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SUPPLY CHAIN MANAGEMENT OF READY-MIX CONCRETE IN LARGE-SCALE PROJECTS AND SHORT TIME (CASE STUDY: CONSTRUCTION OF YOGYAKARTA INTERNATIONAL AIRPORT, KULONPROGO)

Ery Supratomo*, Jati Utomo Dwi Hatmoko, Ferry Hermawan
Universitas Diponegoro, Indonesia
Email: ery.supratomo@gmail.com

ABSTRACT

The Yogyakarta International Airport Project, valued at IDR 5.8 trillion, demands an exceptionally high daily supply of ready-mix concrete—approximately 7,000 m³—within a tight timeframe of only eight effective months. Given that concrete work constitutes 20% of the total project value, an efficient and reliable supply chain becomes essential. This research aims to simulate and analyze supply chain management (SCM) strategies specifically for the procurement of ready-mix concrete, with the objective of identifying the most efficient supply pattern to ensure both quality and timely delivery. Using production capacity analysis and SCM simulation, the study reveals that existing batching plants on and around the site can only meet a daily capacity of 5,272 m³. To bridge the gap, a self-managed batching system is proposed, which involves establishing three new batching plants at the project site, each with a 1,000 m³/day capacity, while centralizing raw material procurement under the project team for quality control. The simulation results show that the self-management model is more cost-effective, reducing the price of ready-mix concrete from IDR 936,833.00 to IDR 895,392.00 per m³, yielding a cost efficiency of IDR 41,441.00 per m³. These findings highlight the importance of SCM optimization and self-management strategies in large-scale infrastructure projects for enhanced cost and quality control.

KEYWORDS *batching plant, ready-mix concrete, supply chain management*

INTRODUCTION

The construction industry is one of the oldest industries (Al-Werikat, 2017a) which has uniqueness and characteristics that are different from other industries, where many parties are involved in the process, namely *owner*/clients, consultants, contractors, and suppliers who have their respective roles in a supply chain or supply chain (Mirnayani, 2015). (Tucker et al., 2001) Assessing that the construction industry is an inefficient industry because there are several problems that often arise such as increased implementation costs, delays, conflicts and disputes. One way to overcome these problems is through the application of *Supply Chain Management*

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adapted from the concept of the manufacturing industry, because the design *Supply Chain* Bad results can significantly increase the risk of additional project implementation costs (Wirahadikusumah & Susilawati, 2006). In practice, *Supply Chain* It consists of 3 flows that must be managed, namely the flow of goods from upstream to downstream, the flow of money from downstream to upstream, and the flow of information from upstream to downstream or vice versa (Pujawan & Mahendrawathi, 2017).

Although the construction industry adapts the process *Supply Chain* from the manufacturing industry, but in practice the network *Supply Chain* that is formed in the construction industry will not be more stable, effective, and efficient than the manufacturing industry because of the uniqueness of each construction project and the project implementation period is relatively short so that the learning process in network formation *Supply Chain* tend to be narrower. *Supply chain* It is considered to have a dynamic nature but involves three constant flows, namely information flow, product flow, and money flow which has the purpose of meeting consumer needs in which there is a flow of goods from raw materials to the end consumer accompanied by information and money flows (Chopra & Meindl, 2016).

(Wirahadikusumah & Susilawati, 2006) Concluding that the supply chain in the construction industry has several characteristics, namely: (1) having unique products because they are made based on certain requests from *owner*/client, (2) is carried out by a temporary organization so that when production ends, then *Supply Chain* that has been formed will end, (3) the construction industry product is tied to a certain place, (4) the construction process consists of two processes, namely *On site* and *Off site production*, and (5) the production process carried out at the construction site is influenced by the natural environment so that it has a high uncertainty nature. Therefore, judging from the existing characteristics, it is important to implement supply chain management (SCM), which is an effort to coordinate or integrate activities related to the provision of goods and services between parties involved in *Supply Chain* with the aim of improving operational efficiency, quality, and service to clients (Wisner et al., 2012). Other objectives of the implementation *Supply Chain Management* is to achieve better customer satisfaction with the least possible cost expenditure (Christopher, 2011). Supply chain management requires a series of activities needed to plan, control, and run product flows in the most efficient and cost-effective way possible by sharing information (Alam & Tui, 2022).

