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Study on The Analysis of Kemayoran Drainage Channel, Kemayoran Urban Village, Bangkalan Sub-District, Bangkalan Regency

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Abstract

The success of development in Bangkalan regency is marked by the increase in housing and shops. The existence of changes in the spatial layout of Bangkalan city can increase surface runoff, causing roads and residential areas to experience puddles of water. The height of the flood inundation that occurs on average is at an elevation of 30 cm to 40 cm above the road surface. The Kemayoran drainage channel is an open channel, so the method used in this planning begins with a hydrological analysis which includes calculating the maximum daily rainfall at the study site for 10 years starting from 2011 to 2020, then calculating the design rainfall intensity using the Distribution method. Gumble, Normal Distribution, Log Normal Distribution, Log Pearson III Distribution, as well as a distribution match test was carried out to test whether the existing rainfall data matched the selected method. The suitability test used is the Chi-Square test and the Smirnov – Kolmogorov test. Next, an analysis of the planned flood discharge was carried out using the Rational method in which the calculation of the flow coefficient (C), the time of concentration (tc), and calculating the intensity of the rain was carried out. Furthermore, analysis of the discharge of the existing drain with the Manning formula is carried out to determine the maximum discharge capacity of the exhaust channel. From the calculation results, it is found that the planned discharge of the Kemayoran drainage channel for Q2 = 90,657 mm, Q5 = 116, 627 and Q10 = 133,627 mm, so that the results of these calculations indicate that the cross section of the xisting canal cannot accommodate the existing water The results obtained from the calculation show that, the existing channel cross section cannot accommodate the existing water discharge, so treatment is needed in the form of re-dimensioning the channel using a U-ditch with dimensions of 100,100,120.8 along 288 m, and using a trapezoidal stone pair with a channel width. 1.2 m and high 1.3 m long 872 m. In the short term, the handling of flooding and inundation that occurs in the Kemayoran drain can be done by normalizing the channel, so that the problem of flood inundation can be overcome for a return period of 2 years, 5 years, 10 years, 20 years and 50 years.

Keywords :
Design Discharge, Flood, Kemayoran Drainage Channel Capacity, U-ditch

1. Introduction

1.1 Background

Bangkalan regency is a district that has experienced significant development from year to year, the success of development in Bangkalan regency is marked by the increase in housing and shops, especially in Bangkalan city, it causes an increase in newcomers who move from rural areas to Bangkalan city.

With the change in the spatial layout of Bangkalan city, it will increase surface runoff, surface runoff is the flow of water flowing over the surface due to the full capacity of the soil infiltration, so that the water flow will flow to the storage location in this case the drainage channel.

Based on field observations, it is known that flood inundation is caused by the drainage channel on Soekarno-Hatta road not being able to accommodate flood discharges, sedimentation in several canal sections due to lack of maintenance and increasingly dense housing of residents, plus the condition of several canal sections that have narrowed cross-section so it is necessary there is improvement. The condition of the land contour in the area is relatively flat which results in slow water flow. The average flood inundation height is 30 cm to 40 cm, which causes roads and residential areas to experience waterlogging.

The current condition of the Kemayoran drainage channel is an old stone masonry channel that has started to break down, is shallow and there is a lot of narrowing of the channel cross section, this is because on the right and left sides of the channel a lot of housing has been built, so it is necessary to normalize and rehabilitate the channel.

Map of the location of the Kemayoran drainage channel in the Kemayoran urban village, Bangkalan sub-district, Bangkalan regency along ± 985 m.

Figure 1. Map of Kemayoran Drainage Channel Location

1.2 Formulation of the problem

Based on the research background above, the formulation of the problem that can be described is as follows :

What is the planned flood discharge for Q2, Q5, and Q10 in the Drainage Channel, Kemayoran urban village, Bangkalan sub-district?

What is the Existing Capacity of the Kemayoran Urban Village Drainage Channel in Bangkalan sub-district?

