Quest Journals
Journal of Architecture and Civil Engineering
Volume 6 ~ Issue 10 (2021) pp: 27-36
www.questjournals.org

Research Paper

Urban Residential Drainage Network System Evaluation (Case Study: GunungBatu Housing, Jember Regency)

Noor Salim
Civil Engineering Study Program, Faculty of Engineering, Muhammadiyah University of JemberCorresponding Author:Noor Salim

ABSTRACT:*At GunungBatu Housing on Jalan Madura, Sumbersari District, Jember Regency, when there is quite heavy rain, there are often quite a lot of puddles around the road, so that water overflows onto the highway and becomes a puddle which is very disturbing to road users. To overcome this, one of the steps that need to be taken is to evaluate the drainage system of the residential area. From the evaluation results, it can be concluded that the capacity of the drainage channel (existing discharge) in GunungBatu housing is in channel 1, channel 2, channel 5 and 6 of 0.108 m³/second, and channel 3 and 4 of 0.022 m³/second. The runoff discharge in the GunungBatu residential area in each channel is based on the total of rainwater discharge and dirty water discharge, which is 3.0037 m/sec. The dimensions of the channel in order to accommodate the runoff discharge are for one channel, the channel width is 50 cm and the height is 50 cm. cm. Channel two, channel width of 60 cm with a height of 60 cm. Channel three, channel width 65 cm and height 65 cm. Channel four, channel width of 75 cm and height of 75 cm. Channel five, channel width 70 cm and height 75 cm. Channel 6, the width of the channel is 90 cm with a height of 95 cm. It is recommended that channel widening be done to reduce inundation that often occurs in the residential area, and it is necessary to clean each channel so that there is no garbage that clogs the flow of water in each channel.*

KEYWORDS: *Channels, Drainage, Runoff.*

Received 17 October, 2021; Revised: 30 October, 2021; Accepted 01 November, 2021 © The author(s) 2021. Published with open access at www.questjournals.org

I. INTRODUCTION

Drainage is a system designed to deal with the problem of excess water, both excess water above the ground surface and water below the ground surface. Excess water or flooding can be caused by high rainfall intensity or as a result of a long duration of rain. analysis of intensity, duration and frequency required data series obtained from rain data [1]. The peak time of the flood is more in line with the characteristics of the watershed. [2] In general, drainage is defined as the study of efforts to drain excess water in an area [3]

Jember Regency is one of the capitals of East Java Province which is experiencing rapid development. It is one of the most densely populated areas. Housing development is one of the factors that affect population density. Rainwater that falls to the ground surface will be difficult to seep into the ground because the land which was originally a natural environment that can absorb rainwater has now turned into a residential area. Because the imbalance between road distribution and resistance is getting smaller, the portion of rainwater runoff increases and creates a critical flow in the existing channel. Critical flow in an open channel can occur because the channel bottom elevation is reduced [4,5], reduced channel cross-sectional area [6,7] and raised channel base [8,9].

At GunungBatuPermai Housing on Jalan Madura, Sumbersari District, Jember Regency, when there is quite heavy rain, there are often quite a lot of puddles around the road, so that water overflows onto the highway and becomes a puddle which is very disturbing to road users, and vice versa. During the dry season, the residential area suffers from water shortages. Therefore, to overcome this, one of the steps that need to be taken is to show the rainwater management system in an area in the context of water conservation, namely by paying attention to the drainage system of the residential area.

II. METHODOLOGY

Research Site

The research site is located in the GunungBatuPermai Residential area, which is on Jalan Madura. Jember Regency, the complete location data is presented in Figure 1.

Figure 1 : Research Location

Research Flowchart

The flow chart in this study which illustrates the study of the evaluation of the drainage network system in housing in urban areas is presented in Figure 2.