According to (Al-Werikat, 2017b), benefits from *Supply Chain Management* For a company, among others: reducing costs and waste, reducing risk with a more definite final cost, enabling long-term planning, and the continuation of sustainable business or recurring business with clients. As one of the efforts to develop a pattern *Supply Chain Management* in the construction industry in Indonesia, it is necessary to conduct research related to the implementation of *Supply Chain Management* on large-scale projects with very short execution times.

One of the large-scale projects that has been implemented in Indonesia is the construction of Yogyakarta International Airport (YIA) which is located in Kulonprogo Regency or ±45 km from the center of Yogyakarta. This airport was built to replace Adisutjipto Airport in Sleman Regency, Special Region of

Yogyakarta Province. The reason for the replacement is Adisutjipto Airport which stands on an area of 88,690 m2 with an existing terminal that can only accommodate 1.72 million *Pax*/year, while passenger traffic at that time (in 2019) reached 7.21 million *Pax*/year (Setiawan, 2019). The increase in passengers at Adisutjipto Airport also occurred quite rapidly with a passenger density of 8 million/year (Harselinda, 2020). In addition, Adisutjipto Airport is a *Civil enclave* owned by the Indonesian Air Force with the number of aprons that can only accommodate 11 aircraft (Setiawan, 2019).

Yogyakarta International Airport (YIA) is ±45 km from the center of Yogyakarta which is built on a land area of ±637 Ha, with a runway of 3,250 m, and is designed for aircraft of the largest type, namely the Boeing 777 (Setiawan, 2019). The construction of Yogyakarta International Airport began in 2018 and April 2019 has been operating minimally, which means that the airport can be used for *Landing* and *Take-off* airplane. Thus, the biggest challenge in the development of Yogyakarta International Airport is that its effective implementation time is only about 8 months. The next challenge is the considerable need for concrete reaching 814,000 m3 with a concrete work weight of almost 20% of the total contract value of the Yogyakarta International Airport Development Package of IDR 5.8 trillion.

Concrete, in this case concrete *Ready Mix* is one of the major components in the construction of Yogyakarta International Airport. When the supply of concrete *Ready Mix* If it is not sufficient according to daily needs, then the risk of delays in work in the field is very possible. Ready mix concrete material is a material that has a high level of risk because it must be used immediately when ordered without being stored in a warehouse (Sholeh & Wibowo, 2015). As a finished product, concrete *Ready Mix* formed from raw materials such as crushed stone, sand, and cement that need to be planned, technical specifications and the location of origin of the raw materials. Concrete procurement *Ready Mix* that involves several sectors that require *Supply Chain Management* so that the implementation of the work is successful both in terms of time, quality, and cost.

Based on the explanation in the background above, considering the increase in the construction industry in Indonesia, it is necessary to conduct research related to the application *of ready mix concrete supply chain management* in large-scale projects that are carried out in a short time by taking case studies on the Yogyakarta International Airport Development project.

This research aims to simulate and analyze supply chain management (SCM) strategies specifically for the procurement of ready-mix concrete, with the objective of identifying the most efficient supply pattern to ensure both quality and timely delivery.

RESEARCH METHOD

In this study, solutions related to several problems in the Yogyakarta International Airport Development project will be discussed, including: (1) the need for a large volume of concrete so that it requires the identification of concrete needs for each average daily work area to facilitate the planning of *ready mix concrete supply*, (2) the number and distance of *batching plants* that can supply *ready mix* concrete in the project, (3) the volume of *ready mix concrete* that can be produced by each *batching plant* to meet the production targets needed in the field, and (4) the scenario of fulfilling *the supply of ready mix* concrete in the field according to the needs. In order to answer these problems, research was carried out using quantitative methods. This research will provide a presentation of data in the form of numbers or quantitative that is estimated (*scoring*) using statistics.

