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Comparative Analysis of Cost and Time of River Stone Drainage Channels with Ready Mix and Precast Concrete on Boyolangu Roads - Campurdarat, Tulungagung Regency

Saddam Al Akbar Al Satria*[1], Kustamar[2], Lies Kurniawati Wulandari[3]
[1, 2, 3]Civil Engineering Program Study, Postgraduate, National Institute of Technology (ITN) Malang, Indonesia
* Corresponding Email: saddam.als91 @ gmail.com

Abstract**—***The road section of Boyolangu - Campurdarat is the main route to a tourist destination on the south coast of Tulungagung district, this route during the rainy season floods often occur because the drainage channel is unable to accommodate rainwater, causing water to overflow and inundate the road. Besides, passing vehicles slow down their speed, which causes congestion and even traffic jams, which must be immediately addressed by normalizing channels or constructing new drainage channels. An alternative method of material for making drainage channels is needed to shorten the time of execution of the work and minimize the number of workers. One type of material for making drainage channels is from ready mix concrete and U-ditch precast concrete. The difference between the type of material for making this channel from the conventional one is that it is made in a fabricated manner, which is carried out at the job site and does not require a long time, so it does not cause prolonged traffic jams. Based on the calculation of the drainage channel with a length of 7,750 meters with a workforce of 200 people/day, the cost of the drainage channel with river stones is Rp. 17,242,200,000, - with an implementation time of 393.78 days, the drainage channel with ready mix concrete Rp. 20,896,325,000, - with an implementation time of 305.72 days, drainage channels with precast u-ditch Rp. 41,546,200,000, - with an implementation time of 164.6 days.*

Keywords**—** *Feasibility, Housing, Optimization*.

I. INTRODUCTION

The construction of the Southern Cross Route (Jalur Lintas Selatan) that crosses the coast in the southern coastal area of Tulungagung Regency opens new tourist attractions such as Gemah Beach which is crowded with local and out-of-town tourists (www.pu.go.id, 28 August 2017), this shows transportation infrastructure. It plays an important role in encouraging economic improvement in the tourism sector.

The road section of Boyolangu - Campurdarat is the main route traversed by private vehicles and large buses to get to tourist destinations on the south coast, besides that the natural stone industry for raw materials for ceramics and marble ornamental stones has begun to show an increase in the last ten years. Large trucks carrying natural stones are also passing through this road, heading for factories around Surabaya.

From the location or geographical location in the lowlands of Tulungagung Regency during the rainy season, floods often occur during high rainfall, the heavy flow causes the drainage channel to be unable to accommodate rainwater, resulting in water overflowing and inundating the road. In addition, passing vehicles slows down their speed, causing congestion and even traffic jams, so this problem must be immediately addressed by normalizing channels or constructing new drainage channels.

In the process of building drainage channels, the majority of planning at the Public Works Office still uses conventional materials that are carried out directly at the project site, but there are drawbacks, including requiring a long time to work, and laying construction work materials consuming the road body causing traffic jams in the long run. long time (www.surabaya.tribunnews.com, 05 June 2018).

The method of comparing the types of material for making drainage channels is needed to shorten the time of carrying out work and minimize the number of workers. One type of material for making drainage channels is from ready mix concrete and U-ditch precast concrete.

The difference between the type of material for making this channel from the conventional one is that it is made in a fabricated manner, which is carried out at the job site and does not require a long time, so it does not cause prolonged traffic jams.

II. LITERATURE REVIEW

Drainage

Drainage means to drain, remove, or divert water. In the field of civil engineering, drainage can generally be defined as a technical measure to reduce excess water, either from rain, seepage or excess irrigation water in an area / land, so that the function of the area is not disturbed. Drainage is also defined as an attempt to control groundwater quality in terms of salinity. Thus, drainage concerns not only surface water but also groundwater. (Suripin: 2004).

