CERUCUK
Volume 8 No. 6 2024 (249-258)

ROAD DRAINAGE SYSTEM DESIGN EVALUATION (CASE STUDY OF PRAMUKA ROAD, BANJARBARU CITY)

Firstyarinda Poppy Secondhanti, Ulfa Fitriati
Lambung Mangkurat University Civil Engineering Study Program
Jl. General Achmad Yani Km. 35.5 Banjarbaru, South Kalimantan - 70714
E-mail: firstyarindapoppy22@gmail.com *ufitriati@ulm.ac.id*

ABSTRACT

The drainage canal development project discussed is one of the projects undertaken by the Public Works and Spatial Planning Office of the City of Banjabaru. This drainage is located along Jalan Pramuka, North Loktabat. As a result of changes to the urban planning system in the city of Banjabaru, the work on improving the city's drainage system on the surrounding roads began. Many things cause an increase in the flow coefficient, which can trigger sedimentation in drainage channels and even runoff in the following years. The causes include the development and increasing density of the urban area of Banjarbaru and the bad habits of the people, such as throwing garbage in the canal. This research aims to redesign the drainage system in order to obtain a drainage network system that is more optimal in terms of environment, materials, and costs. This research was conducted by analyzing the design flood discharge at the location of the Banjarbaru City Urban Drainage System Development Project, calculating the existing drainage system calculation analysis, and evaluating a more optimal and economical drainage system design that could be suggested.

Data analysis was carried out by hydrological analysis and hydraulic analysis. Furthermore, to process the data obtained, several calculation steps are carried out, such as processing daily rainfall data, frequency analysis, and discharge calculations. Through these calculations, the design discharge Qr 2 years is 0.0733 m3/second, Qr 5 years is 0.1075 m3/second, Qr 10 years is 0.3280 m3/second, Qr 15 years is 0.3599 m3 /second, Qr 20 Years of 0.3827 m3/second. The cross-sectional size of the box culvert used was 50 x 40 x 100 x 15 cm with a discharge capacity of 0.4148 m3/second, while the size of the masonry used was 30 x 40 x 40 with a discharge capacity of 0.4367 m3/second.

Keywords: discharge plan, highway drainage, discharge capacity, runoff, channels

1. PRELIMINARY

The drainage canal construction project that will be examined below is one of the projects implemented by the Office of Public Works and Spatial Planning, Banjarbaru City, with a canal length of 317 m. The making of this drainage channel is road drainage located on the edge of Jalan Pramuka, North Loktabat Village, which is located along Jalan Pramuka, North Loktabat Village. Previously this drainage was a type of drainage with soil excavation or just dredging. Due to changes in the urban planning system that will be repaired in Banjarbaru City, improvements to the city's drainage system to the neighborhood roads have begun. Therefore, the project was carried out in which the planning of drainage system in this project used the maximum rainfall data in South Kalimantan, which is located in the city of Banjarbaru. The general drainage system in this project includes precast box drainage and closed masonry.

2. LITERATURE REVIEW

Drainage System

Drainage means draining, draining, removing, or diverting water. In general, drainage is defined as a series of waterworks that function to reduce and/or remove excess water from an area or land so that the land can function optimally. Drainage is also interpreted as an effort to control the quality of groundwater in relation to sanitation (Suripin, 2004).

Hydrological Aspect

Hydrology can be defined as a science related to water on earth, the process of occurrence, distribution and distribution, chemical and physical properties, and reactions with the environment, including its relationship with living things (International Glossary of Hydrology in Seyhan, 1995). Hydrology can also be called the science that studies precipitation, evaporation and transpiration, surface streamflow, and groundwater (Suyono, 1977).

