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Evaluating the Effectiveness of Construction Management on Quality, Time, Cost, and Risk Performance in the Nuclear Medicine Building Project at Dr. Soedarso Regional General Hospital, Pontianak

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Abstract: *The Nuclear Medicine Building is a strategic healthcare facility that utilizes open radiation sources for diagnosis and treatment. Due to its high structural complexity and radiological risks, this study aims to analyze the construction management implementation of the Nuclear Medicine Building project at Dr. Soedarso Regional General Hospital, Pontianak. The research utilizes primary data from field observations and secondary data from project documents, analyzed through four critical aspects: cost, time, quality, and human resources. The study produces an Implementation Budget Plan (RAP) totaling IDR 7,904,689,106.53. Time management planning establishes a project duration of 15 weeks or 108 calendar days, utilizing Network Planning and Bar Charts to monitor the critical path. Quality management is implemented through a quality control table to ensure technical specification compliance, while human resource planning identifies a peak labor requirement of 100 workers per day during the 7th week. Analytically, the integration of cost and time in this project validates the "Iron Triangle" theory, where precision in substructure work (foundations) serves as the primary determinant of schedule success due to the specialized loading requirements of nuclear facilities. These findings suggest that for specialized medical infrastructure, radiation safety standards demand more stringent productivity coefficients compared to general building projects. The academic implication of this research indicates that the application of national AHSP regulations (PUPR No. 8 of 2023) requires adjustment for site-specific risk variables in high-hazard buildings to prevent deviations between technical planning and field reality. These results contribute to the project management literature on the necessity of integrated frameworks in enhancing the resilience of regional medical referral infrastructure.*

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INTRODUCTION

Nuclear medicine is a modern field of medicine that utilizes small doses of radioactive materials for the diagnosis and treatment of various diseases. With the development of technology and the increasing public demand for fast and accurate health services, the existence of nuclear medicine facilities has become crucial. Nuclear facilities require planning and construction with a high level of structural safety that takes into account radiation factors, extreme loads, and international standards in risk control[1]. This not only requires complete medical equipment, but also building infrastructure that meets radiation safety standards, spatial efficiency, and compliance with technical regulations. The construction of the Dr. Soedarso Pontianak Regional General Hospital Nuclear Medicine Building is a strategic step by the West Kalimantan Provincial Government in strengthening medical referral services in the region.

Construction management is a system of planning, implementing, controlling, and coordinating projects to ensure their implementation is in accordance with the plan[2]. Management is responsible for coordinating resources efficiently and effectively to achieve objectives. Effectiveness means successfully achieving targets, while efficiency indicates how optimally resources are used to achieve those objectives[3]. Construction management plays an important role in ensuring the success of large-scale health infrastructure projects. Not only does it supervise physical work, construction management also serves as an integrated system that regulates the relationship between cost, time, quality, and resources. While general construction management principles are well-documented, academic literature specifically addressing the integration of cost-time efficiency with radiation safety protocols in regional healthcare facilities remains sparse. The academic urgency of this study lies in addressing the knowledge gap concerning how labor productivity coefficients and national Unit Price Analysis (AHSP) standards must be adapted to meet the significantly more stringent technical specifications of nuclear buildings compared to conventional structures.

There are four main aspects of construction management. First, cost management, which regulates budget control through the preparation of an Implementation Budget Plan (RAP) based on market price surveys [4]. Second, quality management, which ensures that the work complies with technical standards using a monitoring system and quality checklist[5]. Third, time management, which guarantees the accuracy of the implementation schedule through bar chart, S curve, and network planning methods [6]. Fourth, human resource management, which regulates the distribution of labor based on actual needs in the field.

High-risk buildings, such as nuclear medicine facilities, require extreme structural precision, particularly in foundation and massive wall components to prevent radiation leakage. This research contributes significantly to the field of high-risk healthcare facility management by providing an analytical framework that links human resource management with quality control in specialized structures. Academically, this study extends the application of the "Iron Triangle" theory (cost, time, and quality) within the context of critical medical infrastructure, where management failures impact not only financial loss but also public safety risks and long-term operational failures of healthcare services.

This study aims to analyze the implementation of construction management in the construction project of the Nuclear Medicine Building at Dr. Soedarso Regional General Hospital in Pontianak. The results of this study are expected to serve as a reference in the application of construction management principles in health infrastructure projects, particularly in ensuring the effectiveness and efficiency of project implementation.

