VOLUME 4 | NUMBER 3 | MAY 2022
Available online at http://proceedings.worldconference.id.
ISSN: 2656-1174 (online)

Analysis of The Implementation of The Excavation Work of Blasting Stone in The Quarry For Rockfill Pile of The Beringin Sila Dam Construction Work Project Package-1 Sumbawa Regency, NTB.

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Abstract

Embankment dams based on the grain size of the embankment material used are divided into 2 types, namely rock filled dams and earth fill dams. The Beringin Sila Dam is a random and rock fill dam with an upright core which is in the process of being built by stockpiling materials such as stone, gravel, clay, and soil. Blasting is an activity of breaking up a material (rock) using explosives or the process of an explosion, in blasting one of the important things that must be considered is the fragmentation of rock resulting from blasting.

The method is carried out by observing the realization in the field and analyzing project data. The purpose of this study was to determine the productivity of heavy equipment, to analyze the realization costs of excavation and heap of blasted rock at the quarry location.

The results of this study indicate that the productivity of drilling tools for drilling tools, with the Crawler Rock Drill (CRD) tool, it gets 5 holes/hour, while with the Hydraulic Crawler Drill (HCR) it gets 4 holes/hour. Productivity of loading and unloading equipment on excavation work and blasting heaps of rock at the quarry location, with an average of 25 units of transportation equipment and 4 units of CAT 330 excavator as loading equipment. For loading equipment, the production yield is 41.40 m3/hour, while for transportation equipment the production yield is 6.62 m3/hour. The realization cost for excavation work and rock heap from blasting at the quarry location in July – September required a cost of Rp.11,124,373,500.00 including the cost of wages, materials, and tools.

Keywords:
Blasting, Cost Analysis, Heavy Equipment, Time Analysis, Work Efficiency.

1. Introduction

Infrastructure development in the city of Sumbawa Besar is growing along with the increase in the human population and technological advances.The construction of the Beringin Sila dam will provide many benefits for the surrounding community, including providing irrigation for existing 2400 ha and developing 1100 ha, providing 6 liters of raw water, 1 x 1400 kw of electricity, and the ability to reduce flooding by 90.37 m/sec.

Embankment dams based on the grain size of the embankment material used are divided into 2 types, namely rock-fill dams and earth-fill dams (Suyono Sosrodarsono 1981). The Beringin Sila Dam is a random and rock fill dam with an upright core. There are 6 zones within the main body of the Beringin Sila Dam, namely: waterproof core, fine filter, coarse filter, random, rockfill, and rip-rap.

The purpose of research on the Beringin Sila Dam Project is generally to evaluate the results of blasting and productivity of drilling tools for rockfill excavation work, evaluate blasting results as well as the productivity of transport and loading equipment in rockfill rockfill work, analyze the realization costs that exist in excavation work and stockpiled rock results. blasting at the quarry location, and knowing the technical and non-technical constraints that occur during the execution of work at the quarry location.

2. Methodology

Broadly speaking, the stages of this research are contained in the flow chart in the figure below:

