Productivity analysis and efficiency of concrete casting using mini-cranes with a capacity of 200 kg based on appropriate technology

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Abstract
The main objective of this study was to analyze the productivity and efficiency of concrete casting using a mini crane with a capacity of 200 kg as designed by the researcher, compared to using the manual method. The method used in this study is the assembly of mini cranes with a capacity of 200 kg, then field or work tests are carried out and accompanied by observations and subsequent data analysis. The results of the analysis are that using a mini-crane is more profitable compared to the manual method. The authenticity of this research is that mini-cranes are designed and made by researchers with style and models adapted to the conditions of small towns and inland areas in Indonesia, made based on Appropriate Technology not using imported materials and prioritizing scrap metal waste which is the authenticity of this research , thus our research has the principle of producing innovations and works that are useful for human life.

Keywords: Mini-crane, Productivity, Efficiency**,** Appropriate Technology

Introduction

Concrete is a construction that is made as infrastructure, so that durability is a thing that is strongly influenced by work methods (Uysal et al., 2019), as well as the ability of concrete to withstand the durability of steel in order to prevent corrosion is very limited and requires long research (Uysal et al., 2019). Very diverse people in the process of making concrete construction must be very thorough so that it can be done cheaper, easier and the most important thing is also durable, good for natural conditions and especially for seawater and areas with very high humidity. concrete durability and durability can be improved.

Concrete, of course, cannot work alone, many other components support each other so that the concrete structure or construction can work more resistant and does not suffer from carrying loads (Uysal et al., 2019), including stainless steel reinforcement is a concrete reinforcement material (García et al., 2019). For concrete, it cannot stand alone and there must be fiber as reinforcement (Saleem et al., 2019). increased compressive strength is achieved due to metakaolin pozzonalic reaction and fly ahs blocking pores (Köroğlu, 2019). The concrete is not able to withstand the tensile load, therefore it is necessary to add steel reinforcement because the steel can withstand tensile loads.

The research on concrete is very broad, even concrete can be made using old concrete waste or recycled concrete (Gutiérrez Moreno et al., 2015), and the most important thing in research on concrete is about the strength of concrete, the durability of concrete, and most importantly low-cost concrete. The use of waste from the recycling of old concrete or demolition of old buildings, turns out to have an impact can reduce costs in a very large volume of concrete, and the most profitable economically, what if in an area there is no local material, then the old concrete waste or demolition of

old buildings existing in the region can be used, only what needs to be considered is that the final concrete obtained must meet the requirements set according to technical specifications.

The world is increasingly progressing in the development of infrastructure development, ways and efforts to improve the quality of productivity of human resources and tool resources are growing rapidly (de Lassio & Haddad, 2016). However, these developments will generally progress, if the investment costs needed can be balanced with the costs of infrastructure benefits, either directly or indirectly, and if not estimated, then not all infrastructure can be built, thus many rural areas, coastal areas, and small islands are still very and lagging behind. The productivity of human resources and tool resources will continue to develop, especially in rural areas that still require appropriate technology to complete small and simple projects. So that all will affect the completion of projects that often experience delays (de Lassio & Haddad, 2016). This cost is influenced by the availability of resources and productivity, especially equipment that is highly dependent on parts, fuel, tool conditions, and weather. Thus, whatever our efforts and our ways to overcome the constraints of project execution depend on the method and management used in a project (Garcia-Bernal & Garcia-Casarejos, 2016). The key to success in working on a project is inseparable from the role of project management and construction.

Concrete is not only used in buildings on the ground below or in concrete ground still in use (Gonzalez Stumpf et al., 2014) based on the place where concrete will be used, of course, requires tools for lifting, installing or what tools will be used for casting the concrete itself, in the ground concrete needs to be lowered and above ground also needs to be lifted. Thus, wherever the concrete will be used, it definitely requires sophisticated equipment, including simple technology-based equipment. Concrete is a part of the construction that is very widely used in infrastructure development (Hansen, 2015), this is because concrete is very easy to make, formed and uses local materials, only cement materials are made in the factory.

The use of ready-mix concrete in Kendari city is not very popular, this is because price is very high, even though the use of ready-mix concrete is very guaranteed (de la Rosa et al., 2018). In addition to guaranteed quality, the use of ready-mix concrete is also more practical because orders according to the quality required, all equipment is prepared by the ready-mix concrete company (Paleologos, 2018).

Ready-mix concrete is very expensive so private projects are not very interested, and prefer concrete casting using manual methods or using construction workers (Iñeguez et al., 2019; Arriagada & Alarcón, 2014). Manual concrete casting has a problem, many construction workers are needed, for projects in remote areas it is very difficult to get construction workers, if available then the wages requested are very expensive. But it's still cheaper than using ready-mix concrete.

