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PROJECT SCHEDULING ANALYSIS USING THE CRITICAL PATH METHOD – CASE STUDY: SUBSIDIZED HOUSE CONSTRUCTION PROJECT IN HILL MULYA HOUSING, SAMARINDA CITY

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Abstract

Samarinda City has a total of 123 housing estates with 20 subsidized housing (MBR) and 4 mixed housing. Project scheduling in construction greatly determines the project's success because it is a benchmark that the project is successful within the allotted time. CPM (Critical Path Method). CPM is a method that introduces an element of project time by using a predefined activity time estimate. This method is used for crushing the Bukit Mulya housing project, which only applies to the implementation of crash time. From the analysis results, the initial scheduling time, which was originally 87 days, was trimmed by 9 days using CPM, the optimal time was 78 days.

Keywords: Estate Construction, CPM, Time Schedule, Crushing

1. INTRODUCTION

In Law no. 11 of 2011 concerning Housing and Residential Areas, a house is a building that functions as a livable place to live in, a means of fostering a family, a reflection of the dignity of its inhabitants, and an asset for the owner. Hence, the house is the primary need of every human being, but the problem is only some old or new families can afford to buy a house at a relatively high price. The inability to buy a house is caused by several factors: the cost of buying land/houses, the poverty level, and city income (Regional Statistics of Samarinda City, 2021). To overcome this problem, Indonesian President, Joko Widodo (Jokowi) created the one million houses program, which has been running since 2015. The one million houses program is a collaboration between the central government, local governments, developers and the community in providing decent Housing. This policy aims to accelerate the provision of Housing for low-income people (MBR) to obtain decent Housing at affordable prices (Maisona Magazine Ministry of PUPR, 2016)

According to the housing recapitulation in Samarinda City until 2022, it currently has 123 housing estates with 20 subsidized housing (MBR) and 4 mixed housing. The construction of Housing for low-income people has yet to be fully distributed when viewed from each existing sub-district. The stages of project management must support good development project planning from the initial stage to the end of the work. Project scheduling in construction greatly determines the project's success because it is a benchmark that the project is successful within the allotted time. One method that can be used is the CPM (Critical Path Method) to achieve the correct scheduling results. CPM is a method that introduces an element of project time by using a predefined activity time estimate. From the estimated time, it is planned to control the time aspect of the project. CPM ensures that the time used is appropriate, appropriate, and reasonable (Wateno, 2014).

2. LITERATURE REVIEW

2.1. Previous Research

Researchers will present the results of previous research that has similar research. For this reason, the author will reference the research results to avoid plagiarism related to the title, case studies, and the methods used.

2.2. Housing Area

Housing combines several houses developed by the government and the private sector and functions as a place to live or an environment (Sunarti, 2019). Based on the type of division of who is involved in housing construction, it can be divided into two, namely formal and informal Housing. Formal Housing is Housing built by developers/developers (business entities in the field of Housing and settlements) and the government (can be through BUMN/BUMD).

2.3. Project Scheduling

Project scheduling is part of the project planning stages related to the time duration. Time planning by determining the schedule of work sequences from the start of the project to completion. Project scheduling aims to control activities to avoid project delays. Before designing an implementation schedule, it is necessary to consider several factors that may affect the implementation. Factors to be considered include: (Telaumbanua et al., 2017).

1) Environmental conditions and project location.
2) Depending on the functions and needs of the project to be implemented.
3) The accessibility of affordable project locations can be seen from the connecting facilities.
4) Availability of material resources, equipment, and other supporting materials.
5) The capacity of the scope of the work area that can accommodate the resources that have been prepared.
6) Productivity of resources, equipment and human resources who understand the reference and calculation of technical rules.

2.4. Critical Path

In CPM, there is such a thing as a critical path. The definition of a critical path is an activity with a large amount of time and shows the shortest duration of completion time. This path is an important part of project scheduling because if implementation on the critical path is late, it will cause delays in other activities. In identifying the critical path, there are terminology and calculation formulas as follows (Suharto, 1999).

2.5. Crash Method

The terminology of the crushing process is that reducing the duration of the work will affect the project completion time. Crashing activity is a deliberate, systematic and analytic process by testing all activities in the project focused on activities on the critical path trajectory (Mahapatni, 2019).