Project management is the process of planning, organizing, directing, and controlling resources to achieve project objectives within a specified time frame [7]. In the context of construction, the main function of project management is to ensure that activities are carried out effectively, efficiently, and in accordance with technical specifications.

According to the Project Management Institute, cost management includes the processes of estimating, budgeting, monitoring, and controlling costs so that projects are completed within budget [8]. The importance of integrating cost, time, and quality. The main component of cost management is the Implementation Budget Plan (RAP) [9], which is an actual budget based on market prices and field conditions [10].

Based on PUPR Regulation No. 8 of 2023 [5], the Unit Price of Work (HSP) is calculated as follows:

$$HSP = (Wages \times Coefficient) + (Materials \times Coefficient) + (Equipment \times Coefficient)$$

The final stage of cost management is the recapitulation of the total budget for all work items.

Effective time management in construction projects is a key factor in the overall success of the project, ensuring that all activities are carried out according to the planned schedule[11]. In time management, there is a time schedule that identifies the activities during the project in detail, then determines the relationship between activities to obtain the sequence of work in the project [12].Bar Charts are used to display the sequence and duration of activities. Each activity has a required completion time, which is presented as a line on a time scale, usually printed in bold to resemble a block, with the length of the block indicating the duration of the work [13], as well as S Curves to monitor the progress of the project over time. The calculation of work duration is based on the calculation of work productivity to obtain an efficient time and take into account field conditions [14].

1. Quality Management

The stages include quality planning, quality management implementation, and quality control. Quality control is carried out through material inspection, work result testing, and implementation evaluation [15].

2. Human Resource Management (HRM)

HRM involves effective workforce planning and management to achieve project targets [16]. Calculations are made to determine the workforce requirements for construction [17], and the workforce requirements are calculated using the AHSP coefficient with the following formula [18]:

$$Productivity = 1 / AHSP\ Coefficient$$

$$Number\ of\ Workers = Volume / Productivity$$

This approach helps determine the optimal number of workers according to field conditions [19].

Construction projects carry high risks in terms of cost, time, and quality. Project management consists of three main functions: a. strategic planning and work steps, b. implementation of activities and mobilization of resources, and c. control to evaluate and correct deviations. These three functions form an adaptive and sustainable construction management system [20].

THEORETICAL FRAMEWORK

The development and implementation of construction management practices have been widely analyzed in previous research, especially regarding complex and safety-sensitive projects such as health facilities and nuclear-related buildings. Bangash (2011) emphasizes that buildings associated with nuclear medicine services require robust structural design, radiation protection, and strict adherence to international safety requirements. These considerations highlight the importance of integrating advanced planning and risk-mitigation strategies from the earliest stages of project development.

Construction management theories discussed by Ervianto (2023) and Rani (2016) identify several fundamental components, including planning, resource allocation, coordination, and supervision. These elements collectively ensure that the project progresses effectively and efficiently. Yakub et al. (2021) further state that construction project success relies heavily on the interrelationship between cost, time, and quality—commonly known as the "iron triangle." In specialized infrastructure projects, such as medical facilities, this relationship becomes increasingly critical due to higher precision and safety standards.

Cost management has been extensively explored by the Project Management Institute (PMI, 2017; 2018) and Kerzner (2017), who highlight the importance of accurate cost estimation, budgeting, and financial control to prevent overruns. Several studies, including those by Pitaloka et al., recommend using real market prices when preparing an Implementation Budget Plan (RAP), which aligns with national regulations such as the Indonesian Ministry of Public Works and Housing (PUPR) Regulation No. 8 of 2023 on Analysis of Unit Prices (AHSP).

Time management has also been addressed in various studies. Afiya et al. (2023) and Kusumo & Hakim (2023) explain that tools such as bar charts, S-curves, and Critical Path Method (CPM) network planning are effective for tracking progress and managing construction schedules. Ramadhan & Anwar (2022) demonstrate that CPM is particularly beneficial for identifying activities with zero float, which directly determine the duration of a project.

Quality management in construction is covered by Mulyono (2012) and Surbakti (2013), who emphasize the importance of inspection, quality documentation, and compliance with technical specifications. These principles are essential for ensuring that construction outputs meet the required standards, especially in healthcare infrastructure which demands high levels of reliability and safety.