Concrete with high artistic value or Glass Fiber Reinforced Concrete-GRC can be made with low cost (Vergara et al., 2017), concrete in addition to being the main construction in a building, it can also be made as high-value artwork or GRC, with curved variants according to the characteristics of the shell Beautiful can save costs by 40% to 80%. And even the use of additives and hybrid technology is an alternative to the manufacturing approach by no longer using the machine. The use of formwork in the manufacture of curved concrete will experience many difficulties, both installation of formwork itself and releasing of hardened concrete, the use of new technology will enable alternatives to greatly assist and speed up the process of making GRC or concrete with high artistic value. Thus the process of making concrete is very influential on the strength of concrete and the ease of making concrete with high artistic value.

Chloride is a chemical compound, it can be an inorganic or organic compound with the chemical formula Cl, this compound is sought not to enter the concrete because it can damage and affect the life of the concrete to be short, for that concrete coating treatment using rendering mortar is very helpful to reduce and maintain so that concrete is protected from chloride (Malheiro et al., 2016). Chloride or its general form is salt, it is sought to be prevented from entering the concrete by using mortar rendering and epoxy resin coatings. Concrete treatment like this is specifically used on concrete located on the beach and buildings in the sea such as ports, bridges, light towers, and offshore buildings, this effort is made so that the concrete is not easily damaged by seawater containing chloride and this coating is carried out periodically depends on the chloride content and the strength of the chloride which can affect the concrete conditions. Thus it turns out that in addition to the planned strength of concrete and concrete casting methods, apparently there are still treatments that must be given or periodic maintenance of concrete.

The use of alternative methods or new methods, especially the use of equipment with simple technology or appropriate use, with small-scale capacity in concrete casting work in simple areas and islands that are very suitable and very helpful, this is related to using simple equipment, appropriate technology, small scale, can move fast, low investment costs, use local parts and can be made and managed by local people who use simple tools will be more effective and efficient

(Mujumdar & Maheswari, 2018). For the work of small-scale projects in remote areas and small islands, the use of equipment should be adjusted to the needs, if using large-scale equipment is very inefficient, because the cost of mobilization will be high and the productivity of the tool is too large, thus the project will suffer losses. The use of equipment should be adjusted to the volume of work to be done, but in general projects in remote areas and islands are small scale projects, such as short span bridges, beacon lights towers, coast guard buildings, electricity and transmission grid towers telecommunications, rural health service center buildings and home officers and the most numerous are building villas for settling while vacationing on the beach or in the mountains.

The use of Tower Crane (Kaveh & Vazirinia, 2018) for small cities in Indonesia with a project budget of under 10 billion rupiahs, is very inefficient, the costs of mobilization and demobilization are very high (Hartono et al., 2018). What's more the existence of the project in the regency cities located in small islands. With mini-cranes, using the tools of innovation and creativity of young people with the use of scrap metal waste, it can be an innovation that can build high-rise building infrastructure (Syamsyul Bin Rakiman et al., 2018). The phenomenon that occurs in areas that are canceled or on small islands, the work of building multi-story buildings is done using the manual method of using construction workers, whereas to get construction workers is very rare and if there is repair work is very high, people have been busy and have jobs under the intended work such as farmers and fishermen. Using ready-mix concrete is not possible, because there is no company to provide it, so using a mini-crane that is assembled can be an alternative tool.

Concrete is part of construction that is widely used for infrastructure development because concrete is easy to work on and the price is relatively cheaper than steel and resistant to natural influences, this is according to the opinion Sumajouw (2013) as follows: "Conventional concrete consists of Portland Cement, aggregate course, fine aggregate, sand, and water. This type of concrete is very common and can be produced locally using a simple method. Concrete is a very important material and is widely used to build various infrastructures such as bridges, highways, dams and other urban infrastructure. This makes concrete, in terms of quantity, the most widely used material for humans after water".

Concrete is widely used in Indonesia, this is because concrete has special characteristics, mostly local material, mainly used as reinforced concrete, this is explained by Imran & Zulkifli (2014) that "reinforced concrete material is widely used in concrete construction in Indonesia. This material has many advantages compared to other building materials, including 1) Competitive price; 2) Easy to form (related to architectural functions); 3) High fire resistance; 4) Having high strength; 5) Low maintenance costs; 6) The forming material is easily obtained".

The implementation of concrete casting must choose the right equipment in accordance with the scale of need, between small, medium and large scale, in order to produce concrete according to purpose, this is in accordance with the opinion Sajekti (2013): must be truly chosen, in order to fulfill several objectives, namely: economy; avoid segregation; laying concrete before the concrete starts to become hard. The method of implementation and transportation can be carried out in several ways, namely by buggy, bucket, and crane, hoisting tower, cableway, gutters (cuts), belt conveyors, dump-trucks, concrete pumps, and agitators-trucks. Each has advantages and disadvantages under certain conditions and must take into account the capacity requirements and timeliness of small scale concrete casting, use of large scale equipment is very inefficient and the project will suffer losses. Likewise in large scale concrete casting, using small scale equipment is very inefficient and the project will suffer losses. Then all capacity of the equipment to be used must be considered first. The use of alternative mini-cranes resulting from innovation is a solution.

