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STUDY OF VALLE VERDE RESIDENTIAL DRAINAGE SYSTEM IN PASIRHALANG VILLAGE

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Abstract---*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 and residential planning. Valle Verde Residential located in the village of Pasirhalang, Cisarua District, Kabupaten Bandung Barat needs to make a study of the drainage system in order to avoid flooding or inundation. The purpose of this study is to determine the peak discharge and drainage system capacity of the plan. In this study the analysis carried out is the drainage zone, rainfall, average rainfall in the area, choosing the type of rainfall distribution, calculating the time concentration, determining the amount of rainfall intensity at the return period of 2 years, calculating flood discharge and calculating the capacity of the planned channel. From the results of the analysis and calculation it is known that for the main drainage channel can use an open channel with dimensions of height 0.25 m and a base width 0.30 m and freeboard 0.20 m. As for channels that are in residential areas, can use closed channels with diameter dimensions D = 0.30 m.*

Keywords---*Drainage system, peak discharge, channel*

I. 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. Residential is a group of houses that functions as a residential environment that is equipped with environmental infrastructure and facilities. Valle Verde Residential located in Pasir Halang Village, Cisarua District, Kabupaten Bandung Barat is one of physical growth in an area that is a basic human need. In building residential, it is also necessary to consider drainage planning. Poor drainage will result in various kinds of problems that can harm humans themselves. One of them is the problem of flooding. Therefore, this study of drainage systems in Valle Verde Residential needs to get important attention in order to avoid floods or inundation, and to support the lives of people who live comfortably in the residential in their daily lives.

II. Literature Review

This study was conducted at Valle Verde Residential, Pasirhalang Village, Kabupaten Bandung Barat. Location of the study can be seen in the following figure.

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Figure 1. Study Location Orientation

To analyze the hydrological conditions in the study area, rain data from the nearest observation station are needed, namely the Padalarang, Cipeusing and Lembang rain stations. The maximum daily rainfall data available at the rain station is from 2002-2013.

The topography of the land is the most fundamental in the study of the water system. From the topographic map, the condition of the elevation contour of the region can be observed so that it can be determined the direction of water flow of a planned water system. Based on the results of the field survey, this area has a very steep topography. The difference in land height varies, because in several locations within the residential area to be built are already plots. This residential area is ± 2.83 hectares with the breakdown of land use composition as follows.

Table 1. Land Use Composition

No	Land Use	Area (m2)	Close Area (m2)	Open Area (m2)
A	**Kavling**			
1	Type A	3801	1330	2471
2	Type B	8120	3000	5120
3	Commercial	1218	490	728
B	**Social facilities**			
1	Prayer room etc	1045	280	765
2	Road (asphalt / paving block)	7172	3586	3586
C	**Green Open Space**			
1	Green Open Space	6921	0	6921
D	**Area Total**	**28277**	**8686**	**19591**

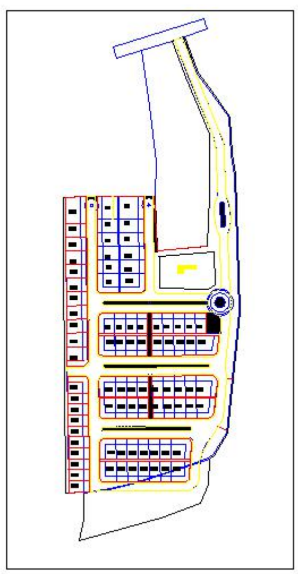

Figure 2. Residential Layout

III. Methodology

The process of completing this research can be explained as follows:

1. Preparation
2. Secondary data collection (existing location conditions, topographic maps and hydrological data)
3. Field identification (survey of existing drainage conditions and flow surveys)
4. Hydrological analysis (rainfall plan and rainfall intensity)
5. Analysis of the hydraulics condition of the plan
6. Conclusions and suggestions

IV. Analysis and Discussion

General Condition of Study Location

This study was conducted in the Valle Verde Residential area, Pasirhalang Village, Kabupaten Bandung Barat with a total area of ± 2.83 hectares. The existing condition of existing land is open land that is ready to be built residential.

