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CASE STUDY: USE OF DRY MIX CONCRETE AS A SUBSTITUTE MATERIAL FOR READY MIX CONCRETE ON DEVELOPMENT PROJECTS OCC BUILDING–JABODEBEK LRT DEPOT

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Abstrak:
The construction of the OCC Building is the main target of all buildings that must be completed in the Jabodebek LRT Depot area located in Jatimulya, East Bekasi. In writing this thesis, only discusses the stages of casting concrete structures on the foundation. The condition of a very large area with various other construction works around it and very limited execution time requires contractors to be creative and find solutions about the most effective and efficient methods. The construction of the OCC Building uses concrete construction with quality K-250 (fc'20.75 MPa) and K-350 (fc'29.05 MPa). The problem occurs is because this area is between the side of the Jakarta-Cikampek toll road and the edge of Kalimalang which also has the Kalimalang highway which both are roads that have a very dense traffic flow, so alternative foundry work methods are needed. In this project, 2 casting methods are used, namely by using Ready Mix Concrete and Dry Mix Concrete. Meanwhile, the writing of this case studies only reviews aspects of quality, time, and cost if the casting method only uses Dry Mix concrete as a substitute material for Ready Mix concrete. If only viewed from the cost of casting, the use of dry mix concrete requires higher costs than ready mix, but when viewed as a whole from all aspects of work costs, the use of dry mix can increase time efficiency in project completion, so that it can affect cost efficiency which at the end of the project can be completed faster at a lower cost. Meanwhile, from the results of data processing with the Analitycal Hierarcy Process (AHP) method, Dry Mix concrete is more chosen by respondents, it can be concluded that Dry Mix concrete is better than Ready Mix concrete for use in the OCC Building-Depo LRT Jabodetabek construction project.

Keywords: AHP; Cost; Dry Mix; Method Of Implementation; Ready Mix; Time.

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INTRODUCTION

The Jabodebek Integrated Cross Rail Project or abbreviated as Jabodebek LRT is a rapid transit system with light rail / Light Rail Transit (LRT) that is being built in Jakarta and integrated with the Jakarta, Bogor, Depok, and Bekasi areas (Bintari & Pandiangan, 2016). Jabodebek LRT operations will be operated by PT. Kereta Api Indonesia (KAI) Operation Area I Jakarta (Farda & Lubis, 2018). The LRT engine control room is centered entirely in the Operation Control Center (OCC) located in the Operation Control Center Building.

Operation Control Center Building (OCC Building) is one of the supporting buildings for operational facilities in the Jati Mulya-East Bekasi Depot Area (Kuntjoro & Aji, 2018). This building structure is built with concrete construction, where there are 2 types of instant concrete used, Amran (2022) namely: (a) Ready Mix instant concrete for casting structures. (b) Dry mix instant concrete for non-structural casting.

The project area is located between the side of the Jakarta-Cikampek toll road and the edge of Kalimalang, which also has the Kalimalang highway. Given the short period of work and the very dense traffic flow on both roads which resulted in the smooth delivery of Ready Mix concrete material from the batching plant to the location (Zekavat et al., 2014);(Nemati & Uhlmeyer, 2021). So that large volume casting work is very dependent on the situation, an alternative Construction Value Engineering is needed in the casting method using Dry Mix concrete in small volumes and large volumes so that the work can be completed in a more effective and efficient period (Birgitta et al., 2020);(Soekarno & Hari Murti, 2022). This Construction Value Engineering needs to be done considering the actual condition of the concrete compressive strength test results in Dry Mix relatively faster than Ready Mix against the quality target design (Tangnga, 2022). Where dry mix usually reaches 100% of the target quality design at the age of concrete on the 3rd or 7th day.

The purpose of this study is to find out the best alternative by determining the ratio between dry mix and ready mix concrete in terms of quality, time, and cost. The benefits of this research are: (a) Demonstrate the ability to innovate in the field of construction. (b) Save time and cost. (c) Reduce environmental impact.

