Construction Material and Equipment Demand Estimation in Indonesia

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SUMMARY
Increased national infrastructure investment will have an impact on the demand for reliable construction resource availability support. Currently, one of the issues of concern to the Indonesian Government is the absence of accurate the demand information for material resources and construction equipment. The annual requirement information in each region is currently based on estimated data. Meanwhile, the formulation of material resource requirements and construction equipment cannot be formulated properly because development priorities vary each year of the budget. It should not occur when there is a comprehensive data and information system related to construction materials and equipment. If data on construction material and equipment resource requirements, volume and time of procurement can be available well at the beginning of the fiscal year, it will be easy to predict the availability of existing resources within the country to meet the needs of all construction project activities. The research was conducted to obtain an annual data formula from the needs of materials and construction equipment within the Ministry of Public Works by utilizing the Bill of Quantity (BOQ) data of the previous year, which will be used for policy makers in the construction sector. Finally a formula of estimation of material and construction equipment demand is found that can be used by the Ministry of Public Works in planning and coordinating with relevant ministries such as the Ministry of Industry so that there is no shortage of material and equipment in the construction projects in Indonesia.

RINGKASAN
Meningkatnya investasi infrastruktur nasional tentu berdampak juga pada kebutuhan dukungan kesiapan sumber daya konstruksi yang andal. Saat ini, salah satu isu yang menjadi perhatian Pemerintah adalah belum adanya informasi yang akurat antara kebutuhan (demand) sumber daya material dan peralatan konstruksi. Informasi kebutuhan per tahun di setiap daerah saat ini masih berdasarkan data estimasi. Sementara itu, formulasi kebutuhan sumber daya material dan peralatan konstruksi tidak bisa dirumuskan dengan baik karena prioritas pembangunan berbeda-beda setiap tahun anggaran. Seharusnya masalah tersebut tidak perlu terjadi apabila tersedia data dan sistem informasi yang komprehensif terkait dengan material dan peralatan konstruksi. Jika data-data kebutuhan sumber daya, volume dan waktu pengadaan bisa tersedia dengan baik di awal tahun anggaran, maka akan dengan mudah untuk memprediksi ketersediaan sumber daya yang ada di dalam negeri mampu memenuhi kebutuhan seluruh kegiatan atau tidak. Riset ini dilakukan untuk mendapatkan formula data tahunan dari kebutuhan material dan peralatan konstruksi di lingkungan Kementerian Pekerjaan Umum dengan memanfaatkan data Bill of Quantity (BOQ) tahun sebelumnya, yang akan digunakan sebagai bahan untuk pengambil kebijakan di sektor konstruksi. Akhirnya

didapatkan suatu formula estimasi kebutuhan material dan peralatan konstruksi yang dapat digunakan Kementerian PU dalam merencanakan dan mengkoordinasikannya dengan kementerian terkait seperti Kementerian Perindustrian sehingga tidak terjadi kekurangan material dan peralatan pada proyek konstruksi di Indonesia.

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1. INTRODUCTION

The condition of good infrastructure is believed to have a very big role in encouraging economic growth of a State. The Government of Indonesia through the Working Cabinet has established several strategic infrastructure development targets whose numbers are increasing very sharply. In harmony with this, the activity of infrastructure will experience a considerable increase, massive, and evenly distributed in almost all parts of Indonesia. Increased national infrastructure investment will also have an impact on the need for reliable construction resource availability support. Currently, one of the issues of concern to the Government of Indonesia, particularly Ministry of Public Work (MPW), is the absence of accurate information between the demand for material resources and construction equipment. The annual requirement information in each region is currently based on estimated data. Meanwhile, the formulation of the need for material resources and construction equipment can not be formulated properly because development priorities vary each year of the budget. This problem should not occur when there is a comprehensive data and information system related to construction materials and equipment (CME). If data on resource requirements, volume and time of procurement can be available well at the beginning of the fiscal year, it will be easy to predict the availability of existing resources within the country to meet the needs of all activities. In addition, the database can be used as an initial guide for manufacturers, distributors and contractors to undertake planning related to the procurement of CME in Indonesia MPW construction projects. This can be one of supporting the achievement of contruction activity implementation target in the field according to plan (MPW, 2017)

Ultimately, the availability of credible and reliable information will improve the effectiveness and efficiency of construction work. Thus, the availability of needs data which includes the main material types, construction equipment, the volume of needs and distribution needs to be immediately prepared in the framework of orderly administration, management and control, and the continuity of the business of providing CME. The purpose of this study was to formulate the need of CME through the Bill of Quantity (BOQ) document of projects from Indonesia MPW in year 2016.

