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Evaluation of Drainage System in Simorejo Settlement Area, Kelurahan Simomulyo, Kecamatan Sukomanunggal, Surabaya City

*M Gilang Ridwanafriansyah Satriya[1], Faradlillah Saves[2]

[1]Faculty of Engineering, University of 23 Agustus 1945, Surabaya[2]
*ridwanalma2201@gmail.com
*farasaves@untag-sby.ac.id

Abstract

Flooding is something that often occurs in the Simorejo Settlement Area, Kelurahan Simomulyo, Kecamatan Sukomanunggal, Surabaya City. The flooding that occurred showed that the capacity of the existing channel was no longer able to accommodate the flood discharge. Evaluation of drainage channels is carried out by looking for planned flood discharges, existing flood discharges and channel re-planning measures with rain data for the last 10 years from 2012 to 2021. The calculation of maximum rainfall is carried out by the arithmetic method. The calculation of planned flood discharge and existing channel discharge is based on a rational method with a maximum rainfall of 2 years, 5 years, and 10 years. The calculation results showed that the condition of the channel was not able to accommodate the planned flood discharge with a 2-year, 5-year, and 10-year anniversary, therefore a re-envisionation of the channel dimensions was carried out. Re-planning is carried out by trial and error method until it is declared capable of accommodating the planned flood discharge. The results of the re-plann obtained a cross section of the enlarged drainage channel with dimensions of 1.2 m x 1 m x 1 m.

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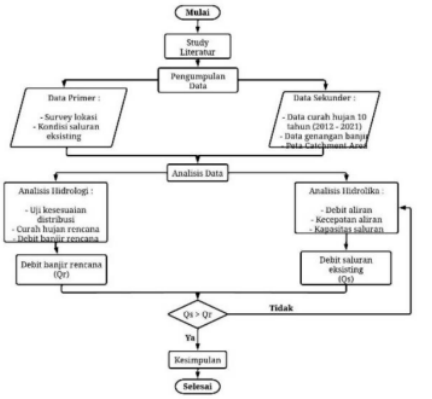
1. Introduction

Drainage is a system for removing excess water and waste water originating from residential and residential areas, industrial areas and other business activities, roads and other pavements (Arifin 2018). The rise of residential development in big cities like Surabaya is often not accompanied by a good spatial management system, especially drainage management. This results in a decrease in the infiltration rate of rainwater that enters the soil and flows more on the ground surface. So that there is an overflow of water that is greater than the capacity of the drainage channel or what is often called a flood. SThe problem of flooding in the Simorejo area, Simomulyo Village, Sukomanunggal Sub-District, Surabaya City has not yet been fully resolved. Floods often occur and become a regular when it rains in this area resulting in an elevation of the surface between one house and another. This is due to the fact that the canal can no longer accommodate runoff water so that it has an impact on the amount of water runoff that goes to the drainage channel which eventually flows down the street causing flooding. For this reason, it is necessary to do an analysis of the capacity of the drainage channel to find out whether the channel is adequate or not in accommodating rainwater runoff discharge.

2. Materials and Methods

Research Method is a procedure or systematic way of compiling knowledge, usually referring to a form of research.



2.1 Research Significance

The purpose of this study is to analyze how much flood discharge flows in the channel, analyze the channel's carrying capacity, and redesign the cross-section of the drainage channel. research using arithmetic methods, rational methods, and trial and error methods.

2.2 Research Location (any)

The research location was conducted in the Simorejo Residential area, located on Jl. Simorejo, Simomulyo Village, Sukomanunggal District, Surabaya City, shown in Figure 1 with a yellow line polygon. The research was conducted with the study location boundary to the north of Jl. Simorejo Gg. II, west Jl. Simorejo Gg. III, south of Jl. Simorejo Gg XXXVII and Jl. Kali Kundang, and east of Jl. East Simorejo Gg III. The rainfall data used is data for the last 10 years (2012-2021).

***Figure 1** Study Area Map*

2.3 Data

This stage is the stage of data collection which functions to obtain data that will be used as research material, this is necessary to obtain the required data. This stage is also the field observation stage, namely by directly observing activities in the field and also to obtain data that will be needed for writing purposes. The data in this study consisted of primary data and secondary data, the primary data contained field surveys in the form of drainage channel dimensions and documentation. While the secondary data contains rainfall data for a 10-year return period from 2012-2021, channel cross-sectional dimensions, and a study area map.

