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Application of Project Management using CPM (Critical Path Method) and Pert (Project Evaluation and Review Technique) in the Nava House Bekasi Cluster Housing Development Project

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Abstract:- Housing development projects are developing very rapidly. Housing development projects will increase people's income and standard of living. One of the housing development projects in Bekasi City is the Nava House Cluster housing complex. Nava House housing is a Cluster type housing complex. When working on a development project, project scheduling is required. In project scheduling, there are several methods that can be used, namely the CPM and PERT methods. Both methods can be used to minimize the time lag in project work. This thesis aims to determine the path formed in the network, the activities included in the critical path and the completion time contained in the critical path. The results of this research on the Nava House housing development project are: first, there are 3 routes in the network. second, the activities included in the critical path are A, B, C, D, E, G, H, I, J, L, M, N, O, P. Third, the house that has been worked on is analyzed using the CPM method, getting results The critical path is 57 days. Meanwhile, houses that are still early in construction or houses that are about to begin construction are analyzed using the PERT method, obtaining critical path results of 66 days.

Keywords:- *CPM, Critical Path, Network, PERT.*

I. INTRODUCTION

Along with the economic growth of the Indonesian nation, development projects in various types of sectors are developing very rapidly. Many parties are involved in developing construction projects, various processes, different phases and stages of work and contributions from two sectors, namely government and private, with project success being the main goal. Development projects carried out include construction projects, infrastructure projects, even housing construction and development projects. One of the projects that is currently being carried out is housing development projects. The existence of housing development projects will increase people's income and standard of living [1].

As we know, housing is a primary need for humans. The construction of housing and residential areas makes it easier for people to find livable places to live. The government has a responsibility in the development of housing and residential areas to become a facilitator, such as providing assistance and facilities to the community, and carrying out research and development covering various related aspects, including planning, land, spatial planning, environmental infrastructure, industrial materials and components, construction services as well as development design, institutions, finance, human resources, local wisdom, as well as supporting legislation [2].

Housing development projects are not only carried out with government assistance, but can also be carried out by private parties who are not controlled by the government. During the construction of the Nava House housing project, there were obstacles that hampered the construction work, caused by weather, such as during the rainy season, and caused by building materials that had run out, causing the construction to experience a time lag. With this problem, it is very important to carry out project scheduling. Having project scheduling will help work activities, so that work on the project gets optimal results by taking into account the limitations caused by building materials that have run out so as not to experience a long time lag. If a project has good quality, scheduling, costs and agreed time limits, then the project can be said to be successful. Therefore, it is necessary to use time effectively and efficiently [3].

A. Management

According to Terry in his book *Principles of Management*, management is a process which use method knowledge as well art For carry out the functions of planning, organizing, directing and controlling the activities of a group of people equipped with resources or factor production For reach target Which has set more first, effectively and efficiently. According to Terry in his book *Principles of Management*, management is a process which use method knowledge as well art For carry out the functions of planning, organizing, directing and controlling the activities of a group of people equipped with resources or factor production For reach target Which has set more first, effectively and efficiently.

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B. Definition of Operations Management

Operations management is an activity aimed at managing resources data on process transformation input to output. Management operational is something business management in a way optimal in use All existing production factors, including labor (HR), machines, equipment, *raw materials* and other production factors are in the transformation process to become a product, goods or services [5] . According to Handoko (2010) management operation is implementation or the implementation of a managerial activity that is carried out in the selection, design, renewal, operation and supervision of productive systems. On process in change material standard become product or services, there are production factors which include, labor, machines, equipment, and etc. Management operational as form management optimal aspects of labor, goods or other production factors that can be used as products that are commonly traded [6] .

Process management consists from planning, organizing, managing employees, directing and controlling. In the operations management function, the operations manager establishes the management process for decision making. Based on the above aspects, the scope of operational management is defined in ten operations management decisions [7] , namely:

- Design product And service
- Manage quality
- Strategy process
- Strategy location
- Strategy system location
- Source Power man
- Management supply
- Scheduling
- Maintenance.

C. Project

In a project, there is project performance that is needed to determine efficiency and effectiveness in its implementation, resulting in problems in project management can identified as well as look for solution And made an experience that can later be compared in the implementation of subsequent projects [8] .

D. Definition of Project Management

According to Soeharto (1999), project management is the process of planning, organizing, directing and controlling the activities of organizational members and other resources to achieve predetermined organizational goals . . Project management has the main goal, namely that the project can be carried out on time, efficiently and achieve the expected results . . Projects that drag on often occur in the process so that the project must be carried out scheduling repeat. So from That, role Planning for a project is very important, everything must start from a plan that is mutually agreed between the *stakeholders* involved in the project. What is meant by *Stakeholders* here is the project owner , the steering committee (*steering committee*), users of the results projects and project implementers [9] .

E. Project Management Function

According to Dimyati & Nurjaman (2014) project management has several functions, namely:

- Planning function (*Planning*), the purpose of this function is to make decisions in managing selected data and information for the future, such as making long-term and short-term plans, etc.
- Function Organization (*Organizing*), objective from function This is to unite every human activity which has its own activities and is interconnected, and interacts with the environment to achieve objective organization, like compile scope activity, And etc.
- Implementation Function (*Actuating*), the aim of this function is to adapt all relevant organizational actors in carrying out project activities, such as task direction and motivation.
- Controlling Function (*Controlling*), the purpose of this function is to measure the quality of appearance as well as to analyze and evaluate activity, like give suggestion repair, And etc.

F. Project Management Function

According to Nurhayati (2010) there are various types of project activities, namely activities related to analysis of economic aspects, environmental problems, *engineering design* , manufacturing *marketing* , etc. [10] .

