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Analysis of Construction Management of Retaining Wall Structures in The CWC-1BKC Babakan and Cisanggarung River Works Project: A Case Study of The CS-5 Kalibuntu Segment, Cirebon Regency

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Construction Management; Retaining Wall; Critical Path Method; Cost Estimation; River Infrastructure

Abstract

Flood-control infrastructure requires effective construction management to ensure that limited resources are converted into reliable structures within the planned cost and duration. This study aimed to analyze the work quantities, budget, implementation schedule, critical activities, and planned progress of the retaining-wall structure in the CS-5 Kalibuntu segment of the CWC-1BKC Babakan and Cisanggarung River Works Project. A quantitative case-study approach was applied using contract documents, working drawings, and secondary project data. AutoCAD was used for quantity take-off, Microsoft Excel for Work Unit Price Analysis and budget estimation, and Microsoft Project for Work Breakdown Structure development, Critical Path Method analysis, and S-curve preparation. The analysis covered 60 repetitive segments along 720 meters. The estimated construction cost was IDR 54,535,705,559.17, with fill-material transportation contributing approximately 47%, reinforcement work 21%, K-225 concrete 14%, bored-pile reinforcement and casting 10%, and other activities 8%. The planned duration was 137 calendar days. Most evaluated activities had zero total float, indicating that delays in bored-pile, reinforcement, and concrete work could directly postpone project completion. The study concludes that integrating quantity, cost, schedule, and progress analyses provides a practical and coherent basis for controlling retaining-wall construction and anticipating cost and schedule deviations in river-infrastructure projects during project implementation.

INTRODUCTION

Construction management is an effort to use limited resources efficiently, effectively, and on time in completing a project, which includes three basic functions, namely planning, implementing, and controlling labor resources, equipment, materials, money, and methods (Fitriyana & Pratiwi, 2016).

Retaining walls are an important element in river management projects in Indonesia, especially in flood-prone areas such as the Cimanuk-Cisanggarung watershed which includes Brebes, Kuningan, and Cirebon. The CWC-1BKC Babakan Project and the Cisanggarung River Works aim to increase the capacity of the river to reduce the risk of flooding that threatens hundreds of thousands of people and agricultural land. The floods that occurred in January 2025 caused significant overflows in Kalibuntu,

Pabedilan, while the increase in extreme rainfall due to climate change exacerbated cliff erosion, requiring cost- and time-efficient retaining wall construction (Nasional, n.d.).

Previous research in the 2020-2025 period focused on stability and retaining wall design, such as the analysis of safety factors in Cimahi using SNI 8460:2017, the planning of segmental walls with geosynthetic reinforcement in the Bah Simalungun River (2022), the calculation of dimensions and basic RAB in Way Batu Merah (2020), and the application of value engineering for 25% cost savings in Mojokerto (2025). A major gap of these studies is the lack of integration of quantitative time schedules with contextual RABs in river projects such as CWC-1BKC (Benton & Omura, 2021) .

This study overcame these limitations by calculating RAB and specific time schedules for retaining walls of the CS-5 Kalibuntu segment using CWC-1BKC project field data, as well as applying the Critical Path Method (CPM) in a holistic management model. The novelty of this research lies in the linear integration of multi-software workflows, namely AutoCAD for quantity take-off, Microsoft Excel (Alexander & Kusleika, 2022) for AHSP and RAB based on the latest regulations, and Microsoft Project for CPM and S-Curve synchronization, as well as contextualization of labor productivity coefficients and local material prices based on Ministerial Regulation of PUPR No. 1 of 2022.

This challenge is evident in the Cimanuk–Cisanggarung River Basin, which covers strategic areas of West Java and Central Java, including Cirebon, Kuningan, and Brebes. Riverbank instability, sedimentation, fluctuating discharge, and erosion threaten communities and productive land located along the river corridors. In response, the Government of Indonesia implemented the Flood Management in Selected River Basins Project through several civil-work packages, including the CWC-1BKC Babakan and Cisanggarung River Works in Brebes, Kuningan, and Cirebon. The package had an allocated procurement ceiling of IDR 188.85 billion, illustrating the substantial public investment required to improve flood-control infrastructure within the basin (Ministry of Public Works and Housing, 2024).