There is also a similar study conducted by Raharja (2013), In his research entitled "The Effect of Using Rice Husk Ash as a Partial Cement Replacement Material on the Compressive Strength and Modulus of Elasticity of High Performance Concrete" in his research resulted in that the use of rice husk ash as a substitute for some cement resulted in an increase in compressive strength value. The largest increase occurred in the 10% variation of rice husk ash, which was 18.15% (from 85.55 MPa to 101.07 MPa). The effect of rice husk ash on the modulus of elasticity is directly proportional to its compressive strength.

METHOD

Special Value Engineering is applied to the upper structure work of the OCC Building building using the method or technique of the Value Engineering Work Plan. The research flow diagram related to the application of the Value Engineering method can be seen in the following figure:

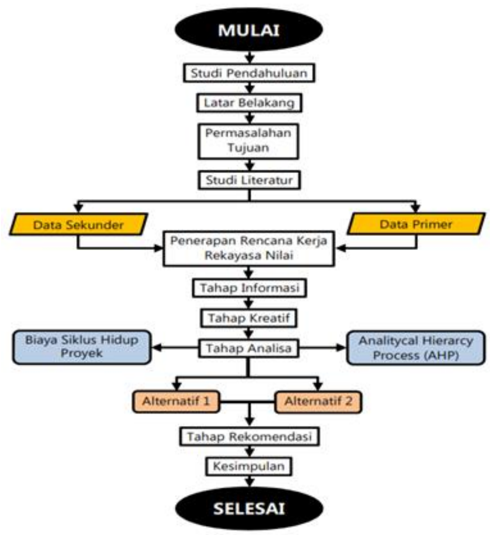

Figure 1 Research Flow Chart

Data collection techniques in writing this Thesis are obtained through (a) Observation. (b) Interview. (c) Making field notes.

Analytical Hierarcy Process (AHP) Method

The Analytical Hierarchy Process (AHP) method is not an Expert System but is included in one of the Decision Support Systems (DSS) which is an interactive information system for information providers, modeling, and data manipulation (Sarabi & Darestani, 2021). This method is one of the methods used in decision-making systems that take into account factors of experience, preferences, intuition, and perception and is perfect for combining personal judgments logically (Eling et al., 2014). Furthermore, the personal assessment is processed with AHP so that it changes form into a number that is easy to calculate. In using the AHP method, several principles must be understood Utomo (2019), namely (a) Creating a Hierarchy. (b) Assessment of Criteria and Alternatives.

Table 1
Saaty Comparison Scale

Intensity of Importance	Information
1	Every element is equally important
3	One element is slightly more important than the other
5	One element is more important

	than another
7	One element is more important than another
9	One element is essential over the other
2,4,6,8	Values between two adjacent counterweight values
Opposite	If activity I get one number compared to activity j, then j has the inverse value compared to i.

After getting all the data needed, then a Value Engineering analysis is carried out to produce cost savings. Furthermore, the calculation of the data obtained into the AHP method is carried out, so that definite results are obtained in the form of Ranking which is used to help the object in breaking the problem (Franci et al., 2016).

RESULTS AND DISCUSSION

A. Foundry Work Segment

Table 2
Casting Segment Volume

OCC BUILDING-DEPO LRT JABODEBEK									
No	**Type of Construction**	**Concrete Quality**	**Lt.D Vol/Seg**	**Lt.1 Vol/Seg**	**Lt.2 Vol/Seg**	**Lt.3 Vol/Seg**	**Lt.4 Vol/Seg**	**LR Vol/Seg**	**UR Vol/Seg**
1	Column Structure	K-350		22.76	18.66	25.04	23.13	14.70	
2	Structure Beam	K-350		3.13	17.94	26.60	26.36	19.49	22.01
3	Seperator Beam	K-350		0.59	0.59	0.59	1.17	1.56	
4	Plate	K-350	20.29	3.60	17.86	28.43	28.40	23.05	18.14
5	Ladder	K-350	2.64	7.95	6.15	5.17	3.99		
6	Terrace Embankment, Parapet, Wall &; Dog House	K-350				2.97	5.13	7.54	7,09
7	Planter Box	K-350				2.39	2.44		
8	AC Outdoor Stand	K-350				0.75	0.87		
9	Pedestal GRC,CW & Hoist	K-350						2.88	
10	Close Dog House	K-350						1.70	
11	Floor Thickening 75 mm	K-250				6.18	8.23	14.03	8.49

Casting criteria in this work are divided into 3 types of foundries, namely:

1. **Type I (points 1, 2, and 4)**

   The volume of concrete needs is quite high in each casting segment and must be prepared, calculated, and carried out continuously according to land readiness and it is ensured that there is no time lag until the casting is completed.