Type project categorized as based on that activity most dominantly carried out on a project, namely:

- *Engineering* Projects , the main activities in this type of project include feasibility analysis, *engineering design* , supply and construction. Like development *real estate* , *fly over* , building factory, etc.
- *Engineering* Project , the aim of this project activity is to create a new product. Such as, making boilers, vehicles, computers, and others.
- Project Management Services, the activities of this project are more specific to product Which later product the Finally form service. Such as an information systems development project.
- Research and Development Project, the activities of this project are carrying out research and development of a particular product.

G. Project Scheduling

Scheduling can be determined using technical methods that have been used such as the *Bar Chart project scheduling method* , PDM (*Precedence Diagraming Method*), CPM (*Critical Path Method*), and PERT (*Project Evaluation And Review Technique*) [11] . CPM (*Critical Path Method*) is generally known as a critical path method to assist in scheduling, monitoring and controlling large and complex projects. CPM was developed in 1957 by JE Kelly from Remington Rand And MR Walker from DuPont to help build and maintain a chemical factory in Dupont (Prasetya and Lukiastuti, 2009). The critical path is used to determine time solution A project, Which covers series activity with the fastest total time and the longest time in completing a project [12] .

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To calculate the critical path, there are two methods that can be used, namely:

- The forward count (*forward pass*) begins with a starting point and then ends on point end, as well as own component ICE (*Early Start*) namely time fastest For start something activity And E.F (*Early finish*) namely the fastest time to complete an activity.
- The countdown (*backward pass*) starts from the end point to the start point which functions to determine the longest time in a project, and has components in the form of LF (*Late Finish*), which is the slowest time to complete the activity and LS (*Late Start*), which is the slowest time to start. activity.

There are two differences in describing a project network, namely:

- Use model AON (*activity on nodes*), model This own function for describe A network project on point. On model This point serves to show an activity.
- Using the AOA (*activity on arrow*) model, this model has a function to describe a network project on the arrow.

II. RESEARCH METHODOLOGY

Type study Which used by researcher that is quantitative. Quantitative research methods are usually used when researchers want to obtain accurate data, based on empirical and measurable phenomena. By using a quantitative type of research, the researcher will present data in the form of numbers in the form of the time duration for each work activity on the Nava House housing construction project. In this research, researchers used the Nava House housing complex as an object study. Housing area Nava House is A project housing development Which Cluster type with type House 36/84 m^2 . This project plans to build 33 housing units with a land area of ±1 hectare. Determining the research area deliberately (*purposive method*) in Tambun, Bekasi.

A. Critical Path Method (CPM)

CPM method use network Work (*Network*) to describe project activities that will later be networked Such work can show the existence of a critical path [13] . The critical path namely a path that has a set of activity components with the fastest time duration and the longest time duration for completion project. Track critical consists from arrangement activity critical, start from activity First until activity project final. track critical very important Because on track This there is activities which if implemented late could result in late completion A project. In network Work even sometimes There is more of one critical path [14] .

B. Program Evaluation and Review Technique (PERT)

The PERT method is a method that aims to minimize production delays and disruptions during project work, as well as coordinate various part work in a way overall so that project completion can be accelerated . . The PERT method allows users not only to calculate the expected duration of a project, but also to measure the likelihood (probability) of a project, or the share of a project completed within a certain time period [15] . There are components to the PERT method, namely:

- Activity or activity
- Incident
- Activity time
- Estimation time solution
- Scheduling Project

The PERT method determines how long a project will take to complete by setting a pessimistic (slowest) time and an optimistic (fastest) time for each activity or activity [16] . This is due to uncertainty regarding the completion of an activity mentioned in the variant. In PERT there are network components that use three time estimation numbers , namely:

- Optimistic time is the time needed for an activity if the activity carried out goes according to plan.
- Pessimistic time is the time needed for an activity with assumption condition which is very unexpected, this situation occurs when an accident or very unexpected situation occurs.
- Realistic time is the estimated time most possible For complete activities on the project.

PERT (*Program evaluation and review technique*) method in determining the critical path in a work network, starting with calculating time that most beginning (T E) as well time final settlement which is allowed or *latest allowable occurrence time* (T L) every activity which was formulated in [17] :

$$T_j = T_i + T_{ij} \text{ atau } T_j = (T_i + t_{ij}) \max ,$$
$$E \quad E \quad E \quad E \quad E \quad E$$
$$T_i = T_j + t_{ij} \text{ atau } T_i = (T_j + t_{ij}) \min$$
$$L \quad L \quad E \quad L \quad L \quad E$$

For count slack (S) in A activity used formula:

$$S = T_L - T_E$$

Calculating Project probability

Information:

Z = Variant Standard

$$Z = \frac{TD - TE}{\sqrt{v^2}}$$

TD = Target completion time

TE = Expected completion time

v^2 = Variant

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C. Difference between CPM and PERT Methods

There are several differences between the PERT and CPM methods, namely as follows:

- Application of the method, the PERT method is used in planning and controlling projects that have never been carried out before, while the CPM method is used to plan and control activities that have been carried out previously so that the time, data and costs of each activity item are known by the evaluator in advance [19] .
- Processing time, in the PERT method there is an activity duration that uses three types of time, namely optimistic, pessimistic and realistic, whereas in the CPM method there is only one type of processing time information, namely the most appropriate time to complete a project.
- Method focus, the PERT method focuses on completing projects on time, because this method can save time minimize cost project, whereas on method CPM focuses on the accuracy of the realization of project cost plans.
- In method PERT child arrow describe system sequence, while in CPM the arrows represent activities.

