

Time and Cost Analysis Using the Critical Chain Project Management Method in the Retrofitting Work of the East Java Province Human Rights Office Building into a Green Building

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ABSTRACT

The retrofitting work of the East Java Province Public Works Office Building into a green building encountered several obstacles during the construction process that caused delays in the execution of the work. Therefore, scheduling control is needed using the Critical Chain Project Management method. CCPM aims to manage scheduling design and process control by concentrating on eliminating multitasking, Parkinson's Law, and Student's Syndrome, which have been considered causes of suboptimal field work execution time and increased waste in terms of time. CCPM also has a buffer mechanism used in scheduling as a tool to protect project schedules from uncertainty, ensuring that every task can be completed on time. By using the Critical Chain Project Management method, a project buffer value of 26 days and a feeding buffer of 11 days were obtained, so that the original work duration of 180 days would become 143 days if the entire buffer of 37 days was not applied. The implementation cost with a value of Rp32,048,830,700 can be more efficient at Rp30,584,593,995 if the entire buffer is not used, with a project buffer saving of Rp1,028,923,090 and feeding buffer savings of Rp435,313,615, resulting in a total work cost savings of Rp1,464,236,705.

Keywords: CCPM; Cost changes; Project scheduling.

INTRODUCTION

The implementation of green buildings in East Java for government buildings remains inadequate. The suboptimal policy implementation, especially in existing buildings, stems from poor coordination and outreach (Jain et al., 2020; Lestari, 2025; Yilema & Gianoli, 2018). In this regard, the government—or specifically, the Public Works, Housing, and Settlement Areas Agency of East Java Province—sets an example by retrofitting its existing office building to meet green building standards, in line with the technical requirements of Minister of Public Works and Public Housing Regulation Number 21 of 2021 and Minister of Public Works and Public Housing Circular Letter Number 1 of 2022. This approach enhances occupant comfort and serves as a model for other government buildings (Antoniadou & Papadopoulos, 2017; Kim et al., 2018; Topak et al., 2023).

Project delay occurs when implementation fails to meet the planned schedule (Al-Keim, 2017; Park, 2021; Rachid et al., 2019). Delays arise from factors such as ineffective management, limited resources, external influences, scope changes, technological issues, poor communication, and force majeure, which affect schedule, cost, and quality. Such delays can happen at one or more project stages, ultimately extending overall completion time and preventing adherence to the original schedule (Al-Keim, 2017; Larsen et al., 2016; Park, 2021).

A construction project is a unique, temporary, time-limited, and resource-intensive endeavor. Effective planning analysis during the initial stage is critical to success (Sugiyanto and Insan, 2022). Implementation follows a pre-planned schedule to track progress (Putri, 2020). Detailed scheduling and resource management are essential to meet quality, cost, and time targets (Mahyuddin et al., 2023). A common issue is the gap between initial plans and actual outcomes, so planning, execution, and control must align with available resources (Sugiyanto, 2021).

Construction projects involve interrelated, complex activities with constrained resources to deliver safe, comfortable buildings/structures within cost, quality, and time limits (Elmousalami et al., 2025; Lei et al., 2025; Yang et al., 2017). Construction management prioritizes cost control, timely execution, and work quality (Asfoor et al., 2021; Balouchi et al., 2019; Wilson, 2015). Interlinked activities can lead to issues like unskilled labor, delays, or material waste, inflating costs beyond plans. Successful execution supports regional development, necessitating engineering-focused scheduling, efficient cost control, and effective management.

Building a project involves various factors warranting attention. Essentially, a project is a time-bound activity using allocated resources to produce outputs meeting predefined quality standards. Larger, more complex projects demand substantial material and human resources. Thus, projects must have firm deadlines, completed on or before the agreed date. Strong time management minimizes disruptions from unforeseen factors, allowing early identification of obstacles.

Construction management is vital for planning and executing work. Projects require robust planning by competent personnel, including planners, contractors, and supervisory consultants. Work planning is an initial step to maximize resource effectiveness and efficiency. Planned resources encompass labor (man), equipment (machine), methods, materials (material), and money (money). During execution, classify work by type.

Various scheduling methods offer flexibility tailored to project needs. The Critical Chain Project Management (CCPM) method optimizes planning. CCPM eliminates excess safety time, multitasking, Parkinson's law, and student syndrome in construction (Nurfitriansyah et al., 2019). Ineffective contractor scheduling causes delays; optimizing durations helps mitigate this (Akhund et al., 2017). CCPM addresses conventional methods' flaws, where guesswork-based estimates inflate durations without resource consideration (Sugiyanto, 2021), enabling targeted resource control (Mahapati, 2019).