2. **Type II (points 5, 6, 11)**

   The volume of concrete is adjusted on the casting segment, carried out in stages;

3. **Type III (points 3, 7, 8, 9, 10):**

   Very little concrete volume in the casting segment, it can be carried out gradually and related to previous work.

B. Casting Duration

Based on routine observations for the results of the Concrete Compressive Strength Test on test specimens made in the Concrete Mix Experiment, the casting duration is planned by referring to the following: (a) Dry Mix K Concrete-350 (fc'29.05 MPa), Achieve Quality ≥60% or K-210 (fc'17.43 MPa), at the age of concrete 3 days. (b) K Ready Mix Concrete-350 (fc'29.05 MPa), Achieve Quality ≥60% or K-210 (fc'17.43 MPa), at the age of concrete 7 days.

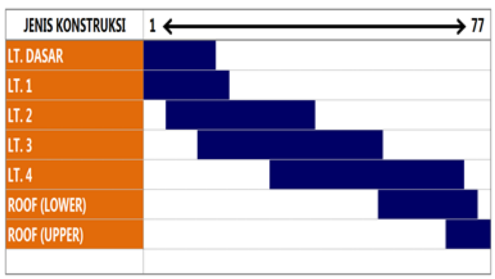

Figure 1 Dry Mix Casting Duration

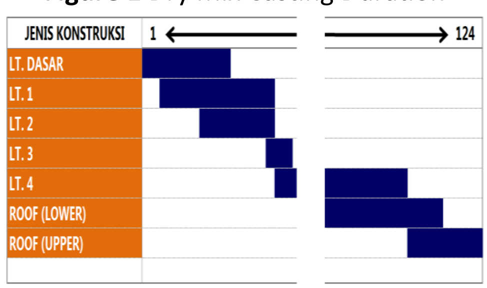

Figure 2 Ready Mix Casting Duration

A comparison of the time required for all casting work on the use of each type of concrete Ramadhani (2021) is (a) the Total duration of Dry Mix is 77 days. (b) The total duration of Ready Mix is 124 days. (c) Time difference of 47 days. (d) Percentage difference in duration -37.9 %.

It is known that the duration of casting with Dry Mix is 47 days faster or 37.9% faster than with Ready Mix. The ratio of the duration of the implementation is Dry Mix 1: 1.61 Ready Mix

C. Casting Cost

Table 3
Concrete Work Cost Budget Plan

NO	Type of Construction	Volume	Dry Mix Price (Rp) Sum	Ready Mix Price (Rp) Sum
1	Column Structure	566.96 m^3	5,728,696,013	5,121,973,336
2	Structure Beam	698.47 m^3	5,716,126,999	4,968,671,116
3	Separator Beam	4.50 m^3	36,827,024	32,011,425
4	Plat	997.70 m^3	7,444,945,276	6,377,273,458
5	Ladder	59.50 m^3	371,474,602	296,458,006
6	Terrace Embankment, Parapet, Wall &; Dog House	52.44 m^3	350,887,478	294,769,697
7	Planter Box	7.26 m^3	48,578,244	40,809,077
8	Outdoor Ac Stand	3.23 m^3	21,612,635	18,156,105
9	Pedestal GRC, CW & Hoist	5.76 m^3	38,541,416	32,377,450
10	Close Dog House	1.70 m^3	11,375,071	9,555,845
11	Floor Thickening 75 mm	132.57 m^3	295,178,125	171,406,382
	Total Concrete Work		20,064,242,883	17,363,461,895

