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Research Paper

Study of Use of Biopory Hole for Flood Management in Housing Area
(Case Study of Permata Indah Housing, Jember Regency)

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ABSTRACT: *In Permata Indah Housing, which is located in Sumbersari District, Jember Regency, when it rains quite heavily, there are often quite a lot of puddles To overcome this, one of the steps that need to be taken is to examine the use of biopore infiltration holes for flood control in the Permata Indah residential area. From the results of this study, it can be concluded that the flood discharge that occurred in Permata Indah Jember Housing for the 25 year return period was 3,409m³/sec. The existing line discharge in Permata Indah Jember Housing is 0.0584 m³/sec. So that the capacity of the existing drainage channel is not sufficient to accommodate the flood discharge that occurs. Permata Indah Jember housing requires 17045 biopore infiltration holes. It is recommended that each channel be cleaned so that there is no garbage that clogs the flow of water in each channel. And further research is needed to apply other types of drainage to cope with flooding in housing*

KEYWORDS: *Rain, Flood Discharge, Biopori Infiltration*

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I. INTRODUCTION

Water is one of the most important natural resources for all living things, especially humans. As creatures who are given the advantage of reason, humans are able to manage water resources so that they can maximize the function of water for human life. In addition to playing an important role in life, poor environmental management can cause the loss of water functions and bring disaster. This matter in line with the increasing development of residential areas in urban areas in recent years. The increasing residential area and increasing land use, causing less land area and narrowed. This phenomenon has an impact on decreasing water catchment areas so that it can causing inundation due to rainwater and eventually causing flooding [1]. Areas that have poor water catchment areas cause the rate of soil infiltration to decrease, causing waterlogging and even flooding [2]. Water problems that often occur as a result of poor environment are floods. In residential areas, flooding often occurs because the soil layer cannot absorb or drain rainwater, so that the rainwater that falls will become surface runoff. Or in other words, the residential area has a poor drainage system. Drainage aims to reduce runoff both from rainwater and from other irrigation activities that change land use [3]. The current drainage system that is generally used is a conventional drainage system that drains runoff into rivers. If the rainwater runoff increases, it will cause the river to overflow. Environmentally friendly drainage is needed as a control of runoff which directly absorbs into the ground which is able to be a water conservation so that it can maintain ground water quality.[4]. The application of environmentally friendly drainage can be done by using biopore infiltration holes. The biopore infiltration hole has a working principle where runoff rainwater must be able to absorb at that time into the ground without adding water discharge to the river [5].

In Permata Indah Housing, which is located in Sumbersari District, Jember Regency, when there is heavy rain, there are often quite a lot of puddles. Therefore, to overcome this, one of the steps that need to be taken is to implement environmentally friendly drainage, namely by using biopore infiltration holes for flood control in the Permata Indah residential area. The results of previous studies stated that the application of biopore infiltration holes can increase the absorption capacity of the soil thereby reducing runoff and inundation [6]. Biopore infiltration hole is a hole with a diameter of 10 - 30 cm as deep as 80 cm -1 00 cm which is used as a rainwater reservoir to then be absorbed into the ground. Biopores are able to reduce waterlogging and become groundwater reserves in it [7]. Inundation heights in the annual maximum rainfall plan for 2, 5, and 10 year return periods using holes 100, 160 and 400 for 100 m² respectively were lower from 9.01% to 77.43% compared to not using biopore holes. [8] Infiltration of biopori holes allows it to absorb water into the soil so that it becomes a flood solution and maintains groundwater availability.[9]

II. METHODOLOGY

Research Site

The research location is in the Permata Indah Housing Area, which is located in Sumbersari District, Jember Regency. The location data is presented in Figure 1 below.

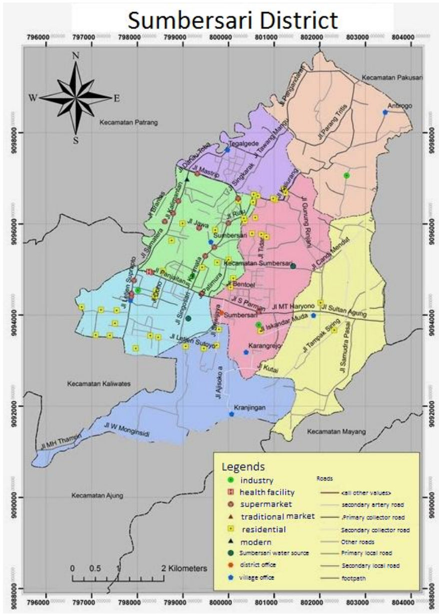

Figure 1. Research Location

Research Flowchart

The flow chart in this study which describes the study of the use of biopore infiltration holes in residential areas is presented in Figure 2 below

