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Analysis of Drainage System Planning in Newtown Park Housing Development Sidoarjo District

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Abstract

Some areas in Indonesia often experience flood problems, therefore it is necessary to have an adequate and good drainage system planning so that community activities in an area are not disturbed. The location of this research is located in the newtown park housing development in Damarsih Village, Buduran District, Sidoarjo Regency. with land area ± 72.548 m². Rain station data used were from Bono, Sruni, Sedati, Banjarkemanten in the period 10 years 2009-2019. The direction of discharge of water from the study site was directed at small afv pepe, then continued to afv pepe. With the analysis of HSS Nakayashu at the 25 year return period, the discharge that occurred was not greater than the carrying capacity of Small afv pepe and afv pepe. The maximum discharge that occurs at the research location with the Rational method is 17,404 m^3/s, the maximum discharge in the Weduwen method is 27,917 m^3/s. Rational Discharge was chosen because the calculation of the length of rain can be known for sure so as to strengthen the level of certainty of the results obtained. For the capacity requirements in the research location with the rational method, the peak discharge for the 5-year return period is 1,858 m^3/s and the volume of capacity required during high rain (27 minutes) is 3009 m^3 and can be accommodated with a drainage channel of 5217.43 m^3 and bozem. with a capacity of 720 m3 which has an area of 400 m^2 with a depth of 1.8 m.

Keywords:
Flood, Discharge,Rational, Weduwen,

1. Introduction

1.1. Research Background

Housing is an area designated as a residence where there are many human activities such as education, religion, culture, etc. In order for the activities carried out in the area not to be disturbed, it is necessary to fulfill adequate facilities and infrastructure. One of the aspects is a good drainage channel to avoid flooding problems.

Flooding is one of the consequences of environmental pollution which is influenced by human activities, starting from land conversion and the lack of rainwater catchment areas and this is exacerbated by the lack of human awareness to maintain environmental cleanliness. In the rainy season, many drainage channels already exist but the existing condition cannot accommodate water due to a high accumulation of sediment and garbage, which will cause puddles or flooding in the area.

Drainage is one of the ways that can be done to minimize the occurrence of flooding by processing rainfall data obtained from the nearest rain station in the area under review so that the average rainfall that occurs in a certain area is obtained and the calculation of the planned discharge with several methods including Rational and Weduwen. it can be obtained that the maximum discharge that occurs in the area under review. So that it can be calculated the required drainage channel capacity required.(Fachmi Irawan, 2015)

1.2. Problem Formulation

1. What determinants can cause flooding in the area?
2. How is the Maximum Debit Calculation using the Weduwen and Rational Method in Newtown Park Housing?
3. What is the Need for Channel Dimensions to accommodate the Maximum discharge that occurs at Newtown Park Housing?

2. Litterature Review

2.1. Drainage

Drainage is a water network system that is useful for avoiding the area from inundation or flooding. Drainage means draining, draining, removing, or diverting water.(Eldo Fikri Alvin, 2017)

2.2. Stages of Calculation

In this research, the calculation stages include :

1. Calculation of the average rain Polygon Thiesien $R=\frac{(A1.R1+A2.R2+...+An.Rn)}{A1+A2+...+An}$....... (1)
2. Calculation Log Person Tipe III Y = Y- k S... (2)
3. Distribution Test Chi-Square $Xh^2 = \sum_{i=1}^{G} \frac{(Of-Ef)^2}{Ef}$.. (3)
4. Smirnov-Kolmogorov distribution test, the maximum value of D is not greater than the table Smirnov-Kolmogorov
5. Rain Intensity Analysis $I = \left(\frac{R24}{24}\right) x \left(\frac{24}{A}\right)^{2/3}$ .... (4)
6. Calculation of Concentration Time $Tc = \left(\frac{0.87 \times L^2}{1000 \times So}\right)^{0.385}$ .... (5)
7. Calculation of the maximum debit by the Rational Method

   $W = 72 \text{ x } (\frac{H}{L})^{0.6}$ .... (6)

   $Tc = \frac{L}{W}$ .... (7)

   $I = \frac{R24}{24} \; x \; (\frac{24}{Tc})^{\frac{2}{3}}$ ....(8)

   $Qt = \frac{(C \text{ x } I \text{ x } A)}{3.6} = 0.278 \text{ x } C \text{ x } I \text{ x } A$ .... (9)
8. Calculation of the Maximum Debit of the Weduwen Method

   $\beta = \frac{120+\frac{t+1}{t+9}A}{120+A}$ ....(10)

   $\alpha = 1 - \frac{4.1}{\beta \; x \; qn+7}$..(11)