In each use and selection of equipment for the work of a project, the most important thing is to consider very carefully, both the project conditions, the allocation of time needed and including the allocation of costs provided and the equipment planned to be used (Ridha, 2011) In manual concrete casting work using construction workers, continuous lifting occurs, which will cause injuries and can cause work accidents. Thus, things like this can be avoided and if forced to be done by construction workers, they must meet the ergonomic elements, so that workers can do the job with a sense of security (Berlin & Adams, 2017).

Before the development of science, monumental artifacts or sites were built without having to think about how much money was used, and after civilization and the emergence of philosophies of science and science developed, then monumental and present artifacts or sites were called infrastructure, the development process must use or adhere to the principles of economics and the most famous is called cost estimation or engineering estimation (Heinze, 2017).

In a project activity, construction equipment is a major factor that is of particular concern in budgeting, any detail must be measured in designing the budget, whether it is rented or purchased, if rented, the use will be adjusted to the needs and if purchased, the project does not buy at full price except in a multi-year project (Bartlett, 2014).

Concrete casting is a very important work process, this work must be done properly and correctly, to get high-quality concrete. This is highly recommended by (Neville, 2011). To get high-quality concrete, there are two most important things to do, namely: the first is that all materials must be selected and their composition determined under the quality of concrete to be achieved, the second is how to handle and carry out concrete casting work must be good and right, especially in the process of mixing concrete and transporting it to the place where the concrete will harden. The sequence of the process of mixing concrete is good, all material in the form of cement, aggregate, and water, mixed in a concrete-mixer.

Many concrete casting implementation methods, to determine the choice of concrete casting method depends on the scale of concrete casting or the volume of concrete casting to be worked on (Neville & Brooks, 2010), the choice of equipment to be used must meet the requirements that everything from concrete stirring and transporting concrete to the destination, in conditions fresh concrete and avoid segregation during mixing and transportation. Concrete casting using the hand method is also very necessary if the required volume is only a few cubic meters, only the mixing of concrete using the hand method flows meets the requirements and all must be done very carefully to produce concrete with quality as needed.

Construction project work requires construction equipment, the aim is to facilitate and assist humans in construction work to produce construction work in a relatively shorter time with a relatively very low cost (Rostiyanti, 2008). In every operation of construction equipment, the operator's skill level is needed and what needs to be considered in the use of construction equipment is the power needed, the available power, the power that can be utilized, and the use of construction equipment must be adjusted to the capacity needed. The selection of construction equipment is very necessary and must be adjusted to the capacity of the work, for light work it is necessary to use enough types of construction equipment that are small, for medium and large also adjusted, if not adjusted it will experience waste. Thus, in general, you can use the following equation:

$$Q = \frac{v \times tf \times 60}{1000 \times ct} \qquad (1)$$

where:

Q	=	hourly tool production (m^3/hours)	tf	=	tool efficiency factor
v	=	capacity per cycle m^3	ct	=	cycle time (minutes)

$$D = \frac{i(1+i)^n}{(1+i)^n - 1} \qquad (2)$$

where:

D	=	Depreciation	S	=	Resale value (IDR)
t	=	Total production per year	n	=	Total number of periods
P	=	Annual cash outflows (IDR)	i	=	Discount Rate (%)

$$R = \frac{(L-R)D}{O} \qquad (3)$$

$$I = \frac{2\% \, R}{O} \qquad (4)$$

$$F = (0.125\text{-}0.175)\text{Ltr/HP/Hours} \times P \times Fp \qquad (5)$$

$$Luc = (0.10\text{-}0.20)\text{Ltr/HP/Hours} \times P \times Lp \qquad (6)$$

$$Ws = \frac{(6.25\text{-}8{,}75)L}{O} \qquad (7)$$

$$Sp = \frac{(12.5\text{-}17{,}5)L}{O} \qquad (8)$$

where:

I	=	Insurance and Others	Luc	=	Lubricant
R	=	Return on capital	Ws	=	Workshop
O	=	Operating Hours/year	Sp	=	Sparepart

D	=	Depreciation (Capital factor)	L	=	Local value
F	=	Fuel	P	=	Annual cash outflows (IDR)

Remarks: - (0.125-0.175)Ltr/HP/Hours = Fuel use threshold
- (0.10-0.20)Ltr/HP/Hours = Lubricant use threshold

The approach that will be used to complete productivity and efficiency in mini-cranes, a tool that will be used as a new method in concrete casting, is to use guidelines issued by the Indonesian government in this case issued by the Ministry of Public Works of the Republic of Indonesia namely with the name Price Analysis Guidelines Work Unit (PU-RI, 2013). This guide will be used as a reference. Appropriate Technology in modern times as it is today, is still very much needed for the construction of infrastructure that is useful for human life, especially in small towns, rural areas. And the most important is the coastal areas and small islands (Sunaryo et al., 2019a; Sunaryo et al., 2019b).

Methodology

The method used in this study is the assembly of mini cranes with a capacity of 200 kg, then field or work tests are carried out and accompanied by observations and subsequent data analysis. This approach uses applied research method (Irina, 2017), not using a laboratory, all primary data is taken from the results of measurements in the field when the tool works.