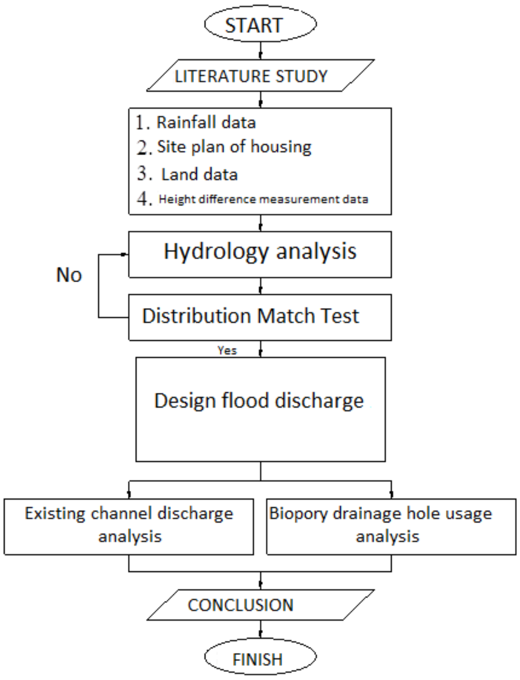

Figure 2. Research flowchart

Data Collection

Data collection in the form of secondary data includes rainfall data and land data for the last 10 years, map of housing situation and primary data which includes measurement of existing canal, measurement of height difference using a waterpass.

Data Analysis

Flood Discharge

The most frequently used method for estimating the discharge in an area river flow where there is no discharge observation data is the method Japanese rationale. In this case the magnitude of the discharge is a function of the area of the watershed, the intensity of rain, the condition of the ground surface which is expressed in the runoff coefficient and the slope of the river [10]. Flood discharge is formulated generically as follows.

$Q = 0.2778.C.I.A$

With :

Q : flood discharge (m^3/sec)

C : runoff coefficient

I : rain intensity

A : area of rain catchment

Existing Channel Evaluation

If the design flood discharge is known, the calculation is continued by evaluating the ischarge capacity of the existing channel. The equation for calculating the channel bottom slope is as llows.

$I=\Delta H/L$

With :

I : Channel bottom slope

H : Channel point height difference (m)

L : Channel length (m)

As for calculating the flow velocity can use the following equation.

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

With :

V : Flow speed (m/s)

n : Manning coefficient

R : Hydraulic radius (m), obtained by R=A/P

A : Wet cross-sectional area (m^2), obtained by A=b*h

P : Wet perimeter (m), obtained by P=2*(b+h)

b : Channel width (m)

h : Channel height (m)

S : Channel bottom slope

The last thing is to calculate the channel discharge. If the channel discharge is greater than the flood discharge, then the existing drainage channel is still safe to accommodate the flood discharge that occurs. However, if the channel discharge is smaller than the flood discharge, the capacity of the drainage channel needs to be improved. The equation for calculating the channel discharge is as follows.

$Q = V.A$

With :

Q = Channel discharge (m^3/s)

V = flow rate (m/s)

A = Wet cross-sectional area (m^2)

Biopore Infiltration Hole

In calculating the need for biopore infiltration holes, supporting data is needed, namely soil permeability data. Soil permeability data is needed to determine the flood discharge capacity that can be accommodated by biopore infiltration holes. In this study, the biopore infiltration hole has a diameter of 10 cm and a depth of 100 cm. The need for biopore infiltration holes depends on the magnitude of the design flood discharge and the capacity of the biopore infiltration holes. The formula for calculating the discharge capacity of the biopore infiltration hole is as follows.

Q = K. I . A
With :
Q : Biopore hole discharge (m3/sec)
K : seepage coefficient (m/s)
I : hydraulic gradient
A : cross-sectional area of biopore infiltration holes (m²)

As for calculating the need for biopore holes, you can use the following equation.

$$\text{number of Drainage holes} = \frac{\text{Plan Flood Discharge}}{\text{Biopore Hole Discharge}}$$

The placement of biopore infiltration holes does not require much space. In this study, biopori infiltration holes will be placed in the backyard and front of the house, road area and public health facilities. So as not to disturb road users. biopori holes are closed so that they are safe for traffic.

