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Rainfall Analysis of Drainage Cross-Sectional Capacity with Comparison of Mononobe Method and Van Breen Method on The Road Asrama Sei Kambing C-Ii (Case Study)

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ABSTRACT

The intensity of rainfall is one of the factors causing inundation in an area which is one of the drainage problems in the city of Medan which is increasingly feared in recent years, population growth in the city of Medan is increasingly rapid and the need for land that was originally green is now becoming a denser residential area and more and more road paving which causes rainwater cannot absorb into the ground. In addition to flooding factors, watershed conditions that often experience erosion make river silting which results in reduced flow carrying capacity so that the increase in discharge is greater so that overflow occurs. The purpose of this rainfall analysis is to find out what problems make puddles not fully drain water when the rain discharge is high and to find out how much cross-sectional capacity is suitable to be used in accommodating flood discharge in drainage at the research site. The research method calculates rainfall intensity by comparing the Mononobe method and Van Breen method by analyzing the plan discharge to determine the feasibility of cross-sectional capacity by analyzing the planned flood discharge, where the results of the analysis of the 2-year period of channel discharge capacity (Q_s) = 262.622 m^3/sec so that the calculation results that the value of the channel discharge capacity is smaller than the plan flood discharge value is greater, so that the capacity proves that the drainage canal is not able to accommodate the flow of water which results in flooding.

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1. INTRODUCTION

Drainage is one of the basic facilities designed as a system to meet the needs of the community and is an important component in urban planning (infrastructure planning in particular)(Butler et al., 2018). Drainage that comes from English, namely drainage means draining, draining, discarding, or diverting water(Butler et al., 2018). In general, drainage can be defined as a technical action to reduce excess water, both from rainwater, seepage, and excess irrigation water from an area or land, so that the function of the area or land is not disturbed. Flooding is a natural event due to high rainfall

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intensity and due to overflow of water where water in the channel cannot accommodate rain discharge or is blocked by the flow of water in the sewer so that it overflows inundating(Agbola et al., 2012). The area drainage is generally defined as a science that studies efforts to drain excessive water in a certain use context both from rain, seepage and others in an area, so that the function of the area is not disturbed. Urban/applied drainage is an applied drainage science that specializes in urban areas that are closely related to the socio-cultural environmental conditions that exist in the city area(Araújo, 2019). In urban drainage systems such as residential areas, industry, commerce, schools, hospitals, sports fields and others(Hoang & Fenner, 2016). It is necessary to design urban drainage in accordance with regional land use and urban spatial planning, this system is planned with sufficient capacity to evacuate rainwater with the planned frequency(Miguez et al., 2012).

The determination of this frequency depends on local conditions and the trustworthiness of the plan, but also takes into account the cost of creating a drainage system(Yazdanfar & Sharma, 2015). According to (Mulyanto: 2012) Drainage is a development system to overcome the problem of excess water caused by excessive rain intensity due to very long rain duration(Khaerudin, 2014). Rainfall intensity is one of the factors causing flooding in an area which is a problem in drainage in the city of Medan which is increasingly feared in recent years, especially Medan City requires efforts to evaluate the state of drainage and rebuild drainage that does not function well in channeling dirty water discharge, to find out drainage channels that are able to accommodate water discharge when the intensity of rainfall is large. The purpose of this study is to find out what problems make puddles not fully flow when the rain discharge is very large which results in drainage cannot accommodate it.

2. RESEARCH METHOD

The object of this research building is located on Jalan Asrama Sei Kambing C-II, Medan Helvetia District which inundated the road and the surface of residents as high as ± 40 -70 cm, located at coordinates 3° 35'36"N 98°37'42"E as shown in Figure.1

Figure 1. Flooded research site

In this study, the data collected was in the form of secondary data used from observation data on drainage conditions field measurements such as drainage width, joint height while the primary data used BMKG Region 1 terrain data(Wahyudi et al., 2019). For data processing in the next stage, namely in the form of emulating maximum rainfall data for 10 periods(Luk et al., 2001). Analyzing maximum rainfall with algebraic averages, frequency and probability analysis is carried out to identify rainfall patterns and distributions calculating with match testing parameters using the parameters of Smirnov Kolmogorov(Cugerone & De Michele, 2015). Then calculating rain intensity analysis with the Mononobe method and Van Breen method(Majeed et al., 1783). Then carried out analysis hydraulics by calculating cross-sectional dimensions to determine the planned discharge as well as determining the average speed on the slope of the channel(Hey, 1978). Further details are shown in Figure 2 as follows(Rackwitz & Flessler, 1978):

