ANALYSIS OF THE ENVIRONMENTAL DRAINAGE SYSTEM OF THE SUGIHWARAS VILLAGE APARTMENT (CASE STUDY OF APARTMENTS IN SIDOARJO REGENCY)

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ABSTRACT

The commercial development of the area in Sugihwaras Village, Sidoarjo has caused a large discharge runoff that can cause inundation in the area due to land conversion that reduces open land for water absorption. So it needs an increase in drainage capacity by knowing the flood plan discharge for a 5 year return period. Rainfall data taken for observations are rain stations Sidoarjo, Putat, Cepiples and Kludan. The method used to find a 5-year return period is the Log Pearson Type III because it is in accordance with the distribution test with a 5-year return period of 81,171 m³ / sec. With an extensive commercial development area of ± 40,191 m² the planned flood discharge obtained by a practical rational method is 0.630 m³ / sec and can be accommodated with planned drainage and bozem channels with a capacity of 1666.95 m³.

Key words: water channel, water discharge, bozem

INTRODUCTION

City requires numerous facilities and infrastructures that are adequate in its development in the future, where increasing population is of course also needed development of Commercial Area and arrangement of the environment. Issue concerning flood in Sidoarjo still becomes major issue which is not properly handle by the government. It is happened due to changes from active land into residential areas and other centres to increase economic activity. As an example is th construction of an apartment that cover around ± 40,191 m² in Sidorjo region.

In accordance with the government policy to create commercial clean and healthy Area Development environment, it is necessary to have a good drainage system and wastewater treatment. To avoid runoff, flooding and inundation in the development area of apartment in which this area cannot absorb water optimally, because this area contains building that posses two functions which are transportation (road) and a building. Therefore it is necessary to build drainage system which environmental friendly. It can be done by combining the drainage channel in the apartment construction.

Drainage System

Based on the Planning Journal for the Drainage System of Palangkaraya City (Tofandiyumahira, 2010) drainage is defined as facilities and infrastructures built to drain rainwater and domestic waste from one place to another in an area

Drainage comes from English word which means to drain, remove or divert water. According to Halim (2011), drainage is generally defined as learning science of technical action to reduce excess water in a particular context of use, both from rain, seepage and

others in an area, so that the function of the area is not disturbed by the water.

Drainage channels must be planned precisely in order to safely pass the discharge plan. Drainage planning according to Suripin follows various stages which are: determining the planned discharge, planning the channel section, planning the building and the drainage system facilities.

METHODOLOGY

The construction of apartments in Sugihwaras Village, Candi is built in rice fields. The land is limited by tertiary channel, settlements and rice fields as shown below:

Picture 1. Location of Apartment Construction

Chart or flowchart of the present research in completing the drainage evaluation research is based on principal data processing and completion of calculations obtained from several rain stations. a number of items for processing data and completing calculations obtained from several rain stations. Results of rain data testing and hydrological calculations is expected to depict reference data for the planned flood discharge therefore it can determine the channel dimensions that are needed. In conclusion, the flow chart / research study framework can be seen in the following figure:

Picture 2. Research Flow Chart

Volume 04 Number 01 September 2020
RESULT AND DISCUSSION

Hydrological Analysis

The rainfalls that are needed to determine the planning requirements for drainage system or capacity in the Apartment Development area is daily average of rainfall surround the observation points in which in the present study are Sidoarjo, Putat, Cepiples, and Kludan Rain stations.

Picture 3. Location of Rain Stations for the observation points

In accordance with the rainfall data, Polygon Thiessen method is applied in order to obtain the rainfall frequency. Meanwhile, rain fall frequency analysis is an analysis of repetition of rainfall event to determine return period. Below is the average daily rainfall data for the period 2006 - 2016

Table 1. Average rainfall analysed by Polygon Thiessen method

YEAR	DATE	RAINFALL STATION				TOTAL (mm)
		SIDOARJO	PUTAT	CEPIPLES	KLUDAN	
		0.217	0.291	0.284	0.207	
2006	23-Feb	6.52	21.82	0.00	15.14	43.482
2007	8-Mar	16.96	20.37	0.00	14.10	51.425
2008	31-Jan	23.91	17.46	0.00	13.06	54.435
2009	6-Mar	15.43	20.37	0.00	22.81	58.612
2010	15-Oct	36.52	23.28	23.60	19.28	102.679
2011	26-Mar	0.87	24.15	23.60	18.87	67.485
2012	18-Dec	18.26	18.33	4.83	14.72	56.147
2013	6-Jun	17.11	25.61	25.59	20.11	88.413
2014	18-Jun	6.74	23.28	4.83	17.21	52.060
2015	19-Mar	0.00	25.31	9.38	18.04	52.736
2016	10-Oct	36.96	26.19	29.28	16.59	109.013

From the average rainfall data mentioned above then the Log Pearson Type III distribution is used to look for data on various recurrence rains to determine the discharge and storage capacity requirements needed in the apartment construction area. The calculation of rain return with log Pearson type III can be seen below.