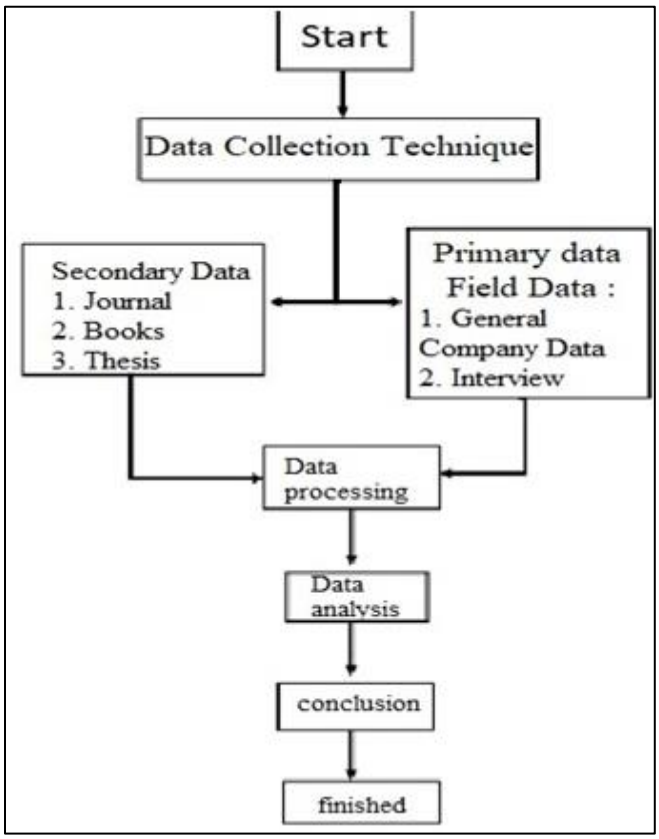

Fig 1 Research Framework

III. RESULTS AND DISCUSSION

Development housing area Nava House is project Which currently implemented, and this project is planned to build 33 housing units. Nava House housing has ± 1 hectare of land, with a plot area 72-92 m ^{2} for each house. The houses in the Nava House housing development project are type 36 and done by 5 craftsmen per house unit. In project work This Already confirmed need material building in the workmanship. The following is an explanation of the building materials used in the Nava House housing project.

A. Chicken Claw Work

Scratch chicken is activity first one installed before work on installing foundations and sloofs, chicken claws are carried out as reinforcement in a construction, the material used for chicken claws is 10 iron with a total of 9 rods.

Table 1 Chicken Claw Work

No	Material	Amount
1	Iron 10	9 Stems

B. Foundation and Sloof Work

Foundation and sloof work is used to support the load of the building and is at the bottom, the foundation and sloof are carried out after the chicken claw work. The foundation and sloof use iron 10 and iron 8 with a total of 24 rods. The following is a table of foundation and sloof work materials:

Table 2 Foundation and Sloof Work

No	Material	Amount
1	Iron 10	24 Stems
2	Iron 8	24 Stems

C. Pole Installation Work

Installing the poles is used for support before installing brick work on the Nava House residential building. The material used for installing the poles is 8 iron with a total of 21 rods. The following is a table of materials for installing poles:

Table 3 Pole Installation Work

No	Material	Amount
1	Iron 8	21 Bars

D. Brick and Frame Installation Work

Brick installation is done after installing the pillars which function as walls in the building. Brick laying is done simultaneously with making jamb. Material Which used in This work is red brick with a total of 8,000 bricks, while the frame with 10 pairs of frames on each house. The following is a table of brick and frame installation materials:

Table 4 Hebel and Frame Installation Work

No	Material	Amount
1	Hebel	600 Hebel
2	Jamb	10 Sills

E. Balk Ring Work

The ring balk work is positioned at the top of the wall, which functions to fasten the brick installation. In working on the ring balk on the Nava House housing, 20 pieces of 8 iron are needed. The following is a table of materials used in making ring balks:

Table 5 Ring Balk Work

No	Material	Amount
1	Iron 8	20 Stems

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F. Electrical Installation Work

Electrical installation for purposes related to electricity such as installing switches, installing *fittings* and lights, sockets and MCBs. Every House Already Certain need electricity For needs daily activities. In this type 45 house, the installation uses cable material 1x2.5 with 1 roll red. And use double switch with 1 red roller, single switch with 2 black rollers. Then there are 5 sockets in the building, while for *fittings* and lights, 6 each. For MCB, namely 2 pieces. Following is the table Materials for electrical installation work:

Table 6 Electrical Installation Work

No	Material	Amount
1	1x2.5 cable	1 Red Roller
2	Double Switch	1 Black Roll
3	Single switch	2 Black Rollers
4	Electric socket	5 PCs
5	*Fittings* and Lights	6 PCs
6	MCB	2 pieces

G. Roof Framework Work

The roof frame is installed as support for the roof installation. Before the roof installation begins, the frame must be made. The material used in the roof frame is C channel light steel with a total of 34 rods, then using battens with a total of 35 rods. The following is a table on roof framing work:

Table 7 Roof Framework Work

No	Material	Amount
1	Ceiling	16 Sheets
2	Holo 4x4	35 Bars
3	Holo 2x4	25 Stems

H. Roof Installation Work

Roof installation is carried out after the roof frame is made. The function of the roof itself is to protect the house from rain. This building requires 105 roof sheets. The following is a table on roof installation work:

Table 8 Roof Installation Work

No	Material	Amount
1	Sand Spandek Roof	15 Sheets

I. Plaster Work

Plaster work is carried out after installing the bricks which serve as the coating the brick that will later become building walls. In this building plastering work only 30 sacks of cement were used. The following is a table on plaster work:

Table 9 Plaster Work

No	Material	Amount
1	Cement	20 Sak

J. Melamir Jobs

Pelamir is used for coating wall for cover gaps in the wall after plastering, so that the wall can become flatter. The materials for the plastering job are 3 cans of plastering. The following is a table on splicing work:

Table 10 Melamir Jobs

No	Material	Amount
1	Applicants	2 Cans

K. Ceiling Work

The ceiling is used to cover the top of the house, to cover the roof so that the house is protected from hot weather. As for materials for ceiling work that is with sheet ceiling, holo size 4x4 with amount 35 rods, and holo size 2x4 with a total of 25 rods. Here's a table on ceiling work:

Table 11 Ceiling Work

No	Material	Amount
1	C Channel Light Steel	24 Stems
2	Batten	35 Bars

L. Ceramic Installation Work

Ceramic work as a floor or what is usually called a teal in a building. On development Nava House type 36 housing is required ceramics measuring 40x40 with a quantity of 40 boxes, and ceramics 35x35 with a quantity of 25 boxes. The following is a table of materials for ceramic work:

Table 12 Ceramic Work

No	Material	Amount
1	Ceramic 40x40	40 Dus
2	Ceramic 35x35	25 So

M. Paint Job

Paint is used to beautify A building, that is where the paint covers the results application, as for the paint material used on House This that is paint cream with Friday 1 files Which Where as color for the outside of the house, white paint with amount 4 files, oil paint with amount 4 cans, and 3 bottles of thinner. Here's a table on the paint job:

Table 13 Paint Job

No	Material	Amount
1	Cream Paint	1 File
2	White Paint	4 Files
3	Oil paint	4 Cans
4	Thinner	3 Bottles

N. Sepiteng Works

Sepiteng is intended for waste disposal. The materials used to make the sepiteng are 250 bricks and 4 inch pipes with a total of 3 sticks, 2.5 inch pipes with 4 sticks and 0.5 inch water pipes with a total of 26 sticks. The following is a table of materials for the Sepengeng job:

Table 14 Sepiteng Jobs

No	Material	Amount
1	Concrete brick	250 Seeds
2	4 Inch Pipe	3 Rods
3	2.5 Inch Pipe	4 Rods
4	0.5 Inch Water Pipe	25 Stems

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O. Garage Work

Garage work is also part of the last activity carried out, the garage is in the front yard of the house. In work garage required cement as much 2 sack, sand as much 2 bro, and 1.5 cubic meters of gravel. The following is a table of materials for garage work:

Table 15 Garage Jobs

No	Material	Amount
1	Cement	2 Sak
2	Sand	2 Sak
3	Gravel	1.5 Cubic

P. Finishing

In the finishing work, cleaning and installing doors and windows in the building are carried out. In the finishing work for installing doors, 4 doors with a size of 80x205cm are needed, while windows require 6 windows with a size of 60x175cm. The following is a table of materials for *finishing work* :

Table 16 *Finishing*

No	Material	Amount
1	Door 80x205 cm	4 Doors
2	Window 60x175 cm	6 Windows

Estimated work time for Nava House housing before using the method, project work is carried out based on the preferences of the project supervisor according to actual conditions in the field.

➢ *Activity Time in the CPM Method*

Table 17 Activity Time Duration Before Using the Method

Code	Activity	Before Using the Method
A	Chicken feet	4 days
B	Foundation and Sloof	6 Days
C	Install the Pole	5 days
D	Installation of Hebels and Frames	14 days
E	Ring Balk	5 days
F	Electrical installation	3 days
G	Framework Roof	4 days
H	Roof Installation	3 days
I	Plaster	11 Days
J	Melamir/Acian	6 Days
K	Ceiling	5 days
L	Ceramics	7 days
m	Paint	5 days
N	Sepiteng	3 days
O	Garage	3 days
P	*Finishing*	2 days

Estimated construction time for Nava House housing using the CPM method One type time or called *single time estimate* . There is each code activity And activity previous as well as duration every activity. Following data to be obtained using the CPM method:

Table 18 Activity Time Duration in the CPM Method

No	Activity	Past Activity	Duration
A	Chicken feet	-	3 Days
B	Foundation and Sloof	A	3 Days
C	Install the Pole	B	3 Days
D	Installation of Bricks and Frames	C	8 Days
E	Ring Balk	D	2 Days
F	Electrical installation	D	1 Days
G	Framework Roof	E	2 Days
H	Roof Installation	G	2 Days
I	Plaster	H	4 Days
J	Plamir/Acian	I	3 Days
K	ceiling	J	2 Days
L	Ceramic	J	4 Days
M	Paint	L	3 Days
N	Sepiteng	M	2 Days
O	Garage	N	2 Days
P	*Finishing*	F, K, O	1 Days

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➢ *Activity Time in the PERT Method*

Method PERT use three type time, Which Where House which will begin work or are in the initial stages of work will be obtained using the PERT method. There is an optimistic time, a pessimistic time and a realistic time for each activity. The following is a table of estimated activity time using the PERT method:

Table 19 Estimated Activity Time Using the PERT Method

Activity	Optimistic Times	Pessimistic Times	Realistic Time
A	2 days	4 days	3 days
B	3 days	5 days	4 days
C	3 days	5 days	4 days
D	17 Days	21 Days	19 Days
E	3 days	5 days	4 days
F	2 days	4 days	3 days
G	1 day	3 days	2 days
H	1 day	4 days	3 days
I	7 days	10 days	9 Days
J	4 days	7 days	5 days
K	3 days	5 days	4 days
L	3 days	5 days	4 days
m	2 days	4 days	3 days
N	1 day	3 days	2 days
O	1 day	3 days	2 days
P	1 day	3 days	2 days

