JOURNAL OF CIVIL ENGINEERING PLANNING and DESIGN

Journal of Civil Engineering, Planning, and Design Vol.1, No.2, November 2022: Page 139-146

Evaluation of Bozem and Drainage Channels of Jade Hamlet Residential in Gresik

Jenny Caroline[1], Arintha Indah Dwi Syafiarti[2]

[1,2] Department of Civil Engineering, Faculty of Civil Engineering and Planning, Institut Teknologi Adhi Tama Surabaya, Indonesia

Abstract. Drainage refers to a vital component for water disposal so that a region or area can hinder potential puddle due to excessive water on the land surface. Therefore, a good plan adjusting the land condition of residential area belongs to a fundamental matter. Jade Hamlet Residence is located on Hulaan highway, Hulaan Urban Village, Menganti District, Gresik Regency, covering an area ±20 hectares and consisting of housing area, park, public facility, and catchment area. The drainage channel at this residence serves as the drainage for rain water and household dirty water disposal. During the rainy season in 2018 and 2019, the channel and bozem or drainage basin of this residence encountered overflowing and eventually caused puddle. To overcome this problem, the capacities of bozem and channel are in need of analysis and evaluation so as to figure out the runoff volume that can be accommodated in the bozem and investigate the discharge planned in the drainage channel by employing Log Person III method, chi-square distribution fit test, Kolmogorov-Smirnov test, rational formula, and exponential method. The results of analysis and evaluation demonstrated that the bozem capacity could not afford the runoff discharge (298.35 m3 > 309.55 m3), thereby demanding additional length and depth against the existing bozem. Meanwhile, the calculation of flood discharge planned for the drainage channels of S4.Ry3, S6.Ry1, S6.D1, S6.I2, S6.Cs1, S6.Rc1, S6.Rc2 indicate that they need redesigning by altering the channel dimension as the discharge capacity exceeds the channel.

Keywords: drainage, channel, bozem, discharge, capacity

Article history: Received: xxx; Revised: xxxx; Accepted: xxx; Available online: xxx (6 pt)
How to cite this article: Family name, A.B., Family Name, C.D., and Family name, E. (year) Title of Manuscript. Journal of Civil Engineering, Planning, and Design, x(x), xxx-xxx. (6 pt)
https://doi.org/10.19907/jcepd.x.x.xxx-xxx

1. Introduction

The rapid population growth in Surabaya Indonesia is currently leading to fast development in the surrounding area, one of which is residential areas in the Menganti District. The trade and services development also occurs in the district with population growth. The increasing number of residential buildings in the Menganti District causes changes in land use and reduced water infiltration into the ground.

Drainage is an essential component of water disposal to an area protected by excess water on the ground surface caused inundation. Drainage needs planning following the land conditions of a residential area so that water runoff to the drainage channel can be functioned optimally and does not cause an inundation [1]. Routine and periodic maintenance of residential drainage channels also needs to be carried out so that there is no sediment at the bottom of the drainage channel caused by waste from residents.

The residence is a collection of houses completed with facilities, infrastructure, and public utilities to attempt the fulfillment of a livable home, both in urban and rural areas. The Jade Hamlet Residence locates on Raya Hulaan Street, Hulaan Village, Menganti District Gresik Regency, covering an area of about 20 hectares, and consists of residential areas, roads, parks, public facilities, and catchment areas.

The drainage channel in this residence serves as a channel for rainwater and household dirty water disposal. The increasing development in this residence causes inundation when it rains. Then it is necessary to analyze the dimensions of the channel so it can accommodate rainwater discharge and dirty water discharge.

2. Design of Channels and Bozem

Water drainage and drainage systems in urban canals include settlements, industrial or commercial areas, schools, hospitals, public facilities, sports fields, parking lots, electrical or telecommunications installations, airports, or other infrastructure. The drainage network pattern includes rectangular, parallel, iron grid, natural, radial, and nets.

