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THE COST OBTAINED BY APPLYING PRECEDENCE DIAGRAM METHOD TOWARD THE TIME OPTIMIZATION ON BUILDING DEVELOPMENT PROJECTS

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Abstract. *The complexity of the project expands along with the progress of human civilization. The problems that appear will be more numerous and complicated. The role of project management is indispensable in order to address and prevent these problems, so that the cost,the quality and the time agreed upon can be realized. Cost and time relationship is not directly proportional, so it is necessary to determine the optimal time by optimum cost. Optimization is a best effort undertaken by planning various alternative methods of implementation, in order to obtain optimal timing of projects with optimum cost. Planning and scheduling are the backbone of the entire project, which is based on clear objectives. Microsoft Project as one of the scheduling software based on Precedence Diagram Method (PDM) provides many advantages, one of which scheduling can be done more quickly and thoroughly.In this research, it is created six alternative models as follows: In the first alternative ,it is acquired the project period of 256 days , at a cost of Rp2,190,234,913.43 ; In the second alternative , the was obtained the project period of 150 days , with a cost of Rp1,903,674,873.6 ; In the third alternative , it was obtained the project period of 102 days , at a cost of Rp1,873,215,897.61 ; In the alternative IV , it was obtained the project period of 99 days , at a cost of Rp1,895,159,526.12 ; In the alternative V , the project period was 96 days , at a cost of Rp2,019,623,191.13 ; In alternate VI , the project period was 89 days at a cost of Rp2,090,543,033.77. From the above calculation, then the result is interpolated in order to obtain the optimum time for the development project. The optimum time obtained is 120 calendar days, at a cost of Rp. 1,884,638,013.61.*

Keywords : Project, Project Management, Planning, Scheduling, PDM, :Optimization, Methods of Implementation, Cost and Time.

1. INTRODUCTION

1.1 Background

Nowadays construction projects have grown increasingly complex and complicated. No doubt the problems faced will be more and more difficult, so it takes the role of project management to the overall stages of the project, in order to minimize the problems posed and the three project targets that are appropriate cost, time, and quality can be met.

Planning is the overall backbone of the project, and it must be realistically structured. Realistic planning is expected to guarantee the completion time of a construction project in accordance with the plan. Because it is not guaranteed that the timing of fast project implementation requires minimal cost, and vice versa. In other words, the time and cost ratio of the project is not directly proportional. Based on this it is necessary to take into account how to get the most optimum time planning with the least cost.

Optimization is defined as a process of deciphering the duration of the project to obtain optimal completion time and reasonable cost, using various alternative methods of implementation, such as: heavy equipment use, increase in the number of workers, additional hours of work and others, tailored to the field conditions and needs.

To plan when a project should be implemented, a scheduling is required. With the scheduling, the problem of delay in completion of the project can be reduced and there will be an increase on the timeliness of completion, so the budget can be saved without any additional costs that are not really needed. There are two kinds of project scheduling techniques that are often used today. Networking is the best scheduling technique right now because it can solve the problems of the only scheduling technique (Gantt-Chart). In its development there are various kinds of networking methods such as CPM, GERT, PERT, PDM etc.

PDM (Precedence Diagram Method) is a scheduling tool that focuses on the equilibrium issue between project cost and time of completion. The PDM diagram does not require dummy / fictitious activity and additional sections to indicate overlap. Based on the above description, the authors are interested to raise the topic of Project Development Cost Building Using PDM (Precedence Diagram Method) ".

1.2 Research Problems

Based on the above description of the background, the issues to be raised in this research are as follows:

a. What is the shape of network (network) with PDM method in Building Construction project?
b. How much is the total cost of the Denpasar Building Development project with optimum duration?

1.3 Research Objectives and Benefits

The purpose of this study are as follows:

a. To determine the network on the Development project.
b. To analyze the cost estimates for a Building Development project whose completion time is accelerated.

