* (Jakarta: Erlangga)
[7] D S Badri 1997 *Dasar-Dasar Network Planning* (Jakarta: PT. Rika Cipta)