Rainfall was obtained from estimates of several rain stations/rainfall observation points. Calculation of the average rain using the average equation

$$P = \frac{P_1+P_2+P_3+\cdots+P_n}{n} \tag{1}$$

Where,

- P = Average rainfall (mm)
- N = Number of observation points or rain stations
- $P_1, P_2, \ldots, P_n$ = Rainfall for each station (mm)

$$\mathrm{Sd} = \sqrt{\frac{\sum(X_i - \bar{X})^2}{n-1}} \tag{2}$$

Where,

- Sd = Deviation standard
- X_i = Data in sample
- $\bar{X}$ = Average value
- n = Number of years of observation

$$Cs = \frac{n\sum(X_i - \bar{X})^3 n}{(n-1)(n-2)Sd^3} \quad (3)$$

$$Cv = \frac{Sd}{\bar{X}} \quad (4)$$

$$Ck = \frac{n^2\sum(X_i - \bar{X})^4}{(n-1)(n-2)(n-3)Sd^4} \quad (5)$$

Where, Cs is skewness, Cv is coefficient of variation and Ck is kurtosis.

The analysis of the frequency of rain on hydrological data intends to meet the magnitude of events related to the frequency of occurrence, using distribution parameters including the average value of rain height, standard deviation, slope coefficient, coefficient variation, sharpness coefficient [2]–[4]. These parameters to determine the distribution method used include normal, normal log, gumbel, type III log person.

Table 1

Statistical Parameters for Determining the Type of Distribution.

Distribution	Requirements
Normal	Cs = 0,0 Ck = 3,0
Log Normal	Cs = Cv3 + 3Cv Ck = Cv8 + 6Cv6+5Cv4+16Cv2+3
Gumbel	Cs = 1,396 Ck = 5,4002
Type III Log Pearson	If it does not show the nature of the three distributions above

The fit test is a data frequency distribution that uses the probability distribution and the value can be estimated so that the frequency distribution can be described, namely Chi-squared and Smirnov-Kolmogorov [5], [6]. The calculation of the flow coefficient is a comparison of the amount of water flowing due to rain in an area with the amount of rain falling in that area. Factors that affect the flow coefficient in an area include rain conditions, land, drainage area shape, the slope of the watershed, riverbed slope, infiltration power, soil porosity, soil permeability, temperature, wind, evaporation, and land use [1].

$$C = \frac{C_i.A_i}{\sum_{1=i}^{n} A} \quad (6)$$

Where,

- C = flow coefficient of flow area
- C_i = flow coefficient according to the type of surface
- A = Total area of drainage
- A_i = area of each land use

Table 2

Flow coefficient C.

Land	Soil Conditions	Ci Value
Unworked area		0,10 - 0,30
Road	Asphalt	0,70 - 0,95
	Concrete	0,80 - 0,95
	Stone	0,70 - 0,85
Roof		0,75 - 0,95

Rain intensity is the height/depth of rainwater per unit time. The general nature of rain is that the shorter the rainfall, the higher the return period and the greater the intensity [1], [4], [7], [8]. If only the daily rainfall is known in the rain data, then the Mononobe equation can be used:

$$I = \frac{R_{24}}{24} \cdot \left(\frac{24}{t_c}\right)^{\frac{2}{3}} \quad (7)$$

Where,

- R_{24} = Daily rainfall (mm)
- I = Rain intensity (mm/hr)
- A = Total area of drainage
- t_c = Rain concentration time (hr)

Concentration Time (tc) The time required for the point of water to flow from the farthest hydraulic point in its flow area to reach a point under consideration (inlet) or the entire flow contributes to the flow at that point.

$$t_c = t_0 + t_d \quad (8)$$

$$t_0 = \frac{2}{3} \cdot 3{,}28 \cdot L \cdot \frac{n}{\sqrt{S}} \quad (9)$$

$$t_d = \frac{Ls}{60V} \quad (10)$$

Where,

t_o	= The flow time required from the surface to reach the inlet
t_d	= The flow time required for the line to reach the outlet
L	= Flow distance above ground level (m)
n	= Manning roughness value
S	= Land slope
Ls	= Channel length (m)
V	= Flow speed in channel (m/s)

Rainwater discharge is the largest discharge that flows in the drainage channel caused by the rain that falls [9], [10]. Rainwater discharge can be calculated using a rational formula which is influenced by the coefficient of drainage in a planning area, the intensity of rain and the area of the drainage area.

$$Qah = 0{,}278 . C . I . A \quad (11)$$

Where,

C	= flow coefficient
I	= rain intensity
A	= total area of drainage (m)