The benefits of this research are as follows:

a. To complete the project on time so that its budget use becomes efficient and there is no waste.
b. To apply the sciences gained in lectures to solve existing problems in the project.
c. To be able to provide input to the agencies involved in construction work projects in order to produce construction products that are timely in progress, precise and cost-effective methods.

1.4 Research Scope

The limitations of the research problems are as follows:

a. The research was conducted on Building Construction project.
b. Project scheduling analysis using PDM method.
c. For alternative optimization of time on the addition of manpower, available resources are considered unlimited.
d. For alternative optimization of time on the addition of working hours (overtime), used normal labor productivity.
e. Normal working hours in one day is 8 hours ie at 08.00 until 12.00, then at 13:00 until 17:00.
f. There is no volume change in each job.

1.5 Literature Review

a. Project

The construction project is a series of activities that are only implemented once and generally takes a short period of time. In the series of activities, there is a process of processing project resources into a result of activities in the form of buildings. In addition, the construction project has 3 (three) characteristics: unique, requires resources (money, machinery, methods, and materials), and requires organization [3].

b. Project Management

H. Kerzner states that project management is planning, organizing, leading, and controlling company resources to achieve short-term goals that have been determined [10].

Project management is the implementation of systematic management functions in a project using limited resources, effectively and efficiently to achieve the project objectives more optimally.

c. Planning

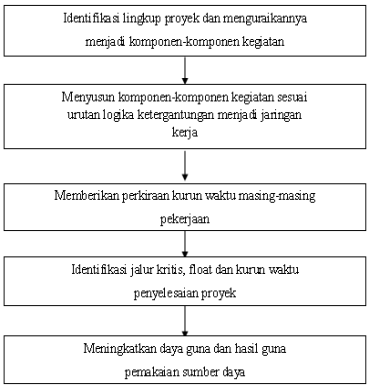
Planning is a process of trying to lay the groundwork of goals and objectives including setting up all resources to achieve them. Planning provides guidance for the implementation of resource allocation to carry out activities (Imam Suharto, 1997). Broadly speaking, planning serves to lay the foundation of project objectives, namely scheduling, budget and quality.

d. Scheduling

Scheduling is the elaboration of project planning into a sequence of steps on the implementation of work on a time scale to achieve the target. Scheduling determines when activities are initiated, deferred and resolved, so that the financing and use of resources will be timed according to predetermined needs [8]. Planning a project schedule can be done well and realistically, if in the planning process schedule is done in stages with the steps as follows:

1) Making WBS
2) Determining the implementation method
3) Determining duration
4) Determining relation between activities
5) Looking back to whether the duration and sequence of activities are reasonable and workable in the field

There are a variety of project scheduling methods to plan graphically from the construction activities, but only two methods are commonly used; they are gantt charts and networking (CPM, PERT, PDM, GERT, etc.). Here is the systematizing of scheduling on networking methods:



Picture 1 Network Scheduling Systematic

e. PDM

PDM was developed in the 1960s by the US Navy in collaboration with Professor Dr. John Fondahl of Stanford University to develop a CPM calculation method that will also solve the use of "Dummy" dependencies. Dr. Fondahl reversed the AOA diagram method to the traditional AON method known as the precedence method. The Fondahl method then became an option for the critical path method (Uher, 1996). Although the approach is substantially different between CPM and PDM, the results are the same (O'Brien and Plotnit, 1999).

The advantage of Precedence Diagram Method (PDM) compared to CPM is that PDM does not require fictitious / dummy activities so the networking becomes simpler [5]. This is because different overlapping relationships can be created without increasing the number of activities.

f. Optimization

Optimization is a process done in the best way in a job to gain profit without having to reduce the quality of work. There are several alternatives to optimize the time and cost of project completion that can be done, namely:

1) Use of Heavy Equipment.
2) Replacement or Repair of Working Methods.
3) The addition of Labor.
4) Implementation of Working Hours (Overtime).
5) Work shift

g. Implementation method

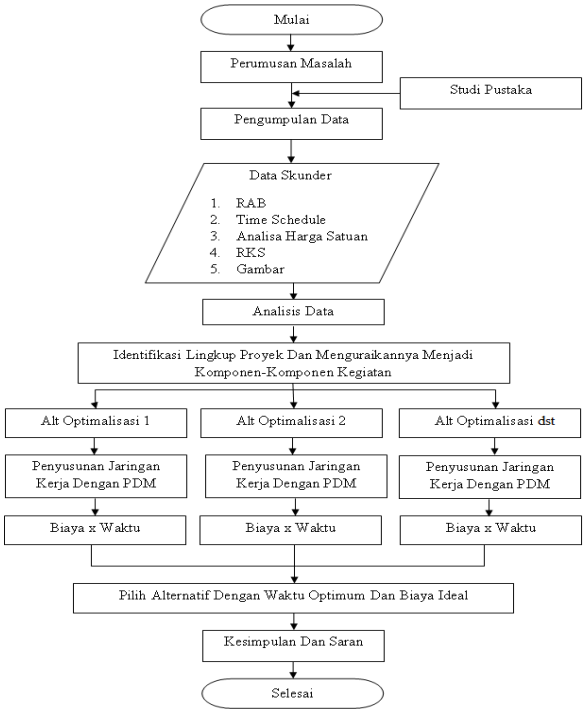
Method of work implementation represents the elaboration of procedure and technique of the implementation. The use of appropriate, practical, fast and secure methods is helpful in the completion of work on a construction project. So precise quality, exact cost / quantity and timely as determined, can be achieved. The method of implementation has an enormous impact on the direct costs of a project. The aspects that affect the method of job implementation include:

1) Implementation method is a technological innovation aspect required by the terms of the contract
2) Selected implementation methods must be tailored to the various environmental conditions of the project.
3) The method of implementation is affected by the availability of resources.

2. RESEARCH METHOD

2.1 Flow Chart

In conducting a research, obviously, a research method plan should be developed so that the research can run systematically and directed. Here is the systematic research in the form of flow chart.



Picture 1 The Flow Chart of the Research Stages

2.2 The Time of Data Collection

The research execution time is 10 weeks.

2.3 Research Location

For the location of this research, it was taken the building project.

3. RESULT AND DISCUSSION

3.1 Data Analysis

a. Identification of the Project Scope

Identification of project scope is the first step in networking. Identification of the project scope aims to know the activities that exist within a project and grouped into work groups. Arrangement of project scope is based on the sequence of job execution which is adjusted to sequence of work on Time Schedule that already exists.

b. Calculation of Project Cost

In this study, it is assumed that, costs other than the overhead cost are in the scope of the direct costs. Based on the journal Asri Nurdiana (2015) which is related to indirect cost analysis, it is mentioned that overhead cost is 5% of the budget plan, so direct cost can be formulated as follows:

Direct cost = (100% - Overhead cost) x Budget plan
= (100% - 5%) x Budget plan
= 95% x Budget plan
= 95% x Rp. 2,094,055,054
= Rp. 1.998,838,970.30

Based on the calculation of the direct cost, the indirect cost can be calculated as follows:

Indirect cost x d = Budget plan – Direct cost
= 2094055054 – 1998838970.30

Indirect cost x 150 = Rp. 95,216,083.50

Indirect cost = Rp. 95,216,083.50/150 days
= Rp. 634,773.89/day

c. Calculation of Project Resources

The calculation of the project resources in this case is labors, equipments, and materials. The calculation of the project resources applied PU unit work analysis. Here is an example of the need calculation of project resource (labors):

1 m' Analysis of Bore Pile Foundation Work (Labors)

0.03	oh	Foreman	@	Rp. 75,000	Rp. 2,250
0.18	oh	Digger	@	Rp. 60,000	Rp. 10,800
0.425	oh	Bricklayer	@	Rp. 60,000	Rp. 25,500

Produktivitas mandor = koefesien x volume pekerjaan
Produktivitas = 0.03 x 212.8
= 6.384 oh
Upah mandor = produktivitas x upah
= 6.384 x Rp. 75,000
= Rp. 478,800