The object of this study is the use of concrete *Ready Mix* quality concrete fc' 30 MPa in the Yogyakarta International Airport Development project. Concrete volume requirements *Ready Mix* large and short execution times lead to the need for a *Supply Chain Management* that is appropriate and has a positive impact on the implementation of the project. The data used in this study is data from the time range of September 2018 until the project is completed. The research methodology can be described through *Flowchart* at Figure 1 next.

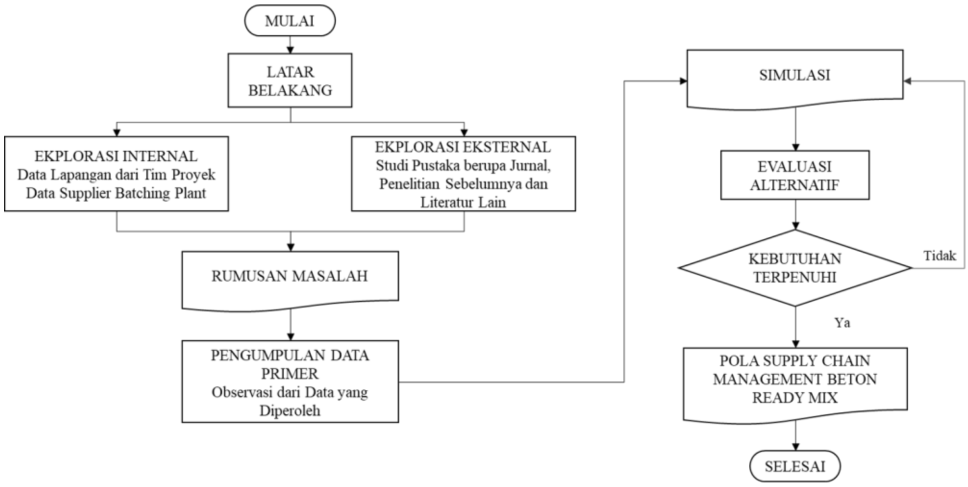

Figure 1. Research Methodology
Source: Processed Data

To support the research, data was collected on *ready mix* concrete needs which included the overall *ready mix concrete needs,* ready mix *concrete needs* for each work area, completion time targets, and ready mix concrete daily production targets. In addition, a survey of local *batching plants* located around development projects that have the closest proximity to the workability of *ready mix* concrete *is also carried out*. The *batching plant data* used in addition to the location and distance traveled is the maximum production capacity in 1 day to the project site. Because the production of ready-mix concrete is influenced by the supply of *raw materials*, data collection was carried out in the form of daily *raw material capacity*, raw material *collection locations*, and laboratory test results for *raw materials*.

In determining the results of the analysis, several simulations were carried out to meet the needs of ready mix concrete in order to obtain the most effective and efficient results in the process of the ready mix concrete supply chain in the Yogyakarta International Airport Development project. The 3 (three) alternative simulations used, namely:

1. Alternative 1 is to maximize the *local batching plant* or those around the project. After the number is known, an evaluation is carried out on things that can be done to increase production capacity to meet field needs.
2. Alternative 2 is the addition of partners or *suppliers of ready mix* concrete by establishing a *new batching plant* around the project site (full concrete *ready mix*).
3. Alternative 3 is the addition of partners or *suppliers of ready mix* concrete by establishing *a new batching plant* around the project site but with a self-management system or *mixing fee*. In this system, the procurement of *raw materials* is carried out by the project team itself.

In summary, the three alternatives can be presented through Figure 2.