➢ *Comparison of Activity Time Before and After Using Metode*

Table 20 Estimated Activity Time Using the PERT Method

Code	Activity	Before Using the Method	Realistic Time	PERT method
A	Chicken feet	4 days	3 days	3 days
B	Foundation and Sloof	6 Days	3 days	4 days
C	Install the Pole	5 days	3 days	4 days
D	Installation of Hebels and Frames	14 days	8 Days	10 days
E	Ring Balk	5 days	2 days	4 days
F	Electrical installation	3 days	1 day	3 days
G	Framework Roof	4 days	2 days	2 days
H	Roof Installation	3 days	2 days	3 days
I	Plaster	11 Days	4 days	9 Days
J	Melamir/Acian	6 Days	3 days	5 days
K	Ceiling	5 days	2 days	4 days
L	Ceramics	7 days	4 days	4 days
m	Paint	5 days	3 days	3 days
N	Sepiteng	3 days	2 days	2 days
O	Garage	3 days	2 days	2 days
P	*Finishing*	2 days	1 day	2 days

➢ *Form a Work Network*

From the data that has been obtained, the form of the network of activities in the table is shown the. The working network that is formed has 16 lines, the working network is in the picture below:

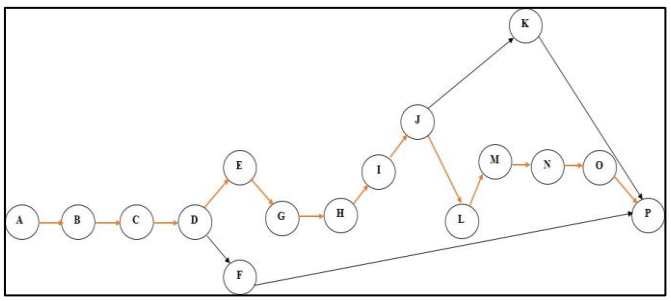

Fig 2 Form *of Activity on Node* (AON) Network

An activity on node (AON) type working network, where the results of the working network are found three lanes. That is:

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- A, B, C, D, E, G, H, I, J, K, P
- A, B, C, D, E, G, H, I, J, L, M, N, Oh, P
- A, B, C, D, F, P

Arrows can be depicted for *activity on arrow* (AOA) type networks, the results of the network form are in the image below:

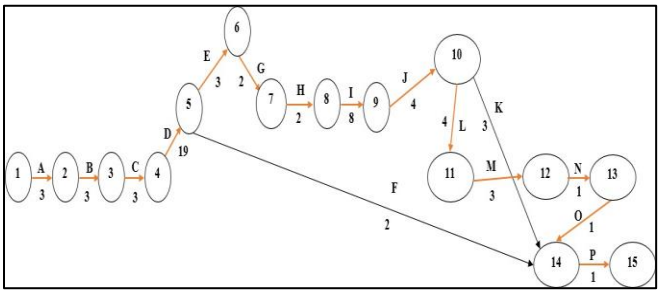

Fig 3 Activity Network *on Arrow*

AOA on CPM method is form network Work from data which is obtained on CPM method

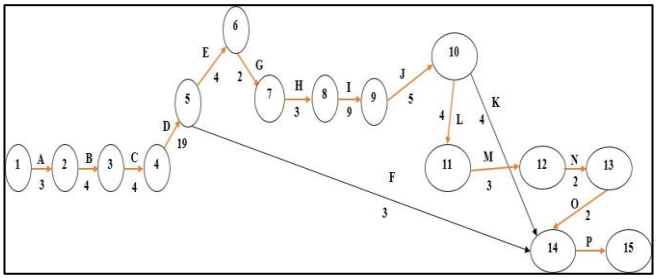

Fig 4 Network *Activity on Arrow*

(AOA) in the PERT method is form network Work from data which is obtained on PERT method

➢ *Determining the Critical Path with the CPM Method*

In Figure 3, the path formed by 3 paths will be added up for each path to determine the critical path, as follows:

- A + B+ C+ D + E + G + H + I + J+ K + P
  + 3 + 3 + 19 + 3 + 2 + 2 + 8 + 4 + 3 + 1 = 51
- A + B+ C+ D + E + G + H + I + J+ L + M+ N + O + P
  + 3 + 3 + 19 + 3 + 2 + 2 + +8 + 4 + 4 + 3 + 1 + 1 + 1 = 57
- A + B+ C+ D + F + P
  + 3 + 3 + 19 + 2 + 1 = 31

Results critical path time above is 57 days, which is where 57 days namely time longest between 3 track the. In determine track Critical analysis can also use a picture made of a working network, where the critical path will be found through the results ES, EF, LS, LF calculations are as follows:

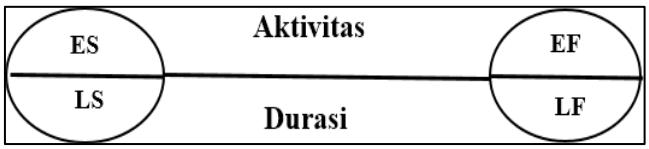

Fig 5 ES, EF, LS, LF

Critical path results found in housing development projects Nava House for One units House, addressed on picture under This:

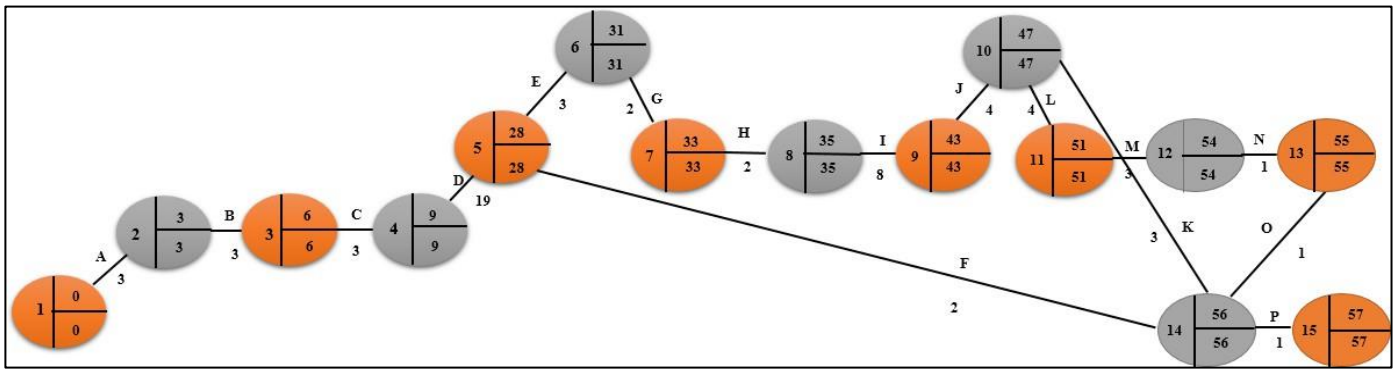

Fig 6 Determining the Critical Path in the CPM Method

The numbers that there is on circle figure 6, results from ICE, E.F. LS, LF that have the same value are called critical path activities. This activity cannot be postponed.

For the same value on the circle the calculation results of ES, EF, LF, The LF will be added up to determine the completion time of the critical path in the housing units that have been completed or carried out, namely:

A + B + C + D + E + G + H + I + J + L + M + O + P
3+ 3 + 3 + 19 + 3 + 2 + 2 + +8 + 4 + 4 + 3 + 1 + 1 + 1 = 57

The activity on the critical path is chicken claws (A), foundation and sloof (B), installation of poles (C), installation of bricks and frames (D), ring balk (E), roof frame (G), installation of roof (H), plaster (I), plaster (J), installation of ceramics (L), paint (M), paint (N), garage (O), finishing (P).

➢ *Determining the Critical Path using the PERT Method*

To find out the expected time using the PERT method, use the formula:

$$Te = \frac{To + 4Tm + Tp}{6}$$

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In the figure, activity F and activity K are not included in the critical path, because for the forward count (forward pass) by adding up the previous activities, then the sum of the larger results will be chosen to be written in the work network circle, and for the backward count (backward pass) by reducing the next activity to the previous activity and the result of the smaller amount will be written in the working network circle. In determining the critical path, activity F has two arrows and gets an ES result of 28 and an LS of 54, while the EF is 30 and the LF is 56. Likewise with activity K, where the activity has two arrows with a number or result. different. Where the ES is 47 and the LS is 53, while the EF is 50 and the LF is 56. Activities F and K have different ES, EF, LF, LS results in the work network circle.

Therefore, the completion time on the critical path is 57 days for one housing unit.

Table 21 Expected Completion Time (TE)ktu Penyelesaian Yang Diharapkan (T_E)

Activity	Calculation	T_E
A	(2 + 4 (3) + 4) / 6	3
B	(3 + 4 (4) + 5) / 6	4
C	(3 + 4 (4) + 5) / 6	4
D	(17 + 4 (19) + 21) / 6	19
E	(3 + 4 (4) + 5) / 6	4
F	(2 + 4 (3) + 4) / 6	3
G	(1 + 4 (2) + 3) / 6	2
H	(1 + 4 (3) + 4) / 6	2.83
I	(7 + 4 (9) + 10) / 6	8.83
J	(4 + 4 (5) + 7) / 6	5.17
K	(3 + 4 (4) + 5) / 6	4
L	(3 + 4 (4) + 5) / 6	4
m	(2 + 4 (3) + 4) / 6	3
N	(1 + 4 (2) + 3) / 6	2
O	(1 + 4 (2) + 3) / 6	2
P	(1 + 4 (2) + 3) / 6	2

From table 22 which produces the expected time (T_E), we can determine *the Early Finish* (EF), to get the EF results for Nava House housing for each type 36 housing unit, namely by adding T_E with ES, namely as follows:

Table 22 Early Finish (EF)

Activity	Time (T_E)	ICE	E.F
A	3	0	3
B	4	3	7
C	4	7	11
D	19	11	30
E	4	30	34
F	3	30	33
G	2	34	36
H	2.83	36	38.83
I	8.83	38.83	47.66
J	5.17	47.66	52.83
K	4	52.83	56.83
L	4	52.83	56.83
m	3	56.83	59.83
N	2	59.83	61.83
O	2	61.83	63.83
P	2	63.83	65.83

Determine *Late Start* (LS) And on housing area Nava House For per type 36 housing unit by subtracting T_E from LF, as follows:

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Table 23 *Late Start* (LS)

Aktiivitas	Waktu (T_E)	LF	LS
A	3	3	0
B	4	7	3
C	4	11	7
D	19	30	11
E	4	34	30
F	3	63,83	60,83
G	2	36	34
H	2,83	38,83	36
I	8,83	47,66	38,83
J	5,17	52,83	47,66
K	4	63,83	59,83
L	4	56,83	52,83
M	3	59,83	56,83
N	2	61,83	59,83
O	2	63,83	61,83
P	2	65,83	63,83

After know results from calculation EF, ES, LS, LF, then will calculate the amount Slack with how to reduce LS with ICE. The results of these calculations are shown in table 24

Table 24 *Slack*

Activity	T_E	ICE	E.F	LF	L.S	Slack
A	3	0	3	3	0	0
B	4	3	7	7	3	0
C	4	7	11	11	7	0
D	19	11	30	30	11	0
E	4	30	34	34	30	0
F	3	30	33	63.83	60.83	30.83
G	2	34	36	36	34	0
H	2.83	36	38.83	38.83	36	0
I	8.83	38.83	47.66	47.66	38.83	0
J	5.17	47.66	52.83	52.83	47.66	0
K	4	52.83	56.83	63.83	59.83	7
L	4	52.83	56.83	56.83	52.83	0
m	3	56.83	59.83	59.83	56.83	0
N	2	59.83	61.83	61.83	59.83	0
O	2	61.83	63.83	63.83	61.83	0
P	2	63.83	65.83	65.83	63.83	0

