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Implementation Study of Critical Path on Educational Building Construction Project in East Jakarta Using AON-PDM Method

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ABSTRACT

Construction project scheduling plays a critical role in ensuring project efficiency, particularly for multistory educational buildings with complex work dependencies. This study analyzes the implementation of the Activity on Node Precedence Diagram Method (AON-PDM) on a real construction project located in East Jakarta. The research aims to map out the sequence of project activities, identify the critical path, and evaluate time optimization opportunities. Project data such as activity lists, durations, and precedence relationships were processed using Microsoft Project 2019 to generate a network diagram and determine early start, late start, and total float values. The findings reveal that PDM is highly effective in visualizing interdependencies among activities and detecting tasks on the critical path that must be closely monitored. The application of AON-PDM in this case study resulted in a reduction of the total project duration from 575 to 554 calendar days. This study underscores the importance of precise scheduling techniques for minimizing delay risks and achieving optimal resource allocation in building construction projects.

Keywords: Activity on Node (AON), Critical Path, Construction Scheduling, Precedence Diagram Method (PDM)

1. Introduction

The success of construction projects is significantly influenced by the effectiveness of scheduling and time management. Scheduling plays a pivotal role in ensuring that the activities in a project are properly sequenced, resource usage is optimized, and deadlines are met efficiently. In the field of civil engineering, especially in complex building construction projects, schedule planning is essential to prevent delays, cost overruns, and misallocation of manpower and equipment. As the construction industry faces increasing demands for efficiency and accountability, the application of scientific scheduling methods has become more critical than ever [1][2].

One of the common challenges in the construction of multistory educational buildings is the need to manage a large number of interrelated activities, each with dependencies and specific time constraints. In urban areas such as East Jakarta, where projects often face site limitations, high-density work zones, and strict timelines, the need for reliable and systematic project scheduling becomes even more pronounced [3]. Traditional methods like Gantt Charts and Bar Charts, although still widely used, often fail to reflect the logical dependencies among activities. They offer limited functionality when it comes to identifying the critical path or analyzing delay impacts in projects with multiple concurrent tasks [4][5].

To overcome these limitations, network-based scheduling techniques such as the Critical Path Method and the Program Evaluation and Review Technique were introduced. These methods use graphical representations to determine the sequence of activities, estimate the total project duration, and highlight critical activities that influence the completion of the project. However, the Critical Path Method is deterministic in nature and does not account for uncertainty in activity durations, while the Program Evaluation and Review Technique is more probabilistic but sometimes difficult to apply in routine construction settings [6][7].

The Precedence Diagram Method, or PDM, has emerged as a more flexible and advanced tool in project scheduling. Compared to the older Activity on

Arrow representation used in the Critical Path Method, PDM uses the Activity on Node format where each activity is represented by a node or box. This method allows for four types of logical relationships between tasks: Finish to Start, Start to Start, Finish to Finish, and Start to Finish. These relationships enable planners to model complex interactions among activities, including overlapping and parallel execution of tasks, which are often required in real construction environments [8][9][10].

In addition, modern software tools such as Microsoft Project have made the implementation of the Precedence Diagram Method more accessible and effective. Microsoft Project enables engineers and project managers to define tasks, assign durations and resources, and visually map out the entire project schedule. The software automatically calculates early start, early finish, late start, late finish, and float for each activity. It also highlights the critical path, allowing project teams to focus their attention on high-impact tasks that could cause project delays if not managed properly [11][12].

Several recent studies have validated the usefulness of the Precedence Diagram Method in various construction settings. Research conducted by Siregar and Harahap [13] found that PDM significantly improved scheduling accuracy in high-rise construction projects. Similarly, Rahman and Prasetyo [14] showed that the use of PDM reduced overall project duration and improved activity relationship modeling in construction scheduling. These findings underscore the increasing adoption of PDM in practical applications and its relevance in modern construction management.

Despite the growing interest in the Precedence Diagram Method, there remains a gap in applied research that demonstrates its effectiveness in actual construction projects, particularly in educational building developments that often face tight schedules and rigid budget allocations. Moreover, few case studies specifically explore its implementation in the Indonesian context, where construction practices are still transitioning from conventional to digital-based systems.