2.4 Analysis Method

2.4.1 Hydrological Analysis

Hydrological analysis was carried out to find out in detail about the hydrological parameters with the results in the form of a planned flood discharge. Hydrological analysis in the form of analysis of daily rainfall data from 5 rain stations with 10 years of data. After obtaining the annual average rainfall from the five stations, regional rainfall calculations are carried out using the arithmetic method. After that, an analysis of the frequency distribution was carried out using the gumbel distribution method, the normal distribution, and the Pearson III log distribution with 3 return periods, namely 2 years, 5 years and 10 years respectively. From the three distributions, a fit test was carried out using the Chi-Square test and the Smirnov-Kolmogorov test to test whether the hypothesis can be accepted or not from the two distribution fit tests. After the distribution compatibility test was carried out, then the rain concentration analysis calculation was carried out for each channel. After obtaining the rain concentration values from each channel, then the rain intensity calculation is carried out using the Mononobe method. After the rain intensity value is obtained, the design flood discharge is calculated with a return period of 2 years, 5 years and 10 years for each channel using the rational method.

2.4.2 Hydraulics Analysis

Hydraulics analysis was carried out to find out how much the cross-sectional ability of the channel can accommodate the discharge that enters the drainage channel. Hydraulics analysis was carried out by collecting existing channel data in the form of channel depth (h), channel wall slope (z), channel manning coefficient (n), length of each channel (L), and channel width (b). These data are used to calculate the wet cross-sectional area (A), wet circumference (P), hydraulic radius (R), flow velocity (V) and then obtain the discharge of the existing channel for each channel.

2.4.3 Drainage Channel Evaluation

Evaluation is carried out by comparing the planned flood discharge with the existing channel discharge. In evaluating the existing channel then given a solution to the problem taken by re-planning the channel. When re-planning drainage, predetermined standards are used, both the discharge plan and the

method of analysis used, the height of the guard, the channel structure, etc. (Kusuma 2017). In designing the dimensions of the channel, efforts must be made to obtain an economical cross-sectional dimension. Channel dimensions that are too large mean it is not economical, conversely channel dimensions that are too small will have a large loss rate (Milliandi 2022).

3. Result and Discussion

3.1 Hydrological Analysis

The analysis was carried out using rainfall data for the last 10 years from 5 rain stations namely Simo, Gubeng, Gunung Sari, Wonokromo and Kedung Cowek stations from 2012 to 2021.

3.1.1 Rainfall Data Analysis

This analysis was carried out to find the average value of rainfall each year from 5 rain stations with a 10-year series.

Table 1 *Maximum Rainfall*

No.	Tahun Pengamatan	Rata - Rata
1	2012	79,2
2	2013	86,2
3	2014	84,2
4	2015	67,2
5	2016	97,8
6	2017	109,6
7	2018	68,6
8	2019	72,2
9	2020	99,8
10	2021	95,0
n = 10		859

1. Gumble distribution

Table 2 *Gumbel Distribution Calculation Results*

Periode Ulang (T tahun)	Xr	Kt	Sd	Xt (mm)
2	85,98	-0,1355	14,4197	84,0259
5	85,98	1,0581	14,4197	101,2370
10	85,98	1,8483	14,4197	112,6322

2. Normal distribution

Table 3 *Normal Distribution Calculation Result*

Periode Ulang (T tahun)	Xr	Kt	Sd	Xt (mm)
2	85,98	0	14,4197	85,98
5	85,98	0,84	14,4197	98,0925
10	85,98	1,28	14,4197	104,4372

3. Pearson log type III distribution

Table 4 *Pearson Log Type III Calculation Results*

Periode Ulang (T tahun)	Log Xr	Kt	Sd Log X	Log Xt	Xt (mm)
2	1,929	0	0,0734	1,9289	84,89
5	1,929	0,842	0,0734	1,9907	97,88
10	1,929	1,282	0,0734	2,0230	105,43

3.1.2. Spread Match Test

Table 5 *Distribution of Matching Test Results*

Pers. Distribusi	Uji Kecocokan			
	Uji Chi-Kuadrat			
	Xh^2	Nilai	X^2cr	Ket.
Gumbel	1	<	5,991	OK
Normal	1	<	5,991	OK
Log Pearson Type III	3	<	5,991	OK
Pers. Distribusi	**Uji Kecocokan**			
	Uji Smirnov-Kolmogorov			
	D_{max}	Nilai	D_o	Ket.
Gumbel	0,0519	<	0,41	OK
Normal	0,1042	<	0,41	OK
Log Pearson Type III	0,1042	<	0,41	OK

From the **Table 5** it can be seen that all distribution equations are acceptable. Therefore it is taken with the smallest Xh^2 and D_{max} values, namely in the Gumbel Distribution Equation which is then used for re-calculation of rainfall.

3.1.3. Rain Concentration Analysis

This analysis is carried out on each channel, because each channel has a different cross section.