Human resource management also plays a crucial role in the success of construction projects. Studies by Astri (2022), Listiani & Kamandang (2023), and Syahbani et al. (2022) highlight that productivity, expertise, and availability of labor significantly influence project timelines and costs. The use of AHSP productivity coefficients is widely recognized as a standard method for estimating labor requirements based on work volume.

Overall, existing literature supports a comprehensive approach that integrates cost, time, quality, and human resource management. This integrated framework provides a strong theoretical foundation for evaluating and improving construction project performance. The present study builds on these concepts by assessing their application in the implementation of the Nuclear Medicine Building at Dr. Soedarso Regional General Hospital in Pontianak.

The evaluation of the Nuclear Medicine Building construction is grounded in a synthesized framework that integrates conventional project management pillars with the specialized requirements of high-risk radiological facilities:

- Cost Management and Regulatory Compliance: The analysis of the Implementation Budget Plan (RAP) transcends mere financial control; it serves as a mechanism for ensuring adherence to national standards, specifically PUPR Regulation No. 8 of 2023, to guarantee the accuracy of unit price analysis for specialized materials required in radiation shielding.
- Time Management and Critical Path Reliability: Utilizing the Critical Path Method (CPM), the framework identifies activities with zero float, particularly substructure

and massive wall works, where any deviation would result in a systemic failure of the project timeline.

- Quality Assurance in High-Precision Environments: The quality evaluation is focused on achieving a "zero-defect" standard, ensuring that technical specifications for structural elements, such as the f'c 25 MPa (K-300) concrete quality, comply with international safety benchmarks for nuclear facilities to prevent radiation leakage.
- Competency-Based Resource Optimization: The workforce requirement is evaluated through a productivity matrix based on AHSP coefficients, balancing the high volume of work with the specialized skills of technical labor, such as blacksmiths and ironworkers, to ensure structural integrity.

RESEARCH METHODS

This research employs an evaluative case study design to systematically assess the implementation of construction management principles in a specialized high-risk environment. This approach is selected because the primary objective is to measure the extent to which the field execution of the Nuclear Medicine Building project aligns with predefined technical specifications, national regulations such as PUPR No. 8 of 2023, and theoretical benchmarks of project efficiency. Unlike a purely descriptive or analytical study, an evaluative framework allows for a rigorous comparison between planned parameters, specifically in cost, time, and quality, and the actual results achieved during construction. For instance, the study evaluates structural elements like the P1 foundation to verify if the f'c 25 MPa concrete quality and reinforcement specifications meet the safety standards required for radiological facilities. By synthesizing data through this evaluative lens, the research provides a critical judgment on the effectiveness of resource utilization and offers evidence-based recommendations for future high-precision healthcare infrastructure projects.

This study uses two types of data, primary data and secondary data.

1. Primary data was obtained directly through observation and interviews in the field, while secondary data was obtained from project documents and supporting references related to the construction of the Nuclear Medicine Building at Dr. Soedarso Pontianak Regional General Hospital.

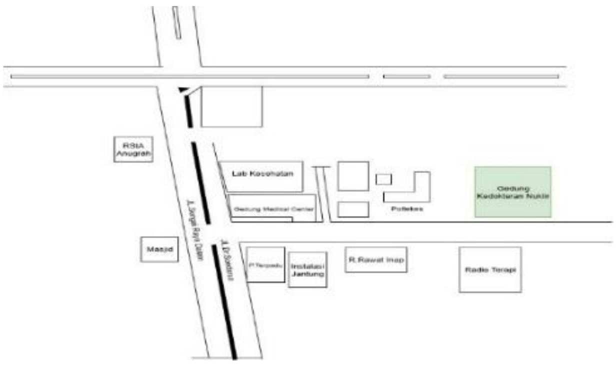

Figure 1. *Location Map*

Figure 2 shows location A, which is a project adjacent to locations B and C, where the project uses material sites or material stores.