Within the CWC-1BKC package, the CS-5 Kalibuntu segment in Pabedilan District, Cirebon Regency, involves the construction of a 720-meter riverbank retaining structure divided into 60 repetitive segments. The work includes earth excavation, bored-pile foundations, reinforcement, formwork, structural concrete, and complementary components such as waterstops, weep holes, dowel bars, joint fillers, and joint sealants. These interdependent activities create considerable managerial complexity because inaccuracies in quantity take-off, unit-price analysis, resource allocation, or activity sequencing can accumulate across all segments. The project's strategic importance is also reflected in the Asian Development Bank's monitoring report, which recorded overall physical progress of 47.702% for the CWC-1BKC package as of June 30, 2025 (Asian Development Bank, 2025).

Previous studies have demonstrated the importance of systematic scheduling and cost control in construction projects. (Ulfa & Suhendar, 2021) applied the Critical Path Method to the Synthesis Residence Kemang project and identified the activities that

directly determined its 484-day completion period. (Agbonaye & Oriakhi, 2023) similarly showed that critical-path analysis could clarify activity dependencies and improve scheduling decisions in a small-town water-supply project. (Kerzner, 2017) and (Mubarak, 2025) further emphasized that integrated planning, scheduling, and controlling are necessary to maintain consistency among project scope, duration, resources, and cost. These studies confirm the analytical value of CPM, although their project characteristics differ from repetitive riverbank-retaining-wall construction (Shrock & Heather, 2022) .

Research concerning retaining walls has generally concentrated on geotechnical stability, structural dimensions, material selection, safety factors, and alternative structural systems. Other studies have examined cost efficiency through value engineering. (Rahman et al., 2025), for example, evaluated cost and time optimization in a retaining-wall project in Mojokerto, while (Pramana et al., 2025) applied value engineering to identify cost-efficient retaining-wall alternatives supporting sustainable tourism infrastructure. Although these studies provide useful evidence regarding structural and economic decision-making, they do not comprehensively integrate quantity take-off, location-specific unit-price analysis, budget estimation, CPM scheduling, and S-curve development within a single river-infrastructure case (Altuwaim & El-Rayes, 2018; Ammar, 2013; Elmousalami, 2020; Kalemci et al., 2020) .

A research gap therefore remains in the integrated assessment of cost and time planning for repetitive retaining-wall works using actual project drawings, local resource prices, regulated work coefficients, and detailed activity dependencies. Existing studies frequently analyze either structural stability, budget estimates, scheduling, or value engineering separately. This separation limits the ability of project managers to trace how design quantities influence the cost budget and how cost-weighted work packages subsequently determine the implementation schedule. Moreover, limited empirical research has addressed this integration in the context of the CWC-1BKC project, particularly the CS-5 Kalibuntu segment, where bored-pile construction, river conditions, material transportation, and repetitive segment execution produce distinctive cost and scheduling constraints.

Addressing this gap is urgent because delays and cost overruns in river-protection projects can prolong community exposure to erosion and flooding while reducing the efficiency of public infrastructure expenditure. A technically feasible retaining-wall design cannot provide its intended benefits if the construction process is hindered by inaccurate work volumes, unrealistic productivity assumptions, material-price fluctuations, or poorly coordinated critical activities. Accordingly, an integrated cost-time analysis is needed to identify dominant expenditure components, establish realistic activity durations, determine zero-float activities, and create a measurable baseline for monitoring construction progress and anticipating deviations.

The novelty of this research lies in integrating a cross-software construction-management workflow based on actual data from the CS-5 Kalibuntu segment. AutoCAD is used to validate working drawings and calculate construction quantities; Microsoft

Excel is used to prepare the Work Unit Price Analysis and Cost Budget Plan based on applicable regulations and local prices; and Microsoft Project is used to develop the Work Breakdown Structure, activity dependencies, Critical Path Method network, and cost-weighted S-curve. Unlike studies that treat cost and schedule calculations as independent outputs, this research links geometric quantities, unit-price coefficients, total costs, activity durations, and weekly progress weights within one coherent planning framework.

This study aims to analyze the construction management of the retaining-wall structure in the CS-5 Kalibuntu segment of the CWC-1BKC Babakan and Cisanggarung River Works Project. Its specific objectives are to calculate the volume of each work item, determine the required materials and equipment, prepare the Work Unit Price Analysis and Cost Budget Plan, estimate the implementation duration, identify the critical path and activity float, and develop an S-curve as a project-control baseline. Academically, the study contributes case-based evidence regarding integrated cost and schedule analysis for repetitive river-infrastructure works. Practically, its results can assist contractors, consultants, and project owners in allocating resources, controlling dominant costs, coordinating critical activities, monitoring progress, and reducing the risk of delays and budget deviations in comparable flood-control projects.