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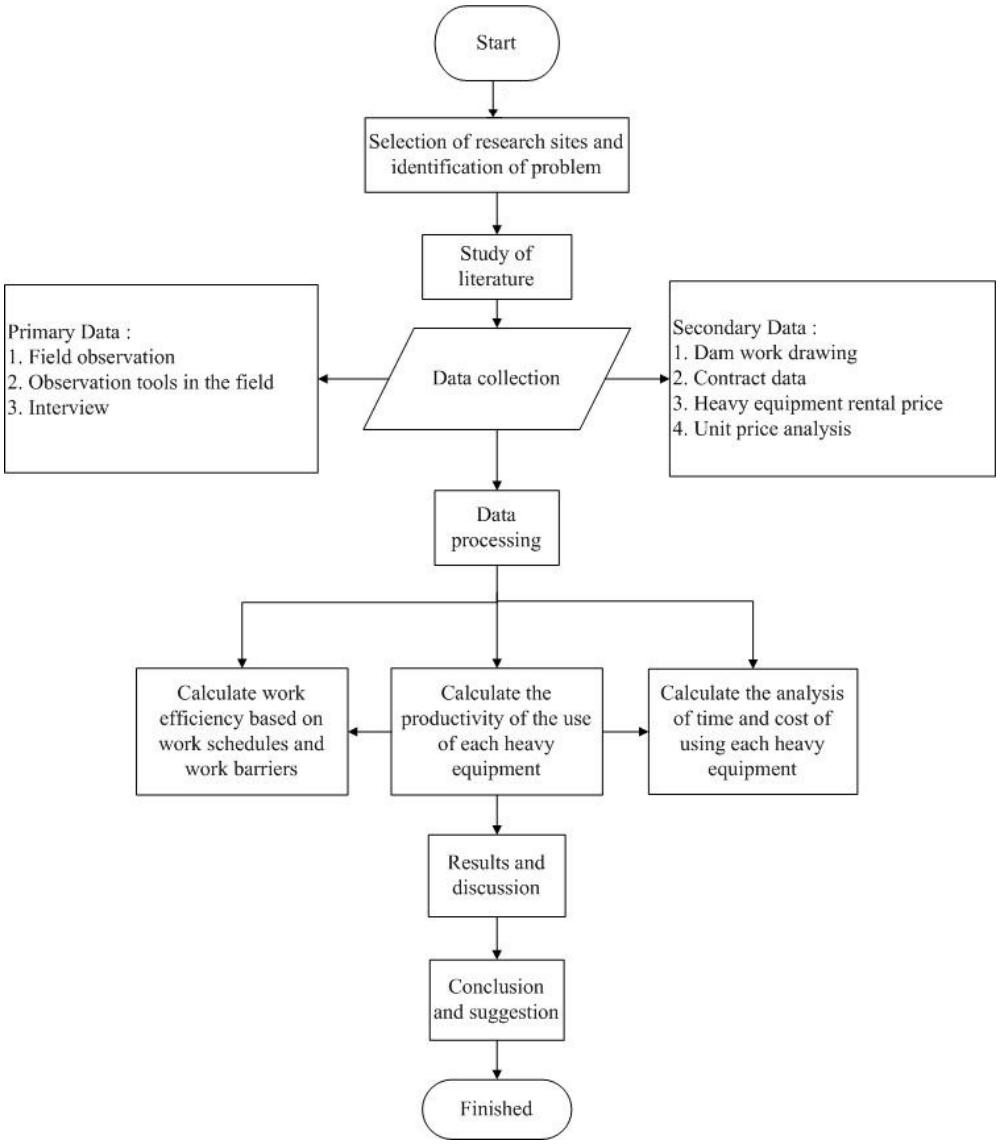

Figure 1. Research flowchart

3. Results and Discussion

3.1 Results

A. Work Efficiency

Work efficiency is the ratio between effective working hours and available working hours. Effective working hours are the number of working hours that are actually used for production activities. Effective working time can be calculated using the following formula:

$$\mathbf{We = Wt - (Wd + Wtd)}$$

Description :

We = effective working time
Wt = working time available
Wd = Total idle time
Wtd = total delay time

After obtaining the value of effective working time (We) then we can calculate the value of its work efficiency by using the following formula:

$$Work\ Efficiency = \frac{effective\ working\ time}{\text{working time available}} \text{ x } 100\%$$

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Table 1. Work Schedule for the Beringin Sila Construction Project Please

Work schedule	Description	Time (Hour)
08:00 - 12:00	Working time	4
12:00-13:00	Time off	1
13:00-17:00	Working time	4
17:00-18:00	Overtime	1
Total		9

On Friday, the lunch break starts from 11.30 – 13.30 so that the working hours are reduced to 8 hours. The average effective working hours will be:

= (9 * 6)hours/week + (8 * 1)hours/week
7days/week
= 8.86 hours
= 531.43 minutes

Table 2. Work Obstacles In Loading Equipment And Transport Equipment

Resistance		CAT-330 excavator (minutes/day)	Dump Truck (minutes/day)	Hydraulic Crawler Drill (minutes/day)
Suppressible barriers	Late start of shift	10	15	10
	Operator requirements	10	10	10
Total		20	25	20
Daily check by operator		10	10	10
Total		10	10	10
		30	35	30

B. Rock excavation work using the blasting method

Rock excavation work activities using the blasting method include blast hole drilling, charging, blasting and hauling blast results. Each activity requires a duration of time. To determine the time efficiency of rock excavation work using the blasting method in rock excavation work on the Beringin Sila construction project, please describe the analysis of the duration of time required for rock excavation work in the quarry area.

C. Loading Equipment Work Efficiency

Productive working time is the available working time in one day minus the amount of non-productive time.