The crashing process estimates variable costs to determine the time duration that experiences the project's maximum and most economical reduction. Projects can be accelerated in several ways, namely:

1. Increase working time
2. Add human resources
3. Changing work methods
4. Use construction tools for acceleration

2.6. Research Models

The first important part of this research is the framework. The flow of research thinking is an easy-to-understand technique and a definite research sequence. In the thought flow sub-chapter, this research presents the sequence from the beginning to the end of the activity.

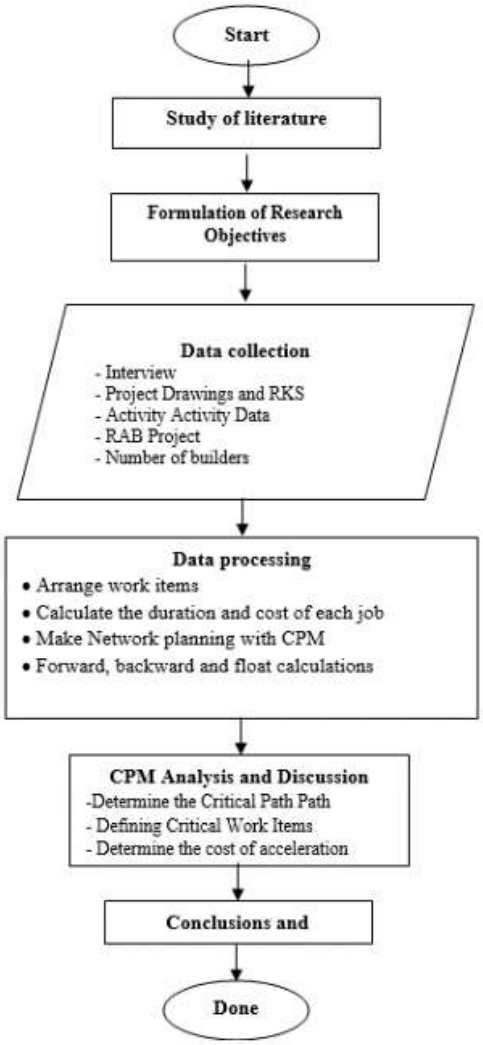

Figure 1 Research Framework

3. RESEARCH METHOD

The research uses qualitative methods, in which the main instrument of data collection is the researchers themselves by collecting data from information sources (informants) by observing, asking, listening, requesting, and retrieving research data. In compiling research instruments, two data are processed: primary and secondary. In this study, the construction of subsidized Housing at Bukit Mulya, Karang Mulya, Loa Bahu Village, Sungai Kunjang District, Samarinda City is the object to be studied. Locations included in the residential area zone will later be targeted for low-income people (MBR). Bukit Mulya Housing has 36 houses with supporting facilities in the area and was developed by PT. Griya Rayyan Development as the developer.



Figure 2 Map of the location of the Bukit Mulya housing complex
Source: Consultant Data (2022)

The location of the case study taken was the Bukit Mulya Subsidized Housing Development Project or MBR, Jalan Karang Mulya Rt. 18, Loa Bahu Village, Sungai Kunjang District, with PT. Griya Rayyan Development is the developer of the Housing. The total number of housing developments is 61 units 6 units have been under construction, and 55 units still need to be built. The research was conducted from September 2022 to completion.

As for the primary data was collected through questionnaires in the form of questions regarding the respondent's data, development progress in the field on scheduling time, expected work time, factors that indicate changes in completion time, and shortened work activities, resulting in categorical data.

Furthermore, the questionnaire results obtained data on the number of respondents' answers to the level of importance of an event for further analysis, which will be discussed in the next section. Meanwhile, secondary data was obtained through the study of literature books and previous journals. The data from consultants and developers are concept reports, working drawings, budget plans, and time schedules.

1) RAB (Budget Budget Plan)

Housing, the total estimated by planners is IDR 9,737,174,100.00 with the division between the construction of all housing units worth IDR 8,500,411,000.00 (87.29%) and Infrastructure, Facilities, Utilities (PSU) worth IDR 1,236,771 000.00 (12.71%). The budget per housing unit is IDR 139,351,000.00.