   $I = \frac{Rn}{240} \; x \; \frac{67.65}{t+1.45}$ .... (12)

   $t = 0.25 \; x \; L \; x \; Q^{-0.125} \; x \; I^{-0.25}$ .... (13)

   Q Maks = α x β x qn x A .... (14)
9. Selection of maximum debit
   Comparing the results obtained from the results of the Weduwen and Ratioanal methods in order to get the most appropriate results.
10. Calculation of Channel Dimensions

    $V = \frac{1}{n} \; x \; R^{\frac{2}{3}} \; x \; S^{\frac{1}{2}}$.. (15)

    $R = \frac{A}{P}$.. (16)

    A = B X H.. (17)

    P = B + (2 x H) .... (18)

    Q = V x A (The channel discharge must be greater than the planned debit) ....(19)
11. Volume Run Off Calculation
    The Run off volume must not be greater than the total capacity of the channel

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3. Methodology

3.1. Data source

This study uses two types of data namely. Primary data obtained from observations of existing canal measurements and mapping of existing drainage networks at the research location. Secondary data were obtained from several related agencies as well as the Sidoarjo Regency Construction Service.

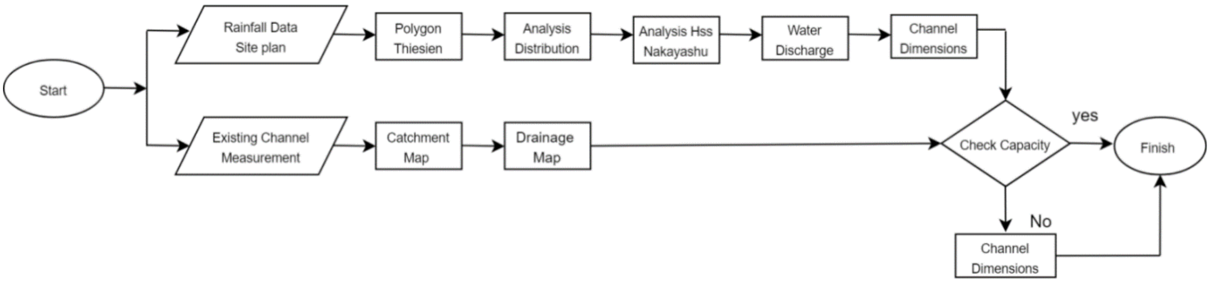

Figure 1. Flow Chart

3.2. Research sites

Figure 2. Research Location

The research location is located on Margo Utomo Street, Damarsih Village, Buduran District, Sidoarjo Regency. With a land area of ± 72,548 m² with many locations directly adjacent to the rice fields and ponds.

4. Result and Discussion

Rainfall data was taken from four rain stations namely Bono, Sruni, Sedati, Banjarkemanten. Daily rainfall data were taken from 2009-2019 with a total area of Drainage area small afv pepe of 18.75 km^2 and an area of Drainage area afv pepe 21 km^2, with a total impact of 39.75 km^2 . Bono rain station (with an area of 5.73 km^2), Sruni rain station (with an area of 3.66 km^2), Sedati rain station (with an area of 21.90 km^2), Banjarkemanten rain station (with an area of 8.46 km^2).(Melisa Permatasari, M. Candra Nugraha, 2020)

Figure 3. Rain Station map with Polygon Thiessen Method

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Table 1. Averege Rainfall With Polygon Thiessen Method

Year	Date	Bono	Sruni	Sedati	Banjarkemanten	Total
		Rain Measuring Station				
		0.144	0.092	0.551	0.213	
2009	23-Feb	10.80	8.74	44.08	13.85	77.465
2010	15-Oct	15.12	10.67	50.69	24.50	100.979
2011	17-Dec	20.16	14.81	83.75	26.63	145.349
2012	15-Jan	14.40	6.72	54.00	22.58	97.692
2013	02-Jan	16.56	8.37	78.24	26.63	129.799
2014	08-Mar	22.61	15.64	60.61	25.56	124.418
2015	19-Mar	14.40	15.64	52.35	20.87	103.259
2016	12-Feb	12.24	13.80	36.92	31.52	94.481
2017	30-Mar	7.92	6.81	22.04	14.91	51.678
2018	08-Mar	0.00	7.18	0.00	5.33	12.501
2019	23-Feb	10.08	8.37	33.06	21.30	72.812

Source : Calculation Results

After obtaining the maximum rainfall data using the Thiessen Polygon method, the frequency distribution is calculated as in the table below:

Table 2. Determination of Frequency Distribution

No	x	$\bar{x}$	$x - \bar{x}$	$(x - \bar{x})^2$	$(x - \bar{x})^3$	$(x - \bar{x})^4$
1	12.501	91.856	- 79.355	6297.216	-499,715.58	39654929.67
2	51.678	91.856	-40.178	1614.272	-64,858.21	2605873.07
3	72.812	92.856	-20.044	401.7619	-8,052.92	161412.6532
4	77.465	91.856	-14.391	207.1009	-2,980.39	42890.77491
5	94.481	93.856	0.625	0.390625	0.24	0.152587891
6	97.692	91.856	5.836	34.0589	198.77	1160.008397
7	100.979	94.856	6.123	37.49113	229.56	1405.584754
8	103.259	91.856	11.403	130.0284	1,482.71	16907.38715
9	124.418	95.856	28.562	815.7878	23,300.53	665509.8064
10	129.779	91.856	37.923	1438.154	54,539.11	2068286.723
11	145.349	96.856	48.493	2351.571	114,034.73	5529886.398
Total	1,010.413	-	-	13327.83	-381,821.43	50748262.22

Source : Calculation Results

Get the value :
Cs = **-** 0.95 Get the value Cs = ≠ 0 then the distribution selection used is Log Person Tipe III

Table 3. Calculation Log Person Tipe III

No.	X(mm)	Log X	$(Logx - \overline{Logx})$	$(Logx - \overline{Logx})2$	$(Logx - \overline{Logx})3$	$(Logx - \overline{Logx})4$
1	145.349	2.1624	0.2610	0.0681	0.0178	0.0046
2	129.779	2.1132	0.2118	0.0449	0.0095	0.0020
3	124.418	2.0949	0.1935	0.0374	0.0072	0.0014
4	103.259	2.0139	0.1125	0.0127	0.0014	0.0002
5	100.979	2.0042	0.1028	0.0106	0.0011	0.0001
6	97.692	1.9899	0.0885	0.0078	0.0007	0.0001
7	94.481	1.9753	0.0739	0.0055	0.0004	0.0000
8	77.465	1.8891	-0.0123	0.0002	0.0000	0.0000
9	72.812	1.8622	-0.0392	0.0015	-0.0001	0.0000
10	51.678	1.7133	-0.1881	0.0354	-0.0067	0.0013
11	12.501	1.0969	-0.8045	0.6472	-0.5206	0.4188
Total	1,010.413	20.92	0.000	0.8712	-0.4892	0.4285

Source : Calculation Results

Get the value Cs = - 2.3 then look for the value in the K Factor table for the distribution of Type III Log Person indicated by the calculations and tables in the table below

Table 4. Rain Various Times with Log Person Tipe III

No.	Tr (year)	K	Log x	X (mm)
1	1.01	-3.705	0.8078	6.425
2	2	0.341	2.0021	100.47
3	5	0.739	2.1195	131.68
4	10	0.819	2.1431	139.04
5	20	0.43	2.1502	141.32
6	25	0.855	2.1538	142.48
7	50	0.964	2.1859	153.44
8	100	0.867	2.1573	143.65

Source : Calculation Results

Table 5. Distribution of Rain by Hour Log Person Tipe III Method

Time Hour	Ratio (%)	Rainfall Every Hour							
		1.01 Th	2th	5th	10th	20th	25th	50th	100th
		6.425	100.470	131.680	139.040	141.320	142.480	153.440	143.650
1	0.55	2.652	41.468	54.350	57.387	58.807	58.807	63.331	59.290
2	0.35	1.671	26.123	34.238	36.152	37.046	37.046	39.896	37.351
3	0.26	1.275	19.936	26.129	27.589	28.272	28.272	30.446	28.504
4	0.22	1.052	16.457	21.569	22.774	23.338	23.338	25.133	23.529
5	0.19	0.907	14.182	18.587	19.626	20.112	20.112	21.659	20.277
6	0.17	0.803	12.559	16.460	17.380	17.810	17.810	19.180	17.956

Source : Calculation Results

4.1. Calculation Rasional Method

Data :

Difference in elevation is viewed from the upstream area (H) = 0.044 Km

The length of the area is reviewed with the Hulu Area (L) = 76.2 Km

Data R_{24} 5 Year = 131.68 mm/day

Drainage Area =18.75 + 21 = 39.75 Km^2

$W = 72 \times (\frac{H}{L})^{0.6} = 72 \times (\frac{0.044}{76.2})^{0.6}$ = 0.82

$Tc = \frac{L}{W} = \frac{76.2}{0.82}$ = 92.93

$I = \frac{R24}{24}\ x\ (\frac{24}{Tc})^{\frac{2}{3}} = \frac{131.68}{24}\ x\ (\frac{24}{92.93})^{\frac{2}{3}}$ = 2.25