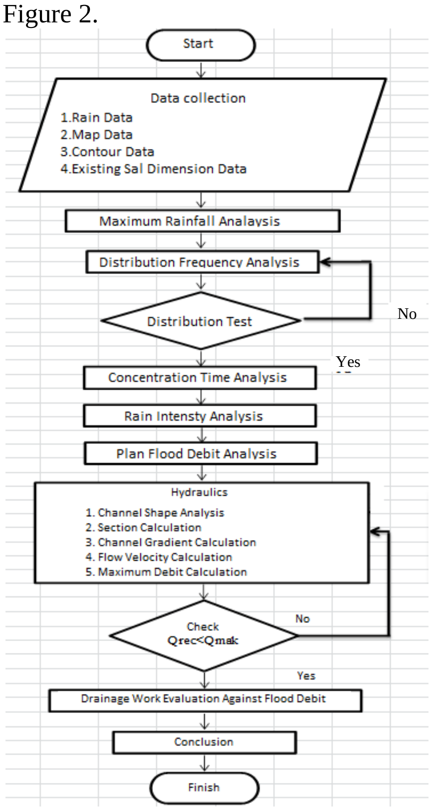


Figure 2. Research flowchart

Data Collection

Data collection is divided into 2, namely primary data and secondary data. Primary data collection is the collection of data obtained directly from the field, while secondary data is data collected indirectly or data sourced from publications of local government agencies. The data needed for this thesis are as follows:

1) Secondary data:
   - Rainfall data for the last 10 years
   - housing site plan
2) Primary data:
   - Existing channel data
   - Measurement of height difference using a waterpass

Data Analysis

a. Existing Debit Calculation

Qs = As. V

Which:

As = Channel cross-sectional area (m2)

V = Average water velocity in the channel (m/detik)

Average water velocity in the channel , can be calculated using Manning formula as following:

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

$R = \frac{A_s}{P}$

Which :

V = Flow Velocity

N = Manning Roughness Coefficient

R = Hydraulic radius (m)

As = Channel cross-sectional area (m2)

P = Wet Circumference (m)

b. Rough water discharge calculation

Using formula below

Q = (((a x b) / (24 x 60 x 60)) x c)x 70%

Which :

a = each person usage per day

b = number of people in each house

c = number of houses in each channel area

c. Surface flow discharge / runoff discharge calculation

Q = 0,278 x C x I x A

Which :

C = flow rate

I = Rainfall intensity

A = Area

d. Final result

Calculation of channel dimensions is based on the discharge that must be accommodated by the channel (Qs in m^3/second) greater than or equal to the discharge

III. RESULTS AND DISCUSSION

Area Rainfall Distribution

The rainfall required for the preparation of the Drainage Channel Evaluation task at GunungBatuJember Housing is the average rainfall from the observation points in this case the Bintoro rain station, Wirolegi rain station and Renes rain station.

Determination of observation points or rain stations based on the calculation of the area of influence of each observation point or rain station using the Teisen polygon method. The city of Jember has several observation points or rain stations scattered in various places. The way to find the area of influence of each observation point or rain station is to connect each observation point or adjacent rain station with a straight line and then determine the midpoint of the associated line with a perpendicular line.

Frequency Analisis

Frequency analysis is an analysis of the repetition of an event to predict or determine the return period along with its probability value. Rain data is monthly rain data for 2009 - 2018 from the Bintoro rain station, the Wirolegi rain station and the Renes rain station. The monthly rainfall data mentioned above are presented in Tables 1,2 and 3.

TAB.1 Monthly Rain Data InRenes Station

Rain Station1RENES														
No	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Ags	Sep	Okt	Nov	Des	Total(m
1	2009	182	256	183	213	160	36	33	0	23	98	191	127	1502
2	2010	490	324	307	355	296	130	167	105	276	264	296	221	3231
3	2011	313	275	174	400	239	4	0	0	0	0	125	142	1672
4	2012	355	469	406	205	152	31	50	0	0	85	68	383	2204
5	2013	745	158	191	187	137	228	103	5	0	100	183	447	2484
6	2014	351	141	202	0	0	0	0	0	0	0	0	0	694
7	2015	359	251	162	288	8	38	0	0	0	0	127	210	1443
8	2016	250	442	161	133	276	302	60	82	117	190	189	384	2586
9	2017	186	173	143	152	139	35	3	0	34	99	374	311	1649
10	2018	470	165	168	93	98	22	0	0	8	0	0	176	1200
Average		370.1	265.4	209.7	202.6	150.5	82.6	41.6	19.2	45.8	83.6	155.3	240.1	1866.5
Maximum		745	469	406	400	296	302	167	105	276	264	374	447	3231
Minimum		182	141	143	0	0	0	0	0	0	0	0	0	694