Hydrological Analysis

Hydrological analysis is carried out based on available daily rainfall data from rainfall estimating stations. This analysis is carried out to determine the planned flood discharge, which will later be used to plan the dimensions of the channel.

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The calculation of maximum area rainfall using the average method uses the following formula

$$Rr = \frac{R_1 + R_2 + ... + R_n .}{n}$$

Note:
Rr = Average regional rainfall (mm).
Rn = Rainfall data from observation stations.
n = Number of observation stations.

Probability Distribution

Determination of the type of probability distribution in accordance with the data is done by matching the data parameters with the terms of each type of distribution as in the following table:

TABLE 1. Determination of Distribution Types

No	Distribution	Requirements
1	Gumbel	C_s = 1,14 C_k = 5,4
2	Normal	C_s = 0 C_k = 4
3	Log Normal	$C_s = C_v^3 + 3C_v$ $C_k = C_v^6 + 6C_v^6 + 15C_v^4 + 3$
4	Log Pearson Type III	Out of the value above

Mononobe Method of Rain Intensity Calculation

If short-term rainfall data is not available, and what is available is daily rainfall data, the regression equation can be derived using the Mononobe Method, with the following formula (Made, 2011):

$$I = \frac{X_{24}}{24} \times \frac{24^{2/3}}{t}$$

Note:
I = Plan rain intensity (mm).
X24 = Maximum daily rain height or plan rain (mm)
t = duration of rain or concentration time (hours)

Calculation of Flood Discharge Plan Rational Method

Calculation of the Flood Discharge Plan Rational Method, can be done with the formula (Made, 2011) as follows:
Q = 0.278 x C x I x A
Note:
Q = Peak runoff discharge (m3 / s).
C = Flow rate (without dimensions).
A = Area of drainage area (Km2).
I = Rainfall intensity (mm / hour).

Channel Capacity

Calculation of the capacity of the drainage channel sees the shape of the channel cross section using Manning's formula as follows:

$$Q = \frac{1}{n} . R^{2/3} . I^{1/2} . A$$

Note:
Q = debit (m/s)
A = Wet cross-sectional area
R = hydraulic radius
I = slope of the channel
n = coefficient of roughness

Time of Work

Time planning and the number of workers can be calculated with the following formula:

$$N = \frac{k \times V}{T}$$

Note :
N = Total Labor
k = Labor Coefficient in Unit Price Analysis
V = Quantity of Work
T = Length of work

III. METHOD

This study uses qualitative research methods using the methods used are:

1) Library Study. The method is done by reading literature or studying various books, especially about theories related to problems and as a comparison to theory and practice.
2) Field Research. The method is done by visiting the research site directly into the field. In this case the techniques used are: documentation techniques and observation techniques.

IV. RESULTS AND DISCUSSION

Maximum Regional Rainfall

TABLE 2. Calculation of Average Rainfall

No.	Year	Station Maximum Rainfall (mm)			Average
		Bandung	Besuki	Campurdarat	
		R1	R2	R3	(R1+R2+R3)/3
1	**2010**	158	320	123	200.33
2	**2011**	86	105	69	86.67
3	**2012**	67	108	61	78.67
4	**2013**	88	89	84	87.00
5	**2014**	61	114	58	77.67
6	**2015**	61	139	54	84.67
7	**2016**	95	151	108	118.00
8	**2017**	51	66	91	69.33
9	**2018**	118	132	91	113.67
10	**2019**	106	96	132	111.33
				Total	**1027.33**
				Average	**102.73**

From the results of the calculation of the maximum area rainfall with the algebraic method at the three observation stations, it is obtained = 102.73 mm / year.

Homogeneity Test

The homogeneity test is intended to determine whether the data series collected from 3 measuring stations located within a drainage area or one of which is outside the relevant drainage area originates from the same population or not.

From the table of critical t values, it can be seen that for dk = 27 and the degree of confidence α = 5% or t0.05, the table value is t = 1.703.

