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EVALUATION OF DRAINAGE CHANNEL CAPACITY ON CINDAI ALUS RT 4 STREET MARTAPURA DISTRICT

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ABSTRACT

The drainage channel that does not function optimally on the existing channel on the eastern side of Cindai Alus RT 4 Street, Martapura District, results in the channel being unable to accommodate the design discharge. It causes puddles in the area. This study aimed to determine whether the capacity of the drainage channel on the west side of the newly planned road can accommodate the designed flood discharge.

The analysis method of this study uses rainfall data for 20 years (2001-2023) from the Syamsudin Noor Meteorological Station. The design discharge calculation was carried out using hydrological analysis using the rational method. To calculate the discharge capacity, hydraulic analysis was used with the Manning and Mononobe formula with a return period of 2, 5, 10, 20, and 25 years to obtain the design discharge from the existing one to find the value of the planned channel dimensions.

The study results indicate that the existing channel on the west side of the road can accommodate the designed flood discharge. Conversely, the channel discharge value with a cover and without a cover cannot accommodate the design flood discharge with values sequentially being 0,28 m^3/second and 0,16 m^3/second, so redesigning is necessary. The channel redesign on Jalan Cindai Alus RT 4 uses a stone masonry channel type. The redesign can adjust the channel dimensions to 0,7 m wide and 0,65 m high. It can also use an economical trapezoidal cross-section with a height of 0,8 m and a width of 0,4 m or a square cross-section with a height of 2,4 m and a width of 0,4 m.
Keywords: Drainage channel, Cindai Alus, flood discharge, evaluation of drainage channel capacity

1. INTRODUCTION

Disturbances in the drainage system can adversely impact the environment and infrastructure. One common problem that arises due to drainage disruption is flooding or the formation of puddles, both on a small and large scale. Besides disruptions in drainage channels, changes or developments in the city and the environment can also affect inadequate drainage channels or no longer functioning correctly.

Flooding and puddles occur frequently in Martapura, including in Cindai Alus RT 4 Street, Martapura District. At the review location, puddles of water were around the area due to the existing channel to the east of the road not functioning optimally. Therefore, construction was carried out in the west direction of the drainage channel at that location.

Along with the city's growth and environmental changes, the existing drainage system on Cindai Alus Street is no longer adequate to overcome the threat of flooding. The existing drainage system in the area being reviewed requires attention so that it does not cause more serious problems in the future. This study evaluated the capacity of the newly built drainage channels. This study only focused on the channel west of the newly built road section because the east drainage channel was not repaired.

2. THEORETICAL STUDY

Hydrology Analysis

According to Soewarno (1995), hydrological analysis will be conducted by reviewing hydrological data in the form of rainfall, flow velocity, and river sediment concentration because it will always change over time. The analysis is conducted in stages, namely determining the maximum annual rainfall from existing data, analyzing design rainfall with a specific return period, and calculating the design flood discharge based on the design rainfall.

The calculation of rainfall at any time based on daily rainfall can be done using the Mononobe equation as follows:

$$I = \frac{R24}{24}\ x\ (\frac{24}{T})^{2/3}$$

The concentration-time can be calculated using the Kirpich equation as follows:

$$tc = (\frac{0{,}87\ x\ L^2}{1000\ x\ s})^{0{,}385}$$

In determining flood discharge, a general method is used, namely the rational method as follows:

$$Qt = \frac{CIA}{3{,}6} = 0{,}278\ C.I.A$$

(Suripin, 2004)

Hydraulic Analysis

According to Triatmodjo (2008), the flow velocity can be determined using several formulas, namely the Chezy, Manning and Strickler formulas. According to Suripin (2004), the Manning method is the equation used to perform reservoir analysis.

$$Q = V\ .A$$

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

$V = \frac{1}{n} . R^{2/3} . S^{1/2}$

Meanwhile, the calculation formula for dimensions according to the cross-sectional shape is as follows:

Table 1. Channel Dimension Calculation Formula According to Cross-Section Shape

Keterangan	Trapezoidal Cross-Section	Rectangular Cross-Section
Area (A)	$A = (B + m.h)h$	$A = B \, . \, h$
Wetted Perimeter (P)	$P = b + 2h\sqrt{m^2 + 1}$	$P = b+2h$
Hydraulic Radius (R)	$R = \frac{A}{P}$	$R = \frac{A}{P}$
Top Width (T)	$T = B + 2mh$	$W = \sqrt{0{,}5\ h}$

Reference: (Suripin, 2004)

3. METHOD

Research Location

The research location is Cindai Alus RT 4 Street, Martapura District, Martapura City. The drainage channel that is the focus of the research is approximately 478 meters long and is located to the west of the road. The image of the research location can be seen in Figure 1. as follows:

Figure 1**.** Map of Reviewed Locations

Research Data

Primary data was obtained by measuring using a waterpass and conducting a direct review at the research location, consisting of the reviewed drainage channels, drainage channel dimensions, and channel elevations, as well as documentation of the research location. Meanwhile, secondary data was obtained from related parties, namely daily

rainfall data for 2001-2023 from the Syamsudin Noor Meteorological Station (BMKG Online).

4. RESULT AND DISCUSSION

Hydrology Analysis

The data used in this analysis are the maximum values per year for the last 20 years (2001-2023) obtained from the Syamsudin Noor Meteorological Station. Rainfall data for 2010 and 2013 were unavailable, so the following year's data was calculated.

Frequency analysis was conducted to obtain an appropriate distribution based on statistical parameters as determinants. These parameters include the average value ($\bar{X}$), standard deviation (S), coefficient of variation (CV), coefficient of skewness (CS), and coefficient of kurtosis (CK).

Table 2. Determining the Type of Distribution

No.	Distribution Types	Requirement	Result	Conclution
1	Normal	Cs ≈ 0	Cs = 2,240	Unqualified
		Ck ≈ 3	Ck = 11,018	
2	Log Normal	$Cs = Cv^3 + 3Cv$	Cs = 2,240	Unqualified
		$Ck = Cv^8 + 6Cv^6 + 15\,Cv^4 + 16Cv^2 + 3$	Ck = 11,018	
3	Gumbel	Cs = 1,14	Cs = 2,240	Unqualified
		Ck = 5,4	Ck = 11,018	
4	Log Pearson III	Apart from the above values	Cs = 2,240	Qualify
			Ck = 11,018	

As can be seen from Table 3, the following calculation is carried out using the Log Pearson Type III distribution type.

In this study, two distribution fit test methods were used to determine whether the probability distribution equation can represent the distribution of the analysis data sample: the chi-square and Smirnov Kolmogorov tests. In the chi-square test, the value ($X2 < X2CR$) was obtained, meaning that the Log Pearson Type III distribution can be accepted for analyzing rainfall data. For the Smirnov Kolmogorov test, the D max value was obtained, which was smaller than D, meaning that the Log Pearson III distribution can be accepted because it has been met.

The concentration-time (tc) of the channel on Cindai Alus RT 4 Street with a length of 478 m and a slope of 0,0033 is 0,3379 hours. Meanwhile, the rainfall intensity is obtained as follows:

Table 3. Rain Intensity Calculation Results

Rain Duration (Hours)	Curah Hujan Maksimum 24 Jam				
	Return Period of 2 years	Return Period of 5 years	Return Period of 10 years	Return Period of 20 years	Return Period of 25 years
0,338	76,555	99,081	115,571	132,397	135,322
0,5	58,965	76,314	89,016	101,976	104,228
1	37,145	48,075	56,076	64,241	65,660
2	23,400	30,285	35,326	40,469	41,363
3	17,858	23,112	26,959	30,884	31,566
4	14,741	19,079	22,254	25,494	26,057
5	12,704	16,441	19,178	21,970	22,455
6	11,250	14,560	16,983	19,455	19,885
7	10,151	13,138	15,324	17,555	17,943
8	9,286	12,019	14,019	16,060	16,415
9	8,585	11,111	12,960	14,847	15,175
10	8,003	10,357	12,081	13,840	14,146
11	7,510	9,720	11,338	12,988	13,275
12	7,087	9,172	10,699	12,256	12,527
13	6,719	8,695	10,143	11,619	11,876
14	6,395	8,276	9,654	11,059	11,303
15	6,107	7,904	9,220	10,562	10,795
16	5,850	7,571	8,831	10,117	10,341
17	5,618	7,271	8,482	9,717	9,931
18	5,408	7,000	8,165	9,353	9,560
19	5,217	6,752	7,875	9,022	9,221
20	5,041	6,525	7,611	8,719	8,911
21	4,880	6,316	7,367	8,440	8,626
22	4,731	6,123	7,142	8,182	8,363
23	4,593	5,944	6,934	7,943	8,119
24	4,464	5,778	6,740	7,721	7,891

In this study, the rain catchment area was taken 75 m from the drainage being reviewed.

Figure 2. Channel Catchment Area Details

Table 4. Calculation of Regional Runoff Coefficient

Rain Catchment Area/A (km^2)	**Percentage(%)**			**Runoff Coefficient (C)**	
Roof	0,00256	0,03	1,44%	0,85	0,495
Green Area	0,00675		1,39%	0,15	
Street	0,00124		0,12%	0,25	

After obtaining the values C, I, and A, the design flood discharge was calculated, and the following results were obtained:

Table 5. Design Flood Discharge for Return Periods of 2, 5, 10, 20 and 25 years

Rain Duration (Hours)	**Qr**				
	2	**5**	**10**	**20**	**25**
0,338	0,312	0,403	0,471	0,539	0,551
0,5	0,240	0,311	0,362	0,415	0,424
1	0,151	0,196	0,228	0,262	0,267
2	0,095	0,123	0,144	0,165	0,168
3	0,073	0,094	0,110	0,126	0,129
4	0,060	0,078	0,091	0,104	0,106
5	0,052	0,067	0,078	0,089	0,091
6	0,046	0,059	0,069	0,079	0,081
7	0,041	0,053	0,062	0,071	0,073
8	0,038	0,049	0,057	0,065	0,067
9	0,035	0,045	0,053	0,060	0,062
10	0,033	0,042	0,049	0,056	0,058
11	0,031	0,040	0,046	0,053	0,054

Rain Duration (Hours)	Qr				
	2	**5**	**10**	**20**	**25**
12	0,029	0,037	0,044	0,050	0,051
13	0,027	0,035	0,041	0,047	0,048
14	0,026	0,034	0,039	0,045	0,046
15	0,025	0,032	0,038	0,043	0,044
16	0,024	0,031	0,036	0,041	0,042
17	0,023	0,030	0,035	0,040	0,040
18	0,022	0,029	0,033	0,038	0,039
19	0,021	0,027	0,032	0,037	0,038
20	0,021	0,027	0,031	0,036	0,036
21	0,020	0,026	0,030	0,034	0,035
22	0,019	0,025	0,029	0,033	0,034
23	0,019	0,024	0,028	0,032	0,033
24	0,018	0,024	0,027	0,031	0,032

Hydraulic Analysis

The existing discharge analysis aims to determine the discharge in the existing channel and compare it with the design discharge so that the channel can work effectively. This analysis uses the channel dimensions according to the planning. The Cindai Alus RT 4 Street channel has a length of 478 meters and a trapezoidal cross-section. According to the planning, the dimensions used are divided into two sizes, with and without a cover plate. The dimensions of the channel with a cover are 40 x 55 cm, while the dimensions without a cover are 40 x 40 cm. The following results are obtained to determine the discharge of the existing channel using the trapezoidal formula.