Table 6 *Rain Concentration Calculation Resuls*

Nama Saluran	Panjang Saluran (m)	S	tc (jam)
Tersier 1	6471	0,000137	13,750
Tersier 2	1255	0,000708	2,477
Tersier 3	800	0,001111	0,894
Tersier 4	2144	0,000415	4,033
Sekunder 2	781	0,001138	0,626
Sekunder 1	470	0,004726	0,399
Primer Sawahan	502	0,006644	0,523
Primer Asemrowo	885	0,003765	1,451
Primer Krembangan	1,239	0,002690	3,517

3.1.4. Calculation of Rain Intensity

In calculating the intensity of this rainfall using the Mononobe method. Rainfall value used from the calculation of the Gumbel distribution.

Table 7 *Calculation of Rain Intensity*

Nama Saluran	tc (jam)	Intensitas Hujan (mm/jam)		
		2 th	5th	10 th
		84,0	**101,2**	**112,6**
Tersier 1	13,75	5,07	6,115	6,803
Tersier 2	2,477	15,9	19,17	21,32
Tersier 3	0,894	31,3	37,83	42,08
Tersier 4	4,033	11,4	13,85	15,41
Sekunder 2	0,626	39,7	47,94	53,33
Sekunder 1	0,399	53,7	64,73	72,01
Primer Sawahan	0,523	44,8	54,05	60,13
Primer Asemrowo	1,451	22,7	27,38	30,47
Primer Krembangan	3,517	12,5	15,17	16,88

3.1.5. Calculation of Planned Flood Discharge

The calculation of the Planned Flood Discharge uses the rational planned flood discharge method.

Table 8 *Results of Planned Flood Discharge Calculation*

Nama Saluran	Q (m^3/det)		
	2 th	5 th	10 th
Tersier 1	0,1353	0,1631	0,1814
Tersier 2	0,0982	0,1183	0,1317
Tersier 3	0,0649	0,0782	0,0870
Tersier 4	0,1024	0,1234	0,1372
Sekunder 2	0,0594	0,0716	0,0796
Sekunder 1	0,0799	0,0962	0,1070
Primer Sawahan	0,1137	0,1370	0,1524
Primer Asemrowo	0,1672	0,2015	0,2242
Primer Krembangan	0,24195	0,29151	0,32433

3.2 Hydraulics Analysis

Hydraulic analysis in this study aims to determine how much the cross-sectional capacity of the channel can accommodate the planned discharge (discharge sought Q_2 years, Q_5 years, Q_{10} years).

Table 9 *Calculation of Canal Hydraulic Analusis with 2 Year Return Period Discharge (Q_2)*

Nama Saluran	Jenis saluran	Q m^3/det
Tersier 1	Trapesium	0,0840
Tersier 2	Trapesium	0,1907
Tersier 3	Trapesium	0,2389
Tersier 4	Trapesium	0,1459
Sekunder 2	Trapesium	0,2418
Sekunder 1	Trapesium	116,3194
Primer Sawahan	Trapesium	399,5758
Primer Asemrowo	Trapesium	688,8284
Primer Krembangan	Trapesium	702,5875

Table 10 *Calculation of Canal Hydraulic Analusis with 5 Year Return Period Discharge (Q_5)*

Nama Saluran	Jenis saluran	Q m^3/det
Tersier 1	Trapesium	0,0840
Tersier 2	Trapesium	0,19072
Tersier 3	Trapesium	0,23893
Tersier 4	Trapesium	0,14593
Sekunder 2	Trapesium	0,24182
Sekunder 1	Trapesium	116,319
Primer Sawahan	Trapesium	399,576
Primer Asemrowo	Trapesium	688,828
Primer Krembangan	Trapesium	702,588

Table 11 Calculation of Canal Hydraulic Analusis with 10 Year Return Period Discharge (Q_{10})

Nama Saluran	Jenis saluran	Q m^3/det
Tersier 1	Trapesium	0,084
Tersier 2	Trapesium	0,19072
Tersier 3	Trapesium	0,23893
Tersier 4	Trapesium	0,14593
Sekunder 2	Trapesium	0,24182
Sekunder 1	Trapesium	116,319
Primer Sawahan	Trapesium	399,576
Primer Asemrowo	Trapesium	688,828
Primer Krembangan	Trapesium	702,588

3.3 Drainage Channel Evaluation

Channel evaluation is carried out by comparing the design flood discharge of each drainage channel with the existing channel discharge as shown in **Table 12**.

