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Article

EVALUATION STUDY OF THE EXISTING CONDITION OF DRAINAGE CHANNELS IN BANGKINANG KOTA DISTRICT (CASE STUDY: PETAI RIVER III)

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A B S T R A C T

The development of the city followed by an increase in the population in Bangkinang City has resulted in the conversion of land functions into residential areas or offices, resulting in disruption of soil absorption capacity and increased surface runoff and resulting in flooding. This final project aims to analyze the ability of existing drainage channels to accommodate and flow flood discharge, analysis of maximum planned rainfall, analysis of planned flood discharge with a return period. The research method used is the method of field data and data analysis. The data used are primary data and secondary data. The discharge value of the existing channel with the planned discharge value is analyzed based on hydrological analysis and hydraulic analysis. This study uses the Log Person Type III distribution because it gives the best results compared to other distributions. Results The calculated rainfall intensity for the 10-year return period is 109.0159 mm/hour. The design discharge is calculated based on the Rational method, it is known that the 10 year return period is Q = 26.3266 m3/s. From the dimensional analysis it turned out that the drainage channel for Jalan Mayor Ali Rasyid was not able to accommodate the discharge of the planned channel, and a width of 1.2 m was added along the flood area, and the channel could accommodate the runoff that occurred in the Petai III river.

1. BACKGROUND

1.1 Introduction

The rapid growth of population in urban areas has led to a decrease in land absorption capacity due to the conversion of land into residential or office areas. This condition increases surface runoff and reduces the soil's ability to absorb water, resulting in frequent waterlogging in residential areas and roads. These inundations not only disrupt daily community activities but can also lead to significant socio-economic losses.

Indonesia experiences two seasons: the dry season and the rainy season. One of the main problems during the rainy season is flooding. Floods typically occur due to heavy rainfall that causes standing water in certain areas for a specific period. According to the Indonesian National Disaster Management Agency (BNPB), floods were the most dominant natural disaster in Indonesia in 2021, accounting for 1,288 incidents or 42.1% of the total disasters (Dihni, 2021).

Nurhamidin (2015) states that population growth and urban development are always followed by an increased demand for infrastructure, including drainage systems. However, many drainage systems have experienced a decline in function. Common issues include inadequate drainage capacity to handle high rainfall, accumulation of waste in drainage channels, misuse of drainage functions, and low public awareness in maintaining environmental cleanliness.

Bangkinang Kota District, located in Kampar Regency, is one of the areas frequently affected by flooding or waterlogging during the rainy season. To address this issue, an evaluation of the existing drainage conditions is necessary to assess the capacity of drainage channels in handling flood discharge and to develop more effective drainage designs.

Calculating the drainage capacity is crucial for understanding how much rainfall the system can manage, thus helping to reduce flood risk. Therefore, the results of this study are expected to assist both the community and the local government in tackling the recurring flooding problems in Bangkinang Kota.

1.2 Research Purposes

1. To find out the existing condition of drainage channels in Bangkinang Kota District, especially in Sungai Petai III
2. To find out the drainage that does not meet the capacity based on the calculation of the discharge data of Kampar Market rainfall obtained from the Sumatra III River Basin Center.

2. LITERATURE RIVIEW

2.1 Drainage

According to Suriphin (2004), drainage is defined as a series of water infrastructure systems designed to reduce and remove excess water from a given area or land, enabling the land to function optimally. Drainage systems also serve as a means to control groundwater quality in relation to sanitation.

Hasmar (2002) outlines the following objectives of drainage systems:

a. To improve the health conditions of residential environments.
b. To safely, smoothly, and efficiently control excess surface water while supporting environmental sustainability.
c. To reduce standing water that may serve as breeding grounds for mosquitoes carrying malaria, dengue fever, and other diseases caused by poor sanitation.
d. To extend the economic life of physical infrastructure such as roads, residential zones, and commercial areas by preventing damage and disruptions caused by malfunctioning drainage systems.