This study aims to address that gap by evaluating the implementation of the Precedence Diagram Method using the Activity on Node approach in a real-world construction project of an educational building located in East Jakarta. The project data, including activity lists, durations, and task relationships, were analyzed using Microsoft Project 2019 to generate a network diagram, identify the critical path, and assess potential improvements in project duration. The primary objective of this research is to demonstrate the feasibility and effectiveness of AON-based PDM in managing complex schedules and minimizing delays in educational construction projects. The findings of this study are expected to provide valuable insights for engineers, project managers, and decision-makers involved in urban infrastructure development.

2. Materials and Method

Project Description and Data Collection

This study was conducted based on secondary data from a real construction project, namely the development of Sierra Intercultural School, located in East Jakarta, Indonesia. The project consists of two interconnected educational buildings, one with four floors and the other with three floors. The total contract value was approximately IDR 101.617 billion, and the planned implementation duration was 575 calendar days. The project data used in this study were obtained from project stakeholders and included the work breakdown structure (WBS), time schedule (Kurva S), and detailed itemized activities with durations and dependencies. The data used in this study are categorized as secondary data, as they were not collected directly by the researchers but rather provided by the project management team. No data involving human subjects or interventionary studies were collected or generated in this research.

The data analyzed in this study include:

a. Project name, location, and timeline
b. List of project activities
c. Duration of each activity
d. Logical relationships (precedence) between tasks
e. Time schedule data (early start, late start, early finish, late finish)

All materials and data used in this study can be made available upon reasonable request. Since the project was managed privately and not under government regulation, the data repository is limited to internal documentation of the construction firm.

Software Tools

For data analysis and project scheduling simulation, Microsoft Project 2019 was employed. This software allows users to model the project timeline using the Precedence Diagram Method (PDM) with an Activity on Node (AON) approach. The software was used to:

a. Input all project activities
b. Assign durations and precedence relationships
c. Generate Gantt charts and Network Diagrams
d. Identify the Critical Path
e. Calculate Early Start (ES), Early Finish (EF), Late Start (LS), Late Finish (LF), and Total Float (TF)

Microsoft Excel 2016 was also used to support data organization, filtering, and preliminary visualization before uploading the structured data into Microsoft Project.

Methodology

This study adopted a quantitative-descriptive approach. The analysis procedure followed the standard steps of Precedence Diagram Method (PDM) scheduling using the Activity on Node model. The research procedure in this study followed a systematic scheduling analysis process using the Activity on Node (AON) approach within the Precedence Diagram Method (PDM). The stages of analysis included project data collection, activity identification, duration assignment, precedence relationship analysis, network diagram development, critical path analysis, float calculation, and schedule optimization.

The overall research procedure is illustrated in Figure 1.

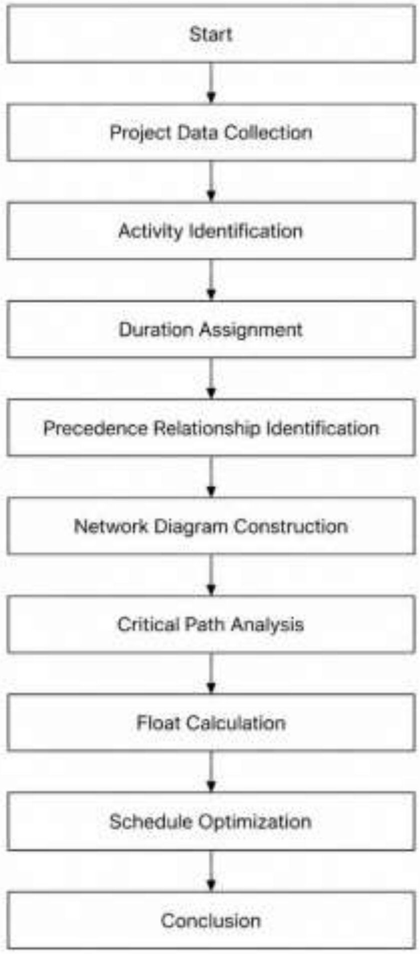

Figure 1. Research Flow Chart of AON-PDM Scheduling Analysis

The methodology consists of the following steps:

1) Activity Identification:

All project activities were identified based on the time schedule and WBS provided by the project contractor. Each task was given a unique code to facilitate sequencing.

2) Duration Assignment:

Each activity was assigned a duration in calendar days. These durations were based on the project's initial schedule and contractor estimations.