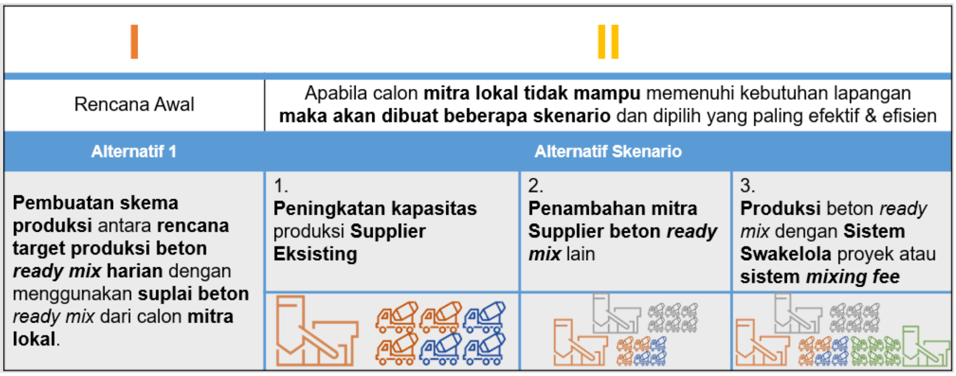

Figure 2. Alternative Scenarios *Supply Chain Management* on the Yogyakarta International Airport Development Project

Source: Processed Data

RESULTS AND DISCUSSION

Need for Ready Mix Concrete

The Yogyakarta International Airport Development Project was implemented in 2018 with a contract value of Rp5.8 Trillion and is targeted to operate at least in April 2019, so that the effective time of project implementation starts from vacant land until it can be functionalized for *Landing* and *Take-off* The plane is only 8 months. Concrete work items *Ready Mix* has a working weight of about 20% of the contract value with concrete volume requirements *Ready Mix* reaches 814,000 m3. The need for ready mix concrete is divided into 8 months of implementation period (October 2018 to May 2019) with the highest need in February 2019 where the need reaches 200,000 m3. The need for ready-mix concrete every month during the implementation period can be seen in the Figure 3 next.

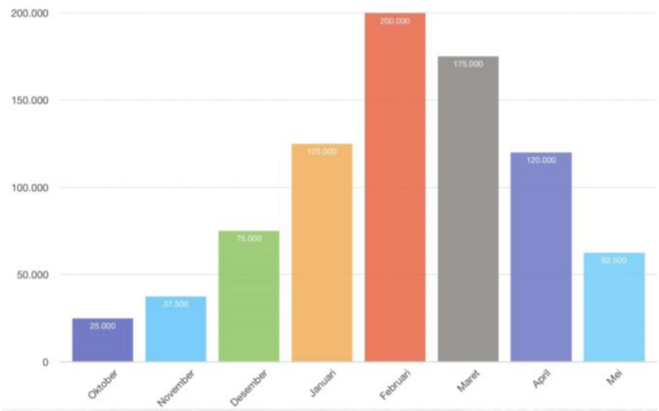

Figure 3. Concrete Requirements Ready Mix (Period October 2018 to May 2019)
Source: Processed Data

By taking into account the completion time of the work, the average daily *productivity of ready mix* concrete reaches 7,000 m3. This volume is quite fantastic because it is equivalent to a 4-lane toll road with a length of 500 m. Based on the calculation of the need for *ready mix* concrete of 7,000 m3 per day, it can be calculated that the *raw* material needs consist of 5,600 m3 of crushed stone, 3,500 m3 of sand, and 2,800,000 kg of cement with the *required stockyard* area of 12,000 m2 or equivalent to 4 fully filled 200-foot barges . To be able to produce *7,000 m3* of ready-mix concrete per day, 12 *fleet batching plants* with a capacity of 800 m3 per day are needed. The need *for that many batching plants* requires approximately 18 hectares of land for *batching plant operations*, parking lots, and material stock.

Batching Plant *Requirements*

Around the location of the Yogyakarta International Airport Development Project, there are several *batching plant* concrete *Ready Mix*. Location distribution *batching plant* The project location can be seen at Figure 4 next.

