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BATCHING PLANT OPTIMIZATION IN GEMPOL – PASURUAN – PROBOLINGGO ROAD AND BRIDGE PRESERVATION PROJECT

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ABSTRACT

The Gempol – Pasuruan – Probolinggo Road and Bridge Preservation Project handles roads along 5 scopes of work, namely major rehabilitation, reconstruction, bridge rehabilitation, bridge periodicals and bridge replacement. Work that requires ready mix concrete is in the scope of major rehabilitation and bridge replacement. Making ready mix concrete requires heavy equipment such as batching plants and mixer trucks. In this case, optimization is carried out to minimize the cost of providing ready mix concrete. This optimization was carried out on STA KM Sby 96+600 to KM Sby 98+390 and KM Sby 102+300 to KM Sby 103+700 and Kademangan Bridge III and IV. The purpose of this optimization is to determine the number of ready mix concrete needs, the optimal number and batching plants, and the selection of the best ready mix concrete provider for this project. The data needed for this thesis work is the volume of work, shop drawings, project work schedules, and heavy equipment specifications. The transportation method is used to optimize the batching plant. The optimization result of the distribution of ready mix concrete is needed for ready mix at location 1 is 2,915 m^3 from batching plant 1 (PT. Waskita Beton Precast); from batching plant 3 (PT. Merak Jaya Beton, Wonorejo) is 1,210 m^3; from batching plant 4 (PT. Merak Jaya Beton, Porong) is 689 m^3; at location 2 is 2,429 m^3 from batching plant 2 (PT. Merak Jaya Beton, Paiton); from batching plant 3 is 872 m^3; from batching plant 4 is 605 m^3; at location 3 is 61 m^3 from batching plant 1; from batching plant 3 is 7 m^3; and at location 4 is 51 m^3 of batching plant 2; from batching plant 3 is 8 m^3. The optimal distribution cost of concrete distribution is Rp20,889,522,557.77,-.

Keywords : batching plant, optimization, preservation road and bridge

1. INTRODUCTION

A road must be maintained continuously so that its quality is maintained so that it can provide maximum service to road users. Roads are connecting regions with one another whose benefits are very large for human life, one of which is in the economic field. Thus, the rapid economic growth in the country, especially in East Java, resulted in a higher volume of traffic both the flow of goods, especially in the main sections of the northern route of East Java.

The Gempol – Pasuruan – Probolinggo Road and Bridge Preservation Package is a work package carried out at the National Road Implementation Work Unit Region III of East Java Province through the Commitment Making Officer 3.5 of East Java Province, whose implementation is currently financed with State Budget funds for Fiscal Year 2022. This project aims to improve road performance and pavement structure and maintain the steady condition of road sections. The implementation of this work is one form of the vision and mission of the Directorate General of Highways, namely realizing safe roads and improving excellent service for road users.

A good road structure is a very important part of the condition of the infrastructure. The rigid pavement type is a type of road pavement that can be used on the northern ring road section of Probolinggo, because it is strong and more durable than bending pavement. This is because the road in the northern ring of Prbobolinggo has a high volume of vehicles.

In Gempol – Pasuruan – Probolinggo Road and Bridge Preservation, there are 4 scopes of activities, namely Major Rehabilitation, Reconstruction, Bridge Rehabilitation, Bridge Periodicals and Bridge Replacement. In major rehabilitation, rigid pavement will be carried out by PT. Restu Mulya Cipta Mandiri located on the North Ring Road of Probolinggo KM Sby 96+600 to KM Sby 98+390 and KM Sby 102+300 to KM Sby 103+700. There is also a bridge change in the Gempol – Pasuruan – Probolinggo Road Preservation Package and Bridge project which requires ready mix concrete in its implementation. This bridge change is located on the northern ring line of Probolinggo, precisely Kademangan III Bridge and Kademangan IV Bridge.

In the work on rigid pavement and bridge replacement in the Gempol - Pasuruan - Probolinggo Road and Bridge Preservation package project, initially received a ready mix concrete supply from 1 (one) batching plant, namely from PT. Merak Jaya Beton, Grati due to its location closest to the project site. However, in the project implementation process, there were problems in the batching plant of PT. Merak Jaya Beton, Grati. So that the ready mix concrete supply switches to 4 (four) batching plants, namely PT. Merak Jaya Beton, Paiton; PT. Merak Jaya Beton, Wonorejo; PT. Merak Jaya Beton, Porong; and PT. Waskita Beton Precast, Tbk Muneng Probolinggo.