3) Precedence Relationship Identification:

Dependencies between tasks were classified into four types of constraints:

a. Finish to Start (FS)

b. Start to Start (SS)

c. Finish to Finish (FF)

d. Start to Finish (SF)

These constraints were used to establish logical relationships between activities.

4) **Network Diagram Construction:**

A Network Diagram was generated using Microsoft Project 2019 to visualize the logical sequence and dependency relationships among project activities. The diagram was developed using the Activity on Node (AON) approach within the Precedence Diagram Method (PDM), where each activity is represented by a node and connected according to its dependency type. The resulting network diagram provides a clear graphical representation of critical and non-critical activities within the project schedule.

5) Critical Path Analysis:

Using the project schedule features in Microsoft Project 2019, the critical path was automatically highlighted. This includes the longest sequence of tasks that must be completed on time for the entire project to be delivered as planned.

6) Float Calculation:

The software calculated Total Float for each activity. Tasks with zero float were marked as critical, while others were considered non-critical and could be delayed without affecting the project end date.

7) Optimization and Comparison:

The original project schedule (575 days) was compared to the optimized schedule obtained through PDM analysis. The aim was to identify whether scheduling could be improved and by how many days.

Ethical Considerations

This study does not involve human participants, animal subjects, or personal identifiable information. Therefore, no ethical approval was required.

Data Availability

The time schedule data and project information used in this study are proprietary to the contractor and construction management company. Access to the original dataset can be granted upon formal request to the project owner and under a nondisclosure agreement (NDA). There are currently no publicly deposited datasets or accession numbers associated with this study.

3. Results

This section presents the scheduling results of the educational building construction project analyzed using the Activity on Node (AON) format within the Precedence Diagram Method (PDM). The total number of identified work items in the full project schedule was 83 activities. A subset of critical activities is displayed in Table 1 to represent the core scheduling logic

Critical Path Identification

Using Microsoft Project 2019, the project schedule was simulated, and the critical path was automatically identified.

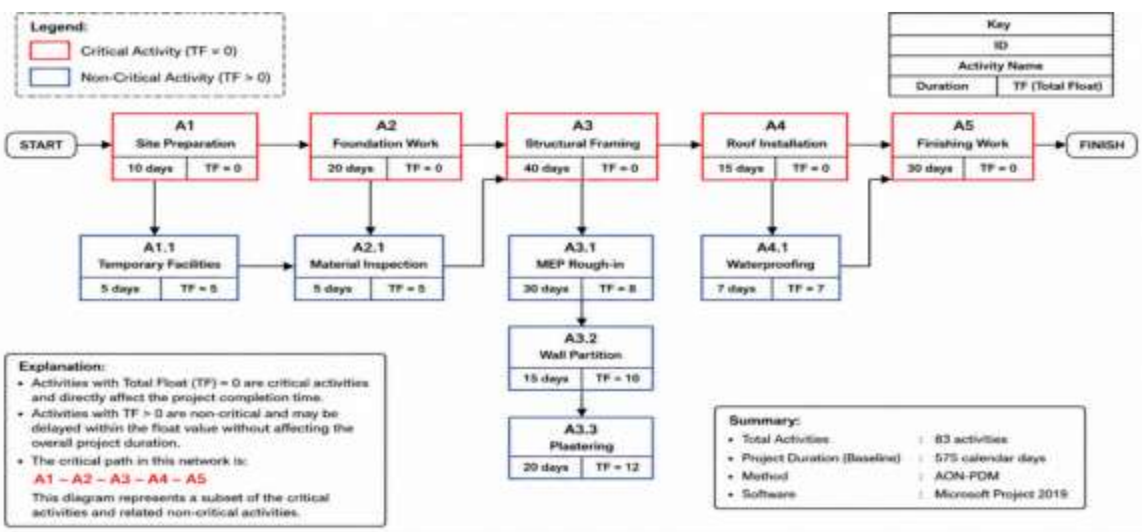

Figure 2. Representative AON-PDM Network Diagram Showing Critical and Non-Critical Activities in the Educational Building Construction Project

Figure 2 illustrates the representative AON-PDM network diagram generated from the project scheduling analysis using Microsoft Project 2019. The diagram presents the logical relationships among construction activities, including both critical and non-critical tasks. Activities A1, A2, A3, A4, and A5 are identified as critical activities because they have total float values equal to zero (TF = 0), indicating that any delay in these activities will directly affect the overall project completion time. Meanwhile, non-critical activities possess positive float values, allowing limited delays without impacting the final project schedule. The network diagram demonstrates the effectiveness of the AON-PDM approach in visualizing task dependencies, identifying critical paths, and supporting project schedule optimization. The critical path includes tasks with zero float, meaning they cannot be delayed without extending the entire project duration.