$Q = \frac{(C\ x\ I\ x\ A)}{3.6}$ = 0.278 x C x I x A

$Q = \frac{(0.7\ x\ 2.25\ x\ 39.75)}{3.6}$ = 17.404 m^3/s

Table 7. Maximum Discharge Rational Method

Year	Q maksimum (m3/s)
1.01	0.839
2	13.125
5	17.404
10	18.163
20	18.461
25	18.612
50	19.914
100	18.675

Source : Calculation Results

4.2. Calculation Weduwen Method

Data :

Drainage Area = 18.75 + 21 = 39.75 Km^2

River Length = 9.38 + 10.05 = 19.88 Km

The mean slope of the river = 0.0012

Data R_{24} 5 Year = 131.68 mm/day

t trial = **25.68 Hour**

$\beta = \frac{120 + \frac{25.68+1}{25.68+9} 39.75}{120+39.75}$ = 0.942

$\alpha = 1 - \frac{4.1}{0.942\ x\ 131.68+7}$ = 0.545

$qn = \frac{131.68}{240}\ x\ \frac{67.65}{25.68+1.45}$ = 1.368

t = 0.25 x 19.88 x 0.942^{-125} x $0.0012^{0.25}$ = 25.68 Hour (Corect)

Qt = Qt = α x β x qn x A = 0.545 x 0.942 x 1.368 x 39.75 = 27.917 m^3/s

Tabel 8. Debit Maksimum Metode Weduwen

Year	1.01 Th	2th	5th	10th	20th	25th	50th	100th
Qn	0.044	1.006	1.368	1.455	1.482	1.496	1.615	1.510
Beta	0.958	0.944	0.942	0.944	0.942	0.942	0.941	0.942
Alfa	12.784	0.383	0.545	0.572	0.58	0.584	0.614	0.588
Q (m3/s)	21.420	14.458	27.917	31.230	32.186	32.714	37.091	33.246
T (hour)	39.42	26.68	25.68	25.48	25.42	25.39	25.15	25.36

Source : Calculation Results

From the table above, it can be seen that the results of the discharge calculation using two different methods, namely the Rational Method and the Weduwen Method. Based on the results of calculations and considerations, safety and efficiency as well as the uncertainty of the amount of flood discharge that occurs in the area, the existing methods use a maximum return period of 5 years. Due to the consideration of the accuracy of the calculation results, the Rational Method design flood discharge was determined to be 17.404 m3 / s, because the length of rain (t) in the Rational Method was clearly known, thereby strengthening the level of certainty of the results obtained.

4.3. Calculation Drainage Dimension

Channel Length = 20.80 m
Channel Slope = 0.001
Channel Catchment Area= 0.0050 km^2
Data R_{24} 5 Year = 131.68 mm/hour
Concentration time (tc) $\left(\frac{0.87 \text{ x } L^2}{1000 \, x \, s}\right)^{0.384} = \left(\frac{0.87 \text{ x } 0.02080^2}{1000 \, x \, 0.001}\right)^{0.384}$ = 0.049 hour
Rain intensity (I) $\left(\frac{131.68}{24}\right) x \left(\frac{24}{0.049}\right)^{2/3}$ = 340.192 mm/hour
Discharge return period flood plan 5 year
Planned Flood Discharge = 0.278 x 0.7 x 340.192 x 0.0050 = 0.331 m^3/s
Planned Channels :
B = 0.80 m = 0; s = 0.00096 ; n = 0.013 (concrete mate)
Formula H = 1.00 m
A = B+ (m x h) x h = 0.80 + (0 x 1.00) x 1.00 = 0.800 m^2
P = B+ (2xh) x $((m^2)+1)^{0.5}$ = 0.80 +(2x1.00)x$((0^2)+1)^{0.5}$= 2.800 m
R = $\frac{A}{P} = \frac{0.800}{2.800}$ = 0.286
V = 1/n x $R^{2/3}$ x $s^{½}$ = 1/0.013 x $0.286^{2/3}$ x $0.00096^{½}$ = 1.035 m/s
Q = V x A = 1.035 x 0.800 = 0.8278 m^3/s
Q Plan / Q Chanel x 100%
0.8278 x 100% = 39.99 %,

So that the Wish (B) and height (H) of the Plan Channel are Appropriate, because the calculated discharge results are the same or greater than the rainfall plan discharge for the 5 year return period.