Wke = Wkt –wht
=531.43 minutes – 30 minutes
= 501.43 minutes

So that the work efficiency of the loading tool can be calculated, namely:

Eff = (Productive working time / Available working time) x 100%
= (501.43 / 531,43) x 100 %
= 94.35%

D. Transport Equipment Work Efficiency

Productive working time is the available working time in one day minus the amount of non-productive time.

Wke = Wkt – Wht
= 531.43 minutes – 35 minutes
= 496.43 minutes

So that the work efficiency of the conveyance can be calculated, namely:

Eff = (Productive working time / Available working time) x 100%
= (496.43 / 531.43) x 100 %
= 93.41%

E. Loader Productivity

Calculation of the cycle time of mechanical devices is carried out by paying attention to the movement patterns of mechanical devices when carrying out their activities. The cycle time of loading equipment using the CAT 330D Excavator is the amount of time spent in one work series starting from taking the digging position until it is empty again to dig again.

The cycle time of loading equipment can be formulated as follows:

$$CT_m = \frac{Tm1 + Tm2 + Tm3 + Tm4}{60}$$

Description :
CTm = Cycle time / total cycle time of loading tools
Tm1 = time to fillpayload
Tm2 = time forswing charged
Tm3 = time forspill the load
Tm4 = time to swingblank
The calculation for the production of one loading tool is:
Qm = Nm(60/Ct) x Cm x F x sf xE, BCM/hour
Description :
Qm = Production capability of loading equipment (BCM/hour)
Nm = Number of tools (Unit)
Ct = Cycle time of loading equipment once loading (minutes)
cm = Standard capacity of loading tool bowl (m^3)
F = Fill factor (%)
E = work efficiency (%)
sf= *Swell factor*
Based on the data from the measurements in the field:
CAT 330D . Excavator Production
CTm = 1.47 minutes
Cam = 1.54 m3
F = 0.8
E = 94.35%
sf= 1.00
Nm = 1 Unit
Qtm = 47.33 m3/hour

So one loading tool with a bucket capacity of 1.54 m3 with a work efficiency of 94.35% can be produced at 47.33 m3/hour, while the production of loading equipment during the author's observations from September 2 to November 30 2019 on average production per hour is 41.40 m3/hour. The unit price in the RBP itself is for rock excavation work items with an hourly target blasting of 49.15 m3/hour. With the existing data, the target for the realization of the loading equipment has not yet reached the production target of the RBP unit price (Rachmayanti 2017).

F. Transport Equipment Productivity

The calculation of the cycle time of transportation means generally consists of the following time:
Time to set the position for loading
Time to charge
Time to transport cargo
Time to set the position to shed the load
Time to spill the load
Time to return to fill in the empty state
Cycle time for transportation means can be formulated as follows:
Cta = Ta1+Ta2 Ta3+Ta4 +Ta5 +Ta6
Description :
CTa = Total time of transportation means
Ta1 = Time to set the position to be charged
Ta2 = Time to charge
Ta3 = Time to transport the load
Ta4 = Time to set the position to shed the load
ta5 = Time to shed charge
ta6 = Time to return to be filled in an empty state
Calculations for the production of conveyances:

Qa = Na (60/Ct) x Ca x sf x E , m3/hour
Description :
Q= Production capability of conveyance (m3/hour)
Na = Number of conveyances (units)
Ct = transportation time (minutes)
Ca = The capacity of the conveyance body (m3)
= nx Cam x F
n = Number of loading equipment buckets to fill the conveyance tub
Cam = Loading tool bowl capacity (m3)
F = Fill factor (%)
E = work efficiency (%)
sf= Swell factor
Based on the data from the measurements in the field:
Production of One Dump Truck Transport Equipment:

Cam	= 1.54 m3
N	= 5 Times
Fill Factor (F)	= 0.8
Tub capacity	= 6.16 m3
Swell factor	= 1
Work efficiency	= 93.41%
Total circulation time HD 465	= 36.95 minutes
Na	= 1 unit
Qta	= 9.35 m3/hour

The average loading capacity of a dump truck is 6.16 m3 with a work efficiency of 93.41%, the production is 9.35 m3/hour with an average circulation time of 36.95 minutes, while the realization of the production of one tool Transport during the author's observation from July 8 to September 30, 2021, the average production per hour is 6.62 m3/hour. For the unit price in the RBP itself, the item for the work of heaping stones with an hourly target of blasting is 15.92 m3/hour (Suryaputra 2009). With the existing data, the target for the realization of the transportation equipment has not yet reached the production target of the RBP unit price.(Lexy J. Moleong 2018)