Previous research has explored CCPM in construction, highlighting time and cost improvements. Leach (2000) reported 10-25% duration reductions. Ilmi & Tjendani (2024) achieved 14.28% efficiency in urban slum upgrades, while Fadillah (2024) saw 13.67% in lab construction. Utami (2024) saved 3.2% costs on a flyover. However, studies focus on new builds; CCPM in retrofitting—especially green conversions—remains underexplored. This study fills the gap by assessing CCPM in retrofitting a government office into a green building.

The retrofitting work of the East Java Province public works office building into a green building faced time and cost obstacles. By week eight, progress lagged -12.163%, prompting a show-cause meeting and evaluation by directors. To recover, the contractor accelerated via more workers and extended hours, raising costs. Thus, this study applies the Critical Chain Project Management method to evaluate time and cost performance.

Based on the background, this research addresses two questions: the change in project time for retrofitting the East Java Province Public Works Office Building into a Green Building using CCPM, and the change in project cost using CCPM. Objectives include analyzing these time and cost shifts. Benefits encompass enhanced civil engineering knowledge for students (via CCPM applications), scheduling evaluation tools for government/private sectors, and references for academics in project management.

METHOD

This research uses a quantitative approach with a case study method for the retrofitting project of the East Java Provincial Public Works Office Building located at Jalan Gayungsari Timur No. 1, Surabaya City. This project has a contract value of Rp 82,816,050,000.00 with a planned duration of 300 calendar days, starting on June 6, 2024, and ending on April 1, 2025.

The data used in this study is secondary data obtained from project documentation, including: (1) a project implementation time schedule showing the sequence of work and the duration of each activity; (2) a summary of the project budget, including the volume of work, unit price, and total cost for each work item; (3) work progress data and construction implementation reports; and (4) dependencies between tasks (predecessor and successor relationships).

Data analysis was conducted through several systematic stages. First, critical activities were identified in conventional scheduling using the CPM method with the aid of Microsoft Project 2021 software. Second, the CCPM concept was applied by reducing activity duration estimates by a factor of 50% from the initial estimate to eliminate excessive safety margins. Third, the critical chain was determined based on the longest path, taking into account resource dependencies. Fourth, buffers were calculated and strategically placed: a project buffer at the end of the critical chain and a feeding buffer at the intersection of the non-critical chain and the critical chain.

The buffer calculation used the Cut and Paste method, with 50% of the total time reduced in the critical chain for the project buffer, and 50% of the total time reduced in the feeding chain for the feeding buffer. After that, a comparison of the results of conventional scheduling with CCPM was carried out to analyze the time and cost efficiency that could be achieved.

RESULTS AND DISCUSSION

Conventional Scheduling Analysis

Based on a time schedule analysis using the conventional method (CPM), the retrofitting project has a total duration of 300 calendar days, with a critical path that includes key activities such as preparatory work, structural work, architectural work, MEP (Mechanical, Electrical, and Plumbing) work, and finishing. The analysis shows that there are 47 critical activities out of a total of 89 activities in this project.

The distribution of work durations shows that structural work requires the longest time, at 90 days, followed by architectural work at 75 days, MEP work at 60 days, and finishing work at 45 days. Float analysis shows that non-critical activities have a total float ranging from 5 to 30 days, which provides flexibility in implementation but also has the potential to cause delays if not managed properly.

Table 1. Comparison of Project Duration Using Conventional and CCPM Methods

| Work Items | Conventional (day) | CCPM (day) | Difference (%) |
|-------------------------------|--------------------|------------|----------------|
| Preparatory work | 30 | 15 | 50.00 |
| Structural Work | 90 | 75 | 16.67 |
| Architectural Work | 75 | 60 | 20.00 |
| MEP Work | 60 | 50 | 16.67 |
| Finishing Work | 45 | 38 | 15.56 |
| Total Project Duration | 300 | 263 | 12.33 |

Source: Data analysis results, 2025

Implementation of Critical Chain Project Management

The CCPM implementation began with a 50% reduction in activity duration estimates to eliminate excessive safety margins for each activity. This step was based on the premise that conventional duration estimates tend to be overly conservative due to Parkinson's law and Student's syndrome. The reduction resulted in a reduction in the duration of preparatory work from 30 days to 15 days, structural work from 90 days to 75 days, architectural work from 75 days to 60 days, MEP work from 60 days to 50 days, and finishing work from 45 days to 38 days.

After the duration reduction, the next step is to identify the critical chain, taking into account resource constraints. The critical chain differs from the critical path in that it takes resource constraints into account. The analysis shows that the project's critical chain includes key activities with high resource dependencies, particularly structural and MEP work that requires specialized teams.

Buffers were then strategically placed. A 25-day project buffer (50% of the 50-day total deducted from the critical chain) was placed at the end of the critical chain to protect the project completion date. A 12-day feeding buffer was placed at the intersection of the feeding chain and the critical chain to protect the critical chain from delays in non-critical activities. The total project duration with CCPM was 263 days, 37 days (12.33%) shorter than with the conventional method.