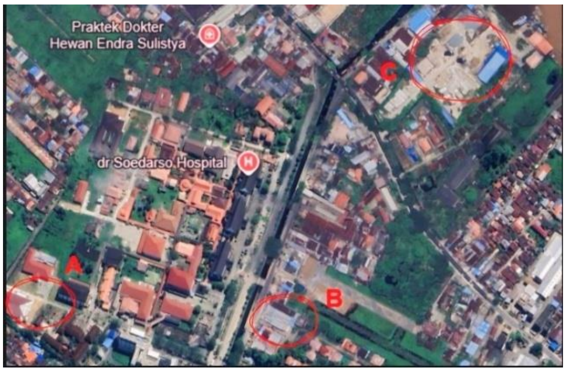

Figure 2. *Distance from Project Area to Material Store*

In interviews regarding information on the prices of each building supply store visited, Table 1 shows that the prices used for this project were the lowest prices available. Meanwhile, Table 2 shows the wages paid by contractors to determine the applicable labor rates in the field.

Table 1. Lowest Material and Tool Prices

No.	Material and Tool Name	Lowest Price
1	Beton Ready Mix K-250	Rp.1.132.000,00 /M3
2	Beton Ready Mix K-300	Rp.1.187.700,00 /M3
3	Wiremesh M6	Rp.359.800,00 /roll
4	concrete pump	Rp.3.000.000,00 /day
5	Ø12	Rp.120.000,00 /stem

Table 2. Wage Rate

No.	Type of Wage	Price
1	Worker	Rp.100.000,00
2	Foreman	Rp.120.000,00
3	Supervisor	Rp.140.000,00
4	Heavy Equipment Operator	Rp.150.000,00
5	Heavy Equipment Assistant Operator	Rp.105.000,00

2. Secondary Data

Secondary data is obtained from project documents and relevant technical references, including:

a. Working Drawings

Contains structural drawings (foundations, beams, columns, and site plans) used as the basis for calculating the volume of work and resource requirements. In drawing 3, the foundation uses 25×25 cm square piles 6 m long, while drawing 4 shows beams of various sizes (25/45 cm to 10/10 cm).

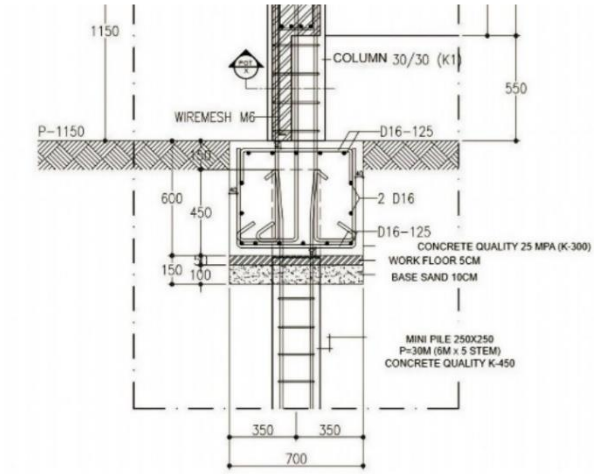

Figure 3. *Mini Pile P1 Details*

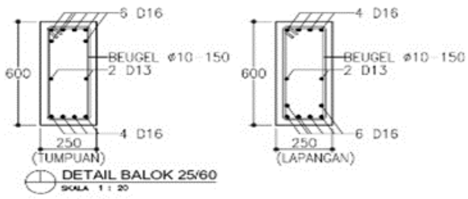

Figure 4. *Beam Detai*

b. Unit Price Analysis (AHSP)

Table 3 refers to Ministry of Public Works and Public Housing Regulations No. 1 of 2022, No. 8 of 2023, and Circular Letter on Construction Development No. 68/SE/Dk/2024. This analysis is used to determine the unit price of materials, wages, and tools based on the AHSP coefficient.

Table 3. AHSP

No.	Description	Coefficient
A.	Worker	
1.	Laborer	0,600 OH
2.	Carpenter	0,200 OH
3.	Mason	0,200 OH
4.	Foreman	0,040 OH
5.	Mandor	0,013 OH

c. Site Plan

Figure 5 shows the layout of the building and project work area as a reference for planning and organizing construction activities.