G. Tool Work Alignment Factor

The factor of compatibility of loading equipment with transportation means can be calculated by the formula:

$$MF = \frac{Na \text{ x } CtL}{Nm \text{ x } CTa}$$

Na = Number of conveyances, unit
CtL = Circular time of loading tool to full, minutes
Nm = Number of loading tools, unit
Cta = Circular time of the conveyance, minutes
The work combinations between loading equipment and transportation equipment at the Quarry are:
Na = 25 units
Nm = 4 units
CtL = 7.37 minutes
CTa = 36.93 minutes
MF = (25 x 7.37) / (4 x 36.93) = 1.247

MF > 1 , it means that the loading equipment works 100%, while the transportation equipment works less than 100%, so there is a waiting time for the transportation equipment, this is because the production of the transportation equipment is greater than the production of the loading equipment so there is a condition that the loading equipment is busy in loading and unloading. the loading process while the conveyance is more waiting, so there is a waiting time for the conveyance as follows:

$$MF = \frac{Na \text{ x n x } CTm}{Nm \text{ x } CTa} \rightarrow Nm \text{ x } CTa \rightarrow Na \text{ x n x } CTm$$

$$\frac{Nm \text{ x } CTa}{Na} \triangleright CTm \text{ x n} \rightarrow CTm \text{ x n} \triangleleft \frac{Nm \text{ x } CTa}{Na}$$

From these equations after being equated because there is a lack of time, then added with WTm, the following equation is obtained:

$$WTm + (\text{CTm x n}) = \frac{Nm \text{ x CTa}}{Na}$$

So the waiting time for the conveyance:

$$WTm = (\text{CTm x n}) - \frac{Nm \text{ x CTa}}{Na}$$

$$= (1{,}47 \text{ x } 5) - \frac{4 \text{ x } 36{,}93}{25}$$

= 1,459 minutes

3.2 Discussion

A. Cost Analysis of Excavation and Pile of Blasting Stone

Evaluation of the cost of excavation and embankment work by comparing the realized operational costs (direct costs) with the planned costs in the RBP derived from unit prices. The unit price of work is needed to compare the actual and planned prices so that it is known whether the excavation and embankment work is profitable or detrimental (Nugraha 2018).

Operational costs are sourced from the analysis of blasting excavation work and downstream and upstream maindam rock piles in the field for 3 months. The unit price of work consists of:

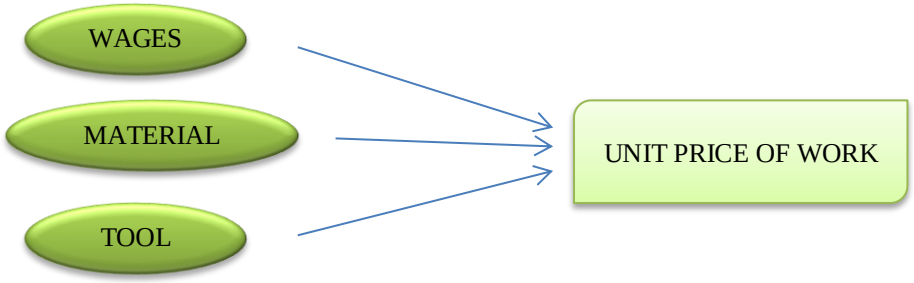

Figure 2. Work Unit Price Scheme

From the total cost of equipment consisting of equipment rental hours, fuel consumption and daily wage costs for the blasting pile work operator, it can be concluded in the following table:

Table 3. The total cost of the blasting pile tool

Month	Equipment Rental Fee (Rp)	Fuel Cost (Rp)	Operator Wage (Rp)	Total (Rp)
July	1,896,165,000	594,737,000	62,930,000	2,553,832,000
August	2,223,090,000	615,901,000	69,420,000	2,908,411,000
September	2,121,380,000	616,352,000	67,750,000	2,805,482,000

The total cost for the realization of excavated work items and blasted piles at the quarry location consists of the above costs, namely wages, materials and tools. The following table shows the actual cost of the embankment during the field observation period, which is approximately 3 months (Koesnaryo 1988).

Table 4. The total direct cost of the realization of the blasted stone heap

Month	Wages (Rp)	Materials (Rp)	Tools (Rp)	Total (Rp)
July	12,168,000	0.00	2,553,832,000	2,566,000,000
August	12,168,000	0.00	2,908,411,000	2,920,579,000
September	12,168,000	0.00	2,805,482,000	2,817,650,000
		Total		8,304,229,000

The total cost for the realization of the blasted rock pile for 3 months is Rp.8,304,229,000.