Kebutuhan mandor untuk durasi 14 hari adalah sebagai berikut:

Produktivitas mandor x d = 6.384 oh
Produktivitas x 14 = 6.384
Produktivitas = 6.384 /14
Kebutuhan (14 hari) = 0.456 org
Upah mandor = produktivitas x upah
= (0.456 x 14) x Rp. 75,000
= Rp. 478,800

Produktivitas tukang gali = koefesien x volume pekerjaan
Produktivitas = 0.18 x 212.8
= 38.304 oh
Upah tukang gali = produktivitas x upah
= 38.304 x Rp. 60,000
= Rp. 2,298,240

Kebutuhan tukang gali untuk durasi 14 hari adalah sebagai berikut:

Produktivitas t. gali x d = 38.304 oh
Produktivitas x 14 = 38.304
Produktivitas = 38.304 /14

Kebutuhan (14 hari) = 2.736 org

Upah tukang gali = produktivitas x upah

= (2.736 x 14) x Rp. 60,000

= Rp. 2,298,240

Produktivitas t. batu = koefesien x volume pekerjaan

Produktivitas = 0.425 x 212.8

= 90.44 oh

Upah tukang batu = produktivitas x upah

= 90.44 x Rp. 60,000

= Rp. 5,426,400

Kebutuhan tukang batu untuk durasi 14 hari adalah sebagai berikut:

Produktivitas t. batu x d = 90.44 oh

Produktivitas x 14 = 90.44

Produktivitas = 38.304 /14

Kebutuhan (14 hari) = 2.736 org

Upah tukang batu = produktivitas x upah

= (2.736 x 14) x Rp. 60,000

= Rp. 5,426,400

Total Upah = 478800 + 2298240 + 5426400

= Rp. 8,203,440.00

d. Alternative Planning of Optimization

The alternative planning of the optimization on the building construction project consists of six alternatives. The detail of each alternative is as follows:

1) There are six alternatives consisting of one plan alternative (existing) and five new alternatives.
2) Five from three alternatives are planned by deciphering the duration and changing the dependency relationship of each alternative work item.
3) The remaining two alternatives are done by addition of working hours (overtime).

e. Deciding the Work Item Duration

In deciding the duration for each work item in each alternative, trial and error method is applied. This method is chosen because of the relation between resources and duration which use fixed work relation. Things to consider in determining duration are overhead, critical paths, dependency relationships and project densities.

f. Flatten the Resources

Resource leveling is important to determine the maximum (peak) effort required in a given period of time. In one period of course there is not only one work item but other work items being carried out in that period. Maximum requirements obtained do not reflect the needs of the unit as a whole, because between the efforts of one period to another is not the same. So the calculation of the need for the next work unit is used with the calculation of the average. This calculation will produce a straight line.

g. Calculating Overtime

In this study, overtime calculations will be planned using Microsoft Project help. The required data is the overtime wage of each labor which is calculated per unit hour. Overtime wages are determined based on Ministerial Decree No. 102/2004. In the regulation, overtime pay is calculated as follows:

3 hours of overtime = 1.5 x normal wages

4 hours overtime = 2 x normal wages

In the above calculations can be drawn conclusions for one hour of overtime requires a fee of 0.5 x normal wage.

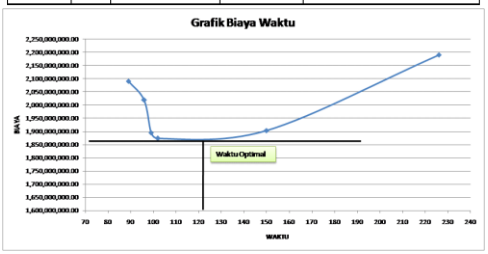
1 hour overtime = 0.5 x normal wage

h. The Calculation Results

To find out the most optimal cost and time, it is planned six alternative models. Once it is processed with Microsoft Project (see the attachment), then the results obtained are shown the following table:

Table 1 Calculation Result

	Waktu	Biaya	Jumlah Tenaga	Alternatif
Alternatif 1	226	2190234913	45	Predessesor
Alternatif 2	150	1903674874	72	Rencana
Alternatif 3	102	1873215898	101	Efisiensi Durasi
Alternatif 4	99	1895159526	101	Predessesor dan Efisiensi Durasi
Alternatif 5	96	2019623191	101	Lembur
Alternatif 6	89	2090543034	101	Lembur



Picture 3 Graphic of Cost and Time Relation

3.2 Discussion

In this research, six alternative models are created. Each alternative is described as follows:

a. In alternative I, it is obtained project time for 256 days, at a cost of Rp2,190,234,913.43;
b. In alternative II, it is obtained project time for 150 days, at a cost of Rp1,903,674,873.6;
c. In alternative III, it is obtained project time for 102 days, at a cost of Rp1,873,215,897.61;
d. In alternative IV, it is obtained time project for 99 days, at a cost of Rp1,895,159,526.12;
e. In alternative V, it is obtained time project for 96 days, at a cost of Rp2,019,623,191.13;
f. In alternative VI, it is obtained time project for 89 days, at a cost of Rp2,090,543,033.77.

From the above calculation, the graph shows that the optimal time is 120 calendar days. So in order to know how much cost incurred, interpolation is applied as follows:

Biaya = 1873215897.61 + (((120-102)/(150-102)) x (1903674873.61-

= 1873215897.61)

= Rp. 1,884,638,013.61

Based on the above interpolation result, it can be concluded that the optimal time in Building Project is 120 calendar days with optimum cost of Rp. 1,884,638,013.61. The percentage of cost efficiency and project time of the plan are as follows:

Efficiency of Project Time

E = Waktu Rencana – Waktu Optimalisasi

= 150 – 120

= 30 hari kalender, atau

E = Waktu Rencana - Waktu Optimalisasi / Waktu Rencana x 100%

= ((150 – 120) / 150) x 100%

= 20%

From the above calculation results, it is known from the time of optimization that there is efficiency / time savings of 30% of the time plan or 30 calendar days.

Efficiency of Project Cost

E = Biaya Rencana – Biaya Optimalisasi

= Rp. 1,903,674,873.61 – Rp. 1,884,638,013.61

= Rp. 19.036,860.00, atau

E = Waktu Rencana - Waktu Optimalisasi / Waktu Rencana x 100%

= ((1903674873.61– 1884638013.61) / 1903674873.61) x 100%

= 1%

From the above calculation, it can be seen from the cost of optimization that there is an efficiency / cost savings of 1% of the cost plan or Rp.19.036,860.00

4. CONCLUSION AND SUGGESTION

4.1 Conclusion

Based on the previous calculation, conclusion can be drawn as follows:

a. The network form on the PDM (precedence diagram method) can be described as an activity on a node or AON (Arrow Activity Node). In this method, the activity is written in a node that is generally rectangular, while the arrow is the indicator of the relationship between the activities concerned. Thus, dummy which is an important sign to indicate a dependency relationship, in PDM is not required.
b. The total cost of implementation of Building Construction Project with optimum duration of 120 calendar days is Rp.1,884,638,013.61.

4.2 Suggestion

a. In choosing various alternative methods of implementation, the risks also need to be considered.
b. The important thing to consider in scheduling planning with PDM (Precedence Diagram Method) method is the logic of work dependence. In scheduling, it should be noted also about the critical path; the more work items through which the critical path is, the higher the risk will be. Good scheduling is scheduling with a project that has a total float lot and has 1 or 2 critical paths starting from the beginning to the end of the project.
c. PDM scheduling is very effective on large-scale projects.
d. In the calculation, it is assumed that the decrease in productivity in all the activities ejected is the same and fixed. In fact, it is very difficult to maintain good work productivity due to many obstacles during the implementation of the activity and because of the different volumes of each job, so good and proper planning is essential in project implementation.
e. In realizing an optimal project, it is required a strict supervision.

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