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## Control of Materials and Costs for Ready-Mix Concrete Using the Material Requirements Planning Method

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### ABSTRACT

One of the stages that must be completed before implementing a construction project is the planning stage. Planning for construction project material requirements is a critical component, as material resources constitute one of the largest components of total project costs, alongside equipment, labor, and work methods. This study aims to optimize the control of materials and ready-mix concrete costs in the Solo Raya Tourism Polytechnic construction project using the Material Requirements Planning (MRP) method. This method assists in efficient material requirements planning, minimizes waste, and improves overall project performance. Based on the results of material requirement calculations conducted for the Solo Raya Tourism Polytechnic construction project, it was found that the most appropriate material ordering method among several Lot Sizing methods is the Lot-for-Lot Method, which yields the lowest operational cost of Rp29,580,000.00, compared to the Part Period Balancing Method at Rp38,238,205.00 and the Least Unit Cost Method at Rp56,442,800.00

## **INTRODUCTION**

Every construction project always begins with a planning process. To ensure the process runs smoothly, the primary objectives must be established first. Because inventory plays a critical role in construction execution, material control is necessary to ensure that inventory levels meet requirements and prevent delays that could impact the project's costs and schedule. This study aims to calculate the comparison of operational costs between material inventory plans and to assess the efficiency of ready-mix concrete material control using the Material Requirements Planning (MRP) method.

In the material procurement process, failures often occur that lead to increased material costs. Some causes include inaccurate estimates of material quantities and suboptimal delivery schedules, resulting in frequent shortages or, conversely, excess orders of materials, as well as inefficient ordering timelines.

In a project, excess material inventory constitutes a waste due to excessive investment. Conversely, shortages are a negative indicator because they can disrupt project progress, causing work to be delayed and inevitably affecting the project's budget. Every construction project always begins with a planning process. To ensure the process runs smoothly, the primary objectives must be established first. Because inventory plays a critical role in construction execution, material control is necessary to ensure that inventory levels meet requirements and prevent delays that could impact the project's costs and schedule. This study aims to calculate the comparison of operational costs between material inventory plans and to assess the efficiency of ready-mix concrete material control using the Material Requirements Planning (MRP) method.

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### **Theoretical Basis**

A construction project is a series of activities that utilize resources (labor, materials, equipment, construction methods, and so on) and are constrained by three factors: cost, quality, and time. In its implementation, a construction project is influenced by both physical and non-physical environmental conditions, which can lead to fluctuations in productivity and result in project execution inefficiencies.

According to Rangkuti (2004), Material Requirements Planning is a method for production planning used to determine the timing of orders and the quantity of materials to be ordered to meet the needs of each material component required at a specific time. The Material Requirements Planning (MRP) method determines what, when, and how many components and materials are needed, thereby preventing material shortages and excessive inventory levels to avoid project delays and minimize storage costs.

## **METHODS**

### **Research Location and Time**

This research was conducted at the Solo Raya Tourism Polytechnic Project, located in Dusun I, Kwangen, Gemolong District, Sragen Regency, Central Java. The study focused on reviewing and evaluating material control and work delays during project implementation. The research was carried out during the Field Work Practice (PKL) period from August 1, 2023, to December 10, 2023.



Figure 1. Solo Raya Tourism Polytechnic Project Location  
 (Source: Drone Documentation of the Solo Raya Tourism Polytechnic Project)

**Research Design**

This study used a quantitative case study approach. The case study approach was selected because the research focused on one construction project as the object of analysis, namely the Solo Raya Tourism Polytechnic Project. The quantitative approach was applied because the analysis involved numerical data related to material quantity, work volume, project schedule, ordering frequency, ordering cost, holding cost, and total material procurement cost.

The main analytical method used in this study was Material Requirements Planning (MRP). MRP was applied to determine the quantity and timing of material orders so that material availability could be

controlled more effectively during project execution. In this study, MRP was combined with lot-sizing techniques to compare alternative material ordering strategies. The lot-sizing techniques used were Lot-for-Lot (LFL), Part Period Balancing (PPB), and Least Unit Cost (LUC). These methods were used to determine the most efficient material procurement plan based on the balance between ordering cost and holding cost.