The design flood discharge is the largest discharge occured in the specified planned return period. The amount of the planned flood discharge depends on the calculation of the amount of rainwater and the amount of household water flowing through the drainage channel in the planning area.

$$QR = Qah + Qak \quad (12)$$

Where,

QR	= Plan flood discharge (m^3/s)
Qah	= Rain water discharge (m^3/s)
Qak	= dirty water discharge (m^3/s)

Channel capacity is defined as the maximum flowrate that each cross section can pass along the channel. This channel capacity used to determine whether the plan discharge can drain through the existing channel without any overflow of water in it.

$$Q = V \ x \ A \quad (13)$$

$$V = \frac{1}{n} R^{2/3} S^{1/2} \quad (14)$$

Where,

QS	= Channel capacity (m^3/det)
V	= velocity of flow (m/det)
A	= Watershed area of channel cross-section (m^2)
n	= Manning roughness coefficient
R	= Channel hydraulic radius (m)
S	= Channel slope

Table 3
Manning Coefficient Value.

Channel type and material	**n Value**		
	Minimum	**Normal**	**Maximum**
Concrete			
• **Culvert straight and free of dirt**	0,010	0,011	0,013
• **Culverts with bends and little dirt/obstruction**	0,011	0,013	0,014
• **Polished concrete**	0,011	0,012	0,014
• **Drain with control body**	0,013	0,015	0,017

Calculation of the channel cross section. (1) Rectangular, (2) Trapezoidal, (3) Circular, (4) Semi-circular.

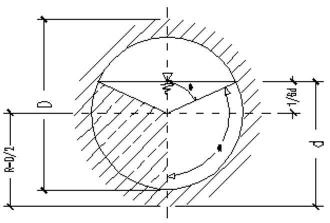

Figure 1. Circular Channel Cross Section.

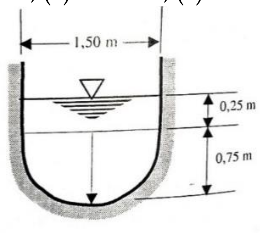

Figure 2. Semi-circular Channel Cross Section.

Circular watershed area

$$A = \frac{2\alpha}{360^o}\frac{1}{4}\pi D^2 + \frac{1}{2}\overline{AB} \times \overline{EC} \quad (19)$$

Circular perimeter of the watershed

$$P = \frac{2\alpha}{360^o}\frac{1}{4}\pi D \quad (20)$$

Semicircular watershed area

$$A = \frac{1}{4}\pi D^2 + D \times (H - r) \quad (21)$$

Semicircular perimeter of the watershed

$$P = \pi r + 2(H - r) \quad (22)$$

Where:

$\overline{AB}$ = flow width
$\overline{EC}$ = Radius of flow from center of circle
D = Channel diameter
r = radius
H = Channel height
h = Flow height = H – r

Discharge through the floodgate can be calculated based on submerged flow and free flow.

Submerged flow,

$$Q = \mu . b . a + \sqrt{2\,g\,H} \quad (23)$$

Free flow,

$$Q = \mu . b . a + \sqrt{2\,g\,H} \quad (24)$$

Where,

b = floodgate width (m)
a = sluice gate (m)
μ = discharge coefficient = 0,8
g = gravity = 9,81 (m/s²)

Determination of storage capacity is based on the largest reservoir and is analyzed every day by tracking floods. Storage is the difference between the amount of water entering and leaving the evaporation that occurs.

$$\frac{I_1+I_2}{2}\Delta t + \left(S_1 - \frac{Q_1}{2}\Delta t\right) = \left(S_2 + \frac{Q_2}{2}\Delta t\right) \quad (29)$$

Where,

S_1, S_2 = Storage volume on bozem (m^3)
I_1, I_2 = Inflow discharge to bozem (m^2/s)
Q_1, Q_2 = Outflow discharge from the bozem door (m^2/s)
Δt = time period (s)

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3. Methodology

The flowchart methodology of this research is available in the Figure 3.