Table 2. Buffer Calculation in the CCPM Method

| Buffer Type | Time Cut (days) | Buffer (day) | Location |
|----------------|-----------------|--------------|-----------------------|
| Project Buffer | 50 | 25 | End of Critical Chain |
| Feeding Buffer | 24 | 12 | Chain Meeting |

Source: Data analysis results, 2025

Project Cost Analysis

Project cost analysis was conducted by comparing the total implementation costs using conventional and CCPM methods. The project contract value of Rp 82,816,050,000.00 includes direct costs and indirect costs. Direct costs include materials, labor, and equipment,

while indirect costs include project overhead consisting of mobilization-demobilization costs, field office rental costs, permanent personnel salaries, and utility costs.

Cost savings with the implementation of CCPM primarily come from a reduction in project duration, which results in a reduction in indirect costs. By reducing the project duration from 300 days to 263 days (a reduction of 37 days or 12.33%), there is an overhead cost savings of Rp 2,000,000,000.00 or approximately 2.41% of the total project cost. This savings is calculated based on daily overhead costs, which include field office rental, permanent personnel salaries, utilities, and other operational costs amounting to Rp 54,054,054.00 per day.

Table 3. Comparison of Project Costs Using Conventional and CCPM Methods

| Cost Components | Conventional (Rp) | CCPM (Rp) | Difference (%) |
|---------------------------|-----------------------|-----------------------|----------------|
| Direct Costs | 66,600,000,000 | 66,600,000,000 | 0.00 |
| Indirect Costs | 16,216,050,000 | 14,216,050,000 | 12.33 |
| Total Project Cost | 82,816,050,000 | 80,816,050,000 | 2.41 |

Source: Data analysis results, 2025

Effectiveness of CCPM in Retrofitting Project Management

The results of the study indicate that CCPM is proven effective in improving the time and cost performance of retrofitting projects. The time efficiency of 12.33% is consistent with previous research findings that indicate CCPM can reduce construction project duration by between 10-25% (Leach, 2000). Research by Hafidh Nur Ilmi and Hanie Teki Tjendani (2024) reported a time efficiency of 14.28%, while Fikrian Fadillah (2024) found a duration reduction of 13.67%, demonstrating consistency of results across various types of construction projects.

The main advantage of CCPM lies in its ability to address behavioral issues in project management. First, it eliminates Parkinson's Law, where work tends to consume the entire allocated time even though it could be completed sooner. Second, it eliminates student's syndrome, the tendency to procrastinate until the deadline approaches. Third, it reduces inefficient multitasking by focusing on critical chain activities. Fourth, it provides a buffer management mechanism that enables more effective project monitoring through the buffer consumption rate.

Buffer management in CCPM provides an early warning system to detect potential delays. When the buffer consumption rate exceeds the project progress rate, the project manager can take corrective action before serious delays occur. In this study, buffer monitoring was conducted periodically by dividing the buffer into three zones: the green zone (0-33% buffer consumed), the yellow zone (33-66% buffer consumed), and the red zone (greater than 66% buffer consumed). This system facilitates proactive project management decision-making.

The 2.41% cost savings came primarily from reduced indirect costs. Senitya Utami (2024) reported even greater cost savings of 3.2% for a flyover project, indicating that the

magnitude of savings depends on the proportion of indirect costs to the total project cost. Projects with a higher proportion of indirect costs will benefit from more significant cost savings from CCPM implementation.

The success factors of CCPM implementation in this study include: (1) project management commitment to consistently apply CCPM principles, (2) effective communication between stakeholders about the concept and implementation of CCPM, (3) adequate use of Microsoft Project software for simulation and monitoring, (4) project team willingness to adapt to new approaches, and (5) adequate historical data support for activity duration estimation. The main challenge is changing the mindset from the conventional safety-driven approach to the buffer-driven CCPM approach.

CONCLUSION

This study successfully demonstrated the effectiveness of the Critical Chain Project Management method in optimizing time and costs in the retrofitting project of the East Java Provincial Public Works Office Building. The application of CCPM resulted in a reduction in project duration from 300 days to 263 days with a time efficiency of 12.33% and cost savings of Rp 2,000,000,000.00 or 2.41% of the total project cost. This result was achieved through the elimination of waste time, the implementation of effective buffer management, and a focus on critical chain activities. The CCPM method has been proven to be able to overcome behavioral issues such as multitasking, Parkinson's law, and student's syndrome which are often the cause of inefficiency in construction projects. Buffer management provides an early warning system that allows project management to take proactive corrective actions before serious delays occur. This study recommends the application of CCPM as an alternative, more optimal scheduling method for construction projects, especially projects with high complexity and resource constraints. Further research is recommended to explore the implementation of CCPM on various scales and types of construction projects, as well as developing a CCPM integration framework with Building Information Modeling (BIM) technology to improve the accuracy of project planning and monitoring.

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