**Data Classification**

The data used in this study were classified into primary data and secondary data. This classification was made to clarify the source, function, and role of each type of data in the MRP analysis.

Table 1. Data Classification

Data Type	Data Source	Data Collected	Function in the Analysis
Primary data	Field observation	Actual work progress, material use conditions, material storage conditions, and field implementation constraints	To validate the actual condition of material control and identify factors contributing to delays
Primary data	Interview with project personnel	Information from site engineers, logistics personnel, supervisors, or project staff regarding material	To support interpretation of material control practices and delay-related issues

		procurement, delivery time, and field problems	
Primary data	Field documentation	Project photos, material stock documentation, and site activity records	To strengthen field evidence and support descriptive analysis
Secondary data	Bill of Quantities (BoQ)	Work item volume and material requirement references	To determine gross material requirements
Secondary data	Unit Price Analysis / AHSP	Material coefficients, unit prices, labor and equipment references	To calculate material needs and procurement cost components
Secondary data	S-Curve	Planned progress and work schedule distribution	To determine material requirement periods based on project schedule
Secondary data	Shop drawings	Technical drawings and construction details	To verify material quantities and work volume requirements
Secondary data	Project schedule	Planned sequence and timing of work implementation	To determine the timing of material orders
Secondary data	Material price and cost records	Ordering cost, holding cost, and material procurement cost	To compare total cost among lot-sizing methods

Primary data were obtained directly from the project site through observation, interviews, and documentation. These data were used to describe the actual field conditions related to material control and delay factors. Secondary data were obtained from existing project documents, including BoQ, AHSP, S-Curve, shop drawings, and project schedules. These data were used as the main input for MRP calculations.

#### **Data Collection Methods**

The data collection methods used in this study consisted of field observation, documentation review, interview, and literature review.

First, field observation was conducted to identify actual conditions related to material availability, storage, usage, and delays during project implementation. This observation helped determine whether material procurement and distribution were consistent with the planned work schedule.

Second, documentation review was conducted by collecting and examining project documents, including BoQ, AHSP, S-Curve, shop drawings, and project schedules. These documents were used to

calculate material requirements and determine the timing of material procurement.

Third, interviews were conducted with relevant project personnel to obtain supporting information regarding material procurement procedures, delivery constraints, ordering practices, and causes of delay. The interviews helped clarify information that could not be fully obtained from project documents.

Fourth, literature review was conducted by reviewing journals, books, standards, and previous studies related to Material Requirements Planning, construction material control, lot-sizing methods, and project delay analysis. This review was used to strengthen the theoretical basis of the study.

#### **Research Procedure**

The research procedure was carried out through the following stages:

##### **1. Problem Identification**

The research began by identifying problems related to work delays and material control in the Solo Raya Tourism Polytechnic Project. The main issue observed was the

need for a more systematic method to plan material requirements and reduce inefficiency in material procurement.

## 2. Literature Review

Literature review was conducted to understand the concepts of Material Requirements Planning, lot-sizing techniques, material control, and construction project delay. This stage provided the theoretical basis for selecting MRP as the main analytical method.

## 3. Data Collection

Data were collected from field observations, interviews, documentation, and project documents. The required data included BoQ, AHSP, S-Curve, shop drawings, project schedule, material prices, ordering cost, holding cost, and field information related to material procurement.

## 4. Data Classification

The collected data were classified into primary and secondary data. Primary data were used to describe actual field conditions, while secondary data were used as quantitative inputs for material requirement calculations.

## 5. Determination of Material Requirements

Material requirements were determined based on BoQ, AHSP, shop drawings, and the project schedule. The S-Curve was used to distribute material needs according to the planned work period. At this stage, gross material requirements and net material requirements were identified.

## 6. MRP Calculation

The MRP calculation was conducted to determine the quantity and timing of material orders. The main inputs in the MRP calculation included gross requirements, scheduled receipts, available inventory, lead time, ordering cost, and holding cost.