Activities that contain slack are not included in the critical path, namely activities F and K. And the results of the work network form in 3 paths, as follows:

- A + B+ C+ D + E + G + H + I + J+ K + P
  3+ 4 + 4 + 19 + 4 + 2 + 2.83 + 8.83 + 5.17 + 4 + 2 = 58.83
- A + B+ C+ D + E + G + H + I + J+ L + M+ N + O + P
  3+ 4 + 4 + 19 + 4 + 2 + 2.83 + 8.83 + 5.17 + 4 + 3 + 2 + 2 + 2 = 65.83
- A + B+ C+ D + F + P
  + 4 + 4 + 19 + 3 + 2 = 35

The critical path found in the PERT method is 65.83, or 66 days of maximum work per housing unit in the Nava House housing development project

The form of the network results to determine the critical path for data obtained from the PERT method is as follows:

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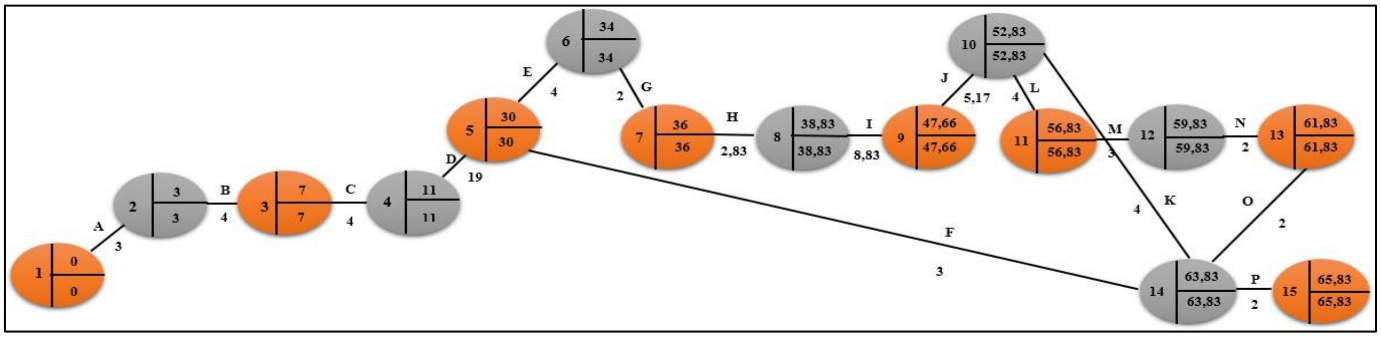

Fig 7 Critical Path on Method PERT

Figure 6 shows that activities A, B, C, D, E, G, H, I, J, L, M, N, O, P. Activities on the critical path are, chicken claws (A), foundation And sloof (B), installation pole (C), installation brick And jamb (D), ring OK (E), roof framework (G), installation roof (H), plaster (I), melamir (J), ceramic installation (L), paint (M), plastering (N), garage (O), finishing (P). As in the explanation of the results of the CPM method, in determining the critical path, activity F own two child arrow And get results ICE that is 30, which is different from the LS result, namely 33, and the LF is 63.83, while the LS is 60.83. Likewise with activity K which the activity has two child arrow with amount or the results different. Which where the ES is 52.83 and the LS is 59.8, while the LS is 59.83, then the EF is amount 56.83, And LF his 63.83. From activity K own results with different amounts in the working network circle.

➢ *Results POM QM For Windows*

POM QM *for windows* shows path results critical Which found in the CPM and PERT methods, as follows:

- Track critical Which there is on method CPM produce 57 day
- The critical path contained in the PERT method produces 65.83 days of POM QM *for windows* show that results from calculation

Manually And device soft, show results the same one.

Tutorials use POM QM *for Windows* will showed via attachment.

IV. CONCLUSIONS AND RECOMMENDATIONS

- The path formed in the network using the CPM and PERT methods has 3 paths and 15 arrows.
- Activity Which including in track critical that is A, B, D, E, G, H, I, J, L, M, N, O, P. Activity on the critical path namely, chicken claws (A), foundation and sloof (B), installation pole (C), installation brick and jamb (D), ring balk (E), frame roof (G), roof installation (H), plaster (I), plaster (J), ceramic installation (L), paint (M), plaster (N), garage (O), finishing (P).
- Housing units that have been completed and analyzed using the CPM method resulted in 57 days of work. Meanwhile, the housing units are still in their infancy processing Which analyzed with method PERT produce 66 working day.

➢ *Suggestion*

- Suggestion Which given by writer For contractors, as well as parties who contributed to the construction of the Nava House housing project paid more attention to the duration of each activity involved in the construction of the project. So that it can reduce and minimize work delays so that the project can be completed within the expected time.
- Suggestions for future researchers are to develop the application of project management to project scheduling using more diverse methods.

REFERENCES

[1]. A. Aziz *et al.* , *PROJECT MANAGEMENT (Theoretical and Practical Overview)* , vol. 1. 2022. [Online]. Available: www.penerbitwidina.com

[2]. A. Yuliana, "Analysis of the Implementation of Reconstruction Project Management on Jalan Kwandang Molingkapoto Prov. Gorontalo," *Radial - J. Perad. Science, Engineering and Technology.* , vol. 4, no. 1, pp. 72–78, 2016.