According to Hardjosuprapto (1998), the functions of drainage systems are as follows:

a. To drain low-lying urban areas and prevent flooding, thereby avoiding damage to infrastructure and property.
b. To convey excess surface runoff from rainfall into nearby water bodies as quickly as possible to prevent inundation and infrastructure damage.
c. To control part of the surface runoff for potential use in water supply and support for aquatic ecosystems.
d. To promote infiltration of surface water for groundwater recharge and preservation.

Suhardjono (1948) categorizes drainage systems into several types:

a. Natural drainage: Formed naturally over time through water erosion, resulting in permanent channels such as rivers, without any artificial structures.
b. Artificial drainage: Man-made drainage systems constructed with specific purposes, using materials such as concrete, pipes, or stone, including gutters and culverts.
c. Surface drainage: Channels located above ground that serve to convey rainfall from the surface of a given area.
d. Underground drainage: Subsurface channels constructed for practical or aesthetic reasons, often used to maintain a clean and organized urban layout.

e. Single-purpose drainage: Systems that carry only one type of flow, such as either stormwater or wastewater.
f. Multi-purpose drainage: Systems designed to convey multiple types of water flows, either simultaneously or alternately, such as a system that channels both household wastewater and stormwater.
g. Open drainage: Typically used for large-scale surface water drainage, often where water is not hazardous to the environment.
h. Closed drainage: Used to channel water that may contain hazardous waste. These systems are enclosed to prevent health risks and environmental damage and are commonly used in urban areas.

2.2 Drainage Calculation

In calculating drainage, what needs to be considered is the form of the drainage itself. Drainage has various forms, but the ones that are often used in urban drainage are as follows (Fakhli, 2018)

a. Trapezoidal Channel

Functions to accommodate and channel rainwater runoff with a large discharge. The nature of the flow is continuous with small fluctuations, this channel can be used in areas where there is still sufficient land available. Calculation of trapezoidal channels (figure 2.5) as explained below:

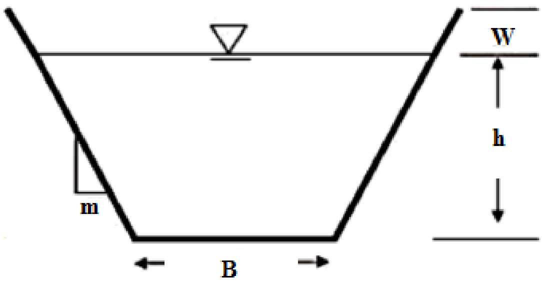

Figure 2.1 Trapezoidal Channel
Source : Fakhli 2018

Information:
W = Guard height
h = Water level height
B = Channel base width
m = Wall slope

The equation used to calculate the dimensions of a trapezoidal channel:

1) Calculate the wet cross-sectional area (A)

$$A = (B + mh)\,h$$

2) Calculate the wet circumference (P)

$$P = B + 2\,h\,(m^2+1)^{0,5}$$

3) Calculating the hydraulic radius (R)

$$R = \frac{A}{P}$$

4) Calculate the flow rate (V)

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

a. Rectangular Channel

Functions to accommodate and channel rainwater runoff with a large discharge. The nature of the flow is continuous with small fluctuations. Calculation of rectangular channels (figure 2.2) as explained below:

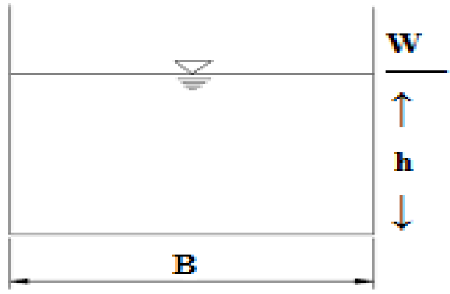

Figure 2.2 Rectangular Channel
Source : Fakhli 2018

Information:
W = Guard height
h = Water level height
B = Channel base width

The equation used to calculate the dimensions of a rectangular channel:

1) Calculate the cross-sectional area of the channel (A)
$A = B \times h$

2) Calculate the wet circumference of the channel (P)
$P = B + 2 \times h$

3) Calculating the hydraulic radius (R)
$R = \frac{A}{P}$

4) Calculate the flow rate (V)
$V = \frac{1}{n}\,(R)^{\frac{2}{3}}\,(S)^{\frac{1}{2}}$

5) Calculating the channel discharge (Q)
$Q = A \times V$

3. METHODOLOGY

This research was conducted in Sungai Petai III, Bangkinang Village, Bangkinang City District, Kampar Regency, Riau Province.