Table 2. Rainfall Distribution

NO.	X (mm)	(X-X) ²	(X-X) ³	(X-X) ⁴
1	109.01	1,769.05	74,406.23	3,129,529.74
2	102.68	1,276.32	45,597.25	1,628,988.99
3	67.48	0.28	0.15	0.08
4	52.06	221.81	-3,303.37	49,197.58
5	88.41	460.52	9,882.61	212,078.06
6	58.61	69.58	-580.36	4,840.97
7	56.15	116.77	-1,261.87	13,636.02
8	54.43	156.71	-1,961.83	24,559.28
9	52.74	202.14	-2,873.91	40,859.99
10	51.42	241.14	-3,744.51	58,146.96
11	43.48	550.92	-12,931.08	303,514.86
TOTAL	736.49	5,065.24	103,229.29	5,465,352.52

Average	66.953
Standart deviation :	22.51
koefisien variasi (Cv) :	0.34
koef. Kemencengan (Cs):	1.10676
koef. Ketajaman (Ck):	3.579908

Based on calculation above, it is obtained Cs and Ck values, which can be concluded that according to table 4.4 the distribution equation used in the analysis of rainfall data is the Log Pearson Type III distribution. The average daily maximum rainfall that has been obtained is sorted from large to small, then analysed based on the selected distribution to get rain with certain return periods, as shown in table 3 below:

Table 3. Rainfall Metode Log Pearson Type III

NO.	X (mm)	Log X	(Logx-Logx)	(Logx-Logx) ²	(Logx-Logx) ³	(Logx-Logx) ⁴	P	%
1	109.01	2.0375	0.2315	0.0536	0.0124	0.0029	8.3333	
2	102.68	2.0115	0.2055	0.0422	0.0087	0.0018	16.6667	
3	67.48	1.8292	0.0232	0.0005	0.0000	0.0000	25.0000	
4	52.06	1.7165	-0.0895	0.0080	-0.0007	0.0001	33.3333	
5	88.41	1.9465	0.1405	0.0197	0.0028	0.0004	41.6667	
6	58.61	1.7680	-0.0380	0.0014	-0.0001	0.0000	50.0000	
7	56.15	1.7493	-0.0567	0.0032	-0.0002	0.0000	58.3333	
8	54.43	1.7359	-0.0701	0.0049	-0.0003	0.0000	66.6667	
9	52.74	1.7221	-0.0839	0.0070	-0.0006	0.0000	75.0000	
10	51.42	1.7112	-0.0948	0.0090	-0.0009	0.0001	83.3333	
11	43.48	1.6383	-0.1677	0.0281	-0.0047	0.0008	91.6667	
TOTAL	736.49	19.87	0.0000	0.1778	0.0164	0.0061		

Average : 1.806
Standart deviation : 0.13
koefisien variasi (Cv) : 0.07
koef. Kemencengan (C) : 0.85
koef. Ketajaman (Ck) : 3.22

Table 4. Various Recurrences Rainfall

NO.	Pr %	Tr (Tahun)	K	Log X	X (mm)
1	99.0099	1.01	-1.698	1.5796	37.98
2	50.0000	2	-0.141	1.7872	61.27
3	20.0000	5	0.775	1.9094	81.17
4	10.0000	10	1.340	1.9847	96.54
5	5.0000	20	1.765	2.0413	109.98
6	4.0000	25	2.008	2.0737	118.51
7	2.0000	50	2.477	2.1363	136.87
8	1.0000	100	2.605	2.1534	142.35

5-year return plan rainfall is 81.17 mm in which to avoid overload within drainage channels it is necessary to make a drainage system in the apartment construction location. Its functions is to decrease volume at peak moment. It can be done by calculating the capacity of the drainage channel which will accommodate the surface flow. The flood plan volume of the apartment development area with an area of $\pm 40,191 \text{ m}^2 = 0.040191 \text{ km}^2$ planned flood discharge which amounted to:

$$QP = 0.278 \times C \times I \times A = 0.278 \times 0.7 \times 81.171 \times 0.040191 = 0.630 \text{ m}^3/\text{dt}$$

$$\text{At raining season } t = 30 \text{ minute, } = 30 \times Q \times 60 = 30 \times 0.630 \times 60 = 1134 \text{ m}^3$$

Hydraulic Analysis

The available rainfall data is the average daily maximum rainfall data, therefore the calculation is done by using a formula from Mononobe where the duration of rain is assumed to be equal to the concentration time value. The magnitude of the flow coefficient (C) in the Apartment Development is based on a table that is equal to 0.7. Rain discharge can be calculated using the rational method formula. Next Example Calculation of dimensions on channel 01-02:

Channel Length = 187.50 m

Channel Slope = 0.001

$$\text{Time of concentration (tc)} = \left(\frac{0.87 \times L^2}{1000 \times s} \right)^{0.384} \left(\frac{0.87 \times 0.018750^2}{1000 \times 0.001} \right)^{0.384} = 0.255 \text{ jam}$$

$$\text{rain intensity (I)} = \left(\frac{81.171}{24} \right) \times \left(\frac{24}{0.255} \right)^{2/3} = 70.023 \text{ mm/jam}$$

Debit return period flood plan 5 years = $0.278 \times 0.7 \times 70.023 \times 0.0150 = 0.204 \text{ m}^3/\text{dt}$

Planning Channel :

$B = 0.50 \text{ m}$; $m = 0$; $s = 0.001$; $n = 0.013$ (concrete pair).

Formulation:

$$V = 1/n \times R^{2/3} \times s^{1/2}$$

$$R = A/P$$

Tested $H = 0.70 \text{ m}$

$$A = B \times H = 0.50 \times 0.70 = 0.350 \text{ m}^2$$

$$P = B + 2H = 0.50 + 2 \times 0.70 = 1.900 \text{ m}$$

$$R = A / P = 0.350 / 1.900 = 0.184$$

$$V = 1/n \times R^{2/3} \times s^{1/2} = 1/0.013 \times 0.184^{2/3} \times 0.001^{1/2} = 0.813 \text{ m/dt}$$

$$Q = V \times A = 0.813 \times 0.204 = 0.2847 \text{ m}^3/\text{dt}$$

Q Plan / Q Channel

$$0.2847 / 0.204 \times 100\% = 71.80 \%$$

Therefore appropriate plan channel is needed because the calculated debit is equal to or greater than the debit of the 5-year return period rain.

For the calculation of the planned channel in the overall apartment construction area, see the table below:

Table 5. Calculation of channel dimensions and capacities

IS th : 81.171													
NO.	Number Channel	CALCULATION OF FLOOD DEBIT PLAN				CHANNEL / DIMENSION CALCULATION							
		L	I	Catchment Area	Q Plan	cross section area (A)	(P)	(R)	Wide (b)	Height (h)	Capacity	S	Run off (V)
		m	(mm/jam)	(km ²)	(m ³ /dt)	(m ²)	(m)		(m)	(m)	(m ³)		(m/dt)
1	01 - 02	187.50	70.023	0.0150000	0.204	0.350	1.900	0.184	0.50	0.70	65.63	0.00107	0.813
2	02 - 03	180.00	72.259	0.1200000	1.687	1.700	4.400	0.386	1.00	1.70	306.00	0.00111	1.360
3	03 - 17	78.50	114.588	0.1500000	3.345	3.300	5.900	0.559	1.50	2.20	259.05	0.00127	1.864
4	06 - 17	137.50	74.421	0.1800000	2.607	3.300	5.900	0.559	1.50	2.20	453.75	0.00073	1.408
5	04 - 05	172.00	74.833	0.1200000	1.748	1.700	4.400	0.386	1.00	1.70	292.40	0.00116	1.391
7	07 - 08	170.00	75.510	0.0100000	0.147	0.350	1.900	0.184	0.50	0.70	59.50	0.00118	0.854
8	09 - 10	172.00	74.833	0.0150000	0.218	0.350	1.900	0.184	0.50	0.70	60.20	0.00116	0.849
9	11 - 12	139.00	88.172	0.0050000	0.086	0.150	1.300	0.115	0.30	0.50	20.85	0.00144	0.692
10	12 - 13	170.35	95.380	0.0300000	0.557	0.500	2.500	0.200	0.50	1.00	85.18	0.00294	1.425
11	14 - 15	9.30	707.489	0.0015000	0.207	0.150	1.300	0.115	0.30	0.50	1.40	0.02151	2.674
12	14 - 16	80.00	134.919	0.0030000	0.079	0.150	1.300	0.115	0.30	0.50	12.00	0.00250	0.912
											1615.95		

From the above calculation, it is found that channel capacity in the apartment construction area is equal to 1615.95 m³ coupled with a broad capacity of Bozem 51 m² and height 1 m so the capacity is approximately 51 m³, therefore the total capacity is equal to 1666.95 m³ in which it is greater than the required capacity or around 1134 m³ so during high rain the apartment development area does not have floods or inundations because it has a large enough capacity to accommodates the rain.

CONCLUSION

According to calculation of rainfall analysis obtained in the last 10 years, it is found that rainfall plans for a 5-year return period with rainfall is around 81.17 mm, debit plan that occurs in the area of the apartment building with a large area ± 40.191 m² factual condition is around 0.630 m³/dt and it requires capacity around 1134 m³ meanwhile the channel capacity in the apartment construction area is around 1615.95 m³ and with bozem around 51 m³. It can be concluded that maximum capacity is around 1666.95 m³ in which it possess safety factor around 46 % from the capacity needed.

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