2) Shop drawing

Project working drawings include architectural, structural, mechanical, electrical, and plumbing drawings. As a reference for workers to complete projects neatly and become a guide in carrying out work activities according to the specified time limit.

3) Schedule

In the project contract, the duration of completion is 87 days (eighty-seven days) which can be used as a benchmark for achieving the project completion time target.

The data that has been obtained is analyzed using the Critical Path Method (CPM) scheduling method to determine the critical path of activities and acceleration costs assisted by using QM software for Windows V5.

4. RESULT AND DISCUSSION

4.1. Research Result

4.1.1. Data Description

The Bukit Mulya type 36 housing construction project is a type of subsidized Housing for the lower middle class (MBR) developed by PT. Griya Rayyan Development as the developer and planned by PT. Deskita Indonesia Sejahtera is a planner as well as a job contractor. The respondents interviewed were directors of each company:

1) Muhammad Iqbal Arifin, director position of PT. Griya Rayyan Development
2) Yulya Puspita Bakti, position as director of PT. Deskita Prosperous Indonesia

From the interview data results, one unit was constructed by 1 chief mason and 2 masons within 87 working days. Construction of the new unit will continue when the previous house is finished. The data obtained support the following:

Table 1 Project Data 2022

The Project Name	Subsidized Housing Development Project in Bukit Mulya Housing
Location	Jalan Karang Mulya RT. 18, Loa Bahu Village, Sungai Kunjang District, Samarinda City, East Kalimantan
House Type	MBR type 36 house
Assignor	PT. Griya Rayyan Development
Planning Consultant/Contractor	PT. Deskita Prosperous Indonesia
Job Duration	2 months 27 days (87 calendar days)
Contract Type	*Lumpsum*
The total cost of the house	IDR 8.500.411.000,00
Budget per unit cost	IDR 139.351.000,00

Source: Processed by Researchers (2022)

4.1.2. Data Findings

In CPM research, original data is needed for planning a house construction project in the Bukit Mulya housing complex. The references used are primary and secondary data so that the function of the building does not change and is in accordance with the original plan. The following data results have been collected:

1) Housing Data

1. Land area : 10.259,71 m^2
2. The total area of the lot : 5046 m^2
3. Area of one plot : 84 m^2
4. PSU size : 3.090,58 m^2
5. Open Space Area : 2.113,97 m^2

2) Site Plan Pictures and House Plans

The Bukit Mulya residential site plan comprises 61 housing units, with 6 under construction measuring one plot of 84 m^2 with type 36 houses.



Figure 3 Bukit Mulya Housing Site Plan
Source: PT. Deskita Indonesia Sejahtera (2022)

Room facilities are 2 bedrooms, 1 toilet, and living room and kitchen into one room, carport for 1 car and 1 motorbike, and front and back yard areas.



Figure 4 House plan type 36/84
Source: PT. Deskita Prosperous Indonesia (2022)

3) Work item

Based on data from PT. Deskita Indonesia Sejahtera work items can be seen in the following table:

Table 2 Project Work Items

No.	Work item	Activity Code
1.	Bouwplank installation	A
2.	Earthfill & excavation work	B
3.	Stone masonry foundation work	C1
4.	Stone pair	C2
5.	Sloop job	D
6.	Column work	E
7.	Building wall work	F
8.	Door and window work	G
9.	Ringback work	H
10.	Roof work	I
11.	Electrical installation work	J
12.	Clean water works	K
13.	Used water & dirty water works	L
14.	Ceiling work	M
15.	Floor job	N
16.	Garden work	O
17.	Painting job	P

Source: Processed by Researchers (2022)

From the table, it can be seen that the initial work only had 10 jobs, and after detailing each activity, the work items totalled 17 work items.

4) Job Duration

In calculating the duration, it is carried out using the help of Microsoft Excel by identifying the type of work, volume, and the number of workers by indexing the coefficient of labour work so that the total duration of work is 87 working days 17 work items.