4.4. Calculation Capacity Channel

Land area = 72548 m^2 = 0.0725 km^2
Flow Coefficient = 0.7
R_{24} 5 Year = 131.68 mm/hour
Peak Discharge = 0.278 x C x I x A = 0.278 x 0.7 x 131.68 x 0.072 = 1.858 m^3/s
In high rain (Tc) the volume of water that has occurred

Tc = $\left(\frac{0.87 \text{ x } L^2}{1000 \, x \, s}\right)^{0.384} = \left(\frac{0.87 \text{ x } 1.250^2}{1000 \, x \, 0.01}\right)^{0.384}$ = 0.46 Hour = 27 Minute
Volume Run Off = 27 minute x 1.858 x 60 = 3009 m3
With a channel capacity of = 5217.43 m3
Volume Bozem =
Large = 400 m2
depth = 1.8 m = 400 x 1.8 = 720 m3
Then the total capacity that can be accommodated becomes
5217.43 m3+ 720 m3 = 5937.43 m3

Then the capacity is greater than the volume run off of 3009 m3 The channel dimensions are in accordance and meet the requirements.

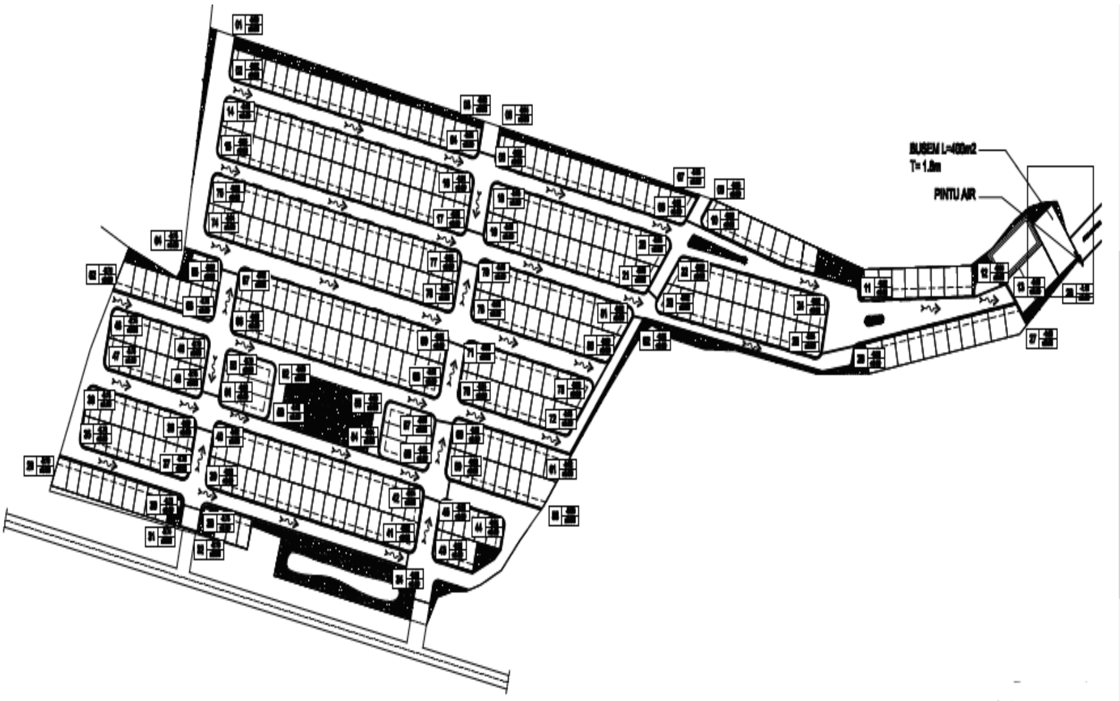

Figure 4. Site Plan

4. Conclussion and Suggestions

Based on the result of analysis of the research above it can concluded. Factors that can cause flooding in the Newtown Park Housing Development area. namely the lack of maintenance of drainage conditions and disposing of trash that is not in its place. The maximum debit with a return period of 5 years, the value obtained by the Rational Method is 17,404 m^3/s and the maximum debit with a 5 year return period is obtained by using the Rational Method of 27,917 m^3/s. With a channel capacity of 5217.43 m^3 and a bozem of 720 m^3, the total capacity is 5937.43 m^3. So with a run off volume of 3009 m^3, the channel dimensions have met the requirements. Based on the above conclusions, it is necessary to implement the following

a. Maintenance of drainage channels is required so that there is no accumulation of sediment so as not to obstruct the channel.
b. There needs to be a re-assessment within 5 years if the channel is not able to accommodate and causes flooding due to land subsidence and other natural factors.
c. Increase public awareness about the importance of protecting the surrounding environment so that the area inhabited is free from flooding.

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