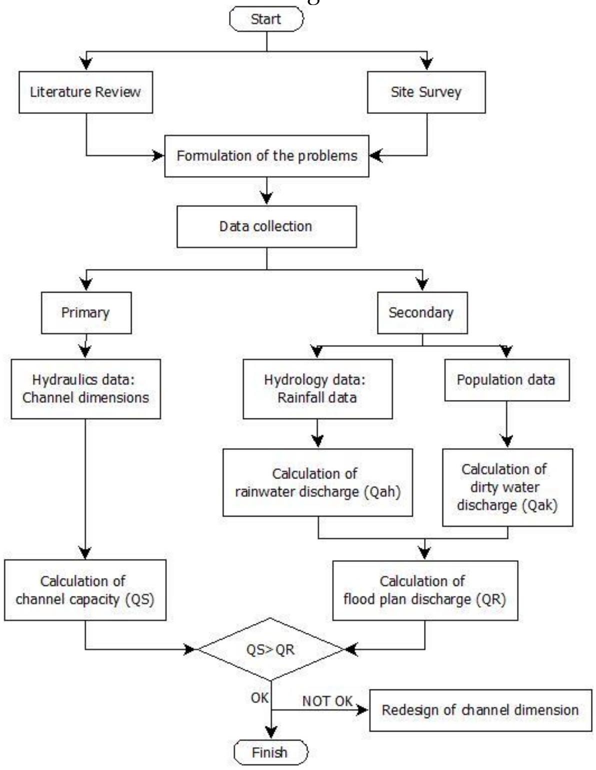

Figure 3. Flowchart of research methodology

4. Results

Hydrological analysis requires rainfall data to calculate rainwater discharge and planned flood discharge. Rainfall data using the maximum daily rainfall data every year at each observation station was taken for the last 10 years from 2010 to 2019.

Table 5.
Average rainfall

No	Year	Krikilan	Cerme	Menganti	Average rainfall (*Max*)
		mm	mm	mm	mm
1	2010	92	111	95	99
2	2011	73	102	73	83
3	2012	110	97	67	91
4	2013	102	110	128	113
5	2014	33	71	130	78
6	2015	90	84	40	71
7	2016	106	87	90	94
8	2017	77	109	80	89
9	2018	57	85	40	61
10	2019	88	86	91	88
Total (Σ)	10	828	942	834	867

The average value of rain height is obtained by taking the average value calculated from the rainfall measurement in the area.

$$P = \frac{P_1 + P_2 + P_3 + \cdots + P_n}{n} = \frac{99 + 83 + 91 + 113 + 78 + 71 + 94 + 89 + 61 + 88}{10} = 86.7\ mm$$

Calculation of statistical parameters the average value of rain height is obtained by taking the average value calculated from the rainfall measurement in the area.

JCEPD-ISSN: 2830-3628

Table 6.
Statistical Parameter Calculation Results

No	Year	X	$\overline{X}$	$(X - \overline{X})$	$(X - \overline{X})^2$	$(X - \overline{X})^3$	$(X - \overline{X})^4$
1	2010	2010	99	86,7	12,30	151,29	1860,87
2	2011	2011	83	86,7	-3,70	13,69	-50,65
3	2012	2012	91	86,7	4,30	18,49	79,51
4	2013	2013	113	86,7	26,30	691,69	18191,45
5	2014	2014	78	86,7	-8,70	75,69	-658,50
6	2015	2015	71	86,7	-15,70	246,49	-3869,89
7	2016	2016	94	86,7	7,30	53,29	389,02
8	2017	2017	89	86,7	2,30	5,29	12,17
9	2018	2018	61	86,7	-25,70	660,49	-16974,59
10	2019	2019	88	86,7	1,30	1,69	2,20
Total (Σ)	10	10	867	867	0	1918,10	-1018,44
Sd	**14,60**	**Cv**	**0,17**				
Cs	**0,001**	**Ck**	**4,40**				

Based on the results of the initial calculation of statistical parameters, the appropriate distribution method is Log Person Type III because it has a condition that the values of Cs and Ck are free, so the distribution is chosen.