Drainage Zone

The catchment area for this residential is ± 2.83 hectares with details of land use composition as in table 1. The drainage zone in this residential area is divided into 10 zones, the division of this zone is based on the condition of the channel requirements.

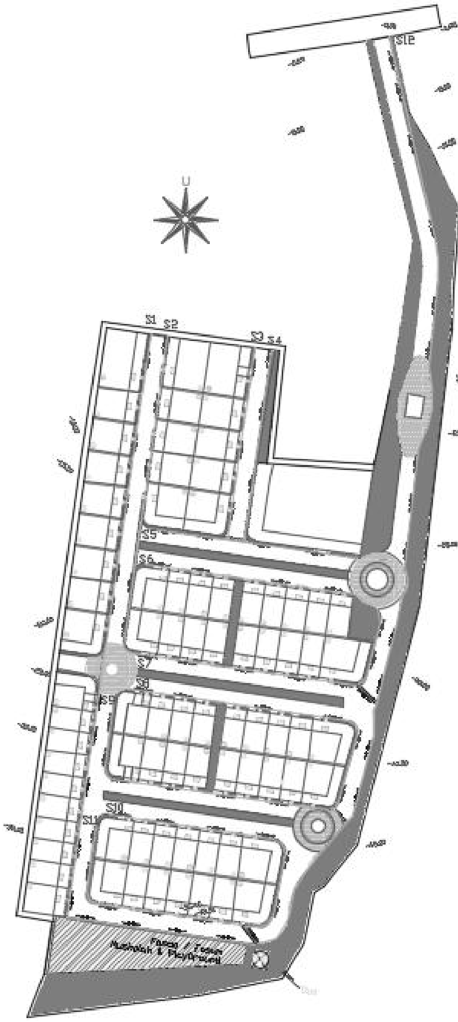

Figure 3. Distribution of Drainage Zones

The area of each zone and the flow coefficient can be seen in table 2. The planned channels can be seen in table 3.

Table 2. Zone Area and Combined Runoff Coefficient

No	Composition	Area (m2)	C Value	C Fraction
1	Roof	5100	0.95	0.17
2	Asphalt road	7172	0.7	0.18
3	Open space	9084	0.25	0.08
4	Green Open Space	6921	0.2	0.05
	Total	**28277**	**C Combined**	**0.48**

Table 3. Planned Channel Data

Channel	Max Elev.	Min Elev.	Δ h	Length (m)	Length (km)
s1	-8.6	-48.47	39.87	280.67	0.28
s2	-8.6	-24.22	15.62	112.89	0.11
s3	-8.91	-18.77	9.86	69.40	0.07
s4	-9.4	-19	9.6	69.40	0.07
s5	-19.92	-29.44	9.52	75.64	0.08
s6	-17.14	-34.44	17.3	115.12	0.12
s7	-24.22	-34.33	10.11	84.11	0.08
s8	-25.78	-37.89	12.11	115.93	0.12
s9	-25.78	-37.89	12.11	108.58	0.11
s10	-32.66	-48.47	15.81	101.40	0.10
s11	-32.66	-48.47	15.81	83.33	0.08
s12 (primary)	0	-48.47	48.47	345.78	0.35

Rainfall Plan

The analysis was carried out using daily rainfall data from 2002 to 2013 belonging to the Badan Meteorologi, Klimatologi, dan Geofisika (BMKG) Station. Rainfall data needed in the design of drainage is rainfall data from rainfall recording stations in the vicinity or nearby study locations. Daily maximum rainfall data for 12 years can be seen in Table 4.