Tab. 2Monthly Rain Data In Bintoro Station

Rain Station 2BINTORO														
No	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	2009	440	185	120	80	75	25	0	0	25	25	220	125	1320
2	2010	430	277	205	247	250	75	20	0	157	210	105	325	2301
3	2011	350	200	277	132	153	32	0	0	5	147	279	418	1993
4	2012	351	143	60	109	69	0	18	0	0	75	94	425	1344
5	2013	329	150	323	160	150	85	10	0	0	85	190	402	1884
6	2014	242	177	205	228	42	16	0	0	0	0	224	465	1599
7	2015	237	250	280	165	16	0	0	0	0	0	147	183	1278
8	2016	117	260	117	161	75	75	110	75	66	138	297	216	1707
9	2017	270	155	137	212	35	40	5	0	47	142	237	176	1456
10	2018	272	483	19	80	0	21	0	0	10	0	0	316	1201
Average		303.8	228	174.3	157.4	86.5	36.9	16.3	7.5	31	82.2	179.3	305.1	1608,3
Maximum		440	483	323	247	250	85	110	75	157	210	297	465	2301
Minimum		117	143	19	80	0	0	0	0	0	0	0	125	1201

TAB.3 Monthly Rain Data InWirolegi Station

Rain Station 3BINTORO														
No	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	2009	254	280	64	90	55	0	7	6	0	9	106	57	928
2	2010	232	266	74	257	191	31	116	2	81	126	86	158	1620
3	2011	178	150	255	148	116	0	40	0	2	36	129	307	1361
4	2012	224	160	241	46	48	18	37	0	0	9	19	54	856
5	2013	186	28	113	128	100	111	47	0	0	37	83	194	1027
6	2014	338	137	129	0	0	0	0	0	0	0	0	0	604
7	2015	98	128	215	89	31	2	0	0	0	0	100	178	841
8	2016	151	424	169	79	38	62	51	84	31	206	217	326	1838
9	2017	211	163	264	161	126	160	8	0	53	217	429	399	2191
10	2018	589	333	88	227	4	0	0	0	75	0	0	170	1486
Average		246,1	206,9	161,2	122,5	70,9	38,4	30,6	9,2	24,2	64	116,9	184,3	1275,2
Maximum		589	424	264	257	191	160	116	84	81	217	429	399	2191
Minimum		98	28	64	0	0	0	0	0	0	0	0	0	604

Before choosing the probability distribution to be used, a calculation is carried out First analyze the existing data. In this case the distribution calculation are as follows :

TAB.4Monthly Rain Distribution

No	Year	Ri	P	(Ri-R)	$(Ri-R)^2$	$(Ri-R)^3$	$(Ri-R)^4$
1	2009	79.39	10.00	-19.0	360,4	-684.6	129880.0
2	2010	83.49	20.00	-14.9	221,3	-3291.3	48957.3
3	2011	96.00	30.00	-2.4	5,6	-13.3	31.5
4	2012	172.27	40.00	73.9	5460,6	403519.9	29818556.2
5	2013	94.65	50.00	-3.7	13,9	-51.7	192.4
6	2014	88.99	60.00	-9.4	87,9	-823.9	7723.3
7	2015	113.16	70.00	14.8	218,9	3238.1	47906.5
8	2016	113.16	80.00	14.8	218,9	3238.1	47906.5
9	2017	77.47	90.00	-20.9	436,7	-9125.2	190688.1
10	2018	65.11	100.00	-33.3	1106,3	-36797.0	1223909.6
	Total				8130	353052	31515751
	Mean	98,37			1478	35305.23	3151575.13

The statistical parameters of the above data are:

a. Mean :

$$\bar{X} = \frac{\sum X}{n} = \frac{983.7}{10} = 98.37$$

b. StandardDeviation

$$S = \sqrt{\frac{\sum(X-\bar{X})^2}{(n-1)}} = 30.6$$

c. Variation Coefficient

$$Cv = \frac{S}{\bar{X}} = 0.31$$

d. Skewness Coefficien

$$Cs = \frac{n(X-\bar{X})^3}{(n-1)(n-2)S^3} = 1.81$$

e. Sharpness Coefficient

$$Ck = \frac{n^2(X-\bar{X})^4}{(n-1)(n-2)(n-3)S^4} = 7.66$$

Distribution Calculation

Normal Log Distribution can be calculated using equation on Table 5.