Because (t calculation result) -4,735 <1,703 (t table), it can be concluded that the rain data from Bandung, Besuki, and Campurdarat stations are homogeneous or come from one population.

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TABLE 3. Calculation of Rainfall Homogeneity Test

		Stasiun Bandung			Stasiun Besuki			Stasiun Campurdarat		
No	Tahun	X_{1i}	X_{1i} - Xrt	$(X_{1i} - Xrt)^2$	X_{2i}	X_{2i} - Xrt	$(X_{2i} - Xrt)^2$	X_{3i}	X_{3i} - Xrt	$(X_{3i} - Xrt)^2$
1	2010	158	68,9	4747,21	320	188,0	35344,00	123	35,9	1288,81
2	2011	86	-3,1	9,61	105	-27,0	729,00	69	-18,1	327,61
3	2012	67	-22,1	488,41	108	-24,0	576,00	61	-26,1	681,21
4	2013	88	-1,1	1,21	89	-43,0	1849,00	84	-3,1	9,61
5	2014	61	-28,1	789,61	114	-18,0	324,00	58	-29,1	846,81
6	2015	61	-28,1	789,61	139	7,0	49,00	54	-33,1	1095,61
7	2016	95	5,9	34,81	151	19,0	361,00	108	20,9	436,81
8	2017	51	-38,1	1451,61	66	-66,0	4356,00	91	3,9	15,21
9	2018	118	28,9	835,21	132	0,0	0,00	91	3,9	15,21
10	2019	106	16,9	285,61	96	-36,0	1296,00	132	44,9	2016,01
	∑	**891**		**9432,90**	**1320**		**44884,00**	**871**		**6732,90**
	Xrt	**89,10**			**132,00**			**87,10**		

The Chi Square Method Probability Distribution Test

a. The Gumbel Probability Distribution

TABLE 4. Calculation of the Chi Square Gumbel Distribution

No	Interval	Ei	Oi	(Oi-Ei)^2	(Oi-Ei)^2/Ei
1	> 143,108	2,00	*1,00*	1,00	0,50
2	143,108 - 109,827	2,00	*3,00*	1,00	0,50
3	109,827 - 86,347	2,00	*2,00*	0,00	0,00
4	86,347 - 63,711	2,00	*4,00*	4,00	2,00
5	< 63,711	2,00	*0,00*	4,00	2,00
Total		**10**	**10**		**5,0**

b. Log Normal Probability Distribution

TABLE 5. Calculation of Chi Square Log Normal Distribution

No	Interval	Ei	Oi	(Oi-Ei)^2	(Oi-Ei)^2/Ei
1	> 126,868	2,00	*1,00*	1,00	0,50
2	126,868 - 105,753	2,00	*3,00*	1,00	0,50
3	105,753 - 90,635	2,00	*0,00*	4,00	2,00
4	90,635 - 75,550	2,00	*5,00*	9,00	4,50
5	< 75,550	2,00	*1,00*	1,00	0,50
Total		**10**	**10**		**8,0**

c. Pearson Type III Log Probability Distribution

TABLE 6. Calculation of Chi Square Log Distribution Pearson Type III

No	Interval	Ei	Oi	(Oi-Ei)^2	(Oi-Ei)^2/Ei
1	> 121,130	2,00	*1,00*	1,00	0,50
2	121,130 - 90,915	2,00	*3,00*	1,00	0,50
3	90,915 - 83,907	2,00	*3,00*	1,00	0,50
4	83,907 - 75,784	2,00	*2,00*	0,00	0,00
5	< 75,784	2,00	*1,00*	1,00	0,50
Total		**10**	**10**		**2,0**

d. Recapitulation of X2 and X2cr Values for 3 Distributions

TABLE 7. Recapitulation of the Values of X2 and X2cr

Distribution of Probability	X2	X2Cr	Note
Gumbel	5,0	5,991	Accepted
Log Normal	8,0	5,991	Rejected
Log Pearson Type III	2,0	5,991	Accepted