Table 4. Daily Maximum Rainfall Data

Year	Rainfall Station (mm/day)		
	Padalarang	Cipeusing	Lembang
2002	88.2	40.0	64.0
2003	67.0	12.0	75.5
2004	56.0	13.0	82.0
2005	81.0	31.0	88.0
2006	48.5	22.0	79.5
2007	69.0	54.0	79.0
2008	90.0	48.0	72.0
2009	75.0	37.3	78.1
2010	51.4	29.0	69.7
2011	223.5	222.5	140.0
2012	68.9	49.5	75.4
2013	62.6	30.0	94.0

Estimated rainfall plans are obtained from the analysis of frequencies with the highest likelihood for a certain period. The results of frequency analysis serve as the basis for calculating to anticipate every possibility that will happen (Sutoyo, 2018). Frequency analysis can be done with probability distribution methods including Normal Distribution, Log Normal Distribution, Log-Person III Distribution, and Gumbel Distribution (Triatmodjo 2010). The time scale used to calculate the value of the planned rainfall is 2, 5, 10, 20, 25, and 50 years. The results of the rainfall analysis plan can be seen in Table 5.

Table 5. Results of rainfall analysis plans

Probability	Rainfall Plan (mm/day)			
(year)	Normal	Log Normal	Gumbel	Log Pearson III
2	71.29	65.73	64.76	57.76
5	104.77	89.47	99.91	78.27
10	122.27	105.11	123.19	101.78
20	136.72	120.08	145.51	135.00
25	140.93	124.82	152.59	148.40
50	152.99	139.48	174.41	201.09

The results of the calculation of the planned rainfall value of each method have different values so they must be tested for compatibility with the nature of each type of distribution. The results of the compatibility test of the maximum rainfall analysis method using the Smirnov Kolmogorov test can be seen in Table 6.

Table 6. Smirnov-Kolmogorov Test

No.	Method	Do	D kritik	Requirement	Information
1	Normal	0.359	0.38	Do < D kritik	Applied
2	Log-Normal	0.278			Applied
3	Gumbel	0.289			Applied
4	Log Pearson III	0.223			Applied

From the suitability test of the maximum rainfall analysis method above it can be seen that the Log-Pearson III Method has the smallest deviation among the other methods. It can be seen in the table that the value of Dmax = 0.223 <Dkritik = 0.380. So the rainfall analysis using the Log-Pearson III Method is used as a rainfall plan for drainage system planning.

Time Concentration

The next calculation is to find the time concentration of each channel by using the Kirpich equation. The recapitulation of the planned channel data is shown in table 3 before.

Existing rainfall data is the average daily maximum rainfall data, so in the calculation of rainfall intensity using the formula from Mononobe, where the duration of rain is assumed to be the same as the time concentration value. As for the choosing return period, for watershed sizes of less than 10 hectares, a 2-year return period is used. The results of calculation of time concentration and rainfall intensity can be seen in table 7.

Table 7. Results of Calculation of Time Concentration and Intensity Time

Channel	L (m)	So	Tc (hour)	R (mm)	I (mm/hour)
1	280.67	0.142	0.053	57.76	142.16
2	112.89	0.138	0.026	57.76	225.37
3	69.40	0.142	0.018	57.76	291.30
4	69.40	0.138	0.018	57.76	289.30
5	75.64	0.126	0.020	57.76	270.15
6	115.12	0.150	0.026	57.76	227.89
7	84.11	0.120	0.022	57.76	252.82
8	115.93	0.104	0.030	57.76	206.83
9	108.58	0.112	0.028	57.76	217.54
10	101.40	0.156	0.023	57.76	245.54
11	83.33	0.190	0.019	57.76	285.61
12	345.78	0.140	0.062	57.76	127.29

Peak Discharge in Each Zone

Peak discharge is calculated using the Rational Method formula:

Q = 0,002778 x C x I x A

with :

Q = peak discharge (m3/s)

C = runoff coefficient

I = intensity of average rainfall (mm/hr)

A = area of drainage (Ha)

The results of the calculation of peak discharge with rainfall intensity data in each zone can be seen in Table 8.

Table 8. Peak Discharge Calculation

Channel	C	I (mm/hour)	A (m2)	Q (m3/s)
1	0.40	142.16	6934.69	0.11
2	0.49	225.37	2169.34	0.07
3	0.52	291.30	1234.69	0.05
4	0.47	289.30	363.02	0.01
5	0.50	270.15	1996.20	0.07
6	0.49	227.89	1821.49	0.06
7	0.51	252.82	1850.21	0.07
8	0.49	206.83	2117.52	0.06
9	0.50	217.54	2013.44	0.06
10	0.50	245.54	1656.84	0.06
11	0.52	285.61	1370.33	0.06
12	0.48	127.29	28277	0.48

Channel Analysis

By knowing the flow rate on the drainage channel, the economical channel dimensions can be planned as follows (assuming a trapezoidal channel).