Tabel 5. Normal Log Distribution Calculation

No	Year	X	Y (Log X)	y-ȳ	(y-ȳ)2	(y-ȳ)3	$(y-\bar{y})^4$
1	2004	79,4	1,90	-2,01	0,006	0,000	0,000
2	2005	83,5	1,92	-1,99	0,003	0,000	0,000
3	2006	96,0	1,98	-1,93	0,000	0,000	0,000
4	2007	172,3	2,24	-1,67	0,067	0,017	0,004
5	2008	94,6	1,98	-1,93	0,000	0,000	0,000
6	2009	89,0	1,95	-1,96	0,001	0,000	0,000
7	2010	113,2	2,05	-1,86	0,006	0,000	0,000
8	2011	113,2	2,05	-1,86	0,006	0,000	0,000
9	2012	77,5	1,89	-2,02	0,008	-0,001	0,000
10	2013	65,1	1,81	-2,10	0,027	-0,004	0,001
	total	983,69	19,78	-19,33	0,12	0,01	0,005
	Mean	98,37	1,98	-1,93	0,00	0,00	0,001

The statistical parameters of the Log Normal Distribution owned by the above data are:

a. Mean:

$$\bar{Y} = \frac{1}{n}\sum_{i=1}^{n} Y_t = 98.37$$

b. Standard Deviation :

$$S = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(Y_i - \bar{Y})^2} = 0.12$$

c. Variation Coefficient:

$$C_v = \frac{S}{Y} = 0.01$$

d. Skewness Coefficient:

$$C_s = \frac{n}{(n-1)(n-2)S^2}\sum_{i=1}^{n}(y_i - \bar{y})^3 = 1.08$$

e. Kurtosis Coefficient:

$$C_k = \frac{n^2}{(n-1)(n-2)(n-3)S^4}\sum_{i=1}^{n}(y_i - \bar{y})^4 = 5.69$$

Distribution Match Test

To determine the suitability of the frequency distribution of the sample data to the probability distribution function which is expected to describe or represent the frequency distribution, parameter testing is required.

a. Chi-square Test

Number of data(n) = 10
Logn = 1.00
Number of classes= 4.22 Class boundaries= 25
Mean LogX1 = 1.9776
S = 0.116989366
Cs = 0.001753161
Equation
LogRt =LogRr+G . Sy
LogRt = 0,74 +0,077*G

TAB.6Opportunity Spread

Pr	G	G*S	LogRt	Rt
75	-0.618	-0.0723	1.905254	80.39958
50	0.139	0.016262	1.993815	98.58588
25	0.735	0.085987	2.06354	115.7552

TAB. 7Chi-Square

x			Oj	Ej	Oj-Ej	(Oj-Ej)2/Ej
0	-	80,39958	2	2	0	0
80,39958074	-	98,58588	5	2	3	4,5
98,58588375	-	115,7552	2	2	0	0
	>	115,7552	1	2	-1	0,5
						5,0

Degree of Freedom (df) : 2
Level of Significance : 5%
Confidence level : 95%
Critical Chi : 5.991

From the Chi-Square calculation for rain distribution using the Log-Pearson III method as shown in the table above, the value is 0.25. Chi-Square 5.0 < 5991 Chi-Critical value, then the hypothesis is accepted.

b. Existing Discharge Calculation

The channel dimension calculation is based on the discharge that must be accommodated by the channel (Qs in m^3/sec) greater than or equal to the design discharge caused by the design rain (QT in m^3/sec). Such conditions can be formulated in the following equation:

$Qs \geq Qt$

The discharge that can be accommodated by the channel (Qs) can be obtained by the following formula:

Qs = As. V

Which:

As = Cross-sectional area (m^2)

V =Average speed of flow in the channel (m/sec) Average speed of flow inside channel, can be calculated using the Manning formula as follows:

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

$R = \frac{A_s}{P}$

Which:

V =Flow Velocity

N =Manning Roughness Coefficient

R =Hydraulic radius (m)

As = Channel cross-sectional area (m^2)

P = Wetted Perimeter (m)

Existing channel caluclation example (Ch 1)