[3]. H. Prabowo and M. Anhar, "Optimizing Project Management at PT.Cipta Ekatama Nusantara Using the CPM/PERT Method in the Cendana Sawangan Regency Housing Development," *Sekol. College of Economics. Indonesia.* , vol. 1, no. 1, pp. 1–17, 2021, [Online]. Available: http://repository.stei.ac.id/id/eprint/2891

[4]. GP Arianie and NB Puspitasari, "PROJECT MANAGEMENT PLANNING IN INCREASING EFFICIENCY AND EFFECTIVENESS OF COMPANY RESOURCES (Case Study: Qiscus Pte Ltd)," *J@ti Undip J. Tek. Ind.* , vol. 12, no. 3, p. 189, 2017, doi: 10.14710/jati.12.3.189-196.

[5]. I. Sudipta, "Project Management Study of Resources in Construction Project Implementation (Case Study: Construction of Villa Bali Air)," *J. Ilm. Tech. Civil* , vol. 17, no. 1, pp. 73–83, 2013.

[6]. AC Siregar and I. Iffiginia, "Use of the critical path method (CPM) to evaluate project implementation time and costs," *Tech. J. Science and Technology.* , vol. 15, no. 2, p. 102, 2019, doi: 10.36055/tjst.v15i2.6816.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24JUL120

[7]. A. Angelin and S. Ariyanti, "Analysis of New Product Development Project Scheduling Using Pert and Cpm Methods," *J. Ilm. Tech. Ind.* , vol. 6, no. 1, pp. 63–70, 2019, doi: 10.24912/jitiuntar.v6i1.3025.

[8]. YS Susilo, "Project Implementation Analysis Using the CPM and PERT Methods (Case Study of the University of Riau Main Stadium Implementation Project (Multi Years)).," *J. Univ. Riau* , p. 16, 2011.

[9]. Abdurrasyid, Luqman, A. Haris, and Indrianto, "Implementation of PERT and CPM Methods in the Ship Building Project Management Information System (Implementation of PERT and CPM Methods in the Ship Building Project Management Information System)," *J. Komput Science. and Inform. Khazanah Inform.* , vol. 5, no. 1, pp. 28–36, 2019.

[10]. MR Adyatma and TS Hadi, "Analysis of Housing Location Determination by Developers for Low-Income Communities Around Industrial Areas," *J. Kaji. Space* , vol. 1, no. 2, p. 198, 2022, doi: 10.30659/jkr.v1i2.20025.

[11]. T. Iluk, A. Ridwan, and S. Winarto, "Application of the CPM and PERT Methods in the 3 Floor Parking Building of Grand Panglima Polim Kediri," *J. Manaj. Technol. Tech. Civil* , vol. 3, no. 2, p. 162, 2020, doi: 10.30737/jurmateks.v3i2.1054.

[12]. U. Hasdiana, "No主観的健康感を中心とした在宅高齢者における　健康関連指標に関する共分散構造分析Title," *Anal. Biochem.* , vol. 11, no. 1, pp. 1–5, 2018, [Online]. Available: http://link.springer.com/10.1007/978-3-319-59379-1%0Ahttp://dx.doi.org/10.1016/B978-0-12-420070-8.00002-7%0Ahttp://dx.doi.org/10.1016/j.ab.2015.03.024%0Ahttps://doi.org/10.1080/07352689.2018.1441103%0Ahttp://www.chile.bmw-motorrad.cl/sync/showroom/ lam/ice/

[13]. T. Alawiyah, YS Mulyani, MA Gunawan, R. Setiaji, and H. Nurdin, "Web-Based Project Management Information System (SIMAPRO) (Case Study: PT. Arya Bakti Saluyu)," *J. Khatulistiwa Inform.* , vol. 10, no. 2, pp. 129–135, 2022, doi: 10.31294/jki.v10i2.14061.

[14]. A. Maulidi, S. Arifin, and H. Suyoso, "Construction Project Scheduling Using the Critical Path Method (Case Study: Integrated Laboratory Building, Faculty of Engineering, University of Jember)," *J. Ilm. MITSU* , vol. 9, no. 1, pp. 1–8, 2021, doi: 10.24929/ft.v9i1.992.

[15]. RA Husna, NF Ilmiyah, and NC Resti, "Implementation of CPM and PERT in Predicting the Duration and Cost of Building Al-Ikhlas Prayer Rooms in West Kotawaringin," *J. Focus Action Res. Math. (Factor M)* , vol. 5, no. 1, pp. 97–109, 2022, doi: 10.30762/f_m.v5i1.633.

[16]. A. Witania, A. Dana Nugraha, L. Fajar Sari, N. Lia Megawati, and N. Nur Fadillah, "Comparative Analysis of The Most Frequently Used IT Project Management Methods in Indonesia and Abroad: Literature Review," vol . 15, no. 2, pp. 299–316, 2022.

[17]. AK Tama, L. Anggraini, and B. Tutuko, "Construction Management Performance Analysis on the Semarang State University Digitized Building Project," *J. Tek. Civil* , pp. 1–15, 2020.

[18]. Christian, Cefiro, and Sentosa, "Case Study of the Application of the PERT Method in the Warehouse X Project," *J. Univ. Kristen Petra* , pp. 1–8, 2013, [Online]. Available: https://media.neliti.com/media/publications/81512-ID-studi-case-penerapan-method-pert-pada-p.pdf

[19]. H. Prasetya, "Application of Project Management Methods in Improving the Quality of Information Technology-Based Libraries," *Ideguru J. Karya Ilm. Teacher* , vol. 6, no. 3, pp. 247–256, 2021, doi: 10.51169/ideguru.v6i3.278.

[20]. A. Ozaga and AA Arzi, "Project Management: Designing a Learning Management System (LMS) for Learning Information Systems Using the Critical Chain Method," *August* , vol. 02, no. 1, p. 1, 2022.