The general description of concrete casting with mini-cranes can practically be explained as follows: 1). Casting work manual way using labour; Casting using manual method or labour is done by transporting it using a bucket and lifted continuously from concrete-mixer to the 2nd floor, 3rd floor or the highest floor then spilled in a wheelbarrow, then the wheelbarrow carries the concrete mixture at foundry, and so on, more can be seen in Figures 1 and 2). Casting work using mini-cranes; Casting by using a mini-crane, concrete-mixer mixtures are poured directly on the wheelbarrow, then the wheelbarrow is lifted using a mini-crane until the 2nd floor, the 3rd floor or the highest floor and then delivered and spilled at the foundry, more can be seen in Figure 2. The performance of the tool in the field is done to retrieve primary data, with the following description: Manual casting work of the number of workers employed in concrete casting, labour wages in accordance with the position of workers working in concrete casting, working hours in a day, how much volume of concrete is produced by the working group.

Casting using mini-cranes, a number of workers used in concrete casting, for mini cranes, cycle-time is taken from the tool or the length of time needed for the mini-crane in one work process.

Figure 1 (a)The concrete casting manual methods, (b) The concrete casting mini-crane methods. Source: Sunaryo

(a) (b)

Figure 2 (a) Motorcycle engine waste (Suzuki Smash), (b) The International CRICU-CUPT Expo. Source: Sunaryo

(a) (b)

The initial data to be taken in this study is that the first wage base price of real direct workers in the field cannot use wages determined by the government, wages are divided into several categories according to the skill level of workers, such as craftsman, skilled labour, and unskilled labour plus again with the operator, each of which has a different wage level. Wage data taken from the field is only available in one day's wages, to make in hours, the wage is divided by the number of hours worked in a day (can be 7 hours and can be 8 hours); the second in this study does not calculate and include the cost of concrete materials, and only the cost of casting concrete. The details are shown in Table 1.

Table 1. Basic Price List. Source: Site data.

No.	Discription	Unit	Basic Price (IDR)		Information
			daily wage (dw)	hourly wage (hw)	
A	Labour				
1	Craftsman	Hours	180,000	25,714	
2	Skilled labour	Hours	150,000	21,429	
3	Unskilled labour	Hours	130,000	18,571	
4	Operator	Hours	200,000	28,571	
B	Materials				Effective working hours = 7 hours/day
1	Gasoline	Liters	10,000		
2	Diesel	Liters	10,000		$hw=\frac{dw}{7\ hours/day}$
3	Lubricant	Liters	50,000		

Equipment rental value. Based on the results of the mini-crane performance and manual method on concrete casting work, and primary data measurement and retrieval has been carried out, then the productivity analysis and coefficients are carried out. However, only the 5th-floor manual method and the 5th-floor mini-crane method are displayed Then it will be obtained as an analysis of equipment rental value by taking from Table 1 processed and will produce processed data as in Table 2.

Table 2. Analysis of equipment rental value. Source: Own elaboration.

No.	Discription	Code	Analysis of equipment rental value			Unit	Information
			Mini-crane	Concrete-mixer	Concrete-vibrator		
A.	General						
1	Power	Pw	10	7	5	HP	
2	Capacity	C	30	200	2	liter	$D=\frac{i(1+i)^n)}{(1+i)^n-1}$
3	Economics period	n	5	5	5	Year	
4	Operating Hours/year	O	2,000	2,000	2,000	hours	
5	Local value	L	25,000,000	12,000,000	7,000,000	IDR	$R=\frac{(L-R)D}{O}$
6	Discount rate	i	10	10	10	%/Year	
7	Tax	T	10	10	10	%	$I=\frac{2\%R}{O}$
8	Fuel prices	Fp	10,000	10,000	10,000	IDR	
9	Lubricant prices	Lp	50,000	50,000	50,000	IDR	
10	Operator		28,571	28,571	28,571	IDR/hours	F = (0.125-0.175)Ltr/HP/ Hoursx Pw x Fp
B.	Direct Cost						
1	Residual value 10%.Lp	R	2,500,000	1,200,000	700,000	IDR	Luc=(0.10-0.20)Ltr/HP/Hours x Pw x Lp
2	Depreciation (Capital factor)	D	0.264	0.264	0.264	-	
3	Direct cost:						
a	Return on capital	R	2,968	1,425	831	IDR	
b	Insurance and Others	I	25	12	7	IDR	
	Subtotal (B)	G	2,993	1,437	838	IDR	$Ws=\frac{(6.25-8.75)}{O}$
C.	Indirect Cost						
1	Fuel	F	15,000	10,500	7,500	IDR	
2	Lubricant	Luc	7,500	5,250	3,750	IDR	$Sp=\frac{(12.5-17.5)}{O}$
3	Workshop	Ws	938	450	263	IDR	
4	Sparepart	Sp	1,875	900	525	IDR	
5	Operator		28,571	28,571	28,571	IDR	
	Subtotal (C)		53,884	45,671	40,609	IDR	
D.	TOTAL	To	56,877	47,108	41,447	IDR	
		Tx	5,688	4,711	4,145	IDR	Tx = T/100 X To
		Total	62,564	51,819	45,592	IDR	

Based on the analysis of Table 2, the mini-crane rental value of IDR62,564 is obtained, the value of the concrete-mixer rental is IDR51,819 and the concrete-vibrator rental value is IDR45,592. These three values are the second variable of this study and the first variable in table 1 is about the basic price.