III. RESULTS AND DISCUSSION

Location of Residential Area

The research location is in Sumbersari District, Jember Regency. The research location is presented in Figure 2. At the research location, there is an existing channel using a closed channel type with material in the form of buis concrete measuring 40cm in diameter. The existing channel will be used as secondary data, to plan the drainage system in the Permata Indah housing complex. Permata Indah Housing has an area of 10909.13 m² with a total of 86 plots. The division of land is a plot of land covering an area of 7071.15m², public facilities covering an area of 360.47m², and road facilities covering an area of 3477.50m². The land layout is presented in Figure 3 below.

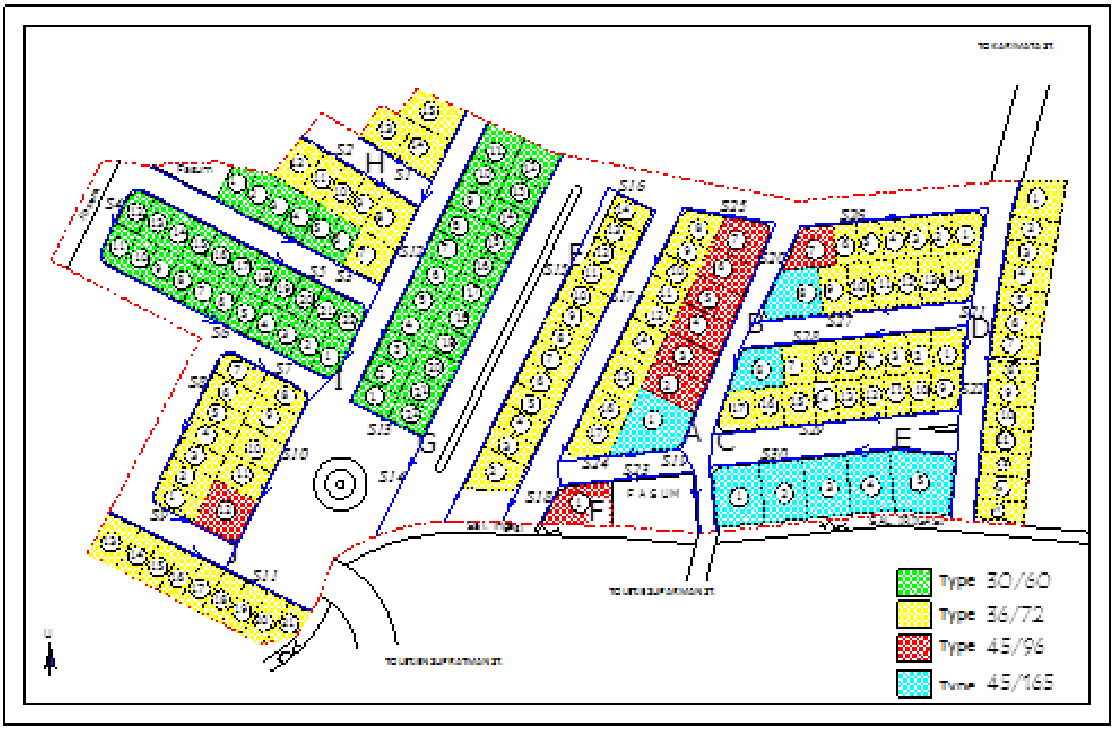

Figure 3. Residential Area Layout

Rainfall Analysis

In the research in the Permata Indah housing area, rainfall data were obtained from the rain stations, namely Seputih Station, Wirolegi Station, and Pakusari Station. From the step-by-step calculation, it is obtained that the planned rainfall is calculated with the return period: 2, 5. 10, 25 years, the planned rainfall is presented in Table 1 as follows.

TAB. Rainfall Plan

No.	Return period (years)	Rainfall (mm)
1	2	106.083
2	5	146.577
3	10	185.900
4	25	253.305

Source: Calculation Results

Concentration time is the time it takes for raindrops to fall on the ground and flow to the nearest drainage point. In this study the concentration time is calculated from the existing channel. The results of the calculation of the concentration time (tc) for each channel are different depending on the length of the channel and the difference in the base height of the channel. The results of the calculation of the concentration time are presented in table 2 below.