The costs required for casting can be seen in the following cost comparison:

Total Cost of Dry Mix= 20.064.242.883

Total Cost of Ready Mix= 17.363.461.895

Cost Difference= 2.700.780.988

Percentage difference in cost= 15,55%

It is known that the cost of casting with Dry Mix is more expensive 2.700.780.988 or 15,55 % more expensive than Ready Mix. The Implementation Cost Ratio is Dry Mix 1.16: 1 Ready Mix. The calculation of the implementation duration ratio between the dry mix and ready mix concrete methods will be different if there are differences in conditions as follows: (a) If the access road to the location is getting farther or more difficult, you can use Dry Mix concrete with the packaging of 50 kg/sack (0.024 m3), but ready mix concrete can only use mini mixer maximum capacity of 3 m3. The casting duration of the dry mix will be faster than the ready mix. While the difference in casting costs is getting smaller, where Ready Mix casting is only slightly cheaper than Dry Mix. (b) If the access road to the site is very far or very difficult, so that it can only be passed by small vehicles, the foundry may only use packaged dry mix concrete or conventional processed concrete.

D. Application of the AHP Method

The data analyzed in the AHP method was obtained by distributing questionnaires to experts regarding the criteria for casting work using Dry Mix and Ready Mix concrete. The purpose of distributing this questionnaire is so that respondents fill out a Google form that is made containing all components of criteria and alternatives, all comparison values that must be filled in by respondents are in the Google form. The respondents were chosen from 50 people, the majority of whom were engineers who worked in the field of structure and infrastructure.

E. Key Criteria Weighted Value

Definition of criteria to be used as a measuring point for problem-solving and the level of importance of each criterion: Hierarchy, Best concrete material.

Table 4
Main Criteria Data of foundry work

Criterion	Code
Location	C1
Working methods	C2
Workforce	C3
Quality	C4
Time	C5
Cost	C6

Table 5
Summation of weights of key criteria

No	Criterion	Respondents						Geomin	Criterion
		1	2	3	48	49	50		
1	Location	0.20	0.20	0.11	0.20	0.33	0.14	0.27	Working Method
2	Location	0.14	0.17	0.14	0.33	0.14	0.20	0.50	Workforce
3	Location	0.11	0.14	0.17	0.11	0.11	0.14	0.20	Quality
4	Location	5.00	0.14	0.17	0.33	0.14	0.20	0.46	Time
5	Location	0.14	0.11	0.13	0.20	3.00	0.14	0.33	Cost
6	Working Method	7.00	5.00	8.00	9.00	5.00	7.00	4.16	Workforce
7	Working Method	0.11	6.00	5.00	0.14	0.33	0.20	0.34	Quality
8	Working Method	5.00	0.13	7.00	9.00	5.00	7.00	2.46	Time
9	Working Method	7.00	0.11	7.00	5.00	3.00	7.00	1.83	Cost
10	Workforce	0.11	0.20	0.17	0.11	0.11	0.14	0.21	Quality
11	Workforce	7.00	0.33	0.17	0.33	0.14	0.20	0.49	Time
12	Workforce	0.11	0.33	0.17	0.20	0.14	0.33	0.48	Cost
13	Quality	9.00	0.14	8.00	9.00	7.00	9.00	4.21	Time
14	Quality	8.00	0.13	8.00	7.00	9.00	5.00	3.84	Cost
15	Time	0.14	8.00	8.00	5.00	3.00	7.00	1.75	Cost

Furthermore, the calculation of the sum of the weights filled in by respondents is 1 – 50, then the total weight is divided by the number of respondents, namely 50 respondents.