Table 7.
Parameter Calculation Results of the Type III of Log Pearson Method

No	Year	X	Log X	$\overline{\text{LogX}}$	$(\text{LogX} - \overline{\text{LogX}})$	$(\text{LogX} - \overline{\text{LogX}})^2$	$(\text{LogX} - \overline{\text{LogX}})^3$
1	2010	99	1,996	1,9323	0,0634	0,0040	0,0003
2	2011	83	1,919	1,9323	-0,0132	0,0002	0,0000
3	2012	91	1,959	1,9323	0,0268	0,00072	0,0000192
4	2013	113	2,053	1,9323	0,1208	0,01460	0,0017640
5	2014	78	1,892	1,9323	-0,0402	0,0016	-0,0001
6	2015	71	1,851	1,9323	-0,0810	0,0066	-0,0005
7	2016	94	1,973	1,9323	0,0409	0,0017	0,0001
8	2017	89	1,949	1,9323	0,0171	0,0003	0,00001
9	2018	61	1,785	1,9323	-0,1469	0,0216	-0,00317
10	2019	88	1,944	1,9323	0,0122	0,0001	0,0000
Sum(Σ)	10	867	19,323	19,323	0,0000	0,0514	-0,0017
Average ($\overline{X}$)		86,7	1,9323	1,9323	0,0000	0,0051	-0,0002

Sd$\overline{\text{LogX}}$	**0,08**
Cv$\overline{\text{LogX}}$	**0,04**
Cs$\overline{\text{LogX}}$	**-0,5**

Table 8.
Calculation Result of Max Value of Type III of Log Pearson Distribution Method

Repeat Period	Cs	K	$\overline{\text{LogX}}$	Sd$\overline{\text{LogX}}$)	LogX	X (R)
2	-0,5	0,083	1,9323	0,08	1,94	86,80
5	-0,5	0,856	1,9323	0,08	2,00	99,30

Table 9.
Chi Squared Type III of Log Pearson Subgroup

Limit Value	Oi	Ei	(Oi – Ei)²	Xh²
X ≤ 1,87	2	2	0	0
1,87 < X ≤1,91	1	2	1	0,5
1,91 < X ≤ 1,95	3	2	1	0,5
1,95 < X ≤ 2	3	2	1	0,5
X > 2	1	2	1	0,5
Total	10	10	4	2

The calculation will be accepted if the theoretical Chi Square value > the calculated Chi Square value. From the calculation above, the value is 5.991 > 2, so the calculation is accepted.

Table 10.
Value of D, Smirnov Kolmogorov Type III of Log Pearson subgroup

m	Log X	(LogX – $\overline{\text{LogX}}$)	P(x) = m/(n+1)	P(x<)	f(t) = (LogX- $\overline{\text{LogX}}$)/Sd	P′(x<)	P′(x)	D
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		(2)- $\overline{\text{LogX}}$	(1)/Σ(1)+1	1-(4)	(3)/Sd	Table continuation	1-(7)	(4)-(8)
1	2,053	0,1208	0,091	0,909	1,60	0,9452	0,0548	0,0361
2	1,996	0,0634	0,182	0,818	0,84	0,7995	0,2005	0,0187
3	1,973	0,0409	0,273	0,727	0,54	0,7054	0,2946	0,0219
4	1,959	0,0268	0,364	0,636	0,35	0,6368	0,3632	-0,0004
5	1,949	0,0171	0,455	0,545	0,23	0,5910	0,4090	-0,0455
6	1,944	0,0122	0,545	0,455	0,16	0,5636	0,4364	-0,1091
7	1,919	-0,0132	0,636	0,364	-0,17	0,4325	0,5675	-0,0689
8	1,892	-0,0402	0,727	0,273	-0,53	0,2981	0,7019	-0,0254
9	1,851	-0,0810	0,818	0,182	-1,07	0,1423	0,8577	0,0395
10	1,785	-0,1469	0,909	0,091	-1,94	0,0262	0,9738	0,0647
(Σ)	**19,323**						***Dmax***	**0,0647**
X	**1,9323**							
Sd	**0,08**							

The value of Dmax = 0.0647 with a degree of confidence = 5% and the number of data = 10, then the value of Do = 0.41 is obtained. Because the value of Dmax < Do (0.0647 < 0.41), the equation can be accepted.