## 7. Lot-Sizing Analysis

Three lot-sizing techniques were applied and compared, namely Lot-for-Lot (LFL), Part Period Balancing (PPB), and Least Unit

Cost (LUC). Each method was used to determine material ordering quantities and ordering periods. The purpose of this stage was to identify the most efficient material ordering strategy.

## 8. Total Cost Calculation

Total material procurement cost was calculated by summing ordering costs and holding costs for each lot-sizing method. The method with the lowest total cost was considered the most efficient alternative for material control.

## 9. Comparison and Evaluation

The results of each lot-sizing method were compared based on order frequency, order quantity, holding cost, ordering cost, and total cost. This comparison was used to evaluate which method provided better material control and cost efficiency.

## 10. Conclusion and Recommendation

The final stage was drawing conclusions based on the analysis results. Recommendations were formulated to improve material planning, material procurement scheduling, and project material control.

## Data Analysis Method

The data analysis was conducted using the Material Requirements Planning method with lot-sizing techniques. The analysis focused on determining material requirements, material ordering schedules, and total procurement costs. The basic stages of the analysis were as follows:

### a. Determining Gross Material Requirements

Gross material requirements were calculated based on work volume from the BoQ, material coefficients from AHSP, and technical details from shop drawings.

### b. Determining Net Material Requirements

Net material requirements were obtained by considering gross requirements, available inventory, and scheduled receipts. This calculation was used to determine the actual quantity of material that needed to be ordered.

**c. Determining Material Ordering Quantity and Timing**

Material ordering quantity and timing were determined using Lot-for-Lot, Part Period Balancing, and Least Unit Cost methods. These methods were applied to identify the most efficient ordering strategy for each selected material.

**d. Calculating Ordering Cost and Holding Cost**

Ordering cost was calculated based on the number of material orders made during the analysis period. Holding cost was calculated based on the amount of inventory stored and the duration of storage.

**e. Determining Total Material Procurement Cost**

Total cost was calculated by adding ordering cost and holding cost. The lot-sizing method with the lowest total cost was selected as the most efficient method for material procurement planning.

**f. Interpreting the Results**

The analysis results were interpreted to determine how the selected MRP method could help reduce material procurement inefficiency, improve material availability, and support better control of project delays.

**RESULTS AND DISCUSSION**

Statistical Description of Data

Based on the data obtained—namely the Bill of Quantities (BoQ), S-Curve, and AHSP—to determine the net requirement for Ready-Mix Concrete and when that requirement must be available. This data processing was performed using Microsoft Excel.

1. Ordering Cost

Based on the interviews conducted, the ordering cost includes transportation costs, administrative costs, and loading and unloading costs. The value of these costs was obtained based on an evaluation of various sources

Table 2. Order Costs for Each Material

No	Concrete Quality	Unit	Vol	Slump	PT. Merak Jaya Beton	
					PRICE	TOTAL
1	Concrete Grade f'c 25	M3	2,539.40	10+-2	785,000.00	553,082,347.50
2	Concrete Grade f'c 30	M3	662.46	10+-2	830,000.00	549,842,140.67
3	Concrete Grade f'c 35	M3	704.56	10+-2	860,000.00	605,924,610.00
4	Concrete GradeK-100	M3	704.56	10+-2		

(Source: Personal Data Analysis, 2024)

**Holding Costs**

Holding costs consist of warehouse construction, maintenance costs, facility costs, reporting, security, and so on. The value of these costs is determined based on an evaluation of various sources.

**Netting**

Netting is a method for calculating net requirements, which is essentially the difference between gross requirements and inventory status (i.e., items currently in stock and those on order). The inputs required to determine net requirements are the quantities of demand to be met during each planning

period. Current inventory status, which consists of inventory at the time of scheduled receipt.

1. Determining Requirements for Each Material

Material requirements are derived from the structural work volume data in the Bill of Quantities (BoQ). This process aims to determine the exact quantity of materials needed to complete the project in accordance with the established design. Accuracy in material determination will significantly impact cost efficiency and project execution time.