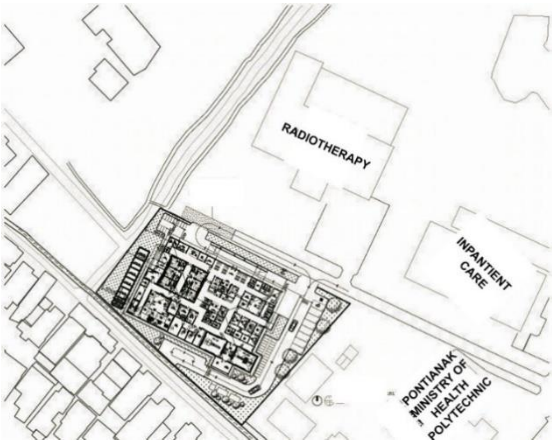

Figure 5. *Site Plan*

3. Analysis and Resolution

Analysis is conducted after all data has been collected using a construction management approach that covers aspects of cost, time, quality, human resources, and implementation methods.

a. Cost Management

Calculated through the Implementation Budget Plan (RAP) based on the formula:

RAP = (Labor Costs) + (Material Costs) + (Equipment Costs).

b. Quality Management

Table 4 shows the quality of foundation p1 with a volume of 0.294 m^3 of 2 D 16-150 mm reinforcement with 60 cm of excavated soil, 10 cm of sand fill, and a 5 cm working floor, using piles with 5 joints.

Table 4. Work Quality List

P1 Foundation	Description
Volume/ Point	0.294 m^3.
Reinforcement	2 D16 , D 16-150 mm
Excavation, Base Sand,Working Floor	60 cm , 10 cm , 5 cm
Connecting	5 joints

c. Time Management

The methods used in time management planning for the construction project of the Nuclear Medicine Building at Soedarso Regional General Hospital in Pontianak include Network Planning, Bar Charts, and S Curves. These methods aim to determine the sequence, interdependencies, and estimated duration of completion for each work item so that the project can run according to schedule.

The steps taken are as follow :

1) Identification of Work Items

All structural work, including foundations, columns, beams, and floor slabs, is described based on the project working drawings.

2) Work Duration Analysis

The duration of each job is calculated based on the volume of work and labor productivity using the following formula:

$$\text{Duration} = \frac{\text{Volume}}{\text{Productivity}}$$

The productivity value is obtained from the PUPR Unit Price Analysis (AHSP) coefficient No. 8 of 2023.

3) Work Weight Calculation

Each work item is given a weight based on its proportion of the total work cost:

$$\text{Weight}(\%) = \frac{\text{Cost of Work Item}}{\text{Total Project Cost}} \times 100\%$$

4) Bar Chart Preparation

Based on the duration and weight of the work, a Bar Chart is prepared to illustrate the weekly implementation schedule for each work.

5) S-Curve Preparation

An S-curve is created to show the relationship between work progress and time, as a control tool for project implementation.

6) Network Planning

The Critical Path Method (CPM) is used to determine the critical path, which is the sequence of activities that cannot be delayed without affecting the project completion time.

d. Human Resource Management (HR)

Determining the number of workers based on productivity, using the formula.

Productivity = 1 / AHSP Coefficient,

Number of Workers = Volume / Productivity.

e. Implementation Method

This covers the coordination of all aspects (cost, time, quality, human resources) from the initial stage to the end of the project so that the construction implementation runs effectively and efficiently.

This methodology is designed to produce efficient, timely, and quality-standard-compliant planning and control of construction implementation for the Nuclear Medicine Building at Dr. Soedarso General Hospital in Pontianak. The methodology is illustrated in a flowchart as shown in Figure 6.

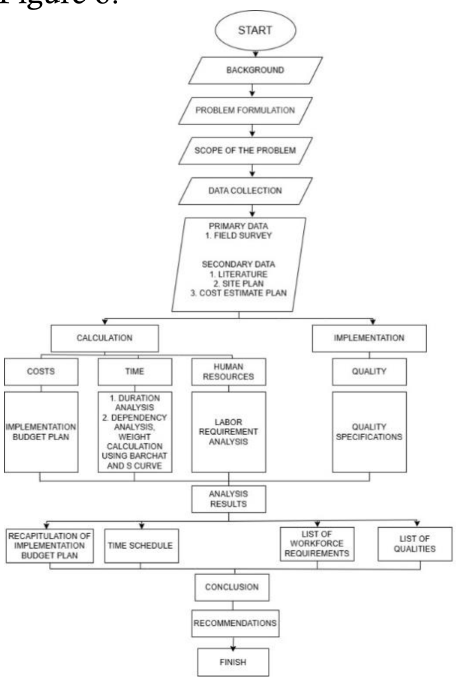

Figure 6. *Flowchart of Methodology*

RESULTS AND DISCUSSION

Cost Management

In cost management, the coverage that will be discussed is the Work Budget Plan (RAP). The implementation of a construction project must be accompanied by an implementation budget plan, because we know that the implementation budget plan plays an important role in obtaining detailed information during the construction process. The following is an example of the calculation of the P1 foundation in the Implementation Budget Plan for the construction of the Nuclear Medicine Building at Dr. Soedarso General Hospital, Pontianak City.