2. CONSTRUCTION MATERIAL AND EQUIPMENT DEMAND ESTIMATION FROM BOQ

In general, the demand estimation of construction material and equipment is derived from BOQ in following steps. For material, first the demand per work unit (e.g. per square meter area) for each material are analyzed with reference to the Unit Price Analysis (UPA) from the BOQ of each project. Especially for PC, fine aggregates, and coarse aggregates in concrete of a certain quality, it can be calculated by its composition approach (Table 1). Once the need

per unit of work is obtained, then the CME demand in the project can be estimated by dividing the total price for the CME divided by the unit price (Mochtar et. al., 2017)

Table 1. Composition of PCs, Smooth Aggregates, and Rough Aggregates of Various Quality Concrete (MPW, 2012)

No	Concrete Quality	PC	Fine Aggregate	Coarse Aggregate
1	fc' 50MPA	1.0	1.5	2.3
2	fc' 45MPA	1.0	1.6	2.3
3	fc' 40MPA	1.0	1.7	2.6
4	fc' 35MPA	1.0	1.7	2.6
5	fc' 30MPA	1.0	1.9	2.8
6	fc' 25MPA	1.0	2.1	2.8
7	fc' 20MPA	1.0	2.3	3.1

In the Unit Price Analysis (UPA) from the BOQ of each project, there is information of equipment demand in hour per day. Consequently, the demand hour of the equipment in a work item can be estimated by multiplying it with the quantity of work item. For example, 1 cubic meter of "stone work" item demands 0.3571 hours per day of "concrete mixer with 0.3-0.6 m^3 capacity" equipment at a price of 97,509.41 rupiah per hour. So if the work item to be done is 100 cubic meters, then it demands concrete mixer equipment work for 100x0,3571 or equal to 35,71 hours, with cost equal to 35,71x 97,509,41 or equal to 3,482,061,03 rupiah. The same procedure may be used to calculate for other work items using "concrete mixer with 0.3-0.6 m^3 capacity", and finally to be summed for the equipment overall demands in the project. The same procedure may be conducted for all other equipment (Mochtar et. al., 2017)

3. FORMULATION OF DEMAND ESTIMATION

Formulations was made for categories according to 4 Directorate Generals (DGs) in MPW for both new consruction and maintenance projects. New construction is the construction work of new infrastructure, while maintenance project includes improvement, renovation, and rehabilitation of infrastructure. This is because the CME demand for new cosntruction activities is certainly different from the CME demand of maintenance project activities because of the nature of the activity itself. Once the CME demand estimation for each project is derived from above steps from the BOQ data, then the demand estimation for each categories of project may be formulated (Mochtar et.al., 2017).

The material to be studied is the main material in the MPW projects presented in Table 2.

Table 2. Main Material in MPW Projects

No	Material	Unit
1	Fine Aggregate	m^3
2	Stone	m^3
3	Coarse Aggregate	m^3
4	Asphalt	Kg
5	Portland Cement	Kg
6	Steel Pipe	m
7	PVC Pipe	m
8	Reinforcement Steel	Kg
9	Profile Steel	Kg
10	Steel Prestress Strand	Kg
11	Ready mix Concrete	m^3
12	Precast Concrete	m^3

The formulation for the material is the price of the raw material against the total value of a project. For example, for Portland Cement (PC) material there is a percentage of 12%, or in the form of equation is:

PC (KG) = (0.12 x PV) / UP

Where:

PV = Project Value (Rupiah)

UP = Unit price of material

With such formulations, the demand estimation for PC for a given project value at a given unit price is known. For example for the upcoming 2019, the estimated value of the project to be done is 50 trillion rupiah, with the unit price of PC is 3000, - rupiah per kg. Then the demand estimate for cement is:

PC demand = (0.12x 50 Trillion) 3000 = 2,000,000,000 kg = 2,000,000 Ton.

The equipment to be studied is the main equipment in the MPW projects presented in Table 3.

Table 3. Main Equipment in MPW Projects

No	Equipment	Unit
1	Asphalt Mixing Plant	Hour
2	Asphalt Finisher	Hour
3	Asphalt Sprayer	Hour
4	Bulldozer/Motor Grader	Hour
5	Compressor	Hour
6	Concrete Mixer	Hour
7	Crane	Hour
8	Dump Truck/Flat Bad Truck	Hour
9	Excavator	Hour
10	Wheel Loader	Hour
11	Roller(Vibra,Tandem,Pneumatik)	Hour
12	Concrete Vibrator	Hour
13	Water Tanker	Hour
14	Jack Hammer	Hour
15	Concrete Finisher	Hour
16	Truck Mixer/ Agitator	Hour
17	Batching Plant	Hour