2. Master Item

An item is material requirement data for a specific period derived from the Bill of Quantities (BoQ), the

curve, and the Annual Hourly Rate Schedule (AHRS).

### Lot Sizing (Order Quantity)

Lot sizing is the process of calculating the optimal order quantity for a material based on the net requirements resulting from the netting calculation. The lot-sizing process is closely related to determining the quantity of material that must be ordered or procured. The lot-sizing process itself is crucial in material requirements planning; therefore, the use and selection of the appropriate method significantly influence the effectiveness of the material requirements plan.

To determine the order size (lot sizing) of materials in this study, the Lot-for-Lot (LFL), Period Balancing (PPB), and Least Unit Cost (LUC) methods were used. The determination of the order size was based on data obtained from the field, namely the Bill of Materials (BOM), S-Curve, and Annual Hiring Schedule Plan (AHSP), as well as data collected from interviews, specifically ordering costs and storage costs.

The Bill of Quantities (BoQ) data serves as an indicator of the scope of the work to be performed; the S-curve data indicates the timing of when materials will be needed; and the AHSP data serves as a reference for the quantity of materials required for a specific task.

### Lot Sizing Calculations

To meet material requirements for construction projects, materials are ordered from suppliers in lot sizes (based on demand). There are three methods used to determine lot sizes: Lot-by-Lot, Part Period Balancing, and Least Unit Cost.

- Information
  - • Lead Time : Lead Time (Weeks)
  - • Period : Period (Weeks)
  - • GR : Gross Requirement
  - • NR : Net Requirement
  - • TO : Total Order (Times)
  - • POH : Projected On Hand
  - • PO RECP : Planned Order Receipt
  - • PO REL : Planned Order Release
  - • Total Inventory Cost = POH × Inventory Cost
  - • Total Ordering Cost = Total TO × Ordering Cost
  - • Total Cost = Total Ordering Cost + Total Inventory Cost

#### 4.5.1 Metode Lot For Lot (LFL)

This is the simplest method among the existing lot sizing techniques. In this method, we order only the amount of material needed. The result of this method is a minimum or zero holding cost, but it incurs the maximum ordering cost.

Table 3. Message Costs

NO	Mutu Beton	Sat	Vol	Slump	PT. Merak Jaya Beton	
					Price	Total
1	Concrete Grade f'c 25	M3	2,539.40	10+-2	870,000.00	553,082,347.50
2	Concrete Grade f'c 30	M3	662.46	10+-2	830,000.00	549,842,140.67
3	Concrete Grade f'c 35	M3	704.56	10+-2	860,000.00	605,924,610.00
4	Concrete GradeK-100	M3	704.56	10+-2		

(Source: Personal Data Processing, 2024)

For material orders with a lead time of one week, the material requirements will be as shown in the table below:

Table 4. Ready-Mix Concrete Batch-by-Batch Data

**LFL**

periode	5	10	11	12	13	14	15	16	TOTAL
GR/NR		192.90	457.76	373.75	330.10	393.77	384.64	342.70	2475.62
TO		4	5	5	5	5	5	5	34
POH		0	0	0	0	0	0	0	0.00
PO RECP		192.90	457.76	373.75	330.10	393.77	384.64	342.70	2475.62
PO REL		457.76	373.75	330.10	393.77	384.64	342.70		2282.72
<b>Ordering Cost</b>			Rp870,000.00						
<b>Inventory Cost</b>			Rp500.00						
<b>Total Ordering</b>			Rp29,580,000.00						
<b>Total Inventory</b>			Rp0.00						
<b>Total Cost</b>			Rp29,580,000.00						

(Source: Personal Data Analysis, 2024)

**Part Period Balancing (PPB) Method**

The Part Period Balancing method is a method used to dynamically balance ordering costs with holding costs. This method uses the Economic Part Period (EPP) approach to determine the quantity or material requirements for each period. The Accumulative Part Period value that most closely approximates the EPP value serves as the basis for determining the lot size of each material, thereby minimizing inventory costs.