Due to the sudden change in the supply batching plant in the middle of the project implementation, the ready mix distribution process became chaotic and the delay in carrying out rigid pavement structure work and bridge replacement. So it can be said that this project has problems in the number, capacity and location of batching plants available. One way to overcome this is to adjust the volume of ready mix concrete distributed from each batching plant. The required volume of ready mix concrete can be calculated using transportation methods to optimize the cost of distributing ready mix concrete materials from various batching plant locations to project sites. So that this can reduce transportation costs and distribution time of ready mix concrete materials.

In connection with the above background, the author intends to take the problem as a topic of discussion with the title "Batching Plant Optimization in Gempol – Pasuruan – Probolinggo Road and Bridge Preservation Project". With the hope that the author can provide alternatives and selection of the optimal and best batching plant layout.

2. METHOD

2.1. Heavy Equipment Produktivity

The calculation of heavy equipment productivity used refers to PUPR Minister Regulation No. 1 of 2022, as follows:

1) Batching Plant

Batching plant is a tool that functions to mix or produce ready-mixed concrete on a large scale. Batching plants are used in large-scale concrete production so that quality, performance and continuity of production can be maintained properly according to established standards.

The productivity of the batching plant is calculated using Formula 1.

$$Q = \frac{V \times F_a \times 60}{1000 \times T_s} m^3 \qquad (1)$$

Information: V = production capacity; Litre; Fa = tool efficiency factor; T_1 = length of time to charge ; minute; T_2 = length of stirring time ; minute; T_3 = length of time pouring; minute; T_4 = long waiting time etc ; minute; T_s = cycle time, $Ts = \sum_{n-1}^{n} T_n$; minute; 60 = conversion of hours to minutes; 1000 = conversion from kilometers to meters.

2) Truck Mixer

Truck mixer is a special truck vehicle equipped with a concrete mixer that functions to stir or mix concrete mixture (functions the same as a concrete mixer).

Truck mixer productivity is calculated using Formula 2.

$$Q = \frac{V \times F_a \times 60}{T_s} m^3 \qquad (2)$$

Information: V = drum capacity; (7 m³); m³; F_a = tool efficiency factor; v_1 = average speed of charge, (15 – 25); km/h; v_2 = average speed of blanks, (25 – 35); km/h; T_1 = length of charge time = (V/Q) x 60; minute; T_2 = length of return time = (L/v_1) x 60; minute; T_3 = length of return time = (L/v_2) x 60; minute; T_4 = length of spilling time etc ; (2 minutes) ; minute; 60 = conversion of hours to minutes; T_s = cycle time, $T_s = \sum_{n-1}^{n} T_n$; minute.

2.2. Heavy Equipment Needs

The need for heavy equipment on construction projects must be calculated so that the project implementation time is not late. To determine the number of equipments used in the project must know the productivity of each equipment to be used. Equipment requirements are calculated using Formula 3.

$$quantity\ of\ equioment = \frac{V}{Q \times T}; unit \qquad (3)$$

Description: V = volume of work; m^3 ; Q = heavy equipment production capacity; m^3/h ; T = project duration ; hour.

2.3. Heavy Equipment Rental Cost

According to PUPR Ministerial Regulation No. 1 of 2022, heavy equipment rental costs (S) include defined costs (G) and operating costs as stated in Formula 4.

$$S = G + P \qquad (4)$$

Information: S = Heavy equipment rental fee (rupiah); G = Fixed cost (rupiah); and P = Operating costs (rupiah).

1) Fixed Cost of Equipment

The following are the fixed cost components of each unit of equipment:

a) Equipment Residual Value (C)

The residual value of the equipment can be taken at an average of 10% (ten percent) of the cost of the tool, depending on the characteristics (of the manufacturer) and the ease of maintenance of the tool as shown in Formula 5.

$$C = (3\% - 10\%) \times B \qquad (5)$$

Information: C = Equipment Residual Value (%); and B = Price of Equipment (rupiah).

b) Interest Rate, Installment Factor, and Capital Control Factor

The ecovery capital factor (RCF) (D) and cost of return on capital (E) can be calculated using Formulas 6 and 7.

$$D = \frac{(1\times(1+i)^{A})}{(1+i)^{A}-1} \quad (6)$$

Information: D = Capital Installment Factor; i = Interest Rate on Investment Loan (% per year); A = Economic Life of Equipment (year).