What are the dimensions of the Kemayoran urban village drainage channel in Bangkalan sub-district in the period of 2 years, 5 years, and 10 years?

2. Literature review

According to Sidharta, 1997, drainage is generally defined as a science that studies efforts to drain excess water in a certain context of use. Drainage is defined as the removal of surface water or groundwater from an area, either by gravity, by water pumps, or by channels. To solve problems related to drainage, it is closely related to hydrological analysis, especially the problem of rain as a source of water that will flow into the drainage system and runoff.

According to Soedibyo, 2003, the purpose of hydrological analysis is to calculate the water discharge for the calculation of the planned channel. Hydrological analysis was carried out in order to determine the validity of the data obtained, such as planned rainfall data, planned flood discharge, and other data. These data will later be processed to determine the planned discharge, so this hydrological analysis plays a very important role.

The design flood discharge must not be too large to avoid overflowing water which can cause damage to the building due to a flood greater than the design discharge.

2.1 Rainfall Plan

To get the amount of rainfall, the distribution method is used, while the purpose of using this method is to get the extreme value of the rainfall series. The method used is the Gumbel distribution method, the normal distribution method, the log normal distribution method, and the Pearson III log distribution method.

From the several distribution distribution methods, a distribution suitability test is then carried out to test whether the existing rainfall data is in accordance with the type of method chosen. The suitability test used is the Chi-Square test and the Smirnov – Kolmogorov test.

2.2 Plan Flood Discharge

One of the methods commonly used to estimate the peak flow rate (design flood discharge) is the USSCS Rational Method. This method is used for areas with drainage areas of less than 300 ha Suripin, 2004. The Rational Method was developed based on the assumption that the rainfall that occurs has a uniform and even intensity throughout the drainage area for at least the same as the concentration time (t_c), the mathematical equation of the Rational Method is as follows :

$Q = 0{,}278.C.I.A$, Where,

Q= Peak Discharge (m^3/sec)

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C= Flow coefficient
I = Rain intensity (mm/hour)
A= Drainage area (km²)

$I = \frac{R_{24}}{24}\left(\frac{24}{t_c}\right)^{2/3}$, Where,

I = Rain intensity
R24 = Rainfall
t_c = Concentration time

2.3 Channel Capacity Analysis

Channel capacity is the maximum amount of discharge that can be passed by a channel section along the channel. The capacity of this channel is used as a reference to state whether the discharge that occurs can be accommodated by the channel in the existing condition without any overflow of water.

The amount of drainage channel capacity is determined based on the following. (Chow, C.W., Haddad, K.M. and Williamson, 1997) :

Qkap = A.v with $v = \frac{1}{n}.R^{2/3}.S^{1/2}$, Where,

Qkap = Channel capacity (m³/s)
A = Channel cross-sectional area (m²)
V = Flow speed (m/s)
R = Channel hydraulic radius (m)
S = Channel slope
n = Manning Coefficient

The general calculation of flow velocity in the calculation of the 10 years return period is as follows :