Table 5. Cost of U42 P1 Reinforcement Work

Labor Force	Estimation	RAP
Blacksmith	1 day	Rp.4.800.000,00
Worker	1 day	Rp.4.800.000,00
Foreman	1 day	Rp.120.000,00
Supervisor	1 day	Rp.140.000,00
		Total Rp.9.860.000,00

The cost analysis results for the Reinforcement U42 P1 project show that the total budget required for labor for one day is IDR 9,860,000. The largest portion of the cost comes from blacksmiths and workers, which each cost Rp 4,800,000.00 per day. These two types of labor are dominant components in the cost structure due to their intensity of involvement and the high technical demands of the reinforcement process.

On the other hand, foremen require Rp 120,000.00 per day, while supervisors require Rp 140,000.00 per day. Although their cost contribution is smaller than that of the main technical personnel, the presence of foremen and supervisors remains crucial in supporting supervision activities and maintaining the quality of work in the field.

Table 6. Recapitulation of the Implementation Budget Plan (RAP)

No	Sub- Item of Work	Total Price RAP
A.	**BUILDING STRUCTURE WORKS**	
I.	PRELIMINARY WORK	Rp.70.278.230,00
II	HEALTH & SAFETY AT WORK	Rp.111.552.120,00
III	FOUNDATION WORK	Rp.2.689.627.474,57
IV	STRUCTURAL WORK	Rp.2.318.743.556,30
V	MASSIVE WALL WORK	Rp. 1.275.900.786,75
VI	STEEL STRUCTURE & ROOF	Rp.96.766.780,75
VII	TERRACE LIGHT STEEL WORK	Rp.520.971.142,50
VIII	RAM WORK	Rp.37.501.446,54
	Total	**Rp.7.121.341.537,41**
	Value Added Tax (VAT)	**Rp. 783.347.569,12**
	Total + VAT	**Rp. 7.904.689.106,53**

The recapitulation of costs in the Implementation Budget Plan (RAP) for Building Structure Works shows that the total value of the work before tax reaches IDR 7,121,341,537.41. This amount is an accumulation of various work groups included in the building structure package.

In the Preliminary Work section, the required budget is IDR 70,278,230.00, while Health & Safety at Work requires IDR 111,552,120.00. The component with the largest cost burden comes from Foundation Work, amounting to IDR 2,689,627,474.57, which reflects the high level of complexity and volume of work at the foundation stage compared to other sub-works.

For Structural Work, an budget of IDR 2,318,743,556.30 was allocated, followed by Massive Wall Work with a value of IDR 1,275,900,786.75. The Steel Structure & Roof Terrace Light Steel Work requires a cost of IDR 96,766,780.75, while RAM Work receives an allocation of IDR 520,971,142.50. In addition, there are other work categories with a total value of IDR 37,501,446.54.

When all components are added together, the total cost of the work reaches IDR 7,121,341,537.41. After adding Value Added Tax (VAT) of IDR 783,347,569.12, the final RAP value becomes IDR 7,904,689,106.53. These findings indicate that foundation and structural work accounts for the largest portion of the overall building structure costs.

Quality Management

Table 7. Quality Table

Evaluated Parameter	Field Observation Result
Concrete Quality	Fc' 25 MPa (K-300)
Concrete Volume per P1 Point	0.294 m³
Reinforcement Specification	2 bars of D16; spacing D16–150 mm
Excavation Depth	60 cm
Sand Bedding Thickness	10 cm
Lean Concrete Thickness	5 cm
Total of P1 Points :	15 points
Total of Connections :	5 connections

The evaluation results for structural element P1, which includes Section A (P1) and Foundation Details (P1) with concrete quality Fc' 25 MPa (K-300), show that all technical aspects examined are within the limits of conformity with the design drawings. Field inspections confirmed that the concrete volume per P1 point was 0.294 m³, in accordance with the value stated in the foundation design details. The reinforcement configuration used 2 D16 bars with a D16–150 mm installation distance, which was in accordance with the vertical reinforcement requirements for structural element P1. Excavation and base preparation activities, including an excavation depth of 60 cm, a base sand thickness of 10 cm, and a working floor of 5 cm, were also found to comply with the technical provisions detailed in the working drawings.