Based on the calculation table above, if X2 < XCr Table. Then the distribution can be accepted, so that the smallest distribution is used is Log Pearson Type III

The Smirnov Kolmogorov Method Probability Distribution Test

TABLE 8. Calculation of the Kolmogorov Smirnov Test

XI (mm)	m	P=m/(N+1)	Log Normal		Log Pearson III		Gumbel	
			P'(Xi)	ΔP	P'(Xi)	ΔP	P'(Xi)	ΔP
200,333	1	0,091	0,010	-0,081	0,032	-0,059	0,021	-0,070
118,000	2	0,182	0,273	0,091	0,219	0,037	0,285	0,104
113,667	3	0,273	0,314	0,042	0,249	-0,024	0,322	0,049
111,333	4	0,364	0,338	-0,025	0,267	-0,097	0,343	-0,020
87,000	5	0,455	0,649	0,194	0,572	0,118	0,614	0,160
86,667	6	0,545	0,654	0,108	0,579	0,033	0,618	0,073
84,667	7	0,636	0,681	0,045	0,616	-0,020	0,643	0,007
78,667	8	0,727	0,761	0,034	0,740	0,013	0,717	-0,011
77,667	9	0,818	0,774	-0,045	0,762	-0,056	0,728	-0,090
69,333	10	0,909	0,868	-0,041	0,937	0,028	0,822	-0,087
ΔP max =				**0,194**		**0,118**		**0,160**
ΔP kritis (Tabel)=		**0,41**						
ΔP hit < ΔP Tabel			***Accepted***		***Accepted***		***Accepted***	

From the Kolmogorov Smirnov Test calculation table above with a degree of skewness α = 5%, the value α = 0.41 is obtained, so if the value of ΔP <ΔP Critical, the calculation is acceptable, so the smallest value (ΔP) is taken, namely the Log Person Type III Probability Distribution.

Calculation of Price Per m 'Channel with stone

Based on the volume calculation and price analysis of the work unit above, it can be calculated:

TABLE 9. Price per m ' River Stone Pair

No.	Job Item	Vol	Unit	Price per unit	Total Price
1	2	3	4	5	6
I	**Works of River Stone Channel**				
1	Soil Excavation	3.700	m3	Rp 65,711,25	Rp 248,388,53
2	Dumping Sand	0.105	m3	Rp 302,940,00	Rp 31,808,70
3	Pas Batu	1.530	m3	Rp 1,049,345,00	Rp 1,605,497,85
4	Pek Siaran	4.500	m3	Rp 57,062,50	Rp 256,781,25
5	Pek Plesteran	1.100	m3	RP 74,848,40	Rp 82,333,24
				Total	***Rp 2,224,809,57***
	Channel Length	7.750.000	m	Rp 2,696,300,00	***Rp 2,224,800,00*** ***Rp 20,896,325,000,00***

Calculation of Price Per m ' Channel with ready mix concrete

TABLE 10. Price per m 'of Ready mix Concrete Pair

No.	Job Item	Vol	Unit	Price per unit	Total Price
1	2	3	4	5	6
I	**Work of Ready Mix Concrete Channels**				
1	Soil Excavation	2.970	m3	Rp 65,711,25	Rp 195,162,41
2	Dumping Sand	0.090	m3	Rp 302,940,00	Rp 27,264,60
3	Concrete Work	0.720	m3	Rp 1,323,927,00	Rp 953,227,44
4	Pek Pembesian 08	25.497	kg	Rp 15,562,25	Rp 396,794,58
5	Pek Bekisting	3.000	m2	Rp 374,638,00	Rp 1,123,914,00
				Total	***Rp 2,696,363,03***
	Channel Length	7.750.000	m	Rp 2,696,300,00	***Rp 2,696,300,00*** ***Rp 20,896,325,000,00***