Square section shape

B=0,4 meter

H =0,5 meter

Guard height =0,2 meter (secondary channel) Hn =1,0 meter

Channel Length =214 meter

$$\text{Cross} - \text{sectional Area} = \frac{B}{2} x Hn = 0.2\ m^2$$

$$\text{P(wetted perimeter)} = B + 2\ x\ \sqrt{\left(\frac{B}{2}\right)^2} + hn^2 = 2.44\ m$$

$$\text{R (hydraulic radius)} = \frac{A_s}{P} = 0.082\ m$$

$$\text{N of channel} = 0.035\ \text{(riprap)}$$

$$\text{S of channel} = 0.01$$

$$\text{V (velocity)} = \frac{1}{n} R^{\frac{2}{3}} S^{\frac{1}{2}} = 0.539\ \text{m/s}$$

Hydraulics Q =Ax V= 0.2x 0.539=0.108 m^3/s

TAB.8Calculation results from all existing channels

Channel No	B	H	As(m²)	P (Keliling Basah)	R (radius)hidrolik	nchannel(riprap/ batukali)	S saluran	L(m)	V (m/dtk)	Qs (m³/dtk)	Qt (m³/dtk)
Sal.1(sekunder)	0.4	0.5	0.2	2.44	0.082	0.035	0.010	214	0.539	0.108	0.131
Sal.2(sekunder)	0.4	0.5	0.2	2.44	0.082	0.035	0.010	112	0.539	0.108	0.241
Sal.3(tertiary)	0.25	0.3	0.075	2.27	0.033	0.035	0.010	137	0.295	0.022	0.321
Sal.4(tertiary)	0.25	0.3	0.075	2.27	0.033	0.035	0.010	52	0.295	0.022	0.494
Sal.5(sekunder)	0.4	0.5	0.2	2.44	0.082	0.035	0.010	121	0.539	0.108	0.467
Sal.6(sekunder)	0.4	0.5	0.2	2.44	0.082	0.035	0.010	47	0.539	0.108	0.089

Calculation of Dirty Water Debit

The calculation of dirty water discharge is based on dirty water discharge from the number of houses accommodated by the channel and the number of people in each house. For the following calculations, some data need to be assumed, namely, the use of each person per day is assumed to be 200 liters / day, and the number of people per house is assumed to be 5 people / house. Discharge of dirty water used is 70% of the water in the waste.

TAB.9 Calculation of Dirty Water Debit

QDirty water
Q1= ((200x5)/ (24x60x60))xnumber of housesx70% = ((200x5)/ (24x60x60))x10x70% = 0.081
Q2= ((200x5)/ (24x60x60))xnumber of housesx70% = ((200x5)/ (24x60x60))x25x70% = 0.203

Q3=	((200x5)/ (24x60x60))xnumber of housesx70% = ((200x5)/ (24x60x60))x25 = 0.203
Q4=	((200x5)/ (24x60x60))xnumber of housesx70% = ((200x5)/ (24x60x60))x9x70% = 0.07292
Q5=	((200x5)/ (24x60x60))xnumber of houses x70% = ((200x5)/ (24x60x60))x47x70% = 0.381
Q6=	Q1+Q2+Q3+Q4+Q5= 0.940

Rain Discharge Calculation

Calculation of rainwater discharge is based on the result of the amount of dirty water discharge with the rainwater discharge itself. The formula for calculating rainwater discharge itself is Q = 0.278 x I x C x A. The formula above is a Rational method, which is one of the oldest methods and was originally used only to estimate peak discharge [10]. The total discharge used to plan the channel originating from rainwater runoff and household waste water which is then added up to get the planned channel discharge [11].