$$E = \frac{(B-C)\times D}{W} \quad (7)$$

Information: E = Cost of Return of Capital; B = Price of Equipment (rupiah); C = a) Equipment Residual Value (rupiah); D = Capital Installment Factor; W = Operation Hours per year (hour).

c) Insurance and Tax

The amount of insurance (Ins) and equipment ownership tax is generally taken on average per year of 0.1% for insurance and 0.1% for taxes, or a total of 0.2% of the cost of equipment, or 2% of the residual value of the equipment (if the residual value of the equipment = 10% of the cost of equipment) as shown in Formula 8.

$$F = \frac{0.002\times B}{W} \quad (8)$$

Information: F = Insurance and Tax Costs (rupiah); B = Price of Equipment (rupiah); W = Operation Hours per year (hour).

d) Total Fixed Cost

The formula for calculating the fixed total cost can be seen in Formula 9.

G = E + F (9)

Information: G = Fixed Cost (rupiah); E = Cost of Return of Capital (rupiah); dan F = Insurance and Tax Costs (rupiah).

2) Heavy Equipment Operating Cost

The following are the components of the operating costs of each unit of equipment:

a) Fuel (H)

The amount of fuel per hour used by the engine moves and depends on the amount of engine power capacity, usually measured in units of HP (Horse Power) and calculated by Formula 10.

$$H : (10.00 - 12.00)\% \times HP \times Ms \quad (10)$$

Information: H : the amount of fuel used in 1 (one) hour with units of liters / hour; HP : Horse Power, the power capacity of the propulsion engine; Ms : Price of diesel oil (rupiah/liter); 10% : for heavy equipment used lightly; 12% : for heavy equipment used by weight.

b) Lubricating Oil Cost (I)

The amount of lubricant (including the use of other oils and grease) used by the equipment concerned is calculated by Formula 11 and based on the engine power capacity.

$$I : (0.25 - 0.35)\% \times HP \times Mp \quad (11)$$

Information: I : the amount of lubricating oil used in 1 (one) hour with units of liters / hour; HP : Horse Power, the power capacity of the propulsion engine; Mp : price of lubricant oil (rupiah/liter); 0,25% : for heavy equipment used lightly; 0,35% : for heavy equipment used by weight.

c) Workshop Cost (J)

The amount of workshop cost per hour is calculated by Formula 12.

$$J : (2.2 - 2.8)\% \times B/W \quad (12)$$

Information: B : Price of Equipment; W : total of hours of equipment work in a year; 2,2% : for heavy equipment used lightly; 2,8% : for heavy equipment used by weight.

d) Maintenance and Repair Costs (K)

To calculate the cost of repairs including replacement of worn parts is used Formula 13.

$$K : (6.4 - 9)\% \times B/W \quad (13)$$

Information: B : Price of Equipment; W Total of hours the equipement works in one year; 6,4% : for heavy equipment used lightly; 9% : for heavy equipment used by weight.

e) Driver (L) and Driver's helper (M) Fee

Driver and helper operator or driver fee, calculated with Formula 14 and Formula 15.

L = 1 person/hour x U1 (14)

M = 1 person/hour x U2 (15)

f) Total Operating Cost

The formula for calculating total operating costs can be seen in Formula 16.

$$P : H + I + J + K + L + M \quad (16)$$

2.4. Transportation Methods

The method used to find the optimal Batching Plant is to use the Transportation Method. According to Parinduri (2020), the transportation method is a method used to organize the distribution from sources that provide the same product to places that need it optimally.

Supranto, M.A (2019) gives an example of a type of goods transported from several origin areas to several destination areas. Suppose m origin regions: A_1, A_2, ..., A_i, ..., A_m and n destinations: T_1, T_2, ..., T_i, ..., T_n. D_i A_i there are n goods to be transported (supply) as much as S_i and at the destination the goods are demanded as much as D_i (demand). X_{ij} = the amount of goods transported (in units) from A_i to T_j. C_{ij} = The cost of one unit of the goods from A_i to T_j. Thus to transport X_{ij} units requires a cost C_{ij}, X_{ij}. Total demand = Total supply.

