Analysis of Time Acceleration Costs in Level Building Using Critical Path Method

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Abstract

The multi-story building construction project was carried out according to the schedule at the time of the initial session's work. There was a delay in the agreement for the receipt of land which caused work to be delayed. The researcher's aim is to find out the work time using the Critical Path Method (CPM) method, in this analysis the time from the acceleration of the duration obtained from the CPM, so that in analyzing the estimated normal and up-normal costs of labor wages and the estimated amount of the budget due to the acceleration of implementation time. By making direct observations, and interviewing project team members, the data obtained are used to base analysis. Based on the results of the data obtained and analyzed using CPM. The results of the normal duration of work with the CPM method produce 119 working days, the results of the acceleration of the time done by the CPM method obtained 104 working days. Therefore, using labor analysis, the total cost of normal labor costs is IDR 30,901,500.00 and the total up-normal costs of labor costs are IDR 26,037,000.00. So the results of the analysis, save labor costs of Rp.4,864,500.00. Thus, the total normal cost budget is Rp. 1,337,999,697.00 and the total up-normal cost budget is Rp. 1,333,135,197.00.

1. Introduction

The multi-story building construction project was done on time as scheduled. In reality, the problems faced by the multi-story building construction project experienced delays in the submission of land documents that caused work to start late, within 2 weeks. Initial development project planning for 119 working days. But at the time of implementation, there was a delay of 14 working days so, it was carried out 105 working days. To pursue the target time that is by the 006 / GD-KRW / PPK-DIST/ARCIP / 201 contract, the researcher applies the CPM (Critical Path Method) so that planning according to schedule is efficient to produce project costs according to the contract and minimize the time to avoid occurring project delay. The analysis states What is the duration of the work analyzed using CPM and based on the Critical Path, what is the duration of the possible time acceleration of a multilevel development project? If the acceleration of the project duration uses labor analysis what is normal and up to the normal cost of labor costs. [1]

Critical Path Method (CPM) is a technique of analyzing network activities/activities when running a project to predict the total duration. A project's critical path is a sequence of activities that determines the fastest time possible for a project to be completed. A critical path is the longest path in a network diagram and has the fewest errors. Some things to note about this critical path: Delayed work on the critical track will delay the completion of the overall project track. Completion of the project as a whole can be accelerated by accelerating completion of work - work on the critical path. The critical path slack work is equal to 0 (zero). This allows the relocation of resources from non-critical work to critical work. [2]
2. Material and method

Objects in research analyze time consistently in the critical path cpm to make it more efficient, in the method of data collection. [3]

![Figure 1. Model of network development life cycle](image1)

2.1 Analysis Budget Plan Data
Data is analyzed per item and per project from beginning to end according to the work contract agreement and using time schedule data and cost budget plans in accordance with the unit price analysis, in analyzing the data collected is done by drawing a network with the CPM method the data used in the Budget Plan Data (RAB) and Work Unit Price Analysis.[4] In the data analysis is done by drawing a network with CPM (Critical Path Method) which consists of a total time count of completion of multi-storey building construction projects and determine the critical path in accelerating some activities to achieve the scheduled targets and adding workforce to be known whether the overall cost will be cheaper or more expensive. [5]

![Figure 2. Critical Path Method](image2)

2.2 CPM Critical Path Method
Three Basic Assumptions in calculating the critical path method:
1. The project has only one initial event (start) and one terminal event (finish).
2. The fastest time for the initial event to occur is day zero.
3. The slowest time for a terminal event to occur is LS = ES

The technique to calculate the critical path method Forward Pass
Starting from the Start (initial event) to Finish (terminal event) to calculate the fastest completion time of activity (EF), the fastest time for the occurrence of an activity (ES) and the fastest start of an event (E).[6]

2.3 Rules for forwarding Pass
Except for the initial activity, then the activity can only begin if the predecessor activity has been completed and the earliest time to finish an activity is the same as the earliest start time, plus the time period of the activity that preceded it EF (i-j) = ES (i-j) + t (i-j) If an activity has two or more previous activities that combine, then the earliest start time (ES) of the activity is the same as the earliest finish time (EF) which is the largest of the previous activities.
1) Backward Pass
Starting from Finish to Start to identify the time the slowest occurrence of an activity (LF), the time the slowest occurrence of an activity (LS) and the slowest time an event occurs (L).