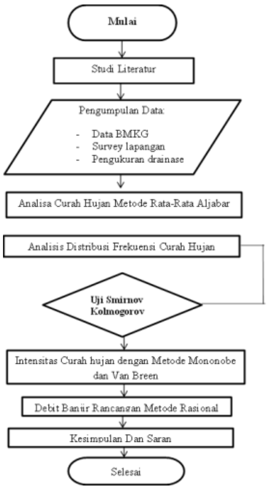

Figure 2. Research flow chart

3. RESULTS AND DISCUSSIONS

Evaluation of rainfall to obtain the annual rainfall height, year n which will be used to find the design flood discharge(Arnaud & Lavabre, 2002). If in an area there are several measuring devices or rainfall recorders, then an average value can be taken to get the value of the area's rainfall(Ferraro, 1997). To get the price of rainfall area can be calculated by the algebraic average method:

Table 1. Maximum rainfall data for 2013 - 2022 Year Maximum rainfall (mm)

Year	Maximum precipitation (mm)
2013	498,3
2014	325,7
2015	448,6
2016	580,8
2017	529,4
2018	609
2019	455,6
2020	615
2021	519,4
2022	525,9

From the maximum average rainfall data, the distribution pattern is then calculated using frequency evaluation calculations. The distribution distribution that will be sought for frequency analysis includes the clump distribution, normal log distribution, and type III log person distribution(White & Bennetts, 1996).

3.1 Selection of distribution types

Table 2. Parameters of selection of precipitation distribution

Types of distribution	condition	Result	Information
Usual	$Cs \approx 0$ $Ck = 3$	$Cs = -2{,}484 \times 10^{13}$ $Ck = 7{,}14 \times 10^{18}$	Does not meet
Normal logs	$Cs \approx Cv^3 + 3Cv = 0{,}162$ $Ck = Cv^8 + 6Cv^6 + 15\ Cv^4 + 16\ Cv^2 + 3 = 3{,}047$	$Cs = -3{,}7627$ $Ck = 0{,}1125$	Does not meet
Gumbel	$Cs \leq 1{,}1396$ $Ck \leq 5{,}4002$	$Cs = -2{,}484 \times 10^{13}$ $Ck = 7{,}138 \times 10^{18}$	Does not meet
Log person type III	$Cs \neq 0$	$Cs = -3{,}76$	**Meet**

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	Ck = 0	Ck = 0,113	

3.2 Smirnov Kolmogorov exam

This test will calculate the value of D, which is the maximum difference between the cumulative function of the sample and the probability function then the value of D compared to the value of Do The value of D obtained is 0.202 and is smaller than Do = 0.41 with a confidence level of 5% Log Person III distribution is acceptable.

Table 3. Results of rainfall distribution of Log Pearson type III.

Reset period	$\sum \mathbf{Log\ X_i}$	K_T	S	X_T (mm)	Log X_T
x_2	2,702	0,396	0,758	3,002	1005,738
x_5	2,702	0,636	0,758	3,185	1529,667
x_{10}	2,702	0,660	0,758	3,207	1611,984
x_{25}	2,702	0,666	0,758	3,207	1611,984
x_{50}	2,702	0,666	0,758	3,207	1611,984
x_{100}	2,702	0,667	0,758	3,208	1614,803

3.3 Rainfall Intensity Analysis (I)

The rational method is used because of the drainage area of the drainage channel area Jl Asrama Sei Kambing Medan Helvetia, covering an area of ± 1.46 Km² (146 Ha). The following calculation results using two different methods are as follows:

Table 4. Rainfall intensity using Mononobe method

No	Era	R24 (mm)	C	t_c (hour)	I (mm/h)
1	2	1005,74	0,6	22,996	43,1168
2	5	1529,67	0,6	22,996	65,5780
3	10	1611,984	0,6	22,996	69,1071
4	25	1611,984	0,6	22,996	69,1071
5	50	1611,984	0,6	22,996	69,1071
6	100	1614,803	0,6	22,996	69,2280