B. Analysis of Direct Costs of Excavation and Pile of Rock Based on RBP

The operational costs of a job on the project refer to the RBP costs, where the actual costs in the field will be compared with the RBP costs. The analysis of the cost of excavation and stockpiling of RBP is the

product of the unit price in the RBP with the realization of production of excavation and rock heap in the field during the 3-month observation period (I 2018).

Table 5. Direct cost analysis of blasted rock excavation based on RBP

Month	Volume (m3)	Wages (Rp)	Materials (Rp)	Tools (Rp)	Total (Rp)
July	47162.5	209,825,963	354,520,513	1,108,790,375	1,673,184,013
August	71032.5	316,023,593	533,951,303	1,669,974,075	2,520,020,003
September	57915	257,663,835	435,347,055	1,361,581,650	2,054,650,455
			Total		6,247,854,470

Table 6. Analysis of direct cost of blasted heap based on RBP

Month	Volume (m3)	Wages (Rp)	Materials (Rp)	Tools (Rp)	Total (Rp)
July	17124.80	10,274,880	-	718,094,238	728,386,243
August	55316.80	33,190,080	-	2,319,599,374	2,352,844,771
September	57207.92	34,324,752	-	2,398,899,709	2,433,281,669
			Total		5,514,512,684

C. Comparison of Excavation and Rock Pile Costs Based on RBP and Resolution

Calculation of the direct costs of excavation and rock heap from the quarry based on the realization of the author's observations can be compared with direct costs with the unit price of work from the RBP price. The following table shows the total direct cost of excavation and rock embankment based on realization and RBP (Fathoni 2015).

Table 7. Total direct cost of excavation and rock filling based on realization

Month	Wages (Rp)	Materials (Rp)	Tools (Rp)	Total (Rp)
July	56.5600.00	104,279,0000.00	3,282,149,000.00	3,442,988,000.00
August	56.5600.00	150,525,500.00	3,716,613,000.00	3,923,698,500.00
September	56.5600.00	106,861,000.00	3,594,266,000.00	3,757,687,000.00
		Total		11,124,373,500.00

Table 8. Total direct cost of excavation and stockpiling based on RBP

Month	Wages (Rp)	Materials (Rp)	Tools (Rp)	Total (Rp)
July	220,100,842.50	354,520,512.50	1,826,884,613.40	2,401,570,255.70
August	349,213,672.50	533,951,302.50	3,989,573,449.40	4,872,864,773.70
September	291,988,587.00	435,347,055.00	3,760,481,359.36	4,487,932,124.28
		Total		11,762,367,153.68

The deviation of the direct costs of realization from the author's observations with the RBP price obtained is Rp. 637,993,654.

4. Conclusions and Suggestions

4.1. Conclusion

1) From the results of the analysis, it can be concluded that the productivity of drilling work, with the Crawler Rock Drill (CRD) tool, obtained 5 holes/hour, while with the Hydraulic Crawler Drill (HCR) it was obtained 4 holes/hour (Anugrah 2019).
2) From the results of the analysis, it can be concluded that the productivity of loading equipment and transportation equipment in excavation work and rock heaps resulting from blasting at the Quarry location, with an average number of transportation equipment as many as 25 units and 4 units of CAT 330 excavators as loading equipment. For loading equipment, the production yield is 41.40 m3/hour, while for transportation equipment the production yield is 6.62 m3/hour (Syauki 2018).

3) From the results of the analysis, it can be concluded that the actual cost of excavation and heap of blasted rock at the Quarry location in July – September requires a cost of Rp. 11,124,373,500.00 includes the cost of wages, materials, and tools (Hasibuan 2019).
4) From the results of the analysis, it can be concluded that the actual cost of excavation and embankment incurred is Rp. 11,124,373,500, it is said to have been effective because it is still below the planned cost (RBP) of Rp. 11,762,367,154 so that a deviation of Rp. 637,993,654.

4.2. Suggestion

1) There is an evaluation of the composition of the number of work tools used, so there is no waiting time for work tools.
2) The use of HCR as a drilling tool is more effective than using CRD, because the process of drilling on the CRD tool still uses human power when adding and removing drill piles.
3) The selection of the use of drilling tools for steep locations should use the CRD tool, while for drilling locations with gentle terrain using the HCR tool.
4) Repair of the access road from the quarry to the maindam must be carried out regularly, so that material production is not disturbed from the access road.

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