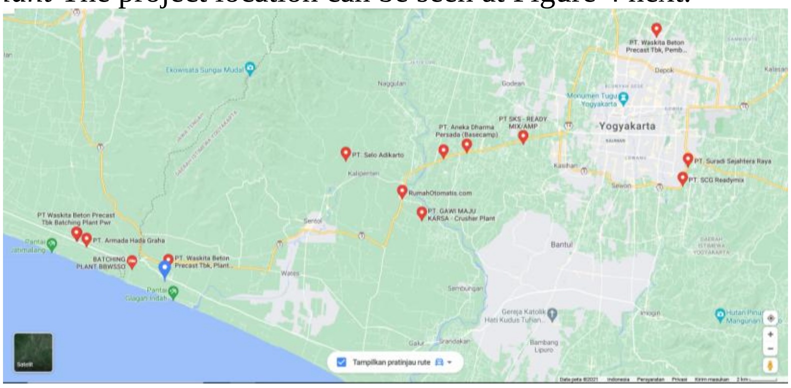

Figure 4. Distribution Location Map Batching Plant Around the Project Site
Source: Processed Data

Based on the map on Figure 4, it is known that there are 6 *batching plant* Ready-mix concrete has the closest distance to the project site. Distance details of each *batching plant* can be seen on Table 1 next.

Table 1. Distance Batching Plant from the Project Location

No.	Vendor *Batching Plant*	Batching Plant *Distance* (km)
1.	PT Waskita Beton Precast Plant Pwr	13,80
2.	PT Varia Usaha Beton (BSP Sedayu)	30,10
3.	PT Aneka Dharma Persada	31,90
4.	PT SKS	36,50
5.	PT SCG Ready Mix	51,70
6.	PT Merak Jaya Beton	55,20

Source: Processed Data

All existing *batching plants* have a considerable distance from the project site, even the nearest *batching plant* location is 13.80 km from the project site, while the daily productivity of *ready mix concrete* is largely determined by the distance of the batching plant to the project site.

Because *batching plant* around the project site is not completely reliable, in order to achieve concrete production targets *Ready Mix* daily, 20 were also brought in at the project site *batching plant* (*on site*) out of 10 *Vendors* With production capacities varying from 30 m3/hour to 90 m3/hour. *On site batching plant* are placed scattered at the project site with a location map as in Figure 5.

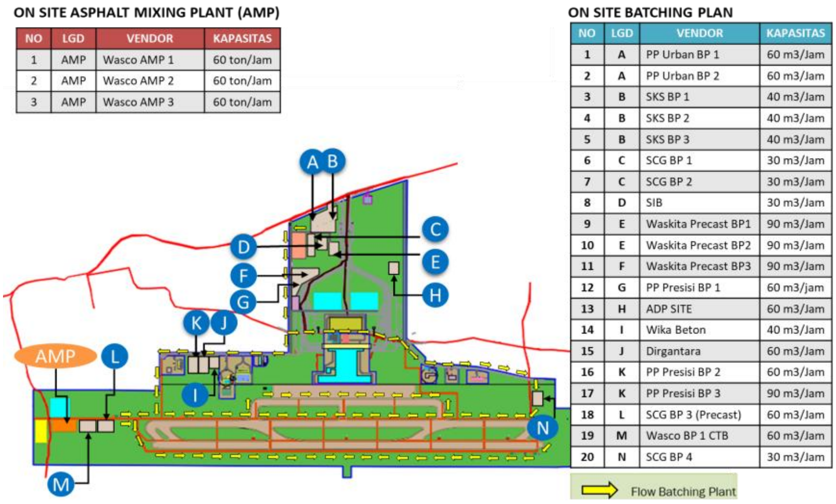

Figure 5. Location Map *On-Site Batching Plan*

Source: Processed Data

From the existing conditions, the achievement of total daily ready mix concrete production of 7,000 m3 per day has not been achieved, for example based on the results of casting *mapping* and the realization of *batching plant* production on April 2, 2019, the production of *ready mix* concrete from all *batching plants* It exists only 5,727 m3, so there is still a productivity deviation of around 1,273 m3. As one of the efforts to overcome the deviation in the production of ready-mix concrete is to increase the number of *batching plants* to increase daily production.