Table 1 Demand from Destination and Supply from Origin

Source: Program Linear 2016

A \ T	T_1,	T_2	….	T_i	….	T_n	S
A_1	$c_{11})x_{11}$	$c_{12})x_{12}$		$c_{1i})x_{1i}$		$c_{1m})x_{1m}$	S_1
A_2	$c_{21})x_{21}$	$c_{22})x_{22}$		$c_{2i})x_{2i}$		$c_{2m})x_{2m}$	S_2
…							
A_i	$c_{i1})x_{i1}$	$c_{i2})x_{i2}$		$c_{ii})x_{ii}$		$c_{im})x_{im}$	S_i
….							
A_m	$c_{m1})x_{m1}$	$c_{m2})x_{m2}$		$c_{mi})x_{mi}$		$c_{mm})x_{mm}$	S_m
D	d_1	D_2		D_i		D_m	$\sum D_i=\sum S_i$

1) Vogel's Approximation Method (VAM)

   Step-by-step calculation:

   a) Calculate the difference between the two smallest costs of each row and column. The difference value is written next to it and is called the row/column penalty.

   b) Select the row or column with the largest penalty value, Then put opening and closing brackets In case there are two largest values of the same, select the row/column that can move the most items.

   c) From the column rows selected from (2), determine the number of goods that can be transported taking into account the restrictions that apply to the row and for the column and cel with the smallest cost Cel or box, where the row and column intersect.

   d) Delete rows and columns that have met the conditions before, meaning that the supply has run out or the demand has been fulfilled Repeat steps (1) through step (4) so that all allocations have been made.

2) North West Corner (NWC)

   Step-by-step calculation:

   a) Start from the top left corner (X_1), Allocate the maximum number of products by looking at the amount of supply and demand.

   b) If X is the last box selected, continue by allocating to X_1 (the box to the right of the box selected on the same row) if n has the remaining demand capacity.

   c) If not (the demand capacity in the selected box row has been met). then allocate it to X_1-1 (box below selected box) and so on so that all needs have been met.

3) Least Cost Methode (LCM)

The smallest cost method is generally better than the NWC method. This is because in this method considers things that exist in the transportation method, namely the cost of the cell. So that using this method can approach the optimal solution desired. The cell containing the highest value will automatically not be used, but if there are cells that have the same cost then the determination of the cell to be filled can be done freely Here is how to fill the base cell from the smallest cost method.

   a) Base cells are filled starting from the cell that has the smallest transport cost (C_2). The base cell is filled with number X, with the smallest number of supplies at source a, and requirement b, in the same row or column as that cell.

   b) Fills the cell with the second smallest transportation cost The base cell is of magnitude X, with the smallest number of supplies at the source of a_i and needs b_j.

   c) Subtract source a, and need b, by X,, the If a, becomes = 0 then row i is not taken into account anymore and if b;=0 then the corresponding column is no longer taken into account.

d) Repeat skip 1-3 but rows or columns that already contain 0 are no longer counted. And so on until all base cells are all filled.

4) Modified Distribution Method (MODI)

The MODI method is a way to find the optimal solution after calculating a feasible solution using the VAM, NWC and LCM methods This method is another alternative that can be used to solve transportation problems Johannes Supranto, M.A in his book also mentions ways to solve transportation problems, as follows:

a) For each table with a fissile first split, calculate the row value (U) and column values (V_1) with formulas:

$$C_{ij} = Ui + V_j \quad (2.17)$$

where is the row = 1, U_i=0.

C_{ij} = freight cost per unit of goods from A_i area, to the destination T_j ; i = 1, 2, …, m dan j = 1, 2, …, n.

b) Calculate Index of improvements $IP_{ij} = C_{ij} - U_i - V_j$ (2.18)

for all boxes not bases. If all 1_{ij} = 0, the solution is optimal. If not, proceed to the next step.

c) Draw a closed path or path (closed patch) from the box with the smallest negative repair index. This box enters the base.

d) Mark then alternately on the charges of the boxes that form the trajectory as in the stepping stone method.

e) Divide the variable coming from the box by the sign of the way whose value is the smallest (minimum). This box must be out of base and its value is reserved for variables from the box that has the largest positive repair index value (the box that enters the base).

f) Create a new table and then calculate the repair index values from all non-base boxes. If all values are zero or negative, the process is stopped because the solution is optimal and the amount of transportation costs is minimum.

3. RESULTS AND DISCUSSION

3.1. Volume of Ready Mix Concrete Requirements

The volume of rigid pavement and bridge work needs to be known to determine the volume of ready mix concrete requirements at the site. The volume of rigid pavement and bridge work can be seen in Table 1.