METHOD

The research method used is a quantitative method with a case study approach in the CS-5 segment of Kalibuntu, Kalibuntu Village, Pabedilan District, Cirebon Regency, which is part of the CWC-1BKC Babakan and Cisanggarung River Works Project along 720 meters which is divided into 60 segments. Data was obtained from contract documents and secondary data from the Cimanuk-Cisanggarung River Region Center (BBWS), with service provider PT Bumi Karsa and supervision consultant PT Wiratman.

The research instruments used consisted of three main software. AutoCAD is used to read and validate shop drawings of retaining wall structures to perform quantity take-off (QTO) volumes of excavation, bore pile, formwork, ironing, and concrete. Microsoft Excel is used to compile the Work Unit Price Analysis (AHSP) referring to the Ministerial Regulation of PUPR No. 1 of 2022 and calculates the Cost Budget Plan (RAB) with the bottom-up estimating method, which is multiplying the volume of each work item by the unit price of the AHSP result. Microsoft Project is used to construct a Work Breakdown Structure (WBS), a Critical Path Method (CPM) network with Start-to-Start and Finish-to-Start predecessor relationships, and model progress distributions in the form of S-Curves based on weekly cost weights.

The data analysis technique is carried out through four stages, namely (1) analysis of the volume of work based on geometric extraction from the work drawing, (2) analysis of the unit price of work (AHSP) which includes the analysis of the coefficient of labor, materials, and tools as well as the analysis of the basic price according to the project location, (3) analysis of the estimated cost (RAB) by summing the results of the volume and unit price of each work item, and (4) scheduling analysis with CPM which includes estimation of activity duration, work network analysis, and float calculation to determine

critical trajectory, which is further represented in the S Curve as a progress monitoring instrument.

RESULTS AND DISCUSSION

General and Technical Data of the Project

The CWC-1BKC Babakan and Cisanggarung River Works project is a river bank protection work in five locations, with the CS-5 Segment in Kalibuntu Village, Pabedilan District, Cirebon Regency as the object of this case study. Project administration data is presented in Table 1.

Table 1. Project Administration Data

Description	Remarks
Job Package	CWC-1BKC Babakan and Cisanggarung River Work in Brebes, Kuningan and Cirebon
Service Users	Cimanuk Cisanggarung River Region Center
Work Units	SNVT Implementation of Cimanuk-Cisanggarung Water Resources Network
Consultant Supervisi	PT Wiratman
Service Providers	PT Bumi Karsa
Location	CS-5 (River Bank Protection), Kalibuntu Village, Pabedilan District, Cirebon Regency
Number of Segments	60 segments
Building Length	720 meters

Based on Table 1 above, the project has a repetitive work scale on 60 segments along 720 meters, which is the basis for multiplication at all subsequent stages of volume and cost analysis. Geometric technical data of the retaining wall structure was obtained from the working drawings (shop drawings) which included the longitudinal profile of the structure placement, the cross section of the K-225 quality concrete cantilever wall, the layout of the bored pile foundation pole formation with a diameter of 40 cm in an arrangement of 4 rows, as well as the details of the repetition and depth of the pole. Figure 1 shows the cover of the working drawing document which is the reference for all quantity calculations in this study.