Table 11.
Result of Calculation of Channel and Planned Discharge

Code	QS (m^3/s)	QR (m^3/s)	Condition	Code	QS (m^3/s)	QR (m^3/s)	Condition
S1.Ry1	3,81	0,09	Fulfilled	S5.E1	6,14	0,005	Fulfilled
S1.Ry2	7,50	0,05	Fulfilled	S6.E1	0,39	0,37	Fulfilled
S2.Ry1	3,21	0,03	Fulfilled	S6.E2	0,40	0,10	Fulfilled
S3.Ry1	0,79	0,06	Fulfilled	S6.E3	0,30	0,09	Fulfilled
S4.Ry1	0,17	0,10	Fulfilled	S6.E4	0,35	0,07	Fulfilled
S4.Ry2	0,16	0,06	Fulfilled	S6.E5	0,45	0,05	Fulfilled
S4.Ry3	0,271	0,273	Exceeded	S6.E6	0,44	0,08	Fulfilled
S4.Ry4	0,16	0,06	Fulfilled	S2.F1	1,78	0,10	Fulfilled
S4.Ry5	0,16	0,05	Fulfilled	S2.G1	1,65	0,08	Fulfilled
S6.Ry1	0,36	2,01	Exceeded	S1.H1	8,49	0,15	Fulfilled
S6.Ry2	0,38	0,08	Fulfilled	S2.H1	1,31	0,10	Fulfilled
S6.A1	0,41	0,23	Fulfilled	S2.H2	1,67	0,08	Fulfilled
S6.A2	0,28	0,17	Fulfilled	S6.H1	0,44	0,20	Fulfilled
S1.B1	6,59	0,79	Fulfilled	S6.H2	0,44	0,27	Fulfilled
S2.B1	2,81	0,05	Fulfilled	S6.H3	0,43	0,16	Fulfilled
S3.B1	0,51	0,08	Fulfilled	S2.I1	1,77	0,08	Fulfilled
S3.B2	0,43	0,08	Fulfilled	S2.I2	1,78	0,07	Fulfilled
S3.B3	0,96	0,83	Fulfilled	S3.I1	0,70	0,58	Fulfilled
S6.B1	0,43	0,15	Fulfilled	S6.I1	0,43	0,19	Fulfilled
S6.B2	0,44	0,16	Fulfilled	S6.I2	0,33	0,34	Exceeded
S1.C1	7,89	0,21	Fulfilled	S1.J1	7,09	0,26	Fulfilled
S3.C1	0,43	0,07	Fulfilled	S3.J1	0,39	0,08	Fulfilled
S3.C2	0,43	0,07	Fulfilled	S3.J2	0,40	0,09	Fulfilled
S6.C1	0,40	0,12	Fulfilled	S6.J1	0,44	0,18	Fulfilled
S3.D1	0,42	0,07	Fulfilled	S3.K1	0,34	0,08	Fulfilled
S3.D2	0,41	0,07	Fulfilled	S3.K2	0,41	0,08	Fulfilled
S6.D1	0,35	0,44	Exceeded	S6.K1	0,41	0,36	Fulfilled
S6.D2	0,44	0,22	Fulfilled	S3.L1	0,35	0,09	Fulfilled
S1.E1	5,46	0,07	Fulfilled	S3.L2	0,73	0,04	Fulfilled
S1.E2	9,65	0,04	Fulfilled	S6.L1	0,39	0,05	Fulfilled
S1.E3	8,76	0,32	Fulfilled	S1.Rk1	2,57	0,18	Fulfilled
S1.E4	5,50	0,10	Fulfilled	S1 Cs1	1,67	0,40	Fulfilled
S3.E1	0,83	0,04	Fulfilled	S6.Cs1	0,30	0,47	Exceeded
S3.E2	0,48	0,05	Fulfilled	S1.Rc1	2,31	1,43	Fulfilled
S4.E1	0,20	0,06	Fulfilled	S6.Rc1	0,38	2,08	Exceeded
S4.E2	0,26	0,05	Fulfilled	S6.Rc2	0,38	4,96	Exceeded
S4.E3	0,20	0,07	Fulfilled	S5.P1	3,82	0,82	Fulfilled

Table 12.
Result of Calculation of Redesign of Channel and Planned Discharge

JCEPD-ISSN: 2830-3628

Kode	QS (m³/s)	QR (m³/s)	Conditions
S4.Ry3	0,29	0,273	Fulfilled
S6.Ry1	2,57	2,007	Fulfilled
S6.D1	0,79	0,438	Fulfilled
S6.I2	0,79	0,337	Fulfilled
S6.Cs1	0,79	0,474	Fulfilled
S6.Rc1	2,57	2,083	Fulfilled
S6.Rc2	6,50	4,963	Fulfilled

So based on the calculations, the existing bozem capacity < bozem storage volume (298.35 m3 < 309.55 m3), so that it overflows in the bozem. Thus, bozem needs to be redesigned to be able to accommodate the volume of the bozem reservoir.