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

3. Research Methodology

3.1 Research Flowchart

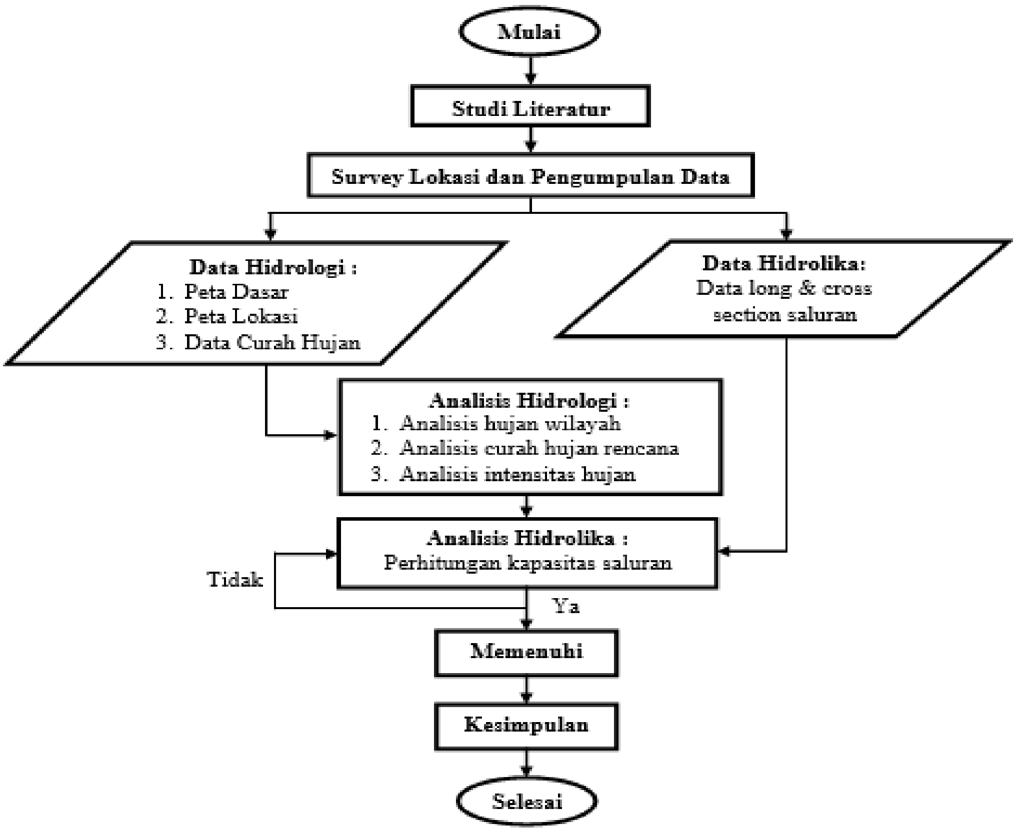

Figure 2. Research Flowchart (in Indonesia)

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3.2 Study Stage

In the early stages of this research, surveys and data collection were carried out, intended to obtain accurate data which would later be used to evaluate the study. These data are divided into two categories:

Primary data is original data obtained or collected directly by researchers according to the field, the data in question is measurement data, measurement data of the existing canal is needed to obtain the geometry and contour conditions of the existing Kemayoran drainage channel. Long section and cross section measurements were carried out along the Kemayoran drainage channel with the distance between points or stakes taken every 50 m.

Secondary data is data obtained by researchers indirectly, the data is obtained from several sources or related agencies, the data in question are as follows:

Map data was obtained from several government agencies, including the Public Works and Spatial Planning (PUPR) department of Bangkalan regency and the Bangkalan district's Public Housing and Settlement Area (PRKP) department. The map required includes a base map that serves to determine the research location in the form of the position of buildings, roads and channels. Next is a land use map that serves to determine the runoff coefficient, as well as a drainage network map that functions to determine the direction of flow from tertiary, secondary, and primary channels around the research area. In addition, the author also took map data from the internet in this case through the google.earth application to find out where the channel is located.

Rainfall data obtained from the Public Works and Spatial Planning (PUPR) department of Bangkalan Regency in the field of Water Resources, daily rainfall data uses rain data for the last 10 years, starting from 2011 to 2020. This data is needed to calculate the planned rain height, rainfall intensity, and rain discharge plan in the calculation of hydrological analysis. The Kemayoran drainage channel has one rain station at the Bangkalan rain station, which is located in the Kraton urban village.

4. Results and Discussion

4.1 Research Result

The rainfall data used is the maximum daily rainfall at the St. Climatology station Bangkalan.