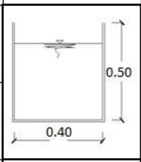
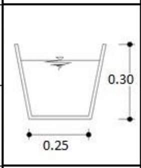
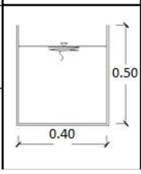
TAB. 10 Result of Total Dischar Calculation

QHujan							
Q1 =	0,278	x	C	x	I	x	A2+A5
=	0,278	x	0,8	x	50	x	0,004523
=	0,0503	m³/s	=	50,30	ltr/s		
Qwaste	=	Q1+Dirty		=	0,131		
Q2 =	0,278	x	C	x	I	x	A5
=	0,278	x	0,8	x	50	x	0,00344
=	0,03826	m³/s	=	38,26	ltr/s		
Qwaste	=	Q2+Dirty Water		=	0,241		
Q3 =	0,278	x	C	x	I	x	A3
=	0,278	x	0,8	x	50	x	0,0034
=	0,0376	m³/s	=	37,60	ltr/s		
Qwaste	=	Q3+Dirty Water		=	0,321		
Q4 =	0,278	x	C	x	I	x	A4
=	0,278	x	0,8	x	50	x	0,00070
=	0,00775	m³/s	=	7,75	ltr/s		
Qwaste	=	Q4+Dirty Water		=	0,494		
Q5 =	0,278	x	C	x	I	x	A1+A4+A3
=	0,278	x	0,8	x	50	x	0,007756
=	0,08625	m³/s	=	86,25	ltr/s		
Qwaste	=	Q5+Dirty Water		=	0,467		
Q6 =	Q2+Q1						
=	0,0886	m³/s	=	88,56	ltr/s		
Qwaste	=	Q6+Dirty Water		=	1,028		

Existing Dimension Calculation

In the results of the comparison between the Existing Debit (Qs) and the calculated debit (Qt), where the comparison must be Qs ≥ Qt. If not, then the channel needs to be enlarged. The final calculation data for the dimensions of the existing channel are presented in Table 11 below.

TAB.11 Existing Channel Dimension Calculation

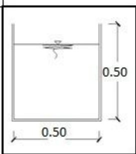
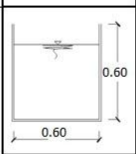
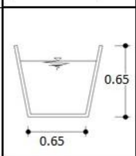
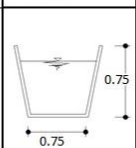
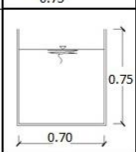
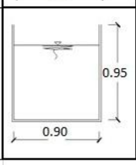
Channel No.	B	H	Figure	As (m²)	P(wetted perimeter)	R(Hydraulic radius)	n of channel (riprap)	S of channel	L (m)	V (m/s)	Qs (m³/s)	Qt (m³/s)	Conclusion
Ch. 1 (secondary)	0.40	0.50		0.20	2.44	0.082	0.035	0.010	214	0.539	0.108	0.131	Enlarged
Ch. 2 (secondary)	0.40	0.50		0.20	2.44	0.082	0.035	0.010	112	0.539	0.108	0.241	Enlarged
Ch. 3 (tertiary)	0.25	0.30		0.075	2.27	0.033	0.035	0.010	137	0.295	0.022	0.321	Enlarged
Ch. 4 (tertiary)	0.25	0.30		0.075	2.27	0.033	0.035	0.010	52	0.295	0.022	0.494	Enlarged
Ch. 5 (secondary)	0.40	0.50		0.20	2.44	0.082	0.035	0.010	121	0.539	0.108	0.467	Enlarged
Ch. 6 (secondary)	0.40	0.50		0.20	2.44	0.082	0.035	0.010	47	0.539	0.108	1.028	Enlarged

From the table of calculation results, all channels need to be enlarged in size.

Channel End Dimension

The results of the dimensions of the channel size after the width and height of the channel are enlarged. This is in line with what Qurniawan said, namely to evaluate the dimensions of the drainage channel, it is necessary to know the capacity of the existing drainage channel according to the formula used to determine the discharge capacity of the channel by Ven Te Chow [12]. The data from the analysis of the final dimensions of the channel are presented in Table 12 below.