Table 2 Volume of Ready Mix Concrete Requirements on Site

Location	STA	Volume (m^3)
Location 1	KM 96+600 - KM 98+390	4,994
Location 2	KM 102+300 - KM 103+700	3,906
Location 3	KM 97+050	68.07
Location 4	KM 97+500	59.28

Source: Calculation result

3.2. Heavy Equipment Produktivity

1) Batching Plant

Productivity at batching plant 1 is known: V = 4500 lt ; Fa = 0.81 ; Ts = 10 minutes; 60 = conversion of hours to minutes; 1000 = conversion from kilometers to meters.

From the information above, the productivity of the batching plant is calculated using formula 1, and obtained 21.87 m^3 / hour.

2) Truck Mixer

The productivity of the mixer truck at batching plant 1 to location 1 is known V = 7 m³; Fa = 0.81 ; good condition; v_1 = 25 km/h ; moderate condition; v_2 = 30 km/h ; moderate condition; Qbp = 21.87 m³/h ; L = 8.1 km; distance from batching plant 1 to location 1; T_1 = (V / Qbp) x 60; minutes = (7/21.87) x 60 = 19.20 minutes; T_2 = (L/v_1) x 60 minutes = (8.1/25) x 60 = 19.44 minutes; T_3 = length of return time = (L/v_2) x 60 minutes = (8.1/30) x 60 = 16.2 minutes; T_4 = 15 minutes; Ts = 19.20+19.44+16.2+15 = 69.84 minutes.

From the information above, the mixer truck from batching plant 1 to location 1 is calculated using formula 2, and obtained 4.87 m^3 / hour.

3.3. Quantity of Truck Mixer

The need for truck mixer at location 1 is known: V = 4994.1 m^3 ; Qtm = 4.87 m^3/h ; productivity of mixer truck from batching palnt 1 to location 1; T = 952 hours ; duration of project work.

From the information above, the need for a mixer truck from location 1 is calculated using formula 3, and 2 units are obtained.

3.4. Heavy Equipment Rental Cost

The calculation of heavy equipment rental costs below uses an example of calculating the cost of renting a mixer truck at batching plant 1.

1) Fixed Cost

a) Known: Koef : 10%; B = Rp. 1,290,000,000. From this information, the remaining value of the tool is calculated by Formula 5 obtained C of Rp 129,000,000.

b) Known: A = 10 years; I : 8.40%; B = Rp. 1,290,000,000. From this information, the Capital

Installment Factor is calculated by Formula 6 obtained D of 0.152 and the Cost of Return on Capital is calculated by Formula 7 obtained E of Rp 88.079 / hour.

c) Known: B = Rp. 1,290,000,000 ; W = 2000 hours/year. From this information, the cost of Insurance and Tax is calculated based on Formula 8 obtained Rp1,290 / hour.

d) The total fixed cost of heavy equipment can be calculated by Formula 9 obtained G of Rp.89,369 / hour.

2) Operating Costs

a) Known: W = 2000 hours/year so it uses a fuel coefficient of 12%; HP = 285 HP; Ms = Rp. 11,000.00. From this information, the fuel cost is calculated based on Formula 10 obtained Rp 376,200.00 / hour.

b) Known: W = 2000 hours/year so it uses a lubricant coefficient of 0.35%; HP = 285 HP; Ms = Rp. 44,000.00. From this information, the cost of lubricating oil calculated based on Formula 11 obtained Rp 43,890.00 / hour.

c) Known: Koef : 2.8% because it is in severe condition; B = Rp. 1,290,000,000; W = 2000 hours/year. From this information, the workshop cost is calculated based on Formula 12 obtained Rp 18,060.00 / hour.

d) Known: Koef : 9% because it is in severe condition; B = Rp. 1,290,000,000; W = 2000 hours/year. From this information, the maintenance cost is calculated based on Formula 13 obtained Rp 58,050.00.

e) Operator Fee
Known: U1 = Rp. 35,000.00; U2 = Rp. 25,000.00. From this information, the operator's fee are calculated based on Formula 14 obtained Rp. 35,000.00 / hour and the operator's helper fee are calculated based on Formula 15 obtained Rp. 25,000.00 / hour.

f) Total Operating Costs
Total heavy equipment operating costs (P) calculated by formula 16 obtained Rp.556,200.00/hour.

3) Truck Mixer Rental Cost

Rental costs (S) are obtained from the addition of definite costs and operational costs according to Formula 4 obtained a result of Rp 645,569 / hour.