Manual method. The productivity analysis and coefficient casting manual method are to calculate productivity as the third variable and the coefficient as the fourth variable, will be explained as in Table 3.

Table 3. Productivity and coefficient manual methods . Source: Own elaboration

No.	Discription	Code	Productivity and coefficient				Unit	Information
			2nd floor	3rd floor	4th floor	5th floor		
A	Concrete-mixer							
1	Transport capacity	V	200	200	200	200	liter	CT = Ct1+Ct2……Ctn
2	Efficiency Factor	Ef	0.85	0.85	0.85	0.85	-	
4	Human Factor	H	1.00	1.00	1.00	1.00	-	
5	Cycle time	CT	10.00	10.00	10.00	10.00		
	- Loading	Ct1	5.00	5.00	5.00	5.00	minute	$Q=\frac{V \times Ef \times H \times 60}{CTx1000}$
	- Mixing	Ct2	3.00	3.00	3.00	3.00	minute	
	- Unloading	Ct3	1.00	1.00	1.00	1.00	minute	
	- Manuver, etc	Ct4	1.00	1.00	1.00	1.00	minute	
6	Production Capacity	Q1	1.02	1.02	1.02	1.02	m^3/hours	$Co1 = \frac{1}{Q}$
7	Coefficient for 1 unit	Co1	0.9804	0.9804	0.9804	0.9804	hours/m^3	
8	Coefficient for 2 unit	Co2	1.9608	1.9608	1.9608	1.9608	hours/m^3	
B	Concrete-Vibrator							
1	Transport capacity	V	200	200	200	200	liter	
2	Efficiency Factor	Ef	0.85	0.85	0.85	0.85	-	Co2 = Co1 x Unit
4	Human Factor	H	1.00	1.00	1.00	1.00	-	
5	Cycle time	CT	5.00	5.00	5.00	5.00		
	- Vibrating	Ct1	3.00	3.00	3.00	3.00	minute	
	- Manuver, etc	Ct4	2.00	2.00	2.00	2.00	minute	
6	Production Capacity	Q2	2.04	2.04	2.04	2.04	m^3/hours	
7	Coefficient	Co	0.4902	0.4902	0.4902	0.4902	hours/m^3	
D	Labour							
1	Production	P	16.32	16.32	16.32	16.32		P = 8 hour x Q1 x 2 Unit
2	Craftsman	t	10	10	10	10	men	
3	Skilled labour	s	30	40	40	40	men	$ct=\frac{8 \text{ hours x t}}{P}$
4	Unskilled labour	u	10	21	43	65	men	
5	Coefficient labour/m^3:							$cs=\frac{8 \text{ hours x s}}{P}$
	- Craftsman	ct	4.90	4.90	4.90	4.90	hours/m^3	
	- Skilled labour	cs	14.71	19.61	19.61	19.61	hours/m^3	$cu=\frac{8 \text{ hours x u}}{P}$
	- Unskilled labour	cu	4.90	10.29	21.08	31.86	hours/m^3	

Based on Table 3, the coefficient values obtained are as follows: for the second floor is concrete mixer 1.9608 hours/m^3, concrete vibrator 0.4902 hours/m^3, craftsman 4.90 hours/m^3, skilled labour 19.61 hours/m^3, and unskilled labour 31.86 hours/m^3. And then until the 5th floor.

Mini-crane method. The productivity analysis and coefficient casting mini-crane method are to calculate productivity as the third variable and the coefficient as the fourth variable, will be explained as in Table 4.

Table 4. Productivity and coefficient mini-crane methods. Source: Own elaboration.

No.	Discription	Code	Productivity and coefficient				Unit	Information
			2nd floor	3rd floor	4th floor	5th floor		
A	Concrete-mixer							
1	Transport capacity	V	200.0	200.0	200.0	200.0	liter	CT = Ct1+Ct2……Ctn
2	Efficiency Factor	Ef	0.85	0.85	0.85	0.85	-	
4	Human Factor	H	1.00	1.00	1.00	1.00	-	$Q=\frac{V \times Ef \times H \times 60}{CTx1000}$
5	Cycle time	CT	10.00	10.00	10.00	10.00		
	- Loading	Ct1	5.00	5.00	5.00	5.00	minute	
	- Mixing	Ct2	3.00	3.00	3.00	3.00	minute	
	- Unloading	Ct3	1.00	1.00	1.00	1.00	minute	
	- Manuver, etc	Ct4	1.00	1.00	1.00	1.00	minute	$Co1=\frac{1}{Q}$
6	Production Capacity	Q1	1.02	1.02	1.02	1.02	m^3/hours	
7	Coefficient	Co	0.9804	0.9804	0.9804	0.9804	hours/m^3	
8	Coefficient for 2 unit	Co2	1.9608	1.9608	1.9608	1.9608	hours/m^3	
B	Concrete-Vibrator							Co2=Co1 x 2 Unit
1	Transport capacity	V	200.0	200.0	200.0	200.0	liter	
2	Efficiency Factor	Ef	0.85	0.85	0.85	0.85	-	
4	Human Factor	H	1.00	1.00	1.00	1.00	-	
5	Cycle time	CT	5.00	5.00	5.00	5.00		
	- Vibrating	Ct1	3.00	3.00	3.00	3.00	minute	
	- Manuver, etc	Ct4	2.00	2.00	2.00	2.00	minute	