Table 1 provides a sample of five consecutive activities on the critical path.

Table 1. Sample of Critical Path Activities :

Activity Code	Activity Name	Duration (days)	Early Start	Early Finish	Late Start	Late Finish
A1	Site Preparation	10	0	10	0	10
A2	Foundation Work	20	10	30	10	30
A3	Structural Framing	40	30	70	30	70
A4	Roof Installation	15	70	85	70	85
A5	Finishing Work	30	85	115	85	115

These tasks represent a continuous path with no allowable delay, confirming them as part of the critical path.

Project Schedule Visualization

The project schedule and critical path analysis were processed and visualized using Microsoft Project 2019. The software generated Gantt chart displays, activity sequencing, dependency relationships, and float calculations to support project scheduling analysis.

The visualization generated from Microsoft Project 2019 is presented in Figure 3.

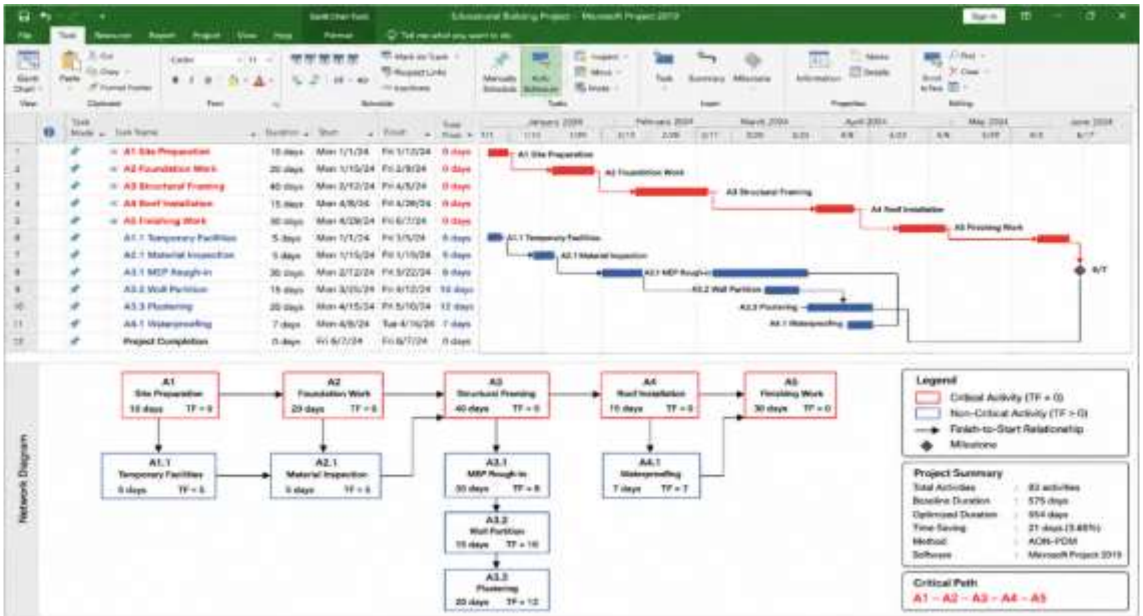

Figure 3. Microsoft Project 2019 Visualization of Project Scheduling and Critical Path Analysis

Figure 3 illustrates the scheduling visualization generated using Microsoft Project 2019, including activity durations, dependency relationships, and critical path identification. Critical activities are highlighted with zero total float values, while non-critical activities possess positive float values that allow limited scheduling flexibility. The software-assisted scheduling analysis improved project monitoring, scheduling accuracy, and optimization of project duration.

Project Duration and Optimization

The original project schedule established by the contractor set a duration of 575 calendar days. After critical path analysis and optimization using PDM, the recalculated duration was reduced to 554 calendar days. This 21-day reduction was achieved by analyzing float values and rescheduling non-critical activities for better resource allocation without affecting project deadlines. This finding confirms the effectiveness of the AON-PDM method in enhancing scheduling precision and uncovering opportunities for project time reduction.