Figure 1Research Location

3.1 Data Collection Methods

Data collection is the initial step in the implementation process which is very important, because it can determine the problem and a series of alternative problem solving determinations that will be taken. There are several methods carried out in the data collection stage, including:

1. Primary Data
   Primary data is data obtained directly from field surveys and existing data on existing drainage channels (data channel length , channel width , and depth channel on channel n drainage in Petai III River, Bangkinang Subdistrict, Bangkinang District City).

2. Secondary Data
   Secondary data is data obtained from previously conducted research.

3.2 Data processing

In this data processing use one of the method rational that is distribution *normal* For count capacity from drainage the to rainfall the existing rain. The result of This Analysis Calculation will compared to with capacity Power capacity existing channel drainage in Petai III River, Bangkinang Subdistrict, Subdistrict Bangkinang City.

4. Results and Discussion

4.1. Hasil

a. Channel Dimensions

The following are the dimensions of the existing channels obtained during the field survey. Can be seen in table 4.1 below:

Tabel 4. 1 Channel Dimensions

Channel Name	Cross-section	Length (m)	Width (cm) Top	Width (cm) Bottom	Height (cm)	Water Level (cm)
Channel 1	Trapezoid	51	114	70	115	30
Channel 2	Trapezoid	47	102	30	100	16
Channel 3	Trapezoid	37	140	60	100	11
Channel 4	Trapezoid	41	110	57	120	7
Channel 5	Trapezoid	70	145	55	115	25
Channel 6	Trapezoid	44	160	75	100	5
Channel 7	Trapezoid	59	160	77	95	35
Total		349 m				

(Source: Analysis Results)

b. Hydraulic Analysis

Hydraulic analysis of the Petai III River drainage channel cross-section was carried out by comparing the design flood discharge with the capacity of the channel to accommodate the flood discharge. If the Q design flood discharge <Q channel storage, the channel will not be able to accommodate the size of the flood.

From the results of the Q design flood discharge analysis and the Q analysis of the storage reservoir above, a comparison of the calculation results was made to determine the condition of the drainage channel as in Table 4.1.

Table 4.2. Comparison of Q Analysis of Drainage Storage and Q Analysis of Design Flood Discharge in Petai III River.

Channel Name	Q Drainage Reservoir	Q Flood Discharge Design 2 Years	5 Years	10 Years	25 Years	Information
Channel 1	0,150m^3/sec	49,14 m^3/sec	64,23 m^3/sec	74,46 m^3/sec	87,58 m^3/sec	Not safe for 2,5,10, and 25 years
Channel 2	0,023 m^3/sec	49,14 m^3/sec	64,23 m^3/sec	74,46 m^3/sec	87,58 m^3/sec	Not safe for 2,5,10, and 25 years
Channel 3	0,022 m^3/sec	49,140 m^3/sec	64,230 m^3/sec	74,462 m^3/sec	87,58 m^3/sec	Not safe for 2,5,10, and 25 years
Channel 4	0,009 m^3/sec	49,140 m^3/sec	64,230 m^3/sec	74,462 m^3/sec	87,586 m^3/sec	Not safe for 2,5,10, and 25 years
Channel 5	0,088 m^3/sec	49,140 m^3/sec	64,230 m^3/det	74,462 m^3/sec	87,586 m^3/sec	Not safe for 2,5,10, and 25 years
Channel 6	0,007 m^3/sec	49,140 m^3/sec	64,2306 m^3/sec	74,462 m^3/sec	87,586 m^3/sec	Not safe for 2,5,10, and 25 years