Table 3 Activity Duration

Work	Volume	Labor	Amount	Index	Duration	Total duration
Bowplank installation	38.00	Foreman	1	0.0100	0.38	1
		Worker	2	0.0120	0.228	
Earthfill & excavation work						
Soil digging	24.05	Foreman	1	0.0563	1.35	7

Work	Volume	Labor	Amount	Index	Duration	Total duration
		Worker	2	0.563	6.769512	
Landfill and backfill	6,40	Foreman	1	0.0125	0.08	
		Worker	2	0.125	0.4	
sand heap	5.05	Foreman	1	0.0318	0.16059254	
		Worker	2	0.318	0.80296272	
Foundation work						
Installation of empty stone (astamping)	5,34	Foreman	1	0.039	0.20826	2
		Worker	2	0.78	2.0826	
Stone installation	9.02	Foreman	1	0.075	0.6765	5
		Worker	2	1.5	6.7635	
Structural concrete work						
Sloop job	1.00	Foreman	1	0.323	0.323646	3
		Worker	2	5.65	2.83065	
Column work	1.08	Foreman	1	0.403	0.43524	4
		Worker	2	7.05	3,807	
Ringback work	1.00	Foreman	1	7.05	0.333666	3
		Worker	2	6.35	3.18135	
Building wall work						
Brick couple	4.98	Foreman	1	0.02	0.099618	8
		Worker	2	0.6	1.49427	
Wall plaster	27,36	Foreman	1	0.02	1	
		Worker	2	0.6	8	
Door and window work						
Installation of P1 Frames and Doors	3.00	Foreman	1	0.24	1	2
		Worker	2	0.8	1	
Installation of Frames and Doors P2	1.00	Foreman	1	0.24	0	
		Worker	2	0.8	0	
Installation of J1 Sills and Shutters	3.00	Foreman	1	0.24	1	
		Worker	2	0.8	1	
Installation of J2 Sills and Shutters	1.00	Foreman	1	0.24	0	
		Worker	2	0.8	0	
Installation of Sills and Ventilation Glass	5.00	Foreman	1	0.24	1	
		Worker	2	0.8	2	

Work	Volume	Labor	Amount	Index	Duration	Total duration
Roof work						
Light steel roof truss	55.98	Foreman	1	4.47872	4	21
		Worker	2	20.5461	21	
0.3mm spandex roof covering	55.98	Foreman	1	0.39	0	
		Worker	2	4,1988	4	
Electrical installation work						
12 Watt LED Installation	4.00	Worker	3	2,6	3.46666667	3
5 Watt LED Downlights	3.00				2,6	
Single Switch Installation	3.00				2,6	
Dual Switch Installation	2.00				1.73333333	
Installation of contact sockets	4.00				3.46666667	
Clean water works						
Faucet installation	3.00	Foreman	1	0.04	0.12	1
		Worker	2	0.01	0.02	
Clean setup and installation	11.00	Foreman	1	0.04	0.14666667	
		Worker	2	0.01	0.03	
Used water and dirty water works						
Installation of dirty liquid water	12.00	Foreman	1	0.01	0.12	1
		Worker	2	0.01	0.06	
Installation of solid dirty water	8.00	Foreman	1	0.01	0.08	
		Worker	2	0.01	0.04	
Ceiling work						
Hollow steel frame installation	12.93	Foreman	1	0.035	0.45	2
		Worker	2	0.35	2,26	
Ceiling truss installation	35,93	Foreman	1	0.005	0.18	
		Worker	2	0.1	1.80	
Floor job						
Ceramic installation	31.88	Foreman	1	0.035	1,12	11
		Worker	2	0.7	11,16	
Rebate installation	3.88	Foreman	1	0.0318	0.12	
		Worker	2	0.318	0.62	

Work	Volume	Labor	Amount	Index	Duration	Total duration
Parking job	1.23	Foreman	1	0.025	0.03	
		Worker	2	1.65	1.01	
Painting job						
Interior wall painting	27.00	Foreman	1	0.02	0.54	8
		Worker	2	0.6	8,10	
Exterior wall painting	19,92	Foreman	1	0.02	0.40	
		Worker	2	0.6	5.98	
Garden work						
Garden and vegetation work	33.00	Foreman	1	0.0318	1.05	5
		Worker	2	0.318	5,25	
Total Project Duration						87

Source: Processed by Researchers (2022)

4.1.3. Project Scheduling

1) Employment Relationship

The step before creating a network is to create a logical network of dependencies between one activity and another. The following is a table of project linkages obtained from interviews with consultants.