Table 1. Maximum Annual Rainfall Data

No.	Year	Bangkalan Station (mm)
1	2011	84
2	2012	62
3	2013	125
4	2014	86
5	2015	105
6	2016	120
7	2017	50
8	2018	110
9	2019	104
10	2020	100
n = 10		946
R Average		94,6

(Source : Department of PUPR Bangkalan Regency year 2020)

To get the amount of rainfall, four distribution methods are used, while the purpose of using these methods is to get extreme values from the rainfall series. The methods used include: Gumble distribution method, Normal distribution method, Log Normal distribution method, Log Pearson distribution method III, as well as the Fit Test.

With the following description:

1. Distribution Analysis Gumble Distribution Method

Table 2. Gumble Distribution Methode Calculation

No.	Year	X	Xbar	(X - Xbar)	$(X - Xbar)^2$	$(X - Xbar)^3$	$(X - Xbar)^4$
1	2011	84	94,6	-10,6	112,36	-1.191,02	12.624,77
2	2012	62	94,6	-32,6	1.062,76	-34.645,98	1.129.458,82
3	2013	125	94,6	30,4	924,16	28.094,46	854.071,71
4	2014	86	94,6	-8,6	73,96	-636,06	5.470,08
5	2015	105	94,6	10,4	108,16	1.124,86	11.698,59
6	2016	120	94,6	25,4	645,16	16.387,06	416.231,43
7	2017	50	94,6	-44,6	1.989,16	-88.716,54	3.956.757,51
8	2018	110	94,6	15,4	237,16	3.652,26	56.244,87
9	2019	104	94,6	9,4	88,36	830,58	7.807,49
10	2020	100	94,6	5,4	29,16	157,46	850,31
n = 10		946			5.270,40	-74.942,88	6.451.215,55

(Source : From Calculation Data)

2. Distribution Analysis Normal Distribution Method

Table 3. Normal Distribution Methode Calculation

No.	Year	X	Xbar	(X - Xbar)	$(X - Xbar)^2$	$(X - Xbar)^3$	$(X - Xbar)^4$
1	2011	84	94,6	-10,6	112,36	-1.191,02	12.624,77
2	2012	62	94,6	-32,6	1.062,76	-34.645,98	1.129.458,82
3	2013	125	94,6	30,4	924,16	28.094,46	854.071,71
4	2014	86	94,6	-8,6	73,96	-636,06	5.470,08
5	2015	105	94,6	10,4	108,16	1.124,86	11.698,59
6	2016	120	94,6	25,4	645,16	16.387,06	416.231,43
7	2017	50	94,6	-44,6	1.989,16	-88.716,54	3.956.757,51
8	2018	110	94,6	15,4	237,16	3.652,26	56.244,87
9	2019	104	94,6	9,4	88,36	830,58	7.807,49
10	2020	100	94,6	5,4	29,16	157,46	850,31
n = 10		946			5.270,40	-74.942,88	6.451.215,55

(Source : From Calculation Data)

3. Distribution Analysis Log Normal Distribution Method

Table 4. Log Normal Distribution Methode Calculation

No.	Year	X	Log X	Log Xbar	(Log X - Log Xbar)	(Log X - Log Xbar)²	(Log X - Log Xbar)³
1	2011	84	1,9243	1,9606	-0,0363	0,0013	-0,000048
2	2012	62	1,7924	1,9606	-0,1682	0,0283	-0,004758
3	2013	125	2,0969	1,9606	0,1363	0,0186	0,002534
4	2014	86	1,9345	1,9606	-0,0261	0,0007	-0,000018
5	2015	105	2,0212	1,9606	0,0606	0,0037	0,000223
6	2016	120	2,0792	1,9606	0,1186	0,0141	0,001668
7	2017	50	1,6990	1,9606	-0,2616	0,0684	-0,017905
8	2018	110	2,0414	1,9606	0,0808	0,0065	0,000528
9	2019	104	2,0170	1,9606	0,0564	0,0032	0,000180
10	2020	100	2,0000	1,9606	0,0394	0,0016	0,000061
n = 10		946	19,6058			0,15	-0,02
	Average		1,9606				
Standard Deviation					0,1275		

(Source : From Calculation Data)