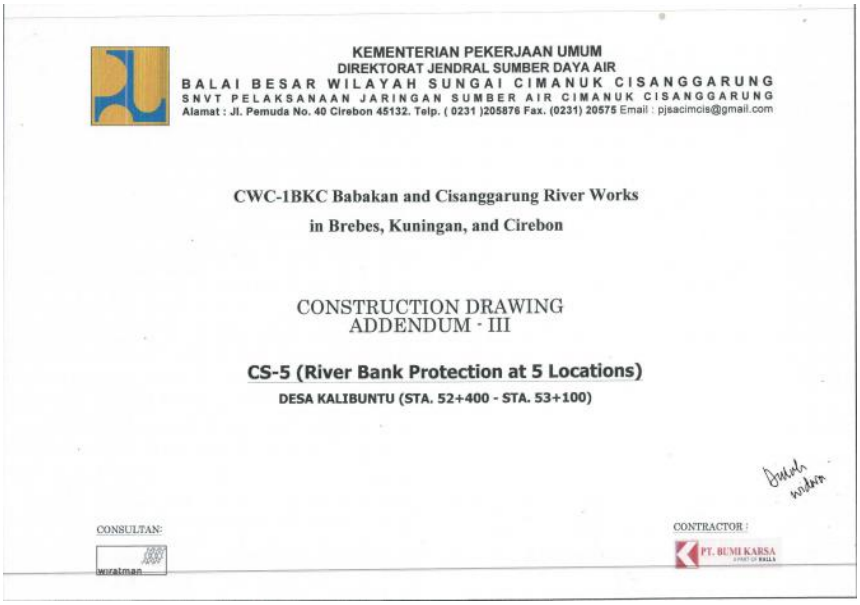

Figure 1. Cover of Work Drawing Document (Shop Drawing) Segment CS-5 Kalibuntu

Figure 2 shows a typical cross section of the K-225 quality concrete cantilever retaining wall structure which is a reference for calculating the area of formwork and the volume of concrete on the walls and foundations, while Figure 3 shows the layout of the formation of a group of bored pile foundation pillars with a diameter of 40 cm which is arranged in 6 rows in the longitudinal direction and 4 rows in the transverse direction of each segment.

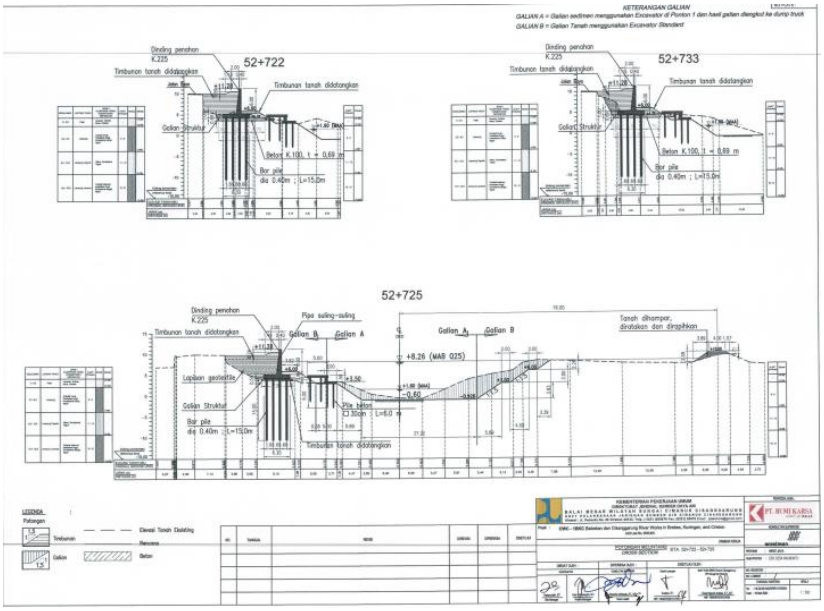

Figure 2. Typical Cross Cut Retaining Wall Structure Concrete Cantilever Quality K-225