Table 4 Interrelationships Between Project Work

No.	Work	Activity Code	Prior Activities
1.	Bouwplank installation	A	-
2.	Earthfill & excavation work	B	A
3.	Stone masonry foundation work	C1	B
4.	Stone pair	C2	C1
5.	Sloop job	D	C2
6.	Column work	E	D
7.	Building wall work	F	E
8.	Door and window work	G	E
9.	Ringback work	H	G, F
10.	Roof work	I	H
11.	Electrical installation work	J	I
12.	Clean water works	K	I
13.	Used water & dirty water works	L	I
14.	Ceiling work	M	J, K, L
15.	Floor job	N	M
16.	Garden work	O	M
17.	Painting job	P	O,N

Source: Processed by Researchers (2022)

After getting the working relationship according to table 4, make a network diagram. Making network diagrams using QM software for windows.

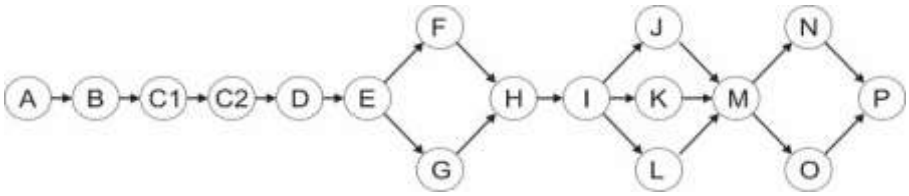

Figure 5 Network diagrams (network planning)
Source: Researchers (2022)

Determination of the completion of the project time on the network diagram can be determined using a forward pass calculation which counts from the beginning to the end of the activity and uses the reverse of the forward calculation, namely a backward pass starting from the end of the activity to the beginning of the activity. The critical path is determined after identifying the slack/float time.

2) Forward Calculation

After obtaining the network diagram, the next steps determine forward, backwards and float calculations. Advanced calculation (forward pass) is obtained from the initial calculation to the end of the activity with a known start time (earliest start) and end time (earliest finish).

Table 5 Calculation Forward (Forward Pass)

Activity Code	Duration	The first	
		Start	Done
A	1	0	1
B	7	1	8
C1	2	8	12
C2	5	12	15
D	3	15	18
E	4	18	22
F	8	22	30
G	2	22	30
H	3	30	33
I	21	33	54
J	3	54	57
K	1	54	57
L	1	57	57
M	2	59	59
N	11	59	70
O	5	59	70
P	8	70	78

Source: Processed by Researchers (2022)

After being processed with advanced calculations obtained for the completion rate in activity M of 78, the final completion process for the construction of a type 36 house in Bukit Mulya was completed within 78 days. The following table 5 advanced calculation of the 36 bukit mulya house project.

3) Countdown

The backward pass starts from the last activity back to the initial activity to determine each activity item's latest start and latest finish values. The countdown begins by determining the LF value in the last activity, namely activity P.

Table 6 Countdown (Back Pass)

Activity Code	Duration	The last	
		Start	Done
A	1	0	1
B	7	1	8
C1	2	8	12
C2	5	12	15
D	3	15	18
E	4	18	22
F	8	22	30
G	2	28	30
H	3	30	33
I	21	33	54
J	3	54	57
K	1	56	57
L	1	56	57
M	2	57	59
N	11	59	70
O	5	65	70
P	8	70	78

Source: Processed by Researchers (2022)

Based on the countdown, activity P is the last activity in the project and becomes the completion time for an activity. Because it is an activity with the longest and longest standard, it can be said that the project duration is 78 days.

4) Float/Slack Calculation

Calculation of float or slack which means slack time in a work activity. Float is divided into two, namely total float and free float. Total float means the time to delay activities without delaying the end of the project. In contrast, free float is the delay time for activities without affecting the start of the next activity.

The formula used is:

1. *Total Floats* (TF) = Latest Start (LS)-Early Start (ES)
2. *Free Float* (FF) = Early Finish (EF)-Early Start (ES)-Duration

If the total float = 0, the activity has no leeway.