There were 15 P1 points inspected in the field, as well as 5 joints recorded in the element. All inspection points showed consistency between the implementation conditions and the design specifications, with no significant deviations leading to non-compliance. Overall, these findings confirm that the work on structural element P1 has been carried out in accordance with the technical standards and specifications in the planning documents, and is therefore declared to meet the compliance criteria based on the results of the field inspection.

Time Management

1. Work duration analysis

Was conducted to determine the length of time required to complete each work item in the Nuclear Medicine Building construction project. Work duration was determined using the following formula and for example, calculations were made for the P1 Foundation Reinforcement (U42 Reinforcement) work with a volume of 693.44 kg. Based on the labor coefficient from the Bina Konstruksi Circular Letter No. 68/SE/Dk/2024, the productivity of each worker was obtained as shown in Table 8.

$$\text{Durasi} = \frac{\text{Volume}}{\text{Productivity}}$$

Table 8. Reinforcement Work for Foundation P1 (U42 Reinforcement)

Labor Position	Coefficient (Person/Day)	Productivity (kg/PD)	Duration (PD)	Number of Days
Worker	0,07	14,28	48,56	6 days
Ironworker	0,07	14,28	48,56	6 days
Foreman	0,007	142,85	4,85	3 days
Supervisor	0,004	250	2,77	1 days

The calculation results show that the P1 foundation reinforcement work requires 6 working days involving an average of 8 workers. The difference in duration between worker positions shows the division of responsibilities and supervision according to their respective skill levels.

2. Job Weight

Work weight is used to determine the percentage contribution of each work item to the total project cost. The formula used is:

Work Weight = Cost of Each Work Item/ Total Project Cost x 100%

For example, for preliminary work, with a duration of 14 days and a cost of Rp 70,278,230.00, and a total project cost of Rp 7,904,689,106.53, the following is obtained.

$$\text{Weight} = 70.278.230/7.904.689.106{,}53 \times 100\% = 0{,}99\%$$

These results show that preliminary work contributes 0.99% to the total project cost. This weighting value is then used to determine the order of priority and its impact on the overall project schedule.

1. Bar Chart

Based on the results of the duration and weight analysis of the work, a bar chart was created to illustrate the implementation time of each work item, the total cost, and the distribution of the weight of the work per week. This bar chart serves as a visual tool to monitor work progress and ensure that each activity runs according to the planned schedule.

The bar chart shows that the initial work (preparation and foundation) has a relatively short duration, but forms the basis for subsequent work such as the superstructure and architecture. Scheduling using this method makes it easy to identify critical and non-critical tasks.

2. S-Curve

The S-curve is created to visualize the relationship between time and cumulative physical progress of the work. The formula for determining the weekly physical plan is:

Weekly Physical Plan= Work Weight/Duration(weeks)

For example, preliminary work has a weight of 0.77% and a duration of 2 weeks, so: Thus, the cumulative physical plan in week 2 reaches 0.77%. The S curve calculation results show the progressive development of work over time, where the slope of the graph reflects the speed of work execution. This graph also helps in evaluating whether the work is running faster, on schedule, or behind schedule.Weekly Physical Plan = 0,77/2= 0,39%

3. Network Planning

Network Planning is a project planning method that shows the logical dependencies between activities. A network diagram illustrates the sequence of work, start and finish times, and identifies the critical path that determines the total duration of the project.

In the Nuclear Medicine Building construction project, the activity network includes preliminary work, foundations, structures, architecture, mechanical and electrical work, and finishing. Using the Critical Path Method (CPM), it can be seen that the foundation and structure work are activities on the critical path that must be strictly controlled so that there are no delays in the overall schedule.as for table 9 shows the dependencies between foundation work items, starting from the procurement of piles.