Production Target Fulfillment Scenarios

Based on productivity data *batching plant* existing from 10 vendors, target needs *Concrete Ready Mix* has not been fulfilled, so it is necessary to carry out a scenario to meet concrete needs *Ready Mix* from *batching plant* and their daily productivity. To simplify addition analysis *batching plant*, then an additional simulation is carried out *batching plant* from other vendors by targeting concrete production capacity *Ready Mix* of each *batching plant* an additional 1,000 m3 per day. Simulation *Supply* and *Demand* Concrete Productivity *Ready Mix* can be seen on Table 2 and Figure 6 next.

Table 2. Production Capacity and Realization *Batching Plant* Concrete *Ready Mix*

No.	Vendor Batching Plant	Offer (m3/day)	Production Capacity (m3/day)	Cumulative Production Capacity (m3/day)	Productivity Realization (m3/day)	Cumulative Productivity Realization (m3/day)
1	PT Presisi	20000	1945.0	1945	2443.0	2443
2	PT. Waskita Beton Precast Plant	19000	1075.0	3020	819.0	3262
3	PT. PP Urban	18000	475.0	3495	136.0	3398
4	PT. Aneka Dharma Persada	17000	764.0	4259	386.0	3784
5	PT. SCG Ready Mix	16000	834.0	5093	755.0	4539
6	PT SKS	15000		5093		4539
7	PT Betonku	14000	200.0	5293	203.0	4742
8	PT SIB	13000		5293		4742
9	PT Wasco	12000	600.0	5893	593.0	5335
10	PT Dirgantara	11000	625.0	6518	392.0	5727
11	A	10000	1000.0	7518	1000.0	6727
12	B	9000	1000.0	8518	1000.0	7727
13	C	8000	1000.0	9518	1000.0	8727
14	D	7000	1000.0	10518	1000.0	9727
15	E	6000	1000.0	11518	1000.0	10727
16	F	5000	1000.0	12518	1000.0	11727
17	G	4000	1000.0	13518	1000.0	12727
18	H	3000	1000.0	14518	1000.0	13727
19	I	2000	1000.0	15518	1000.0	14727
20	J	1000	1000.0	16518	1000.0	15727

Source: Processed Data

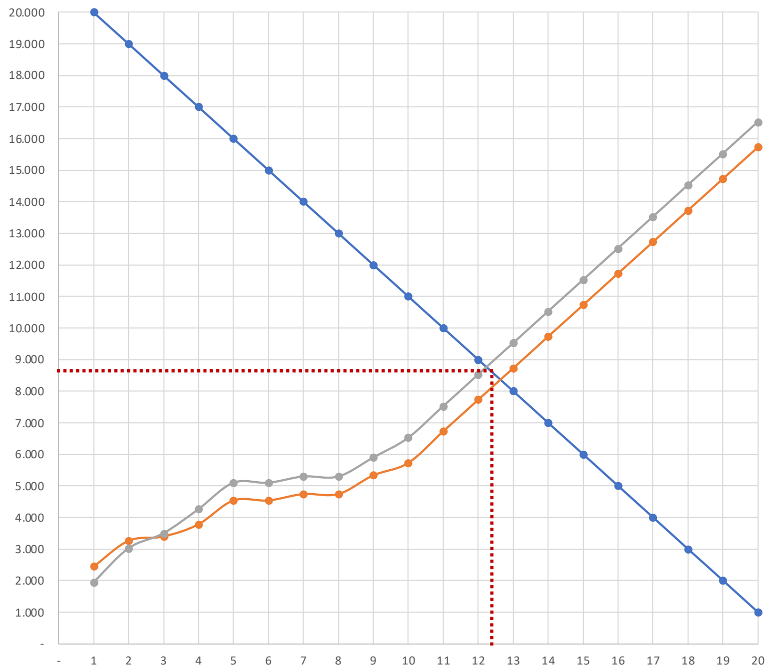

Figure 6. Graphs *Supply* and *Demand* Concrete *Ready Mix*
Source: Processed Data