Table 7 Float/slack calculation

Activity	Duration	ICE	EF	LS	LF	tf	FF	Critical Path
A	1	0	1	0	1	0	0	yes
B	7	1	8	1	8	0	0	yes
C1	2	8	10	8	10	0	0	yes
C2	5	10	15	10	15	0	0	yes
D	3	15	18	15	18	0	0	yes
E	4	18	22	18	22	0	0	yes
F	8	22	30	22	30	0	0	yes
G	2	22	24	28	30	6	0	
H	3	30	33	30	33	0	0	yes
I	21	33	54	33	54	0	0	yes
J	3	54	57	54	57	0	0	yes
K	1	54	55	56	57	2	0	
L	1	54	55	56	57	2	0	
M	2	57	59	57	59	0	0	yes
N	11	59	70	59	70	0	0	yes
O	5	59	64	65	70	6	0	
P	8	70	78	70	78	0	0	yes

Source: Processed by Researchers (2022)

Based on the table data above, it can be determined that the critical path is onAB-C1-C2-DEFHIJMNP activities with details of activities namely: bouw plank installation, fill and excavation work, bare stone foundation work, masonry, sloop job, column work, building wall work, ringbalk work, roofing work, electrical installation work, ceiling work, floor job, and painting job.

Table 8 Activities on The Critical Path

Type of Activity	Code	Floats
Bouwplank installation	A	0
excavation and excavation work	B	0
bare stone foundation work	C1	0
rock pair	C2	0
sloop job	D	0
column work	E	0
building wall work	F	0
ringback work	H	0
roof work	I	0
electrical installation work	J	0
ceiling work	M	0
Floor Job	N	0
painting job	P	0

Source: Processed by Researchers (2022)

PT was originally scheduled based on the search results for the completion time using the CPM method on the type 36 house. Griya Rayyan Development totalled 87 days, cut by 9 days to 78 working days after being analyzed using the CPM method. The CPM network flowchart can be seen in Figure 6 with red arrows as activities that go through the critical path.

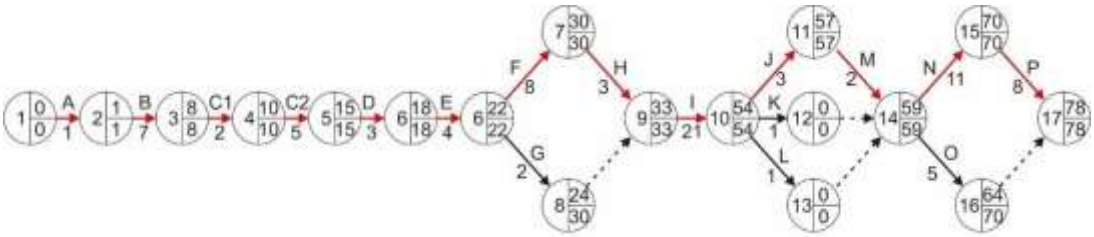

Figure 6 CPM Network
(Source: Researchers, 2022)

4.2. Discussion

Initial project scheduling by PT. Deskita Indonesia Sejahtera for the construction of subsidized housing / MBR Bukit Mulya for the completion of 1 housing unit takes 87 days. Meanwhile, rescheduling using CPM takes 78 days. In other words, project work using CPM is more effective in terms of time, with a difference of 9 days from normal time.

The initial duration planned by planners still uses conventional methods in the form of project s-curves based on completion per unit, resulting in relatively longer work.

5. CONCLUSION

Based on the results and discussion that have been discussed in the previous chapter, the researcher can draw the following conclusions: Scheduling the construction of the Bukit Mulya housing unit using the CPM method yielded more optimal results than the planned time. The initial scheduling time, which was originally 87 days, was trimmed by 9 days using CPM, the optimal time was 78 days. This is because planners/contractors have yet to use specific methods such as CPM in determining development activities and are only based on conventional methods in the form of project s-curves and previous experience.

Based on the discussion that has been done, we suggest that the CPM method effectively finds the optimal time for a project completion because it can determine the critical path to avoid development delays for that in the future PT. Deskita Indonesia Sejahtera should use the CPM method in starting other jobs. From this research, it can be a consideration for the developer so that he can set the target to be achieved. It must be thought through carefully, so there is no request for a completion target when it is still under construction.

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