Flow (Q) = variation

Channel slope (S) = variation

Roughness coefficient (n) = 0.013 (concrete channels)

Q = A x V

$$Q = h^2\sqrt{3}\frac{1}{n}\left(\frac{h}{2}\right)^{\frac{2}{3}}S^{\frac{1}{2}}$$

$$b = \frac{2}{3}h\sqrt{3}$$

with :

Q = flow discharge on the channel (m3/s)

V = flow velocity (m/s)

A = wet cross-sectional area of the channel (m2)

h = water level (m)

b = base width (m)

Table 9. Calculation of Flow Discharge On Channels

Channel	Flowing discharge	Q plan (m3/s)
1	Q1+Q2	0.18
2	Q2	0.07
3	Q3	0.05
4	Q4	0.01
5	Q3+Q4+Q5	0.14
6	Q6	0.06
7	Q7	0.07
8	Q8	0.06
9	Q9	0.06
10	Q10	0.06
11	Q11	0.06
12	Qall	0.48

Channel dimension calculation is done by trial and error method to get economical channel dimensions. Calculation of channel dimensions can be seen in table 10 and table 11.

Table 10. Open Channel Dimension Calculation

Channel	Q (m3/s)	H (m)	Q capacity (m3/s)	B (m)
1	0.18	0.15	0.20	0.17
2	0.07	0.11	0.09	0.13
3	0.05	0.10	0.07	0.12
4	0.01	0.10	0.07	0.12
5	0.14	0.14	0.16	0.16
6	0.06	0.10	0.07	0.12
7	0.07	0.11	0.08	0.13
8	0.06	0.11	0.08	0.13
9	0.06	0.11	0.08	0.13
10	0.06	0.10	0.07	0.12
11	0.06	0.10	0.08	0.12
12	0.48	0.22	0.55	0.25

Table 10. Close Channel Dimension Calculation

Channel	Q (m3/s)	Dia (m)	A (m2)	P (m)	Q capacity (m3/s)
1	0.18	0.30	0.07	0.30	0.35
2	0.07	0.30	0.07	0.30	0.34
3	0.05	0.30	0.07	0.30	0.35
4	0.01	0.30	0.07	0.30	0.34
5	0.14	0.30	0.07	0.30	0.32
6	0.06	0.30	0.07	0.30	0.36
7	0.07	0.30	0.07	0.30	0.31
8	0.06	0.30	0.07	0.30	0.28
9	0.06	0.30	0.07	0.30	0.30
10	0.06	0.30	0.07	0.30	0.37
11	0.06	0.30	0.07	0.30	0.42
12	0.48	0.40	0.13	0.40	0.82

From the results of the analysis and calculation it is known that for the main drainage channel (S12) can use open channels with dimensions of height H = 0.22 m and a base width B = 0.25 m and freeboard W = 0.20 m. As for the channel inside the residential (S1-S11) the economical channel dimension can use a closed channel with a diameter D = 0.30 m.

V. Conclusion and Suggestion

Based on the results of the analysis and calculation in this study it can be concluded as follows:

1. The maximum flow discharge that occurs in Valle Verde Residential is 0.48 m3/s, which is what happens on the S12 channel.
2. The economical channel dimension for the main drainage channel (S12) is to use an open channel with height H = 0.22 m and a base width B = 0.25 m and freeboard W = 0.20 m. It is proposed to implement in the field using channel dimensions with height H = 0.25 m and base width B = 0.30 m and freeboard W = 0.20 m.
3. Based on hydraulic analysis, the discharge capacity of a closed channel with a diameter of 0.30 m can accommodate rain discharges flowing in the channel. Therefore the economical channel dimension for other channels (S1-S11) is by using a closed channel with a diameter D = 0.30 m.

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