Table 6. Existing Channel Discharge Calculation Results

Calculation	Result
Area (A)	0,2494 m^2
Wetted Perimeter (P)	1,3165 m^2
Hydraulic Radius (R)	0,1985 m^2
Flow Rate (V)	0,6322 m/s
Existing Channel Discharge (Q)	0,1577 m^3/s

Next, an evaluation is carried out to determine whether the channel can accommodate the design discharge by comparing the design discharge with the existing discharge.

Table 7. Existing Drainage Channel Evaluation Results

Channel Name	**Qr (Return Period)**					**Qs**	**Qr < Qs**
	2	**5**	**10**	**20**	**25**		
Channel without cover (Q_{s1})	0,312	0,403	0,471	0,539	0,551	0,2835	Unqualified
Channel with cover (Q_{s2})	0,312	0,403	0,471	0,539	0,551	0,1577	Unqualified
Existing channels (STA 0+245 – 0+270)	0,312	0,403	0,471	0,539	0,551	0.614	Qualify

Based on the evaluation results, it was found that the newly built existing channel discharge was unable to accommodate the designed rainfall discharge. Therefore, a redesign is needed. The solution to this problem can be to equalize the dimensions of the existing channel, namely with a width of 0,7 m and a height of 0,65 m. In addition, a redesign can also be carried out. The redesign contains alternative designs with different drainage shapes, namely square and trapezoidal drainage channels with a roughness of manning to adjust to the existing channel, namely the type of river stone.

Table 8. Channel Re-Design Dimension Results

Channel Cross Section Shape	**Dimensions**		
	b	**h**	**m**
Trapezoid	0,4	0,8	0,559
Rectangle	0,4	2,4	-

Based on the hydrological and hydraulic analysis of the calculations that have been carried out, it is known that the newly constructed channel is currently insufficient to accommodate the planned flood discharge with a return period of 2, 5, 10, 20, and 25 years. The following is a recapitulation of the channel dimensions.

Table 9. Drainage Channel Dimension Recapitulation

Nama Saluran	Channel Dimensions								
	n	**m**	**S**	**b (m)**	**h (m)**	**R (m)**	**A (m^2)**	**v (m/det)**	**Qt (m^3/det)**
Channel without cover (Q_{s1})	0,03	0,559	0,0033	0,4	0,55	0,234	0,389	0,728	0,283
Channel with cover (Q_{s2})	0,03	0,559	0,0033	0,4	0,40	0,189	0,249	0,632	0,158
Existing channels (STA 0+245 – 0+270)	0,03	0,559	0,0033	0,7	0,65	0,316	0,691	0,889	0,614
Qre-trapezoid design	0,03	0,559	0,0033	0,4	0,80	0,146	0,678	0,866	0,587
Qre-square design	0,03	-	0,0033	0,4	2,4	0,185	0,960	0,621	0,596

5. CONCLUSION

Based on the problems and discussions in this study, the following conclusions can be drawn:

1. Based on the analysis using the rational method, the results of the design flood discharge (Qr) for return periods of 2, 5, 10, 20, and 25 years are respectively 0,31 m^3/second, 0,40 m^3/second, 0,47 m^3/second, 0,54 m^3/second, and 0,55 m^3/second,

2. Based on the calculation results and comparison of the design flood discharge (Qr) to the existing channel flood discharge (Q_s) that have been carried out, it was found that Q_{s1} and Q_{s2} could not accommodate the design discharge that occurred. Thus, a redesign is needed for this channel.

3. The solution for drainage channels with and without covers can be redesigned by matching the size of the largest existing channel, namely STA 0+245 – 0+270, with a width and height of 0,7 m and 0,65 m. In addition, it can also be redesigned using economical trapezoidal and square cross-sections with stone masonry channel types. The dimensions of the planned channel with a trapezoidal cross-section use a height of 0,8 m and a width of 0,4 m. Meanwhile, the planned channel with a square cross-section has a height of 2,4 m and a width of 0,4 m.

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