Hydraulics analysis to determine puddles that can be held in drainage, the calculation of flow speed from the calculation results above can be the value of the channel discharge capacity smaller than the planned flood discharge can be seen in table 5 as follows:

Table 5. The calculation result of the right existing secondary channel

No	B (m)	H (m)	S	Luas (A) m²	Keliling (P) m	Hidrolis (R)	Kecepatan Manning (V)	Q m^3/det
1	1,90	2,30	0,001	4,370	6,5	0,672	16,536	72,264
2	1,90	2,00	0,001	3,800	5,9	0,644	16,070	61,066
3	1,80	1,87	0,001	3,366	5,54	0,608	15,457	52,029
4	1,80	1,80	0,001	3,240	5,4	0,6	15,328	49,664
5	1,70	1,20	0,001	2,040	4,1	0,498	13,530	27,601
jumlah				**16,816**	**27,440**	**3,022**	**76,921**	**262,622**

No	B (m)	H (m)	S	Luas (A) m²	Keliling (P) m	Hidrolis (R)	Kecepatan Manning (V)	Q m^3/det
Rata-rata				3,363	5,488	0,604	15,384	52,524

This proves that the existing drainage channel is not able to accommodate the planned flood discharge, then calculates the trapezoidal drainage type with the left existing secondary channel.

Table 6. Rainfall intensity using the Van Breen method

No	periode	R24 (mm)	C	t_c(jam)	I (mm/jam)
1	2	1005,74	0,6	22,996	226,29
2	5	1529,67	0,6	22,996	344,18
3	10	1611,98	0,6	22,996	362,70
4	25	1611,98	0,6	22,996	362,70
5	50	1611,98	0,6	22,996	362,70
6	100	1614,803	0,6	22,996	363,33

Table 7. Left Existing secondary channel calculation result

No	B (m)	H (m)	S	Broad (A) m²	Around (P) m	Hydraulic finger (R)	Kecepatan Manning (V)	Q_s (m^3/det)
1	1,20	1,20	0,001	2,640	4,594	0,575	14,893	39,319
2	1,20	1,20	0,001	2,640	4,594	0,575	14,893	39,319
3	1,15	1,15	0,001	2,473	4,403	0,562	14,667	36,264
4	1,10	1,10	0,001	2,310	4,211	0,548	14,439	33,353
5	1,10	1,10	0,001	2,310	4,211	0,549	14,439	33,353
sum				**12,373**	**22,013**	**2,808**	**73,331**	**181,607**
Average				2,475	4,403	0,562	14,666	36,321

Average From the calculation of the comparison of existing and Qrational drainage channels on Jl. Asrama Sei Kambing C-II, it can be seen that the cross section of the right and left drainage channels is not able to accommodate rainfall discharge in periods 2, 5, 10, 25, 50, 100 years by using the Mononobe method

4. CONCLUSION

Based on the results of the calculation of rainfall analysis on the drainage on the C-II goat sei dormitory road, several conclusions were obtained which were described as follows: From the calculation of the comparison of rational Q and existing Q drainage channels both right and left that using the rainfall intensity method, the Mononobe method is more feasible to use than the Van Breen method. For the secondary dimension of drainage, the calculation of rainfall intensity is smaller than the planned flood discharge with a 2-year repeat period, channel discharge capacity (Q_s) = 262.622 m3 / sec so that the calculation results that the value of the discharge carrying capacity For the secondary dimension of drainage, the calculation of rainfall intensity is smaller than the planned flood discharge with a 2-year repeat period, the capacity of the channel discharge (Q_s) = 262.622 m3 / sec so that the calculation results that the value The capacity of the channel discharge is smaller than the value of the planned flood discharge is larger, so that the capacity proves that the drainage channel is not able to accommodate the flow of water resulting in flooding.the value is smaller than the value of the planned flood discharge is larger, so for the capacity proves that the drainage channel is not able to accommodate the flow of water resulting in flooding. By calculating the Mononobe method that is most effective for cross-sectional types of square-type and trapezoidal channel cross-sections by determining the intensity of precipitation and determining rational Q is more able to accommodate rainfall discharge than rainfall analysis using, Van Breen method cross-sections of trapezoidal square-type channels are unable to meet water flow.

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