3.5. Process Optimization with Transportation Method

The optimization process below uses an example calculation on rigid pavement work. And before doing optimization it is necessary to determine decision variables, objective variables, source constraints and objective constraints, which are as follows:

1) Decision Variables

The decision variable is the amount of concrete volume (X_{ij}) to be distributed from the batching plant (i) to the project site (j) whose value can be filled during the optimization process according to the method used in the calculation, namely:

X_{11} = Volume of ready mix concrete of batching plant 1 to location 1

X_{12} = Volume of ready mix concrete of batching plant 1 to location 2

X_{21} = Volume of ready mix concrete of batching plant 2 to location 1

X_{22} = Volume of ready mix concrete of batching plant 2 to location 2

X_{31} = Volume of ready mix concrete of batching plant 3 to location 1

X_{32} = Volume of ready mix concrete of batching plant 3 to location 2

X_{41} = Volume of ready mix concrete of batching plant 4 to location 1

X_{42} = Volume of ready mix concrete of batching plant 4 to location 2

2) Objective Variables

The destination variable is the cost of distributing ready mix concrete which consists of the unit price of ready mix concrete/m^3 and the rental cost of truck mixer/hour, that is:

C_{11} = Rp1,203,476.62
C_{12} = Rp1,277,787.25
C_{21} = Rp2,391,700.62
C_{22} = Rp1,913,544.64
C_{31} = Rp3,177,100.03
C_{32} = Rp2,857,931.36
C_{41} = Rp4,413,149.97
C_{42} = Rp4,002,939.14

3) Source Constraints

The source constraint depends on the productivity of each batching plant. Because each batching plant does not only serve one project, each btaching plant is taken 14% percent of the total productivity, that is:

$X_{11}+X_{12}$ = 2,915 m^3
$X_{21}+X_{22}$ = 2,429 m^3
$X_{31}+X_{32}$ = 2,082 m^3

$X_{41}+X_{42}$ = 2,242 m^3

4) Objective Constraints

The objective constraint is the number of ready mix concrete needs at each project site, namely:

$X_{11}+X_{21}+X_{31}+X_{41}$= 4,994.10$m^3$

$X_{12}+X_{22}+X_{32}+X_{42}$= 3,906 m^3

5) Analysis Results

With the knowledge of the variables above, optimization is then carried out to find feasible solutions using 3 methods, that is:

a) NWC
From the optimization process using the NWC method, a feasible solution worth IDR 21,001,673,470.94 was obtained.

b) LCM
From the optimization process using the LCM method, a feasible solution worth IDR 23,270,229,892.84 was obtained,

c) From the optimization process using the VAM method, a feasible solution worth Rp 20,901,507,749.04 was obtained.

In the problem of distributing ready mix concrete, the optimal solution value is calculated using the MODI method. The method to be taken to calculate optimization is the VAM method because it has the smallest feasible solution value.

The optimization process uses the MODI method by calculating the values of rows and columns in the base cell then continued by calculating the value of the improvement index in non-base cells. The Repair Index (IP) in non-base cells cannot have negative values.

The results of optimization using the MODI method are worth Rp 20,750,226,921.96.

4. CONCLUSION

The results of the discussion on Batching Plant Optimization of Gempol – Pasuruan – Probolinggo Road and Bridge Preservation Project concluded that the optimum ready mix concrete distribution process from the batching plant was Rp 20,750,226,921.96.

From the calculation above, the optimal cost of distributing ready mix concrete is Rp 20,750,226,921.96,- by distributing 2,915 m^3 of ready mix concrete from BP 1 (PT. Waskita Beton Precast) to location 1 with total transportation costs of Rp 3,507,934,096; as much as 2,429 m^3 from BP 2 (PT. Merak Jaya Beton, Paiton) to location 2 with a total transportation cost of Rp 4,648,053,502; as much as 1,210 m^3 from BP3 (PT. Merak Jaya Beton, Wonorejo) to location 1 with total transportation costs Rp 3,844,621,458; as much as 872 m^3 from BP 3 to location 2 with a total transportation cost of Rp2,491,887,510; as much as 689 m^3 from BP 4 (PT. Merak Jaya Beton, Porong) to location 1 with a total transportation cost of RP 3,835,744,022; and as much as 605 m^3 from BP 4 to location 2 with a total transportation cost of Rp 2,421,986,334.

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