To achieve the target of the Yogyakarta International Airport Development, the real need *for ready-mix* concrete in the field is 7,000 m3 per day. If taking into account the depreciation factor of 80%, the theoretical need for *ready mix* concrete is 8,750 m3 per day. Based on the results of the simulation carried out, these needs will be met if 3 ready mix concrete batching plants are added with a capacity of 1,000 m3 for each daily production. The addition is able to increase the daily production of *ready mix concrete* from the original 5,727 m3 to 8,727 m3. The addition *of a ready mix* concrete *batching plant* is carried out with a self-management system, where by establishing *a new batching plant* around the project site, but the procurement of *raw materials* is carried out by the project team itself. The self-management system was chosen because its success was influenced by several factors such as quality, leadership/managerial (*Project Manager*), cost, customer satisfaction, administration, human resources, time, suppliers, labor (*Stakeholders*), and location characteristics (Jamal et al., 2022). Based on the results of the analysis (Jamal et al., 2022), quality occupies the first position as a factor of self-management success with a percentage of 21.33%. This shows that the success of development projects must have a reference to quality standards. Therefore, as one of the quality control efforts is to maintain the quality of concrete *Ready Mix* through procurement *Raw Material* at *batching plant* additions by the project team itself.

Evaluation of the Self-Management *System of the Batching Plant*

After the decision was made to add 3 *batching plants* with a daily production capacity of 1,000 m3 each through self-management, the next step is to evaluate the costs incurred to carry out the self-management. The cost evaluation carried out includes the cost of materials and materials, the cost of renting *a batching plant*, and the cost *of manpower* and equipment operations. The price used in the cost evaluation is the price that has been contracted in the project. The cost calculation has taken into account the *loss* factor of materials and materials, as well as the productivity and life of the equipment used.

Concrete pricing *Ready Mix* fc' 30 MPa in a self-management system is carried out by taking the average price of concrete *Ready Mix* from *batching plant* existing as the maximum price. Average price of concrete *Ready Mix* The quality of 30 MPa concrete from the existing batching plant is Rp936,833.00 per m3. The price comes from the price of ready mix concrete per m3 from 6 vendors *batching plant* around the Yogyakarta International Airport Development project as presented in Table 3 next.

Table 3 Concrete Price *Ready Mix* fc' 30 MPa per m3

No.	Vendor *Batching Plant*	Price per m3 (Rp)
1.	PT. Waskita Concrete Precast Plant Pwr	930.000
2.	PT. Varia Usaha Beton (BSP Sedayu)	946.000
3.	PT. Various Dharma Persada	900.000
4.	PT. Credits	950.000
5.	PT. SCG Ready Mix	950.000
6.	PT. Merak Jaya Beton	945.000

Source: Processed Data

The evaluation of material and material costs is calculated based on *the job mixed formula* (JMF) that has been agreed in the field. In addition, the evaluation also takes into account the loss factor in the process of arriving materials and materials to the project site. Based on the calculation results, the price of materials and materials needed to make ready mix concrete fc' 30 MPa is IDR 713,620.00. Details of the price of materials and materials can be seen below.

Table 4. Evaluation of Concrete Material and Material Costs *Ready Mix* fc'30 MPa per m3

Materials and Materials	Unit	Volume	Unit Price (Rp)	Price (Rp)
OPC Cement	Kg	13.222.285,71	1.025	13.552.842.857
Sand	m3	21.901,64	125.000	2.737.704.737
Broken Stone 1-2	m3	23.223,79	190.000	4.412.520.317
Broken Stone 2-3	m3	-	190.000	-
Water	Litre	5.016.000,00	100	510.600.000
Additive	Litre	18.540,00	11.000	203.940.000
Total Price				**21.408.607.911**
Price per m3				**713.620**

Source: Processed Data

Equipment evaluation is calculated based on the rental price *batching plant* from the mobilization process to demobilization. The type of equipment used is *semi mobile batching plant*, so that in the preparation and operational work it is easier compared to *batching plant* Conventional. Rental price of batching plant for

1 m3 of concrete *Ready Mix* is Rp168,969.00 and details of the evaluation items are presented on Table 5 next.