2) Rules of Backward Pass
The last start time of an activity is the same as the last finish time minus the time period for the activity concerned. LS (i-j) = LF (i-j) t
If an activity is divided into 2 or more activities, then the last time (LF) of the activity is the same as the last starting time (LS) of the smallest next activity.
If both calculations have been completed, the Slack or Float value can be obtained which are a number of time and elasticity allowances in a network. [7]

The earliest time to finish an activity is the same as the earliest start time, plus the period of the activity in question. Forward count formula EF = ES + D or EF (i-j) = ES (i-j) + D (i-j). The result of the work duration with forwarding Calculation is 119 working days. Calculation formula backward The most recent start time of an activity is the same as the most recent completion time minus the time period for the activity concerned or LS = LF-D Network with forwarding and backward calculations for multi-story building projects can be seen and Figure 1. [8]

![Figure 3. Forward and Backward Calculation Network](image)

3. Results and discussion
3.1. BOQ Time Period
Estimated time for each activity is the time needed to complete each of these jobs using the CPM (Critical Path Method) network. For this multi-story building project uses several analyzes, namely determining the amount of time required as can be seen in Table 1 For building an area of 250 m2 determine the cost with the Bill of Quantity (BOQ) such as the Details of Activities Implementation Budget can be seen in Table 2

| No. | Job description                  | the activities | Duration(Day) |
|-----|----------------------------------|----------------|--------------|
| 1   | Preparatory work                 | A              | 7            |
| 2   | Maturation Land Work             | B              | 21           |
| 3   | soil work                        | C              | 14           |
| 4   | Basic Floor Structure Work       | D              | 21           |
| 5   | Upper Floor Structure Work       | E              | 21           |
| 6   | Roof work                        | F              | 7            |
| 7   | Wall / Plastering Work           | G              | 28           |
| 8   | Sills, Doors & Windows Work      | H              | 21           |
| 9   | Ceiling Work                     | I              | 20           |
| 10  | Floor work                       | J              | 21           |
| 11  | Painting wall Work               | K              | 14           |
| 12  | Sanitation Work                  | L              | 7            |
| 13  | Plumbing work                    | M              | 21           |
| 14  | Electrical work                  | N              | 21           |
| 15  | Building Environment Road Work   | O              | 14           |
| No. | Job Description                   | Budgeting   | Duration (Day) |
|-----|-----------------------------------|-------------|----------------|
| 1   | Preparatory work                  | 29,135,500.00 | 7              |
| 2   | Maturation Land Work              | 156,303,981.00 | 21             |
| 3   | Soil Work                         | 3,467,620.00  | 14             |
| 4   | Basic Floor Structure Work        | 107,814,154.00 | 21             |
| 5   | Upper Floor Structure Work        | 293,555,688.00 | 21             |
| 6   | roof work                         | 58,415,768.00  | 7              |
| 7   | Wall / Plastering Work            | 144,233,733.00 | 28             |
| 8   | Sills, Doors & Windows Work       | 80,695,692.00  | 21             |
| 9   | Ceiling Work                      | 51,331,228.00  | 20             |
| 10  | Floor Work                        | 56,907,053.00  | 21             |
| 11  | Painting wall Work                | 31,252,390.00  | 14             |
| 12  | Sanitation Work                   | 13,027,905.00  | 7              |
| 13  | Plumbing work                     | 32,946,992.00  | 21             |
| 14  | Electrical work                   | 96,868,596.00  | 21             |
| 15  | Building Environment Road Work    | 58,073,605.00  | 14             |
| 16  | Landscaping Road Work             | 6,931,250.00   | 14             |
| 17  | Side & Rear Fence Work            | 57,776,704.00  | 14             |
| 18  | Front Fence Work                  | 59,261,831.00  | 14             |

1,337,999,697.00

3.2 Speed up the duration
From the planning of activities to the estimated time discussed, it is known that the results of scheduling exceed the targets set by management, so it is necessary to accelerate in several activities. Based on the critical path of the results of the calculation, it is determined to accelerate several activities including activities (AB-DE-FNKL) which include preparatory work, land maturation work, ground floor structure work, top floor structure work, roof work, electrical work, work painting, and sanitation work. Due to the accelerated time duration of 14 days, the acceleration method was chosen using the addition of manpower so that some of the accelerated activities included activities (A-B-K) which included preparatory work, land maturation work and painting work.