. TAB.2 Calculation Results of Concentration Time (tc)

no	Channel	L (m)	Ups Elv (m)	Downs Elv (m)	ΔH (m)	S	tc (hours)
1	S1	21.73	113.43	113.26	0.17	0.007823	0.022515
2	S2	34.48	113.27	112.98	0.29	0.008411	0.031243
3	S3	65.54	113.2	112.94	0.26	0.003967	0.068420
4	S4	24.06	113.15	113.11	0.04	0.001663	0.044207
5	S5	65.86	113.15	112.89	0.26	0.003948	0.068806
6	S6	65.86	113.11	112.85	0.26	0.003948	0.068806
7	S7	27.66	113.00	112.85	0.15	0.005423	0.031220
8	S8	37.84	113.00	112.91	0.09	0.002378	0.054580
9	S9	27.66	112.91	112.78	0.13	0.004700	0.032988
10	S10	131.04	113.27	112.70	0.57	0.004350	0.112583
11	S11	56.81	112.81	112.55	0.26	0.004577	0.058007
12	S12	79.11	113.27	113.05	0.22	0.002781	0.090679
13	S13	20.92	113.05	112.96	0.09	0.004302	0.027526
14	S14	107.64	113.27	112.70	0.57	0.005295	0.089702
15	S15	93.97	113.24	112.77	0.47	0.005002	0.082590
16	S16	13.00	113.26	113.24	0.02	0.001538	0.028353
17	S17	95.60	113.26	112.77	0.49	0.005126	0.082906
18	S18	87.50	113.31	112.86	0.45	0.005143	0.077342
19	S19	83.84	113.51	113.09	0.42	0.005010	0.075599
20	S20	82.53	113.66	113.25	0.41	0.004968	0.074929
21	S21	78.93	113.75	113.36	0.39	0.004941	0.072550
22	S22	87.35	113.84	113.40	0.44	0.005037	0.077860
23	S23	33.26	112.95	112.80	0.15	0.004510	0.038629
24	S24	31.00	113.00	112.83	0.17	0.005484	0.033938
25	S25	23.82	113.51	113.35	0.16	0.006717	0.025625
26	S26	46.92	113.75	113.66	0.09	0.001918	0.069971
27	S27	55.28	113.69	113.59	0.10	0.001809	0.081199
28	S28	57.47	113.60	113.49	0.11	0.001914	0.081866
29	S29	62.89	113.51	113.36	0.15	0.002385	0.080621
30	S30	62.09	113.46	113.34	0.12	0.001933	0.086564

Source: Calculation Results

The method of calculating the average rain intensity using the Mononobe method. The calculation of the average rainfall intensity is based on rainfall which is calculated using a return period of 2 years, 5 years, 10 years, 25 years and time of concentration (tc). In the calculations in this study, the 25th anniversary period is used. On the return period is 25 years., the Planned Rain is 253,305mm, so the results of the calculation of the average rain intensity are presented in table 3 below.

TAB. 3 Calculation of Average Rain Intensity

no	Channel	tc (hours)	I (mm/hour)
1	S1	0.022515	1101.35006
2	S2	0.031243	885.26140
3	S3	0.068420	524.95003
4	S4	0.044207	702.39162
5	S5	0.068806	522.98489
6	S6	0.068806	522.98489
7	S7	0.031220	885.69613
8	S8	0.054580	610.31071
9	S9	0.032988	853.76043
10	S10	0.112583	376.63858
11	S11	0.058007	586.02986
12	S12	0.090679	435.07975
13	S13	0.027526	963.26241
14	S14	0.089702	438.23319
15	S15	0.082590	463.04341
16	S16	0.028353	944.43920
17	S17	0.082906	461.86605
18	S18	0.077342	483.75977
19	S19	0.075599	491.16715
20	S20	0.074929	494.09075
21	S21	0.072550	504.83378
22	S22	0.077860	481.61176
23	S23	0.038629	768.47729
24	S24	0.033938	837.75273
25	S25	0.025625	1010.33198
26	S26	0.069971	517.16361
27	S27	0.081199	468.31661
28	S28	0.081866	465.76942
29	S29	0.080621	470.55229
30	S30	0.086564	448.76103
Average I			672.06671

Source: Calculation Results

Plan Flood Discharge

The planned flood discharge is calculated based on the area of each area in Permata Indah Housing. To determine the planned flood discharge in terms of the intensity of the planned rainfall, the average return period is 25 years. The results of the calculation of the planned flood discharge for each return period are presented in the following table.