Table 5. Message Costs

NO	Mutu Beton	Sat	Vol	Slump	PT. Merak Jaya Beton	
					Price	Total
1	Concrete Grade f'c 25	M3	2,539.40	10+-2	870,000.00	553,082,347.50
2	Concrete Grade f'c 30	M3	662.46	10+-2	830,000.00	549,842,140.67
3	Concrete Grade f'c 35	M3	704.56	10+-2	860,000.00	605,924,610.00
4	Concrete GradeK-100	M3	704.56	10+-2		

(Source: Personal Data Processing, 2024)

The following is the calculation of the EPP value  
 EPP Value = (Ordering Cost) / (Holding Cost)

Accumulative Part Period = Cumulative Sum of  
 Part Periods

Notes:

REQ = Requirement

Assuming the ordering cost is Rp.870,000.00 and  
 the holding cost is Rp.500

Period Carried = Holding Period

Part Period = Holding Cost for a Given Period

$EPP = Rp.870,000.00 / 500 = 1,740$

Table 6. Message Costs

PERIOD	REQ	PERIOD CARRIED	PART PERIOD	ACUMULATIVE PART PERIOD
10	192.90	0	0	0
11	457.76	1	457.76	457.76
12	373.75	2	747.5	1205.26
13	330.1	0	0	0
14	393.77	1	393.77	393.77
15	384.64	2	769.28	1163.05
16	342.70	0	0	0

Table 7. Ready-Mix Concrete

periode	9	10	11	12	13	14	15	16	TOTAL
GR		192.90	457.76	373.75	330.10	393.77	384.64	342.70	2475.62
TO		18	0	0	24	0	0	0	42.00
POH		831.51	373.75	0	1121.11	727	342.70	0	3396.41
NR		-192.90	374	0	-330.10	393.77	384.64	0	629.16
PO RECP		1024.41			1451.21				2475.62
PO REL	1024.41			1451.21					2475.62

Ordering Cost		Rp870,000.00
Inventory Cost		Rp500.00
Total Ordering		Rp36,540,000.00
Total Inventory		Rp1,698,205.00
<b>Total Cost</b>		<b>Rp38,238,205.00</b>

(Source: Personal Data Analysis, 2024)

### Least Unit Cost (LUC) Method

This approach uses the concept of ordering at the lowest unit cost, where the order quantity or ordering interval may vary. The ordering decision is based on the lowest unit cost, which is equal to the holding cost per unit

Notes:

- REQ = Requirement
- Period Carried = Holding Period
- Carrying Cost LUC = LUC Holding Cost (Holding Cost x REQ x Period Carried)
- Total Cost = Total Cost (LUC Holding Cost + Ordering Cost)
- Cumulative Holding Cost = Cumulative Total for the Period (Total Cost / REQ)

Table 8. Message Costs

NO	Mutu Beton	Sat	Vol	Slump	PT. Merak Jaya Beton	
					NFA Price	Total
1	Beton Mutu f'c 25	M3	2,539.40	10+-2	785,000.00	553,082,347.50
2	Beton Mutu f'c 30	M3	662.46	10+-2	830,000.00	549,842,140.67
3	Beton Mutu f'c 35	M3	704.56	10+-2	860,000.00	605,924,610.00
4	Beton Mutu K-100	M3	704.56	10+-2		

(Source: Personal Data Processing, 2024)

Table 9. Message Costs

PERIOD E	REQ	PERIOD CARRIER	ORDERING COST	CARRYING COST LUC	TOTAL COST	CUMULATIVE CARRYING COST
10	192.90	0	Rp870,000.00	Rp0.00	Rp870,000.00	Rp4,510.11
11	457.76	1	Rp870,000.00	Rp398,251,200.00	Rp399,121,200.00	Rp1,900.56
12	373.75	2	Rp870,000.00	Rp650,325,000.00	Rp651,195,000.00	Rp2,327.76
13	330.1	3	Rp870,000.00	Rp861,561,000.00	Rp862,431,000.00	Rp2,635.56
14	393.77	0	Rp870,000.00	Rp0.00	Rp870,000.00	Rp2,209.41
15	384.64	1	Rp870,000.00	Rp334,636,800.00	Rp335,506,800.00	Rp2,261.86
16	342.7	2	Rp870,000.00	Rp596,298,000.00	Rp597,168,000.00	Rp2,538.66