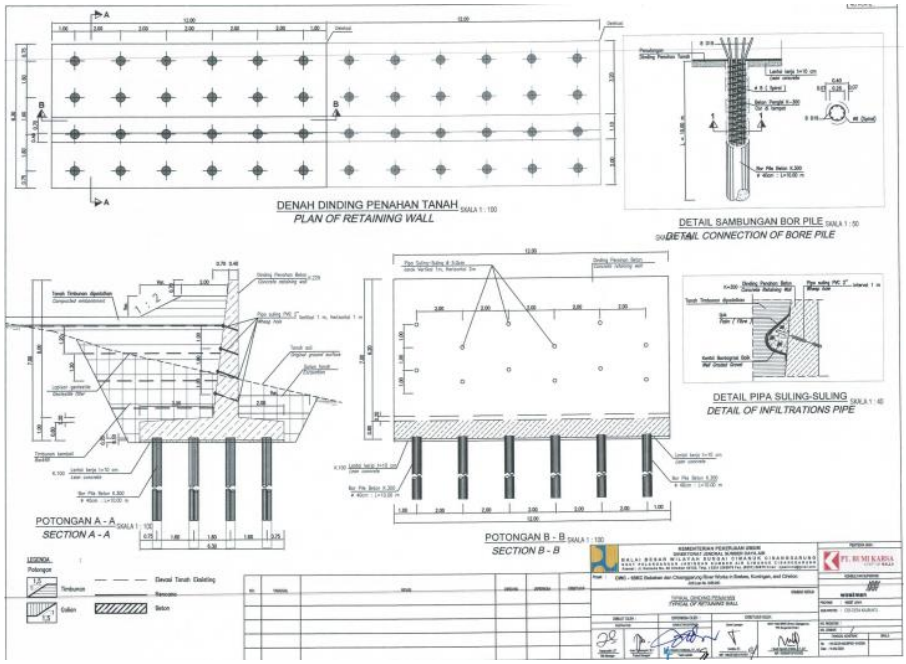

Figure 3. Layout Formation 4 Rows of Pole Group Bored Pile Ø 40 cm

Work Volume Analysis

The calculation of the volume of work (quantity take-off) is carried out by detailing each construction element in the plan drawing, grouping it starting from the preparation stage, earthworks, pile piling up, concrete construction, to complementary work, then multiplying it by the number of 60 segments. A recapitulation of the main work volumes is presented in Table 2.

Table 2. Recapitulation of Calculation of Major Work Volume

Job Name	Total Volume
Excavation of soil with excavator	7.560.00 m^3
Drill arrows Ø 40 cm	14,400 m
Bore pile repeating & casting	21,600 m
Ground retaining wall formwork	4,334.4 m^2
Ironing	599,442 kg
K-100 concrete (working floor)	468 m^3
Beton K-225 (fc = 19,3 MPa)	1,245.6 m^3
Pipe Flute (Weep Hole)	540 pcs
Water stop	414 m
Dowel bar	1,121 pieces
Joint filler	606.52 m
Joint sealant	519.79 m

Based on Table 2 above, the most significant volume work includes 14,400 m of bore pile piling, 21,600 m of bore pile repetition and casting, 4,334.4 m^2 of wall formwork, 599,442 kg of ironing, and 1,245.6 m^3 of K-225 quality concrete. From a methodological perspective, the accuracy of this volume greatly affects the validity of the next stage of analysis, as the slightest error in the cubic step has the potential to accumulate proportionally in the calculation of the RAB. The approach to categorizing work ranging from preparation, earthworks, piling to concrete and complementary work (waterstop, dowel bar, joint filler, and joint sealant) has been in accordance with the principles of drafting Bill of Quantity (BoQ) that are commonly applied to water resources projects, thus making it easier to re-verify the volume recapitulation by the supervisory consultant (Konior & Szóstak, 2020; Rauzana & Dharma, 2022; Tomczak & Jaśkowski, 2022; Wahab & Wang, 2022) .

Analysis of Material Needs, Heavy Equipment, and Unit Prices of Work

The material requirement is calculated for each work item based on the volume that has been obtained, then mapped to the Work Unit Price Analysis coefficient (AHSP) to determine the proportion of cement, aggregate, reinforcing iron, and other complementary materials needs. The need for heavy equipment, such as excavators, concrete pumps, and bore pile piles, is determined by multiplying the volume of work by the coefficient of productivity of the tool and the duration of the planned implementation, referring to the provisions applicable to water resource work.

The analysis of the unit price of work was prepared by referring to the coefficient of labor, materials, and tools in accordance with the Regulation of the Minister of Public Works and Housing, which has been adjusted to the local price of materials in the Cirebon area and the level of local labor wages. This approach ensures that the unit price obtained is relevant to field conditions, rather than simply taking generic unit prices from other regions. The results of the analysis showed that the types of work that required the mobilization of materials from off-site, such as transporting landfill using dump trucks as far as 30 km, as well as major structural works such as bore piles, ironing, and K-225 quality concrete, had a much higher unit price than local earthworks. This condition is consistent with the characteristics of river soil retention projects that require a large volume of stockpile materials, while the material resources around the site are very limited, so transportation costs have a significant influence on the total unit price of work.

Cost Budget Plan (RAB)

The Cost Budget Plan is calculated based on the formula RAB = Σ (Volume × Unit Price of Works), referring to the results of the analysis of unit prices, material needs, and tool needs that have been described earlier. The results of the recapitulation show that the total cost of implementing retaining wall work for the CS-5 Kalibuntu Segment reached IDR 54,535,705,559.17. The contribution of each work group to the total RAB is presented in Table 3.