4. Distribution Analysis Log Pearson III Distribution Method

Table 5. Log Perason III Distribution Methode Calculation

No.	Year	X	Log X	Log Xbar	(Log X - Log Xbar)	(Log X - Log Xbar)²	(Log X - Log Xbar)³
1	2011	84	1,9243	1,9606	-0,0363	0,0013	-0,000048
2	2012	62	1,7924	1,9606	-0,1682	0,0283	-0,004758
3	2013	125	2,0969	1,9606	0,1363	0,0186	0,002534
4	2014	86	1,9345	1,9606	-0,0261	0,0007	-0,000018
5	2015	105	2,0212	1,9606	0,0606	0,0037	0,000223
6	2016	120	2,0792	1,9606	0,1186	0,0141	0,001668
7	2017	50	1,6990	1,9606	-0,2616	0,0684	-0,017905
8	2018	110	2,0414	1,9606	0,0808	0,0065	0,000528
9	2019	104	2,0170	1,9606	0,0564	0,0032	0,000180
10	2020	100	2,0000	1,9606	0,0394	0,0016	0,000061
n = 10		946	19,6058			0,15	-0,02
	Average		1,9606				
Standard Deviation					0,1275		

(Source : From Calculation Data)

4.2 Land Slope Analysis

The calculation of the slope of the land is needed in determining the time it takes for rainwater to reach the intended point. The slope of the soil is obtained by measuring the area of water drainage from the highest point to the intended final channel.

The slope of the land with the equation: $S = \frac{Ht - Ho}{0.9.L}$, earned value S = 0,00044

The concentration time for the drainage area can be described by the following equation :

$tc = \left(\frac{0,87.L^2}{1000.S}\right)^{0,385}$, earned value tc = 1,46 o'clock

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4.3 Rain Intensity

Rainfall intensity is the amount of rain expressed in height or volume of rain per unit time. The magnitude of this intensity is highly dependent on the duration of rainfall and the frequency of its occurrence.

Calculation of Rain Intensity can be formulated as follows : $I = \frac{R_{24}}{24}\left(\frac{24}{t_c}\right)^{2/3}$

4.4 Dirty Water Discharge Analysis

The amount of flood discharge is obtained from the sum of rainwater discharge and household wastewater discharge. Furthermore, the capacity of the existing canal is analyzed, whether it is able to withstand the peak flow rate from rainwater and household waste. If the channel is not able to withstand the current amount of discharge, it is necessary to plan the re-dimension of the existing channel.

The equation used to determine the Dirty Water discharge : $Q_{ak} = \frac{(Pn.q)}{A}$ with $Pn = Po.(1+r)^n$ and rainwater discharge : Qah = 0,278.C.I.A

The runoff coefficient (C) is the comparative value between the portion of the rain that forms direct runoff and the total rain that occurs under various conditions (Sidharta & Arief, 2013). The condition of the flow area around the Kemayoran Drainage Channel at this time has developed into a fairly dense residential area, so the flow coefficient is taken as C = 0,60.

4.5 Channel Capacity Analysis

Channel capacity is the maximum amount of discharge that can be passed by a channel section along the channel. This channel capacity is used as a reference to state whether the discharge that occurs can be accommodated by the channel in its existing condition without any overflow of water (Anggraini & Hendra, 2010).

The Manning coefficient that will be used for the calculation of the Kemayoran drainage channel design using a precast concrete surface is n = 0,014, and using a pair of plastered river stones is n = 0,017. The channel cross section used in the channel uses a channel with a rectangular cross section and a trapezoidal section with a slope of 1 : 2. The capacity of the drainage channel is determined based on the following. (Chow & Te, 1997)ss:

Qkap = A.v with $v = \frac{1}{n}.R^{2/3}.S^{1/2}$

Table 6. Channel Capacity Calculation Evaluation

Name / Pice	b	h	w	S	n	R	v	A	Qkap
Channel	m	m				m	m/dt	m2	m3/dt
P.0 - P.3	1,00	1,00	0,30	0,0018	0,014	0,33	1,45	1,00	1,45
P.3 - P.15	1,20	1,30	0,30	0,0006	0,017	0,59	1,00	1,56	1,56