The formulation for the equipment is the percentage of the material price against the total value of the project. For example for dump truck of 3.5 ton capacity if the percentage is 7%, or in the form of equations are:

Dump Truck (hour) = (0.07 x PV)/UP = X

Where:

PV = Project Value (Rupiah)

UP = Equipment unit per hour

If the dump truck hour demand estimation is X, then the demand estimation of dump truck unit can bw calculated as:

Dump truck (unit) = (X / Y) / Z

Where:

Y = Average duration of the project

Z = Average hours worked per unit per unit of project duration

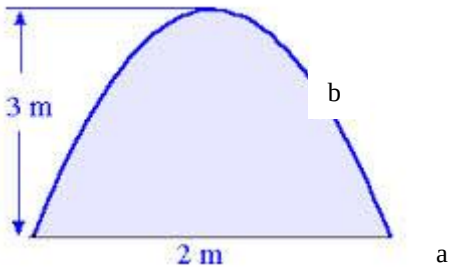
The average project duration (Y) data is obtained from BOQ data, and the average working hours per unit per unit of project duration is assumed to be 8 hours per day.
With such formulations, the need for equipment for the value of a particular project at a given unit price can be calculated. For example for the upcoming 2019 estimated project value to be done is 50 Trillion rupiah, with dump truck unit price is 200 000, - rupiah per hour. Then the need for 3.5 ton dump truck size is:

Dump truck hour demand = (0.07x 50 trillion x 200,000 = 17,500,000 hours

If it is assumed that the average project duration of 4 months (120 working days) and dump trucks work 8 hours per day per unit, then the total number of units required during the year 2019 are:

(17,500,000/120)/8 = 18,229.17 or rounded 18,230 units of dump truck.

The need for equipment in the project generally is to experience an increase over the duration of the project that can be approached with a half-parabolic model as shown below:



The area of the half of the parabola A is equal to 2/3 x a x b

In this example a is equal to 120 days, the total number of equipment is A = 18,230 units, then b (= the peak number of dump truck unit) is:

b = 3/2 x A / a
b = 3/2 x 18,2302 / 120 or equal to 227,875 units or rounded to 228 units per day.

4. METHODOLOGY

4.1. Data Collection

In this study, data collection is focused on CME in Indonesia MPW projects in year 2016; the data of BOQ is collected from Center of Data of Indonesia MPW. The total number of BOQ project data is 5500 data contract holders in 2016. These data are then taken in samples with the principle of random sampling of 160 data (each 40 data for each 4 DGs of Indonesia MPW).

4.2. Data Analysis

The data then is analyzed by using principles and procedures as described in Part 2 and 3 of this paper.

5. FINDINGS AND DISCUSSION

From the sample data, then by calculating the mean of the sample data, the CME demand estimation of Indonesia MPW projects is formulated. Table 4 and 5 is summary of the demand formula for construction material and construction eq uipment respectively, based on BOQ 2016 data.

Use of the formula is to insert the value of available funds of estimated project value in Indonesia MPW in a certain year, so that the demand of CME in that year may be estimated. For example for Portland Cement (PC) material; its unit price (UP) is 1,706.93/kg, if the available fund of MPW projects in 2019 is 50 trillion rupiah (PV), the demand estimation of PC material in 2019 for MPW projects is:

Formula: (0.0494 x PV) / UP

= 0.0494 X 50,000,000,000,000) / 1.706.93 = 1,447,042,350.89 kg

Another example is for Concrete Mixer equipment; its unit price (UP) is 82,842.15

Tabel 4. Summary of Formula Demand of Construction Material

No	Material	Formula	Average Unit Price (Rupiah)	Unit
1	Fine Aggregate	(0,0591 x PV)/UP	271,494.23	M3
2	Stone	(0,0116 x PV)/UP	263,454.15	M3
3	Coarse Aggregate	(0,1662 x PV)/UP	232,125.71	M3
4	Asphalt	(0,0361 x PV)/UP	12,063.89	KG
5	Portland Cement	(0,0494 x PV)/UP	1,706.93	KG

6	Steel Pipe	(0,0033 x PV)/UP	103,341.89	M’
7	PVC Pipe	(0,0085 x PV)/UP	182,951.82	M’
8	Reinforcement Steel	(0,0727 x PV)/UP	12,311.96	KG
9	Profile Steel	(0,0043 x PV)/UP	15,617.71	KG
10	Steel Prestress Strand	(0,0092 x PV)/UP	1,710,642.71	KG
11	Ready mix Concrete	(0,0128 x PV)/UP	1,342,693.62	M3
12	Precast Concrete	(0,0316 x PV)/UP	2,104,654.87	M3