Channel Name	Q	Q Flood Discharge Design				Information
	Drainage Reservoir	2 Years	5 Years	10 Years	25 Years	
Channel 7	0,216 m^3/sec	49,1404 m^3/sec	64,230 m^3/sec	74,462 m^3/sec	87,586 m^3/sec	Not safe for 2,5,10, and 25 years

(Source: Analysis Results)

From the calculation results of the Q value of the drainage capacity with the calculation of the Q value of the flood discharge design for periods 2, 5, 10 and 25 years, the right (South) side is unable to accommodate the large amount of rainfall discharge. The left (north) side for a period of 2 years is still able to accommodate the large amount of rainfall discharge and for periods 5, 10, 25 years, the drainage is unable to accommodate the large amount of rainfall discharge, but the upstream drainage on the left (north) side for periods 2, 5, 10, 25 years is still able to accommodate the large amount of rainfall discharge.

4.2 Discussion

After the discharge calculation from each existing channel is carried out, it is compared with the design rainfall for a 10-year return period. Shown in table 4.3 below:

Tabel 4.3. Comparison of Discharge and Rainfall

Channel Name	Cross section	Debit (m^3/sec) Q Existing	Q Needs	Capacity
Channel 1	Trapezoid	0,150	0,246	Not Okay
Channel 2	Trapezoid	0,023	0,084	Not Okay
Channel 3	Trapezoid	0,022	0,045	Not Okay
Channel 4	Trapezoid	0,009	0,019	Not Okay
Channel 5	Trapezoid	0,088	0,179	Not Okay
Channel 6	Trapezoid	0,007	0,011	Not Okay
Channel 7	Trapezoid	0,216	0,320	Not Okay
		0,515	0,904	Not Okay

(Source: Analysis Results)

Table 4.4. Comparison of Existing and Planned

	Existing				Plan			
	Q	b	m	h	Q	b	m	h
1.	0,150	0,7	1	0,3	0,246	1,2	1	0,3
2.	0,023	0,3	1	0,16	0,084	1,2	1	0,16
3.	0,022	0,6	1	0,11	0,045	1,2	1	0,11
4.	0,009	0,57	1	0,07	0,019	1,2	1	0,07
5.	0,088	0,55	1	0,25	0,179	1,2	1	0,25
6.	0,007	0,75	1	0,05	0,011	1,2	1	0,05
7.	0,216	0,8	1	0,35	0,320	1,2	1	0,35
	Q Total = 0,515 (m3/sec)				Q Total = 0,904 (m3/sec)			

(Source: Analysis Results)

From the results and discussion above, it is shown that several points of the channel are unable to accommodate the existing rainfall and result in flooding in the area.

The results of statistical parameter calculations using Microsoft Excel obtained an average value ($\bar{x}$) of 89.76, standard deviation (S) of 25.1544, frequency factor (K_T) of 1.28. Thus, the distribution that matches the data is the Normal distribution. The results of calculating design rainfall for various return periods using the Normal distribution, obtained design rainfall for a 10-year return period of 2890.057 m^3 / sec. The design rainfall is in the form of daily design rainfall or design rainfall height for 24 hours.

Table 4.5. Catchment Area

CATCHMENT AREA	
A 1	0,33 Ha
A 2	0,69 Ha
A 3	0,35 Ha
A 4	0,20 Ha
A 5	0,42 Ha
A 6	0,37 Ha
A 7	0,78 Ha
A total	3,14 Ha

(Source: Analysis Results)

4. CONCLUSION

1. 1. The existing condition to be studied is seen from the side of inadequate drainage and has small channels. From the calculation results of the discharge condition of the existing total Q drainage capacity is = 0.515m^3/sec. While the total Q requirement is = 0.904(m^3/sec)
2. 2. In the study area, the maximum rainfall from the Kampar market rainfall station, the rainfall calculation was calculated using the log-pearson III method. The results of the design rainfall calculation for a 2-year return period were = 85.2118 mm, the design rainfall for a 5-year return period was = 111.3782 mm, the design rainfall for a 10-year return period was = 129.1219 mm, the design rainfall for a 25-year return period was = 151.8798

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