(Source : From Calculation Data)

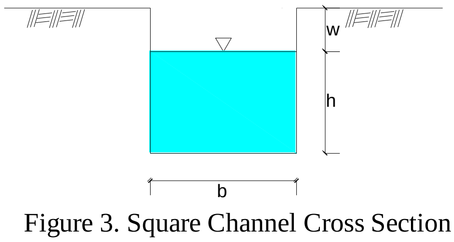

Figure 3. Square Channel Cross Section

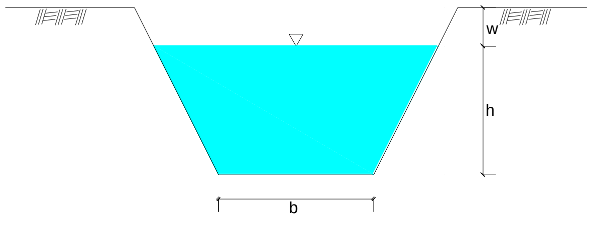

Figure 4. Trapezoidal Channel Cross Section

Where,
b = Channel Base Width (m)
h = Water Level (m)
w= Guard Heigth (m)

5. Closing

5.1 Conclusion

1. The rainfall return period used in the calculation of this Final Project is the Log Pearson III method, with the planned rainfall value for the 2-year return period of 90,657 mm, for the 5-year return period of 116,627 mm, for the 10-year return period of 133,627 mm , for a 20-year return period of 154,982 mm, and for a 50-year return period of 170,822 mm.
2. Evaluation of the results of the Kemayoran Drainage Channel with the Qcap of the drainage channel P.0–P.3 is 1,45 m3/sec, the Qcap of the drainage channel P.3–P.15 is 1,56 m3/sec.
3. The need for channel cross-sectional dimensions, namely for drainage channels P.0–P.3 is B=1,00 m, H=1,00 m, and W=0,30 m, and for drainage channels P.3-P15 is B = 1,20 m, H = 1,30 m, and W = 0,30 m.

5.2 Suggestions

1. Channel repairs need to be carried out in all Kemayoran drainage channels because the channel capacity is no longer able to accept the discharge that occurs, in the short term the repair that can be done is to clean and normalize the drainage channel, because there is a lot of sediment that comes from mud and from community waste which can hinder the speed of water flow in the channel.
2. In repairing the 288 m long Kemayoran drainage channel, it is recommended to use precast concrete (U-Ditch) so that it is practical in implementation and the dimensions can be accurate, as well as a longer life of concrete.
3. For locations that cannot be reached when using precast concrete due to the installation of heavy equipment and because the location is already densely populated, it will be difficult for heavy equipment to enter the work site, so it is recommended to use a pair of plastered river stones with a mixture of 1 Pc : 4 Ps with a trapezoidal cross section.

References

Anggraini, & Hendra, Y. dan P. (2010). Anggaran Berbasis Kinerja; Penyusunan APBD Secara Komprehensif. STIM YKPN.

Chow, C.W., Haddad, K.M. and Williamson, J. E. (1997). Applying the Balanced Scorecard to Small Companies. Management Accounting, 79, 21–27.

Chow, & Te, V. (1997). . Hidrolika Saluran Terbuka. : Erlangga.

Sidharta, & Arief, B. (2013). Ilmu Hukum Indonesia: Upaya Pengembangan Ilmu Hukum Sistematik Yang Responsif Terhadap Perubahan Masyarakat.

Sidharta, S. K. (1997). Irigasi dan Bangunan Air. Guna Darma.

Soedibyo. (2003). Teknik Bendungan. Pradnya Paramita.

Suripin. (2004). Sistem Drainase Perkotaan yang Berkelanjutan. Andi Offset.