6	Production Capacity	Q2	2.04	2.04	2.04	2.04	m^3/hours	
7	Coefficient	Co	0.4902	0.4902	0.4902	0.4902	hours/m^3	
C	Mini-crane							
1	Transport capacity	V	0.03	0.03	0.03	0.03	m^3	
2	Efficiency Factor	Ef	0.95	0.95	0.95	0.95	-	
4	Human Factor	H	1.00	1.00	1.00	1.00	-	
5	Material Factor	M	0.95	0.95	0.95	0.95	-	
6	Cycle time	CT	5.00	6.00	7.00	8.00		
	- Loading	Ct1	1.00	1.00	1.00	1.00	minute	
	- Lift Up	Ct2	2.00	3.00	4.00	5.00	minute	
	- Unloading	Ct3	1.00	1.00	1.00	1.00	minute	
	- Manuver, etc	Ct4	1.00	1.00	1.00	1.00	minute	
7	Production Capacity	Q3	0.32	0.27	0.23	0.20	m^3/hours	
8	Coefficient	Co	3.0779	3.6934	4.3090	4.9246	hours/m^3	
C	Labour							
1	Production	P	16.32	16.32	16.32	16.32		P = 8 hour x Q1 x 2 Unit
2	Craftsman	t	3	3	3	3	men	$ct=\frac{8 \text{ hours x } t}{P}$
3	Skilled labour	s	10	10	10	10	men	
4	Unskilled labour	u	12	12	12	12	men	$cs=\frac{8 \text{ hours x } s}{P}$
5	Coefficient labour/m^3:							
	- Craftsman	ct	1.47	1.47	1.47	1.47	hours/m^3	$cu=\frac{8 \text{ hours x } u}{P}$
	- Skilled labour	cs	4.90	4.90	4.90	4.90	hours/m^3	
	- Unskilled labour	cu	5.88	5.88	5.88	5.88	hours/m^3	

Based on Table 2, the coefficient values obtained are as follows: for the second floor is concrete mixer 1.9608 hours/m^3, concrete vibrator 0.4902 hours/m^3, mini-crane 4.92 hours/m^3, craftsman 1.47 hours/m^3, skilled labour 4.90 hours/m^3, and unskilled labour 5.88 hours/m^3. And then until the 5th floor.

Bill of quantity manual method. Analysis of bill of quantity is the final result based on the four variables above, will be explained as in Table 5.

Table 5. Bill of quantity manual methods. Source: Own elaboration.

No.	Discription	Unit	Unit Price (IDR)	Bill of Quantity (per m^3)							
				2nd floor		3rd floor		4th floor		5th floor	
				coef.	Total (IDR)	coef.	Total (IDR)	coef.	Total (IDR)	coef.	Total (IDR)
A	Labour										
1	Craftsman	Hours	25,714.29	4.90	126,000.00	4.90	126,000.00	4.90	126,000.00	4.90	126,000.00
2	Skilled labour	Hours	21,428.57	14.71	315,214.29	19.61	420,214.29	19.61	420,214.29	19.61	420,214.29
3	Unskilled labour	Hours	18,571.43	4.90	91,000.00	10.29	91,100.00	21.08	391,485.71	31.86	591,685.71
B	Equipment										
1	Concrete-mixer	Hours	51,818.73	1.96	101,605.35	1.96	101,605.35	1.96	101,605.35	1.96	101,605.35
2	Concrete-vibrator	Hours	5,591.58	0.49	22,348.81	0.49	22,348.81	0.49	22,348.81	0.49	22,348.81
	Unit Price per m^3				656,168.45		861,268.45		1,061,654.16		1,261,854.16

Based on Table 5, the final result of the casting manual method for the 2nd floor is obtained by IDR656,168.45, 3rd floor is obtained by IDR861,268.45, 4th floor is obtained by IDR1,061,654.16 and 5th obtained by IDR1,261,854.16.

Bill of quantity mini-cranes method. Analysis of bill of quantity is the final result based on the four variables above, will be explained as in Table 6.

Table 6. Bill of quantity mini-crane methods. Source: Own elaboration.