Table 6
Consistency Calculation

$$\begin{bmatrix} 1.00 & 0.27 & 0.50 & 0.20 & 0.46 & 0.33 \\ 3.74 & 1.00 & 4.16 & 0.34 & 2.46 & 1.83 \\ 2.01 & 0.24 & 1.00 & 0.21 & 0.49 & 0.48 \\ 5.04 & 2.91 & 4.66 & 1.00 & 4.21 & 3.84 \\ 2.15 & 0.41 & 2.06 & 0.24 & 1.00 & 1.75 \\ 3.05 & 0.55 & 2.06 & 0.26 & 0.57 & 1.00 \end{bmatrix} * \begin{bmatrix} 0.05 \\ 0.22 \\ 0.07 \\ 0.41 \\ 0.12 \\ 0.12 \end{bmatrix} =$$

$$\begin{bmatrix} 0.05 & 0.06 & 0.04 & 0.08 & 0.06 & 0.04 \\ 0.20 & 0.22 & 0.30 & 0.14 & 0.31 & 0.22 \\ 0.11 & 0.05 & 0.07 & 0.09 & 0.06 & 0.06 \\ 0.27 & 0.64 & 0.34 & 0.41 & 0.53 & 0.45 \\ 0.11 & 0.09 & 0.15 & 0.10 & 0.12 & 0.21 \\ 0.16 & 0.12 & 0.15 & 0.11 & 0.07 & 0.12 \end{bmatrix} \Sigma \begin{bmatrix} 0.33 \\ 1.38 \\ 0.44 \\ 2.63 \\ 0.78 \\ 0.73 \end{bmatrix} / \begin{bmatrix} 0.05 \\ 0.22 \\ 0.07 \\ 0.41 \\ 0.12 \\ 0.12 \end{bmatrix} = \begin{bmatrix} 6.17 \\ 6.32 \\ 6.07 \\ 6.37 \\ 6.26 \\ 6.14 \end{bmatrix}$$

The Index Consistency calculation for each criterion is location 6.17; working method 6.32; labor force 6.07; quality 6.37; time 6.26; and costs 6.14. This process is carried out to determine the Consistency Ratio (CR) value. Where the consistency requirement must be less than 10% or CR< 0.1. After calculating the weight of the criteria in Table 4.13, the maximum lambda value is calculated (λMaks), summing the result of multiplying priority weights by the number of columns.

The maximum lambda value (λMax), obtained:

λMaks = (6,17 + 6,32 + 6,07 + 6,37 + 6,26 + 6,14) / 6 = 6,221

Calculate the Index Consistency value (CI):

CI= (λMaks – n) / n-1)

= (6,221-6) / (6 -1)

= 0,044 < 0,1 ⍰ consistent

Consistency Ratio Value (CR), is calculated by dividing the Consistency Index (CI) by Random Index (RI). For matrix order n = 6, value RI = 1,24.

CR = CI/RI =0,044/1,24 = 0,036 consistent

The ratio Consistency Value of 0,036 is no more than the tolerance limit of 0,1, Therefore, this comparison matrix is considered consistent and confirms that the study does not need to be repeated or improved.

Table 7
Concrete Alternative Data

Alternatives	Kode
Dry Mix	A1
Ready Mix	A2

After the weight of the criteria is obtained by the AHP method, then analyze the best alternative between the two alternatives of Dry Mix Concrete and Ready Mix concrete based on the criteria of Location, Work Method, Labor, Quality, Time, and Cost.

Table 8
Global Priority Ranking Based on concrete alternatives

Alternatives	Ranking
Dry Mix	0,58
Ready Mix	0,42

From the final result of the calculation of the method AHP (Analytic Hierarchy Process), it is known that the order of Global Priority is as follows:

a. Concrete Dry Mix (A1), First rank by value 0,58

b. Concrete Ready Mix (A2), Second rank by value 0,42

From these results, the concrete that was chosen by respondents for the structural work of OCC Building-Depo LRT Jabodebek was Dry Mix concrete.

Alternative Diagram of AHP Results

CONCLUSION

Quality Target Design Ratio between Dry Mix and Ready Mix concrete methods: (a) 3 days faster Dry Mix quality target 50% dari Ready Mix. (b) The 7-day quality target of 23% faster Dry Mix than Ready Mix. (c) The ratio of implementation duration between dry mix and ready mix concrete method is Dry Mix 1: 1,61 Ready Mix. (d) The Implementation Cost Ratio between Dry Mix and Ready Mix concrete methods is Dry Mix 1,16: 1 Ready Mix.

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