4. Discussion

The implementation of the Precedence Diagram Method (PDM) using the Activity on Node (AON) format in this study produced significant findings related to project scheduling, optimization, and critical path analysis in the construction project of a multistory educational building in East Jakarta. In the AON-PDM approach, project activities are graphically represented using node-box diagrams connected by dependency arrows that illustrate logical relationships among project activities. To strengthen the scheduling analysis, the graphical representation of the AON-PDM network is presented in Figure 2, which displays both critical and non-critical activities along with their dependency relationships and total float values.

Based on Figure 2, activities A1 (Site Preparation), A2 (Foundation Work), A3 (Structural Framing), A4 (Roof Installation), and A5 (Finishing Work) are categorized as critical activities because they have total float values equal to zero (TF = 0). These activities form the critical path that directly determines the overall project completion time. Consequently, delays occurring in any of these activities will directly affect project completion. In contrast, several supporting activities outside the critical path possess positive float values, indicating that they can tolerate limited delays without influencing the final project duration. The identification of critical and non-critical activities through graphical AON representation provides clearer scheduling control, better monitoring capability, and improved decision-making during project implementation.

The primary objective of this research was to evaluate the capability of AON-PDM in accurately identifying the critical path and optimizing project duration compared to the contractor's original schedule. The analysis results indicate that the method successfully identified critical activities with zero float and provided an opportunity to optimize the project duration by 21 calendar days, reducing the total project duration from 575 days to 554 days. This finding confirms that logic-based scheduling methods contribute significantly to improving planning accuracy and project efficiency.

The visualization of Microsoft Project 2019 outputs is presented in Figure 3 in the form of a Gantt chart and network scheduling display. The software automatically generated early start, early finish, late start, late finish, and total float values while simultaneously identifying the project critical path. Figure 3 demonstrates the capability of Microsoft Project 2019 in visualizing activity sequencing, dependency relationships, and scheduling performance. The graphical outputs generated by the software improved scheduling clarity and facilitated communication among project stakeholders. This finding supports the statement of Luthan and Syafriandi [5], who emphasized that integrating digital scheduling software into construction project management significantly improves scheduling accuracy and reduces manual calculation errors.

Furthermore, this study demonstrates that the application of AON-PDM is highly feasible in urban construction environments where project scheduling is often influenced by logistical constraints, regulatory requirements, and stakeholder coordination. Educational building projects generally require strict time control because delays may affect operational readiness and institutional activities. Therefore, identifying activities that cannot be delayed becomes highly important in maintaining project performance and preventing schedule overruns.

Another important finding is that critical path analysis not only identifies urgent activities but also supports project decision-making when unexpected disruptions occur. Delays caused by weather conditions, labor shortages, or material supply interruptions can be mitigated more effectively when project managers understand which activities are critical and which activities possess scheduling flexibility through float values. In this context, the AON-PDM approach provides both analytical and visual advantages for project scheduling control.

Despite these positive findings, this study still has several limitations. First, the PDM approach is deterministic and assumes fixed activity durations, meaning that uncertainty and variability during construction execution are not fully represented. Unlike the Program Evaluation and Review Technique (PERT), which incorporates optimistic, pessimistic, and most likely duration estimates, PDM may produce overconfidence in schedule reliability. Second, this study focused only on scheduling analysis and did not integrate project cost, resource allocation, or quality performance into the evaluation process. Future studies may combine AON-PDM with Building Information Modeling (BIM), cost control systems, or resource leveling analysis to develop a more comprehensive project management framework.

5. Conclusions

This study successfully achieved the research objectives of mapping project activity sequences, identifying the critical path, and evaluating time optimization opportunities using the Precedence Diagram Method (PDM) with the Activity on Node (AON) approach in an educational building construction project in East Jakarta. The analysis identified critical activities with zero float values and distinguished non-critical activities with scheduling flexibility. The implementation of AON-PDM through Microsoft Project 2019 improved scheduling visualization, activity dependency analysis, and project monitoring. The project duration was successfully optimized from 575 calendar days to 554 calendar days, resulting in a time efficiency of 21 days. Overall, the findings indicate that the AON-PDM method is effective for critical path identification and project scheduling optimization in construction projects.

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