No.	Discription	Unit	Unit Price (IDR)	Bill of Quantity (per m^3)							
				2nd floor		3rd floor		4th floor		5th floor	
				coef.	Total (IDR)	coef.	Total (IDR)	coef.	Total (IDR)	coef.	Total (IDR)
A	Labour										
1	Craftsman	Hours	25,714.29	1.47	37,800.00	1.47	37,800.00	1.47	37,800.00	1.47	37,800.00
2	Skilled labour	Hours	21,428.57	4.90	105,000.00	4.90	105,000.00	4.90	105,000.00	4.90	105,000.00
3	Unskilled labour	Hours	18,571.43	5.88	109,200.00	5.88	109,200.00	5.88	109,200.00	5.88	109,200.00
B	Equipment										
1	Concrete-mixer	Hours	51,818.73	1.96	101,605.35	1.96	101,605.35	1.96	101,605.35	1.96	101,605.35
2	Concrete-vibrator	Hours	45,591.58	0.49	22,348.81	0.49	22,348.81	0.49	22,348.81	0.49	22,348.81
3	Mini-crane	Hours	62,564.32	3.0779	192,564.84	3.69	231,077.80	4.31	269,590.77	4.92	308,103.74
	Unit Price per m^3				568,519.00		607,031.97		645,544.93		684,057.90

Based on Table 6, the final result of the casting mini-crane method for the 2nd floor is obtained by IDR568,519.00, 3rd floor is obtained by IDR607,031.97, 4th floor is obtained by IDR645,544.93 and 5th floor is obtained by IDR684,057.90.

Bill of quantities analysis. Based on the results of observations and data processing, it is obtained in terms of the height of concrete casting to be lifted into four parts, namely concrete casting on the 2nd, 3rd, 4th and 5th floors, to obtain a difference in unit price per cubic meter based on height. While based on the way it works is divided into two parts,

namely by manually using workers to lift the concrete mixture to the 2nd, 3rd, 4th and 5th floors. While the next method is to use a mini crane to lift the concrete mixture to the 2nd, 3rd, 4th and 5th floors so that the difference is the concrete unit wage price per cubic meter based on the length of work.

Mini-cranes Specifications. These mini cranes use the principle of appropriate technology, all materials or materials used to make them are taken from scrap metal waste, that is the difference with those offered on the market, can be made and repaired by youth or people in small islands because the main engine uses motorcycle waste. These mini-cranes are sufficiently introduced to the community and given an understanding and information that according to the analysis and calculation greatly benefits the community, they will make it individually or in groups, this is because infrastructure development is experiencing a shortage of construction workers.

The type of mini-crane based on its shape including the type of tower crane is only in mini size, with the following description: Main tower made of elbow iron size 40.40.4 mm with a height of 3 meters and can be added up to 6 meters; The arm as a load bearer can maneuver left and right to be driven mechanically controlled using the steering wheel; The foundation consists of 3 left, right and back sides, this foundation does not need to be planted just put and given an anchor.

Types of mini cranes in terms of how they work, including manual or mechanical types with descriptions as follows: Hoist line cable uses a 4 mm diameter size approximately the size of a mineral water straw, rolled using the waste of the front wheel of the Toyota Kijang which is connected directly to the Suzuki Smash dirty bicycle waste engine using a new motorcycle chain. On hoist-line-cable rolls are equipped with disc brakes using a hydraulic system that serves to hold the load when swinging or maneuvering; When the throttle pedal is pressed with the right foot, it will automatically roll the hoist-line-cable will rotate, meaning lifting the load, this system uses the working principle of the centrifugal clutch that is owned inside the motorbike; To stop the hoist-line-cable roll just stop pressing the throttle pedal; To hold so that the hoist-line-cable roll can hold the load just step on the brake pedal with the left foot; To rotate the arm so that the load can be lowered on the top floor simply turn the steering wheel left or right; To lower the load off the brake pedal slowly on the top floor; And so on.

The specifications of the mini crane are as follows: (a) Making: self-assembled; (b) Main tower height: 4 meters and Arm length: 2 meters; (c) Hoist line cable diameter: 4 mm; (e) Engine volume: 110 cc (Suzuki Smash waste); (f) Engine start: electric starter; (g) Fuel consumption: 3 liters/day; (h) Lifting capacity: 200 kg; (i) Slewing Bearing: front wheel (the Toyota Kijang waste); (j) Brakes: Hydraulic discs (the Toyota Kijang front wheel waste).

How mini-cranes work. (a) The concrete mixture that has been made is immediately poured into the arco cart; (b) Arco carts containing concrete mixers pushed into a mini-crane basket then lifted to the second floor and so on; (c) When the arco cart is pulled up or removed and the basket is replaced with an empty arco cart to be lowered; (d) Then spilled on the prepared concrete mall; (e) Stir the concrete spilled from the closer and the farthest ends. This method is very good when the concrete becomes solid, the arco cart runs on the board, when the trail ends, don't forget to level it.

Summary of Values. Based on the results of the Productivity analysis and efficiency of concrete casting using mini-cranes with a capacity of 200 kg based on Appropriate Technology, concluded as the final result in Table 7.