5. Conclusions

According to the calculations above, there are 3 conclusions which presented below:

1. From the analysis of the evaluation of the capacity of the existing bozem, it is 298.35 m3.
2. From the results of the volume of runoff that can be accommodated by bozem in year 2 and year 5 = 309.55 m3, so that based on these calculations the storage capacity of bozem exceeds the capacity of bozem, it is necessary to redesign by increasing the length and height (deepening) of the existing bozem.
3. Based on the calculation of the planned flood discharge on the drainage channel of the Jade Hamlet Menganti Gresik Housing which exceeds the channel discharge capacity, namely in table 4.28 in the form of channels S4.Ry3, S6.Ry1, S6.D1, S6.I2, S6.Cs1, S6.Rc1, S6.Rc2.

References

[1] Suripin, *Sistem Drainase Perkotaan yang Berkelanjutan*. Yogyakarta: Andi, 2004.
[2] Ahdianoor Fahraini and Achmad Rusdiansyah, "Analisis Keandalan Metode Analisa Frekuensi dan Intensitas Hujan Berdasarkan Data Curah Hujan Klimatologi Banjarbaru," *J Teknol Berkelanjutan Sustain Technol J*, vol. 9, no. 1, pp. 11–23, 2020.
[3] Ana Susanti Yusman, "CURAH HUJAN DAN ANALISA FREKWENSI BANJIR KOTA PADANG," *UNES J Sci Res*, vol. 3, no. 1, pp. 59–67, Jun. 2018.
[4] Andy Hendri, "Analisis Metode Intensitas Hujan pada Stasiun Hujan Pasar Kampar Kabupaten Kampar," in *Proceedings of 1st Annual Civil Engineering Seminar (ACES)*, Pekanbaru, 2015, vol. 1, pp. 297–304.
[5] Togani Cahyadi Upomo and Rini Kusumawardani, "Pemilihan distribusi probabilitas pada analisa hujan dengan metode goodness of fit test," *J Tek Sipil Dan Perenc*, vol. 18, no. 2, pp. 139–148, 2016.
[6] Dimitri Fairizi, "ANALISIS DAN EVALUASI SALURAN DRAINASE PADA KAWASAN PERUMNAS TALANG KELAPA DI SUBDAS LAMBIDARO KOTA PALEMBANG," *J Tek Sipil Dan Lingkung*, vol. 3, no. 1, pp. 755–765, Mar. 2015.
[7] Rahmat Faizal, Noerman Adi Prasetya, Zikri Alstony, and Aditya Rahman, "Evaluasi Sistem Drainase Menggunakan Storm Water Management Model (SWMM) dalam Mencegah Genangan Air di Kota Tarakan," *Borneo Eng J Tek Sipil*, vol. 3, no. 2, pp. 143–154, Dec. 2019.
[8] Marelianda Al Dianty, Rizka Arbaningrum, and Shafira Khalisa, "Pemanfaatan Lubang Resapan Biopori Sebagai Alih Fungsi Lahan Dan Upaya Mitigasi Banjir," *J Pengabdi Dharma Laksana*, vol. 4, no. 2, pp. 209–217, 2022.
[9] Fitra Andika Parse, "Perencanaan Saluran Drainase dengan Analisis Debit Banjir Metode Rasional (Studi Kasus Desa Petapahan Kecamatan Gunung Toar)," *J Perenc Sains Teknol Dan Komput*, vol. 1, no. 2, pp. 31–43, 2018.
[10] Ade Irawan, "PERENCANAAN SALURAN DRAINASE DENGAN METODE RASIONAL (Studi Kasus Desa Kasang Kecamatan Kuantan Mudik)," *J Planol DAN SIPIL JPS*, vol. 1, no. 2, pp. 148–156, 2019.

JCEPD-ISSN: 2830-3628