Tabel 5. Summary of Formula Demand of Construction Equipment

No	Equipment	Formula	Average Unit Price (Rupiah)	Unit
1	Asphalt Mixing Plant	(0,0066 x PV)/UP	7,159,295.13	Hour
2	Asphalt Finisher	(0,0002 x PV)/UP	382,521.67	Hour
3	Asphalt Sprayer	(0,0000 x PV)/UP	116,580.49	Hour
4	Bulldozer/Motor Grader	(0,0127 x PV)/UP	707,049.67	Hour
5	Compressor	(0,0003 x PV)/UP	204,949.03	Hour
6	Concrete Mixer	(0,0081 x PV)/UP	82,842.15	Hour
7	Crane	(0,0104 x PV)/UP	406,966.17	Hour
8	Dump Truck/Flat Bad Truck	(0,1123 x PV)/UP	373,851.57	Hour
9	Excavator	(0,2907 x PV)/UP	691,123.51	Hour
10	Wheel Loader	(0,0015 x PV)/UP	520,133.68	Hour
11	Roller(Vibra,Tandem,Pneumatik)	(0,0188 x PV)/UP	694,513.11	Hour
12	Concrete Vibrator	(0,0062 x PV)/UP	74,596.91	Hour
13	Water Tanker	(0,0023 x PV)/UP	272,160.98	Hour
14	Jack Hammer	(0,0028 x PV)/UP	534,564.65	Hour
15	Concrete Finisher	(0,0017 x PV)/UP	361,236.32	Hour
16	Truck Mixer/ Agitator	(0,0032 x PV)/UP	508,497.21	Hour
17	Batching Plant	(0,0074 x PV)/UP	609,468.08	Hour

rupiah/hour, if the available fund of MPW projects in 2019 is 50 trillion rupiah (PV), the demand estimation of Concrete Mixer material in 2019 for MPW projects is:

Formula: (0.0081 x PV) / UP

= 0.0081 X 50,000,000,000,000) / 82,842.15 = 4,888,815.66 hours

If it is assumed that the average project duration of 4 months (120 working days) and Concrete Mixer work 8 hours per day per unit, then the total number of units required during the year 2019 is equal to:

(4,888,815.66/120)/8 = 5,092.51 or rounded to 5,093 units of Concrete Mixer.

Finally, the demand peak number of Concrete Mixer equipment unit for the in 2019 Indonesia MPW projects may be estimated equal to:

3/2 x 5,093 / 120 or equal to 63.66 units or rounded up to 64 units per day.

By estimating the demand of CME well at the beginning of the fiscal year using the formula, it will be easy to predict the availability of existing resources within the country to meet the needs of all activities. In addition, the demand estimation data can be used as an initial guide for CME manufacturers, distributors and contractors to undertake planning related to its procurement in Indonesia MPW construction projects. This can be one of supporting the achievement of contruction activity implementation target in the field according to planned construction schedule.

Finally, the formulated CME demand estimation will improve the effectiveness and efficiency of construction work. Thus, the availability of demand data which includes the main material types, construction equipment, the volume of needs and its distribution demands to be immediately prepared and coordinated among related parties in a country as a framework of orderly administration, management and control, and the continuity of the efforts of providing sufficient CME.

6. CONCLUSION

From this study it can be concluded that:

a. The BOQ analysis to calculate the demand estimation of CME may be conducted to build the formulation of CME demand in a certain period of time.
b. By using the formulations the CME demand estimation may be estimated with data of project value, unit price, average use per day of the CME, and the average project duration.
c. The demand estimation of CME is important and strategic in the development of planning so that there is no shortage of CME resources in the implementation of the construction projects, and thus the planned schedule and progress in construction may be better achieved.

REFERENCES

Ministery of Public Work (MPW) "Pedoman Analisa Harga Satuan (Unit Price Analysis Guidelines)" , 2012.
Ministery of Public Work (MPW) "Kerangka Acuan Kegiatan Kajian Formulasi Kebutuhan Material dan peralatan Konstruksi berdasarkan BOQ 2016" Term of Reference, 2017.

Mochtar, K., Eko, F., Yono, F., Wahyono, S. "Kajian Kajian Formulasi Kebutuhan Material dan peralatan Konstruksi berdasarkan BOQ 2016" Research Report, 2017

BIOGRAPHICAL NOTES

- Experienced in teaching at universities (home based on Indonesia Institute of Technology-ITI), researching, and consulting (design, supervision and management) in construction areas
- Around 36 publications in various international and national journals and conferences on productivity improvement, pricing strategies, marketing expenditures, production management, and green construction issues.
- Member of Indonesia Construction Experts Association (ATAKI), Indonesia Consultant Experts Societies (INTAKINDO)

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