TAB. 12 Channel End Dimension Calculation

Channel No.	B	H	Figure	As (m²)	P(wetted perimeter)	R(Hydraulic radius)	n of channel (riprap)	S of channel	L (m)	V (m/s)	Qs (m³/s)	Qt (m³/s)	Conclusion
Ch. 1 (secondary)	0.50	0.50		0.25	2.56	0.098	0.035	0.010	214	0.606	0.151	0.131	Enough
Ch. 2 (secondary)	0.60	0.60		0.36	2.69	0.134	0.035	0.010	112	0.748	0.269	0.241	Enough
Ch. 3 (tertiary)	0.65	0.65		0.4225	2.75	0.153	0.035	0.010	137	0.819	0.346	0.321	Enough
Ch. 4 (tertiary)	0.75	0.75		0.5625	2.89	0.195	0.035	0.010	52	0.960	0.540	0.494	Enough
Ch. 5 (secondary)	0.70	0.75		0.525	2.82	0.186	0.035	0.010	121	0.932	0.489	0.467	Enough
Ch. 6 (secondary)	0.90	0.95		0.855	3.09	0.276	0.035	0.010	47	1.212	1.037	1.028	Enough

IV. CONCLUSIONS AND SUGGESTIONS

Conclusion

Based on the results of field surveys and calculations, from the evaluation of the drainage system in the GunungBatu Residential area, Jember Regency, it can be concluded as follows.

1. The capacity of the drainage channel (existing discharge) in GunungBatu housing is channel 1, channel 2, channel 5 and 6 of 0.108 m^3/second, and channel 3 and 4 of 0.022 m^3/second.
2. The runoff discharge in the GunungBatu residential area in each channel is based on the total of rainwater discharge and dirty water discharge, which is 3.0037 m/second
3. The dimensions of the channel in order to accommodate the runoff discharge are for one channel, the width of the channel is 50 cm and the height is 50 cm.Channel two, channel width of 60 cm with a height of 60 cm.Channel three, channel width 65 cm and height 65 cm.Channel four, channel width of 75 cm and height of 75 cm.Channel five, channel width 70 cm and height 75 cm.Channel 6, channel width is 90 cm with a height of 95 cm

Suggestion

Based on the conclusions above, the following can be suggested.

1. It is necessary to widen the channel to reduce inundation that often occurs in the residential area
2. In addition to widening, several infiltration wells can also be made, and it is necessary to clean each channel so that there is no garbage that clogs the flow of water in each channel.

REFERENCES

[1]. Harto, S. HidrografSatuanSintetik Gamma I. DepartemenPekerjaanUmum, Yogyakarta. 1993.
[2]. Sarminingsih, A. Pemilihan Metode Analisis Debit Banjir Rancangan Embung Coyo Kabupaten Grobogan. Jurnal Presipitasi : Media Komunikasi dan Pengembangan Teknik Lingkungan,Vol. 15 No.1: 53-61. 2018.
[3]. Wesli.Drainase Perkotaan. Penerbit Graha Ilmu, Yogyakarta. 2008.
[4]. Samani, Z., Jorat, S., and Yousaf, M. Hydraulic characteristics of a circular flume.J. Irrig. Drain. Eng., Vol. 117 No. 4: 558–566. 1991.
[5]. Samani, Z., and Magallanez, H. Measuring water in trapezoidal canals. J. Irrig. Drain. Eng., Vol. 119 No.1: 181–186. 1993.
[6]. Skogerboe, G. V., Hyatt, M., Anderson, R. K., and Eggleston, K. O. Design and calibration of submerged open channel flow measurement structures. Part 3: Cutthroat flumes. Rep. WG31-4, Utah Water Research Laboratory, College of Engineering, Utah State Univ., Logan, UT
[7]. Hager, W. H. Mobile flume for circular channel. J. Irrig. Drain. Eng., Vol. 114 No.3:520–534. 1988.
[8]. Replogle, J. A. Critical flow flumes with complex cross section. Proc., ASCE Irrigation and Drainage Division Special Conf., ASCE, Reston, VA. 1975
[9]. Bos, M. G., Replogle, J. A., and Clemmens, A. J. 1984. Flow measuring flumes for open channel systems, Wiley, Hoboken, NJ.
[10]. Wanielista,M.P.Hydrologi and Water Quantity Control. John Wiley and Sons, New York, 1990.
[11]. Purnama, A., Najimuddin, D., and Syarifuddin. Perencanaan Sistem Jaringan Drainase Untuk Perumahan Baiti Jannati Sumbawa. Jurnal SAINTEK UNSA, Vol. 1, No. 2: 46-55. 2016.
[12]. Qurniawan, A.Y. Perencanaan Sistem Drainase Perumahan Josroyo Permai RW 11 Kecamatan Jaten Kabupaten Karanganyar. Universitas Sebelas Maret, Surakarta. 2009.