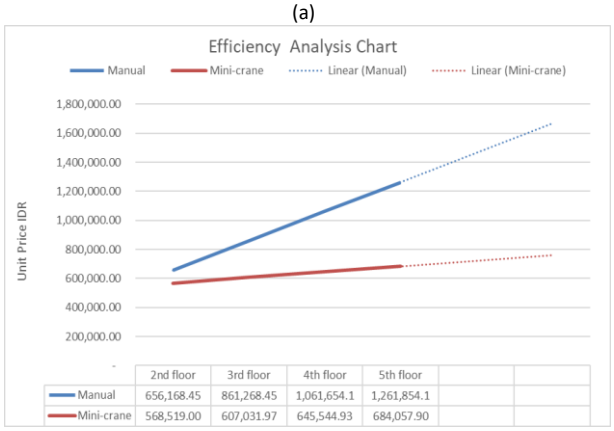
Table 7. Summary Of Value. Source: Own elaboration.

No.	Discription	Unit Price (IDR)		Efficiency value (IDR)	Efficiency value (%)	Information
		Manual	Mini-crane			
1	2nd floor	656,168.45	568,519.00	87,649.45	13.36	
2	3rd floor	861,268.45	607,031.97	254,236.48	29.52	
3	4th floor	1,061,654.16	645,544.93	416,109.23	39.19	
4	5th floor	1,261,854.16	684,057.90	577,796.26	45.79	
	Total	3,840,945.23	2,505,153.80	1,335,791.42	34.78	

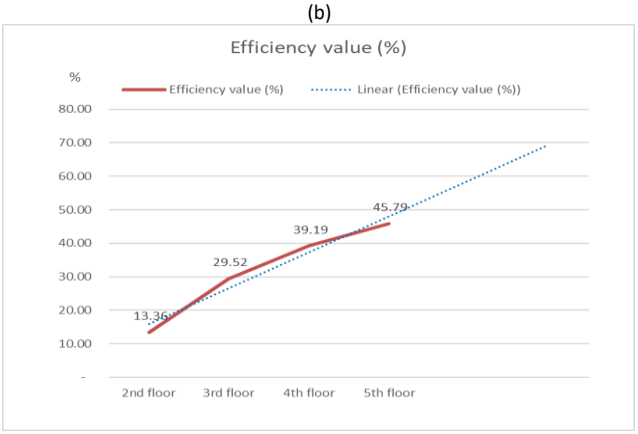
Based on Table 7 on the 2nd floor concrete casting occurs 13.36% cheaper using the mini-crane method, on the 3rd floor occurs 29.52% cheaper using the mini-crane method, on the 4th floor occurs 39.19% cheaper using the mini-crane method and on the 5th floor 45.79% occurs cheaper using the mini-crane method. However, cumulatively there is 34.78% if seen it seems a decline, but in reality, this happens because it is cumulatively divided equally. Thus the overall efficiency of concrete casting using mini-cranes is more efficient or cheaper by 34.78% compared to concrete casting with manual methods. In Figure 3 (a) is a graph of efficiency analysis made based on Table 7 and accidentally and incidentally, the two graph lines are very perfect trend resembling and identical to the linear forecast line. It is different in Figure 3 (b) where the graph formed by the trend does not follow the linear forecast line, so the trend that occurs is a random trend.

Figure 3 (a) Efficiency Analysis Chart, (b) Efficiency value (%). Source: Own elaboration.

(a)



(b)



The new idea of this research, first is that this mini-crane is made of scrap metal waste, the second is a concrete casting method that lifts the arco cart containing concrete from the concrete-mixer is lifted using a mini-crane and spilled at the destination, the third is able to cast concrete on the 5th floor at a price of IDR684,057.90/m^3.

Research limitations and suggestions for further research. Especially in the graph analysis in Figure 5, which is made from Table 7, why do two lines resemble or are identical to the linear forecast line, we are not the research team as our capacity, we are enough to find efficiency values only. If anyone would like to discuss it please, we are open and happy to be able to find out.

Further research suggestions and creative ideas. How the feasibility of ready-mix is established in small islands or cities in eastern Indonesia and other countries that are still lagging behind: (a) Design of mini-cranes using 3 phase electricity compared to 1 phase (Manual and full hydraulic); (b)Design of mini-cranes based on Arduino Uno servo motors (Robotic, Remote control and Automation or without operators); (c) Design of mini-cranes using a 7 HP diesel engine (Manual and full hydraulic); (d) Design of a mini crane using a steam engine made from coconut shell fuel; (e) Design of mini-cranes using solar cell; (f) Design of mini-cranes using a portable Honda engine (starter coil or pull) compared to a motorcycle engine waste; (g) Design of mini-cranes using 200cc engines of Honda Tiger motorcycle waste; (h) Design mini-cranes directly on the wheels of the motorcycle; (i) Design mini cranes directly on the wheels of the car; (j) The effect of the density of concrete due to spilling is spilled from the closer and the most distant ends. The last series to advance our Indonesian nation as a young generation must be innovative and creative, not consumptive.

Conclusions

Based on the results and discussion, it can be concluded as follows: The overall efficiency value is 34.56% more profitable using the mini-crane method than the manual method. Based on the results of the study, for small-scale concrete casting, the use of small-scale equipment is highly recommended, especially equipment based on Appropriate Technology, this type of equipment is still very much needed for the construction and development of infrastructure in small islands.

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