Table 5. Rent Cost Evaluation *Batching Plant*

Items	Unit	Volume	Unit Price (Rp)	Price (Rp)
BP Crew Sticker 5 People	Flight	5,00	750.000	3.750.000
Meal 5 Persons 3x/day	river	150,00	25.000	3.750.000
Preparation of the BP Foundation	Ls	1,00	20.000.000	20.000.000
BP Labor Wages	Ton	13.222,29	25.000	330.557.143
Solar Generator Set 150 kVa	Litre	1.000,00	11.000	11.000.000
Demobilization	Ls	1,00	50.000.000	50.000.000
Mixing Fee	m3	30.000,00	155.000	4.650.000.000
	Total Price			**5.069.057.143**
	Price per m3			**168.969**

Source: Processed Data

In addition to evaluating the cost of rent *batching plant*, an evaluation of costs is also carried out *Manpower* and the operation of the equipment used. Based on the calculation results, the cost *Manpower* and operational support equipment *batching plant* self-management is IDR 12,803.00 for each 1 m3 of concrete *Ready Mix*. Details of the results of the evaluation were presented at

Table ***6*** next.

Table 6. Evaluation *Manpower* and Equipment Operations

Items	Unit	Volume	Unit Price (Rp)	Price (Rp)
Rent TM Unit	Moon	7,00	35.000.000	245.000.000
Rent Wheel Loader Unit	Moon	1,00	50.000.000	50.000.000
Overtime Operator 8 People	Moon	8,00	1.500.000	12.000.000
Eat 8 Persons 3x/day	River	210,00	45.000	9.450.000
Small Solar DT 7 Units	Litre	5.250,00	11.000	57.750.000
Solar Wheel Loader 1 Unit	Litre	900,00	11.000	9.900.000
	Total Price			**384.100.000**
	Price per m3			**12.803**

Source: Processed Data

From the three evaluations carried out, the total cost for self-management activities was obtained *Bacthing Plant* IDR 895.392,00 per m3 concrete ready mix fc' 30 MPa. The price is lower than the average price of concrete *Ready Mix* The quality of fc' 30 MPa concrete from the existing batching plant is IDR 936,833.00 per m3 or there is a price difference of IDR 41,441.00. This self-management plan is effective to implement because in terms of cost it is cheaper than the price of ready mix concrete fc' 30 MPa from *batching plant* Existing. This is in accordance with research conducted by (Jamal et al., 2022) that cost ranked third as a determining factor for the success of self-management with a percentage of 16.89%. Cost factors in this case include *planning, forecasting, budgeting, financing, funding, managing*and *controlling costs* to complete the project according to the agreed budget.

Because other success factors of self-management activities are *Leadership*/Managerial (Jamal et al., 2022), the implementation of project management carried out in order to complete concrete work *Ready Mix* in the Yogyakarta International Airport Development project on a large scale in a timely manner, including: (1) planning the casting schedule the next day on the night before the casting is carried out, (2) placing *Command Center* as coordinators, and (3) evaluate and take steps to maximize production in each *batching plant.*

CONCLUSION

The development of the Yogyakarta International Airport requires a highly efficient supply chain strategy for ready-mix concrete, especially given the tight implementation period and the significant volume of concrete work involved. Based on this research, it was found that the existing batching plants could only meet a maximum production capacity of 5,272 m^3 per day, falling short of the daily demand of 7,000 m^3. To overcome this gap, a simulation was conducted which led to the recommendation of a self-management system involving the establishment of three additional batching plants with a capacity of 1,000 m^3 each, directly managed by the project team for better control of material quality. This approach proved not only effective in meeting production targets but also more cost-efficient, reducing the price per cubic meter of concrete by IDR 41,441.00 compared to third-party suppliers.

In addition to optimizing the supply chain through self-management, this study also emphasizes the importance of integrated project management practices. These include proactive daily planning of casting schedules, the establishment of a centralized command center to coordinate operations, and continuous evaluation to improve batching plant productivity. Future research is encouraged to explore digital integration through Building Information Modeling (BIM) or Internet of Things (IoT)-based monitoring systems to further enhance the precision, scheduling, and quality control in concrete supply chain management for large-scale infrastructure projects.

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