***Table 12** Drainage Channel Evaluation*

Nama Saluran	Kala Ulang 2 Tahun (Q_2)		
	Q exst m^3/det	Q renc m^3/det	Kondisi
Tersier 1	0,0840	0,1353	Tidak Mampu
Tersier 2	0,1907	0,0982	Mampu
Tersier 3	0,2389	0,0649	Mampu
Tersier 4	0,1459	0,1024	Mampu
Sekunder 2	0,2418	0,0594	Mampu
Sekunder 1	116,3194	0,0799	Mampu
Primer Sawahan	399,5758	0,1137	Mampu
Primer Asemrowo	688,8284	0,1672	Mampu
Primer Krembangan	702,5875	0,2420	Mampu

Nama Saluran	Kala Ulang 5 Tahun (Q_5)		
	Q exst m^3/det	Q renc m^3/det	Kondisi
Tersier 1	0,0840	0,1631	Tidak Mampu
Tersier 2	0,19072	0,11834	Mampu
Tersier 3	0,23893	0,07818	Mampu
Tersier 4	0,14593	0,12336	Mampu
Sekunder 2	0,24182	0,07159	Mampu
Sekunder 1	116,319	0,09621	Mampu

Nama Saluran	Kala Ulang 5 Tahun (Q_5)		
	Q exst m^3/det	Q renc m^3/det	Kondisi
Primer Sawahan	399,576	0,13699	Mampu
Primer Asemrowo	688,828	0,2015	Mampu
Primer Krembangan	702,588	0,29151	Mampu

Nama Saluran	Kala Ulang 10 Tahun (Q_{10})		
	Q exst m^3/det	Q exst m^3/det	Kondisi
Tersier 1	0,084	0,084	0,084
Tersier 2	0,19072	0,19072	0,19072
Tersier 3	0,23893	0,23893	0,23893
Tersier 4	0,14593	0,14593	0,14593
Sekunder 2	0,24182	0,24182	0,24182
Sekunder 1	116,319	116,319	116,319
Primer Sawahan	399,576	399,576	399,576
Primer Asemrowo	688,828	688,828	688,828
Primer Krembangan	702,588	702,588	702,588

From the table it can be seen that the Tertiary 1 channel is unable to accommodate the planned flood discharge, therefore in evaluating the existing channel one of the steps that can be taken is to enlarge the cross section in the channel and deepen the channel, so that the capacity of the channel can accommodate the planned flood discharge. The following is in **Table 13** the results of trial and error 3 times channel replanning.

***Table 13** Results of Channel Replanning with 10 Years Return Period (Q_{10})*

Nama Saluran	Q eks m^3/det	Q renc m^3/det	Kondisi
Tersier 1	0,4452	0,1814	Mampu
Tersier 2	1,0109	0,1317	Mampu
Tersier 3	1,2664	0,0870	Mampu
Tersier 4	0,7735	0,1372	Mampu
Sekunder 2	1,2817	0,0796	Mampu
Sekunder 1	116,3194	0,1070	Mampu
Primer Sawahan	399,5758	0,1524	Mampu
Primer Asemrowo	688,8284	0,2242	Mampu
Primer Krembangan	702,5875	0,3243	Mampu

Based on the results of the 10-year third phase replanning, it is able to accommodate rain discharge with the following cross-sections:

1. Tertiary 1 channel with a size of 1.2x1x1 m and channel discharge = 0.30977 m3/second.

2. Tertiary 2 channel with a size of 1.2x1x1 m and channel discharge = 0.70332 m3/second.

3. Tertiary 3 channel with a size of 1.2x1x1 m and channel discharge = 0.88107 m3/second.

4. Tertiary 4 channel with size 1.2x1x1 m and channel discharge = 0.538`2 m3/second.

5. Secondary Channel 2 with a size of 1.2x1x1 m and channel discharge = 2.08418 m3/second.

4. Conclusion

The case of high inundation that often occurs when the rainy season arrives in the Simorejo residential area and often becomes a regular occurrence due to the inability of the drainage canals to accommodate and drain the inundation. For this reason, this research is intended to bring up alternative solutions to the inundation problem. the capacity of the drainage channel in the Simorejo residential area is tertiary 1 = 0.08 m3/second, tertiary 2 = 0.19 m3/second, tertiary 3 = 0.23 m3/second, tertiary 4 = 0.14 m3/second seconds, secondary channel 2 = 0.24 m3/second. Based on the calculation of the design discharge, the average design discharge results for the Simorejo residential area channel with a 2 year return period for tertiary 1-4 and sacunder 2 = 0.0921 m3/second. The average discharge of the planned 5 year return period for tertiary 1-4 and secondary 2 channels = 0.1109 m3/second. The average planned discharge for a return period of 10 years for tertiary 1-4 and sacunder 2 channels = 0.1234 m3/second. After conducting research and analysis on the canal in the Simorejo residential area, it was found that the existing canal with a trapezoidal shape was unable to accommodate rainfall (flooding). , it is necessary to redesign the channel cross-section and depth. so that dimensions are produced that can accommodate flood discharge in tertiary channels 1-4 and secondary channels 2 of 1.2x1x1 m.

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