TAB.4 Calculation of Planned Flood Discharge for return period is 25 years

No	Region	Runoff Coef..(C)	Average Rain intensity (I) (mm/hour)	Area of region (A) (km²)	Plan Discharge (Q) (m³/s)
1	Kavling 30/60	0.75	672.070	0.00235	0.330
2	Kavling 36/72	0.75	672.070	0.00522	0.731
3	Kavling 45/96	0.75	672.070	0.00090	0.127
4	Kavling 45/165	0.75	672.070	0.00124	0.174
5	Road	0.90	672.070	0.01200	2.017
6	Public facility	0.20	672.070	0.00080	0.030
Total Flood Discharge (m³/s)					3.409

Source: Calculation Results

From the calculation of the planned flood discharge, it is known that the flood discharge value with a return period of 25 years for a housing complex is 3,409 m³/sec. Flood discharge with a return period of 25 years which will be used as a guideline for planning the drainage system in the Permata Indah Jember housing complex.

Evaluation of Existing Channel Discharge

Evaluation of the existing channel discharge is carried out to determine the ability to accommodate flood discharge. At the research location there is a drainage channel in the form of a culvert with a diameter of 40 cm. As for calculating the channel discharge capability is as follows.

Known:
1. Channel diameter = 40 cm
2. Wet cross-sectional area (A) = 0.0628 m²
3. Wet Perimeter = 1.0283m
4. Manning coefficient (concrete channel) = 0.013
5. Hydraulic radius = 0.0628/1.0283 = 0.0617
6. Flow velocity (V) $= 1/n.R^{2/3}.I^{1/2}$
$= 1/0.013 \times 0.0617^{2/3} \times 0.006^{1/2}$
= 0.9303m/s
7. Drainage discharge (Q) = V.A
= 0.9303 × 0.0628
= 0.0584 m³/s < 3,409 m³/s

From these results it is known that the existing channel cannot accommodate the flood discharge that occurs. This is caused by the inadequate dimensions of the existing channel so that only a small amount of flood discharge can be accepted.

Biopore Infiltration Hole

In this study, Biopori Infiltration Holes are used which have several advantages, namely improving soil ecosystems, absorbing water and preventing flooding, increasing groundwater reserves, and overcoming drought, facilitating waste management and hygiene maintenance, converting waste into compost, reducing greenhouse gas and methane emissions. , and solve the inundation problem. [11]

To calculate the need for biopore infiltration holes, the debit that can be received for each biopore infiltration hole is calculated first. In this study, the dimensions of the biopore holes are planned with a diameter of 10 cm and a depth of 100 cm. The data needed to calculate the biopore hole discharge was obtained from the results of previous studies which included soil permeability tests, namely to get the value of the hydraulic gradient (I) and seepage coefficient (K). The calculation to determine the discharge of the biopore infiltration hole is as follows.

Soil test data, obtained from previous research:
h1 = 88cm
L = 2cm
I = 44
K = 0.000000058 m/sec

The data of the biopore infiltration hole is planned as follows:
d = 10cm
h = 100cm
A = 78.5cm²
Q =K.I.A
= 0.000000058 × 44 × 78.5 = 0.0002m³/sec

$$\text{Biopore needs} = \frac{\text{Flood Discharge}}{\text{Biopory Discharge Capacity}} = \frac{0.33}{0.0002} = 1650 \text{ holes}$$

$$\text{Biopori needs of each plot} = \frac{\text{Total needs}}{\text{Number of kavlings}} = \frac{1650}{50} = 33 \text{ holes}$$

The hole requirements for each area are presented in table 5. below.

TAB. 5 Biopore Infiltration Hole Needs

No	Region	Plan Flood Discharge (m^3/s)	Biopory flood discharge (m^3/s)	Total biopory needs	Biopory needs each kavling
1	kavling 30/60	0.33	0.0002	1650	33
2	kavling 36/72	0.731	0.0002	3655	39
3	kavling 45/96	0.127	0.0002	635	71
4	kavling 45/165	0.174	0.0002	870	109
5	Roads	2.017	0.0002	10085	
6	Public facility	0.03	0.0002	150	
	Total biopory needs			17045	

Source: Calculation Results

From table 5, it is found that the need for biopore infiltration holes is 17045 holes.

IV. CONCLUSIONS AND SUGGESTIONS

Conclusion

Based on the results and discussion, the conclusions are as follows.

1. The flood discharge that occurred in Permata Indah Jember Housing for the 25th return period was 3,409 m^3/sec.
2. The existing line discharge in Permata Indah Jember Housing is 0.0584 m^3/sec.
3. According to the calculation of the design flood discharge and the capacity of the existing drainage channel, it is known that the existing drainage channel is not sufficient to accommodate the flood discharge that occurred.
4. Permata Indah Jember housing requires 17045 biopore infiltration holes

Suggestion

1. It is necessary to clean each channel so that there is no garbage that clogs the flow of water in each channel.
2. Further research is needed to apply other types of drainage to cope with flooding in housing.

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