Table 3. Contribution of Key Working Groups to Total RAB

Working Group	Contribution to Total RAB
Transportation of heapland from outside (dump truck)	± 47%
Threaded reinforcement iron work (ironing)	± 21%
K-225 quality concrete work (ready mix)	± 14%
Repeating and casting of bore piles	± 10%
Other work (excavation, work flooring, complementing)	± 8%

Based on Table 3, the top four work groups account for more than 90% of the overall RAB, so it can be concluded that the cost control of these projects is greatly influenced by fluctuations in the price of heap materials and reinforcing steel. These findings provide practical implications that cost management strategies should be focused on both elements, for example through the negotiation of fixed-price contracts with material suppliers or optimizing the distance between the transport of landfill sources to reduce transportation costs. This finding is in line with the research of Rahman, Oetomo, and Marleno (2025) which shows that the application of value engineering to the dominant cost element is able to produce significant budget efficiency in similar retaining wall projects.

Project Scheduling and S-Curve

The preparation of the project implementation schedule is carried out through the bar chart method which is then represented in the form of an S Curve, as shown in Figure 4.

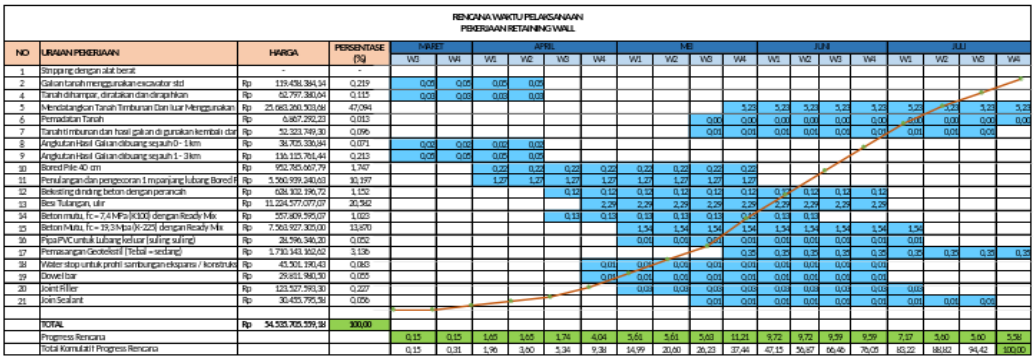

Figure 4. Curve S Progress Plan Retaining Wall Work Segment CS-5 Kalibuntu

The progression distribution pattern in Figure 4 shows the typical shape of the S Curve. In the early weeks of March, progress was relatively slow as it was dominated by preparatory work and excavation. Furthermore, there was a significant increase in progress from April to May, as massive bore pile work, ironing, and casting of concrete structures began in various segments. Progress is sloping again ahead of completion in

July, when the remaining work includes only complementary items such as waterstops, dowel bars, joint fillers, and joint sealants.

The highest weekly progress weight occurred mid-implementation, along with bore pile repetition and wall ironing activities that had a large cost weight and a long execution duration. This pattern confirms that the S Curve not only functions as a tool for visualizing cumulative progress, but also acts as an early warning system if the realization of progress in the field deviates from the plan, especially in periods with significant workload.

Analisis Critical Path Method (CPM)

Analysis of the work network using the Critical Path Method (CPM) method was carried out using Microsoft Project software to identify the dependency relationship (predecessor) between activities and determine which activities can be carried out in parallel. The Activity on Node (AON) diagram of the analysis results is presented in Figure 5.

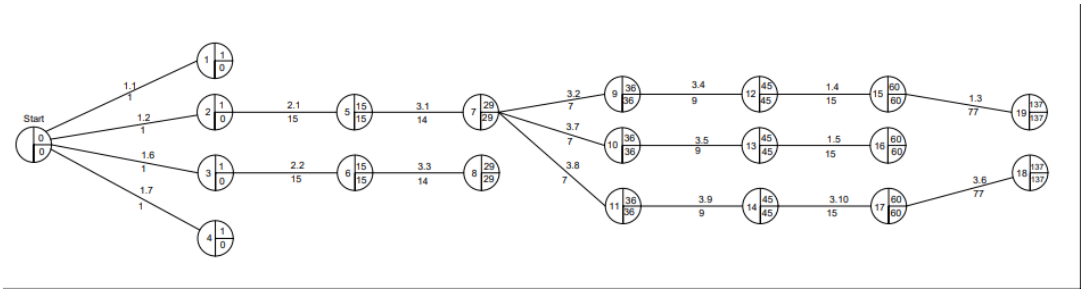

Figure 5. Activity on Node Diagram Critical Path Method Retaining Wall Work Segment CS-5 Kalibuntu