Calculation of Price Per m ' Channel with ready mix concrete

TABLE 11. AHSP U-DItch Installation

No.	Job Item	Vol	Unit	Price per unit	Total Price
1	2	3	4	5	6
I	Work of Precast U-Ditch Channel				
1	Soil Excavation	2.819	m3	Rp 65,711,25	Rp 185,226,87
2	Dumping Sand	0.087	m3	Rp 302,940,00	Rp 26,355,78
3	U-Ditch Installation	1.000	m	Rp 5,149,234,75	Rp 5,149,234,75
				Total	***Rp 5,360,817,40***
	Channel Length	7.750.000	m	Rp 5,360,800,00	***Rp 5,360,800,00*** ***Rp 41.546.200.000.00***

Calculation of the number of personnel and implementation time

The calculation of the number of workers and the time of execution of the work of making drainage channels as follows:
Soil excavation:
Worker coefficient = 0.6750
The foreman's coefficient = 0.0675
= 0.675 + 0.0675 = 0.7425
Volume = 29,295 m3
Mandays = 29,295 x 0.7425 = 21,751.54
Working time = 21,751,54 / 200 people per day = 108,758.

River Stone Pairing Channel Work

Time of work with a workforce of 200 people / day.

TABLE 12. Recapitulation of River Stone Works

No.	Job Item	Vol	Unit	Coefficient	Manday's	
1	2	3	4	5	6 = (3 x 5)	
1	Soil Excavation	29.295.00	m3	0.7425	21.751.54	People
2	Dumping Sand	813.75	m3	0.4400	358.05	People
3	Pas Batu	11.857.50	m3	2.8800	34.149.60	People
4	Pek Siaran	34.875.00	m2	0.4950	17.263.13	People
5	Pek Plesteran	8.525.00	m2	0.6140	5.234.35	People
				Total Mandays	***78.757***	***People***
				Total average of workers per day	***200***	***People/day***
				Total of Working Time	***394***	***day***
					13.13	***Month***

Readymix Concrete Ductwork

TABLE 13. Recapitulation of Readymix Concrete Work Time

No.	Job Item	Vol	Unit	Coefficient	Manday's	
1	2	3	4	5	6 = (3 x 5)	
1	Soil Excavation	23.017.50	m3	0.7425	17.090.49	People
2	Dumping Sand	697.50	m3	0.4400	306.90	People
3	Concrete Works	5.580.00	m3	2.9050	16.209.90	People
4	Pek Pembesian 08	197.603.69	kg	0.0151	2.983.82	People
5	Pek bekisting	23.250.00	m2	1.0560	24.552.00	People
				Total Mandays	***61.143***	***People***
				Total average of workers per day	***200***	***People/day***
				Total of Working Time	***306***	***day***
					10.19	***Month***

U-Ditch Precast Channel Jobs

TABLE 14. Recapitulation of Precast Work Time

No.	Job Item	Vol	Unit	Coefficient	Manday's	
1	2	3	4	5	6 = (3 x 5)	
1	Soil Excavation	21.845.70	m3	0.7425	16.220.43	People
2	Dumping Sand	674.25	m3	0.4400	296.67	People
3	U-Ditch Instalation	7.750.00	m2	2.1166	16.403.65	People
				Total Mandays	***32.921***	***People***
				Total average of workers per day	***200***	***People/day***
				Total of Working Time	***165***	***day***
					5.49	***Month***

V. CONCLUSIONS

Based on the results of the calculations from this study, the following conclusions can be drawn:

1. Drainage work with river stones costs Rp.17,242,200,000, - with a period of 393.78 days.
2. Drainage work with ready mix concrete costs Rp.20,896,325,000, - with a period of 306 days.
3. Drainage work with precast u-ditch costs Rp.41,546,200,000, - with a period of 165 days.
4. From the results of the calculation of a channel of 7,750m long, it requires costs of more than 10 billion with an implementation time of more than 6 months, so it can be suggested that the channel be carried out per segment or locations that are most critically affected by inundation / flooding, given the limited budget at the Public Works Office Tulungagung Regency.

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