Table 10. Least Unit Cost

periode	9	10	11	12	13	14	15	16	TOTAL
GR		192.90	457.76	373.75	330.10	393.77	384.64	342.70	2475.62
TO		36			0	27		0	63.00
POH		1161.61	703.85	330.10	0	727.34	342.70	0	3265.60
NR		-192.90	703.85	330.10	0	-393.77	342.70	0.00	789.98
PO RECP		1354.51				1121.11			2475.62
PO REL	1354.51				1121.11				2475.62
Ordering Cost			Rp870,000.00						
Inventory Cost			Rp500.00						
Total Ordering			Rp54,810,000.00						
Total Inventory			Rp1,632,800.00						
<b>Total Cost</b>			<b>Rp56,442,800.00</b>						

(Source: Personal Data Processing, 2024)

### Total Cost

The total cost is calculated by summing all costs incurred in connection with material procurement, namely ordering costs and holding costs. Based on the processed data—specifically Lot-for-Lot (LFL), Periodic Part Balancing (PPB), and Least Unit Cost (LUC)—the total cost is as follows:

Table 11. Total Costs by Lot

ORDERING COST	Inventory Cost	Total
Rp29,580,000.00	Rp0.00	Rp29,580,000.00

(Source: Personal Data Analysis, 2024)

Table 12. Total Costs for Part Period Balancing

ORDERING COST	Inventory Cost	Total
Rp36,540,000.00	Rp1,698,205.00	Rp38,238,205.00

(Source: Personal Data Analysis, 2024)

Table 4.10 Total Least Unit Cost

ORDERING COST	Inventory Cost	Total
Rp54,810,000.00	Rp1,632,800.00	Rp56,442,800.00

(Source: Personal Data Analysis, 2024)

### CONCLUSION

Based on the results of the analysis and discussion, this study concludes that the Material Requirements Planning (MRP) method can be used to improve material procurement planning for ready-mix concrete in the Solo Raya Tourism Polytechnic Lecture Hall Project. The application of MRP helps determine material requirements, ordering schedules, and procurement quantities more systematically according to the project work schedule.

The comparison of the three lot-sizing methods shows that the Lot-for-Lot (LFL) method provides the lowest operational cost. The operational cost obtained using the Lot-for-Lot method is Rp29,580,000.00, while the Part Period Balancing (PPB) method results in Rp38,238,205.00 and the Least Unit Cost (LUC) method results in Rp56,442,800.00. Therefore, the Lot-for-Lot method

is the most efficient alternative for ready-mix concrete procurement because it produces the lowest total operational cost among the three methods analyzed.

The MRP analysis also shows that material planning can reduce the required volume of ready-mix concrete Fc'25 from 3,475.50 m<sup>3</sup> to 3,375.34 m<sup>3</sup>. This indicates that better material planning can reduce excess material procurement and improve material control during project implementation. Therefore, the use of the MRP method with the Lot-for-Lot technique is recommended as an alternative approach for controlling ready-mix concrete requirements, minimizing unnecessary inventory, and improving the efficiency of material procurement in construction projects.

### 6. RECOMMENDATIONS

1. When applying the MRP (Material Requirements Planning) method in construction projects, it is important to select a lot sizing technique that aligns with the project's specific conditions so that the resulting values match the calculated requirements.
2. Lot Sizing techniques using the Least Unit Cost, Part Period Balancing, and Lot-for-Lot methods must be based on precise calculations to determine the most appropriate and economical method, thereby reducing project costs.
3. The implementation method must be planned as effectively as possible to avoid delays that could result in shortages or excesses in material orders.
4. AHP is one of the methods that can be used for decision-making, allowing us to create something.
5. AHP is one of the methods that can be used for decision-making, allowing us to transform the unmeasurable into the measurable, the subjective into the objective, and the qualitative into the quantitative.

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