Table 9. Foundation Work Dependencies P1

No.	Work Item	Duration (days)	Predecessor
1	Procurement of Mini Piles (25×25 – 6 m, 4D13, K-450)	14	–
2	Mini Pile Installation (25×25 – 6 m, 4D13, K-450)	14	1
3	Mini Pile Chipping Work	8	2
4	Welding Work for Pile Connections	8	3
5	Foundation Excavation	7	4
6	Sand Bedding for Foundation	7	5
7	Lean Concrete (fc 10 MPa, Slump 100 ± 25 mm)	7	6
8	Foundation Formwork (P1)	2	7
9	Reinforcement Installation U42 (P1)	1	8
10	Ready-Mix Concrete Casting K-300 (P1)	1	9

From the results of calculating duration, weight, bar charts, S curves, and network planning, it can be concluded that this time analysis method provides a clear picture of project planning, control, and performance evaluation.

Some important points found include: The duration of work is greatly influenced by the volume and productivity of the workforce. Adjusting the number of workers can change the total completion time.

The weight of the work forms the basis for determining the physical plan and compiling the weekly schedule on the S curve. Bar charts and S curves are effective for monitoring project progress. Network planning facilitates the identification of critical activities and the allocation of resources to keep the project running efficiently. With this analytical approach, project implementation can be more planned and the risk of delays can be minimized.

Human Resource Management (HR)

This approach helps determine the optimal number of workers according to field conditions [20].

Table 10. Workforce Requirement Analysis for Foundation Formwork P1

Parameter	Value
Work Volume	25.20 m²
Duration of Work	2 days
AHSP Coefficients (OH)	Worker: 0.520 OH Carpenter: 0.260 OH Foreman: 0.026 OH
Required Workforce	7 Workers 4 Carpenters 1 Foreman
Productivity Rates	Worker: 1.92 m²/OH Carpenter: 3.85 m²/OH Foreman/Supervisor: 38.46 m²/OH
Total Workforce Assigned	13 workers

The workforce planning analysis for the P1 foundation formwork aimed to identify the optimal labor requirement for efficient execution. With a work volume of 25.20 m² and AHSP labor coefficients of 0.520 OH for workers, 0.260 OH for carpenters, and 0.026 OH for foremen, the calculated needs were seven workers, four carpenters, and one foreman. For a planned duration of two days, productivity rates were 1.92 m²/OH for workers, 3.85 m²/OH for carpenters, and 38.46 m²/OH for supervisory personnel. The results show that the activity can be completed effectively with 13 personnel, demonstrating efficient time and resource utilization in the project.

CONCLUSION

Based on the construction management analysis of the Nuclear Medicine Building at Dr. Soedarso Regional General Hospital, the following empirical results were obtained: the Implementation Budget Plan (RAP) totals IDR 7,904,689,106.53 ; the structural work duration is scheduled for 15 weeks or 108 calendar days ; the quality system adheres to technical specifications through a specialized quality checklist ; and the peak labor requirement reaches 100 personnel per day.

Reflectively, these findings demonstrate that the management of high-risk medical facilities requires a high-precision integration model that transcends conventional construction approaches. Scientifically, this research concludes that while national standards (PUPR No. 8 of 2023) provide a robust baseline, the unique structural demands of nuclear medicine—such as massive wall integrity and radiation shielding—necessitate specialized productivity considerations. Ultimately, the successful implementation of cost, time, quality, and human resource management in this project serves as a critical framework for enhancing healthcare infrastructure resilience and public safety assurance.

Based on the analytical findings and the reflective evaluation of this project, the following recommendations are proposed:

1. Academic Contribution: Future research should explore the development of a "Risk-Adjusted AHSP" (Analisis Harga Satuan Pekerjaan) specifically tailored for nuclear and radiological facilities. There is a scholarly need to quantify how

specialized safety protocols affect labor productivity rates in high-density concrete works.

2. Practical Implication for Project Managers: It is recommended that project managers for high-risk medical facilities adopt an Integrated Quality-Safety Monitoring System. This system should move beyond generic checklists to include real-time verification of structural density and radiation-shielding integrity during the critical path of the substructure phase.
3. Policy Recommendation: Regional health authorities should mandate the inclusion of a Specialized Technical Consultant during the planning phase of nuclear facilities to bridge the gap between national construction standards and the specific radiological requirements of the Ministry of Health and BAPETEN.

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