The results of the forward and backward calculations of all activities, from excavation work, pole drilling, to complementary activities such as geotextiles and joint sealants, show that the project completion time is 137 calendar days, with a total float value of zero in almost all of the activities evaluated. The total float condition of zero on most activities indicates that the project's network is almost entirely critical, which is natural given the repetitive nature of the retaining wall work on 60 segments with a predecessor Start-to-Start relationship with time lag between segments.

The implication is that delays in any activity in the series, especially in bore pile work, ironing, and concrete work that are critical lines, will directly affect the overall project completion date, without any slack time that can absorb the delay. When compared to the CPM research on the Synthesis Residence Kemang project which showed a duration of 484 days (Suhendar, 2021; Ulfa & Suhendar, 2021), the duration of 137 days in this study is much shorter, which is understandable considering the difference in scale and complexity between the multi-storey buildings and the soil retaining wall structure in one river sub-project. These findings are also in line with Agbonaye and Oriakhi (2023) who emphasize that water infrastructure projects with repetitive work tend to result in a network of work with a high level of criticality due to sequential attachment between segments.

Linkages Between Outcomes and Contribution to Research Objectives

Overall, the integration of the results of volume calculations, AHSP, RAB, S Curve, and CPM in this study shows consistency between the stages of construction management analysis. The accurate project volume is the mathematical basis for the calculation of the RAB of Rp54,535,705,559.17, while the duration of 137 days obtained from CPM serves as a time frame for the cost distribution in the S Curve. These three instruments are interrelated and form a cost-time evaluation integration that answers the formulation of the research problem, while affirming the novelty of this research in the form of integration of cross-software workflows (AutoCAD, Microsoft Excel, and Microsoft Project) in the evaluation of construction management relevant to the characteristics of river projects in Cirebon (Fraser, 2024).

However, the results of this analysis need to be understood by considering the limitations of the study, namely not taking into account weather factors and the focus of the analysis which only includes one sub-project, namely the CS-5 Kalibuntu Segment. Therefore, the RAB value and the duration of 137 days obtained are planning estimates that ideally need to be re-verified through monitoring actual progress in the field, so that potential cost overruns and schedule delays can be detected and controlled as early as possible.

CONCLUSION

This study demonstrated that the integrated application of quantity take-off, Work Unit Price Analysis (AHSP), the Cost Budget Plan (RAB), the Critical Path Method (CPM), and the S-curve provided a comprehensive basis for planning the retaining-wall construction in the CS-5 Kalibuntu segment of the CWC-1BKC Babakan and Cisanggarung River Works Project. The analysis covered 60 repetitive segments along 720 meters and produced a total estimated construction cost of IDR 54,535,705,559.17 and an implementation duration of 137 calendar days. Transportation of fill material was the largest cost component, contributing approximately 47% of the total budget, followed by reinforcing-steel work, K-225 concrete, and bored-pile reinforcement and casting. The CPM results indicated that most activities had zero total float, meaning that delays in critical activities particularly bored-pile, reinforcement, and concrete work would directly affect the project completion date. Integrating AutoCAD, Microsoft Excel, and Microsoft Project effectively connected design quantities, cost estimates, activity dependencies, and planned progress, thereby providing a practical framework for project cost and schedule control.

Future research should compare the planned cost, duration, and S-curve with actual project performance to identify schedule variance, cost variance, productivity deviations, and the causes of potential overruns. Subsequent studies should also incorporate weather conditions, river discharge, material-price fluctuations, equipment availability, labor productivity, supply-chain disruptions, and construction risks into probabilistic scheduling and cost simulations. Applying methods such as Earned Value Management, Monte Carlo simulation, Building Information Modeling, or the repetitive scheduling method could produce more dynamic and reliable project-control models. Expanding the analysis to other CWC-1BKC segments or similar riverbank-protection projects would also enable comparative evaluation and improve the generalizability of the integrated cost-time planning framework.

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