3.3 Activity A (Preparatory Work)
In preparatory work there are several sub-jobs to be carried out including the following:
- Measurement of the situation again.
- Demolition of existing barrier walls.
- Field cleansing & leveling.
- Building bow plank measurements & boards.
- DPT bow plank measurement & board.
- CBR soil test.
- Water supply and work electricity.
- Keet Direction
- Project nameplate
- Administration, Documentation & As-built drawing.
Not all preparatory sub-works are analyzed, because in the preparatory work items there is a critical path that can be accelerated, namely the Keet direction work items. Direction Keet is a temporary office/warehouse for storing building materials and tools. There is a direction Keet unit price analysis, such as the coefficient of wages obtained from productivity results. Productivity is the amount of energy to complete a job. For example, 2.00 OH workers (person/day) in this case shows labor productivity to complete an area of 1 m² temporary/warehouse office, in this case, the unit price value follows the classification owned by the company for building construction. BZX. Coefficient x Work volume / duration Remarks coefficient = 2.00 OH Work volume = 12 m² Duration (days) = 7 days So the result of the calculation is Coefficient x Work volume / duration (days) = (2.00 x 12 m² / 7 days) = 3.43 OH. In this case, all unit price values follow the classification owned by the company for building construction. The results of the analysis of direction Keet energy duration of 7 days From the results of the analysis of labor painting the wall for a duration of 7 days When the results of the total cost of completing the work of painting the wall area of 966.24 m² for 7 days amounted to Rp.7,063,000.00. So it is needed:

a. 3 workers.
b. 9 craftsmen.
c. 1 head mason.
d. 1 foreman.

So there is an additional workforce that is 1 worker and 4 workers. Activities (A-B-K) include preparatory work, land clearing work, and accelerated painting work so that, the results of the analysis of the CPM (Critical Path Method) method have met the outlined target of 105 days. So there is no need to accelerate again. To accelerate the project network For preparatory work, land clearing work and painting work required the number of workers in normal duration is 12 people. The number of crash duration workers is 16 people. The number of carpenters of normal duration is 9 people. The number of carpenter crash duration is 15 people. The number of masons with a normal duration is 5 people. The number of masons crash duration is 7 people. The number of head masons of normal duration is 3 people.

3.4 Activity B (Land Maturing Work)
In the land maturation work, there are several sub-jobs that will be carried out, among them are the DPT (Soil Retaining Wall) earth excavation work, 10 cm thick sand fill work. DPT pair camp split 1: 5 work, landfilling work from outside and soil compaction work every 20 cm. Not all sub-ripening sub-works are analyzed because in the land-ripening work items there is a critical path that can be accelerated, namely DPT work items. From the analysis of the Batu Belah DPT workforce for the duration of 16 days listed in Table 4.14 for completion of the foundation stonework. When the results of the total amount of cost for completion of the foundation stonework as much as 72.77 m³ for 16 days amounted to Rp.14,200,000.00. So it is needed: 7 workers, 4 masons, 1 head mason, 1 foreman.

3.5 Activity K (Painting Work)
In the painting work, there are several sub-jobs that will be carried out, including the following: Ground floor, interior wall / concrete painting work, wall painting / concrete weather shield, ceiling painting work. The upper floor includes interior / concrete wall painting work, wall painting work, ceiling painting work. Coefficient x Work volume / duration Remarks: coefficient = 0.02 OH Work volume = 966.24 m² Duration (days) = 14 days So the result of the calculation is Coefficient x Work volume / duration (days) = (0.02 x 966.24 m³ / 14 days) = 1.38 OH. In this case, all unit price values follow the classification owned by the company for building construction. From the results of the analysis of wall painting workers for 7 days are listed in Table 4.17. When the results of the total cost for completing the work of painting the wall area of 966.24 m² for 7 days amounted to Rp.7,063,000.00. So it is needed: 3 workers, 9 masons, 1 head mason, 1 foreman. So there is an increase in labor, namely 1 worker and 4 masons. Activities (A-B-K) include preparatory work, land clearing work, and p
4. Conclusions
Based on the results of the study it can be concluded that the results of the normal duration of work with the Critical Path Method are 119 working days, the same as the planned duration. And with the acceleration of the duration carried out by the Critical Path Method using the addition of labor in activities (A-B-K) including preparatory work, land maturation work, and painting work so as to obtain 104 working days. Therefore, by using labor analysis, the total cost of normal labor costs is Rp.30,901,500.00 and the total cost of labor wage crashes is Rp.26,037,000.00. So that, save labor costs in the amount of Rp.4,864,500.00. So that the normal budget is Rp. 1,337,999,697.00 and the total cost of the crash are Rp. 1,333,135,197.00. Suggestions that can be given based on research that network planning must pay attention to the systematic preparation of the network and the preparation of dependency logic and conduct further analysis in the Evaluation and Review Technique) and PDM (Precedence Diagram Method).

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