In the hydrological aspect, there is a frequency analysis to calculate design rainfall with various return periods (1, 2, 5, 10, 25, and 50 years). This can be done using the Normal, Gumbel, normal log (LN), or Pearson type III log. (LN3) (Permen PU No. 12 of 2014). The design debit is calculated using the rational method or the modified rational method or unit hydrograph for urban areas. The Rational Method equation is as follows:

$$Q = 0.00278.CIA$$

Information :

Q = planned discharge with a return period of T years (m3/s)

C = runoff coefficient

I = rain intensity during concentration time (mm/hour)

A = drainage area (Ha)

Hydraulics Aspect

Liquids can be transported from one place to another through natural or man-made carrier structures. This carrier building can be opened or closed on top. Channels with closed tops are called closed conduits, while those with open tops are called open channels (Herliana, 2016).

Flow velocity (Bambang Triatmodjo, 2008) can be determined through several formulas, namely the Chezy, Manning, and Strickler formulas. However, in this discussion, what will be described is the Manning Formula.

According to Suripin (2004), the equation used to perform reservoir analysis is the Manning method. An expert from Iceland, Robert Manning, proposes the following formula:

$$V = \frac{1}{n} \cdot R^{\frac{2}{3}} \cdot I^{\frac{1}{2}}$$

Information :

V = flow rate (m/s)

n = Manning's coefficient

R = hydraulic radius (m)

I = bottom slope of the channel

3. RESEARCH METHODS

The design method used was field research, which was carried out in the area of Jalan Pramuka, Loktabat Utara Village, Banjarbaru City, and analyzed the data that had existed before. There are two types of data needed, namely primary data and secondary data. Primary data is obtained directly in the field, namely photo documentation, drainage dimensions, and the location of the existing canal; secondary data is obtained from third parties or intermediary media, namely rainfall data, land topography data, and administrative maps. After obtaining the data, the next step is the process of data analysis so that conclusions can be drawn from the evaluation of the design.

4. RESULTS AND ANALYSIS

Maximum Rainfall Data

Rainfall is the primary component for carrying out hydrological analysis in which the end result is the design discharge value at the Banjarbaru City Drainage Development Project site, using rainfall data originating from the Banjarbaru Climatology Station. The rain data used is daily rain data for 20 years, from 2002 to 2021. The results of the maximum rainfall recapitulation can be seen in table 1.1 below.

Table 4.1 Recapitulation of Maximum Daily Rainfall Data for Banjarbaru City

MAXIMUM RAINFALL DATA		
NO	**YEAR**	**X**
1	2002	70,2
2	2003	159.5
3	2004	135.9
4	2005	66,3
5	2006	90.9
6	2007	86.5
7	2008	182,1
8	2009	98.6
9	2010	165
10	2011	158.6
11	2012	95.6
12	2013	87.8
13	2014	213.9
14	2015	116
15	2016	108
16	2017	87,2
17	2018	91.3
18	2019	70.5
19	2020	122,1
20	2021	249
TOTAL		2455

In Table 1.1, the data is obtained based on daily rainfall, which is searched for its maximum value every year. From this data, the largest rainfall data was obtained in 2021 and the smallest in 2005.

Maximum Rainfall Analysis

To analyze the maximum rainfall can be calculated using the frequency analysis method with several distributions, namely the Gumbel distribution, the Normal distribution, the Normal Log distribution, and the Pearson III Log distribution. After analyzing the frequency of rainfall using the Gumbel distribution method, Normal distribution, Log Normal distribution, and Log Pearson III distribution, the design rainfall results for each distribution can be seen in Table 4.2 below:

Table 4.2 Results of Planning Rainfall Calculations from Rainfall Analysis

Return Period T (year)	Dist. Gumbel (mm)	Dist. Normal (mm)	Dist. Normal Logs (mm)	Dist. Pearson III logs (mm)
2	115.3015	123	114.2289	110.7154
5	169.1511	165	157.2558	155.4852
10	204.8069	187.3725	185.9206	189.0529
15	224.8865	196.4600	199,1026	203.6788
20	239.0044	205.5476	213.2192	219.4363

Distribution Suitability Test

The probability distribution test is intended to find out whether the probability distribution equation chosen can represent the statistical distribution of the sample data being analyzed. There are two methods of testing the probability distribution, namely the Chi-Square method and the Smirnov-Kolmogorov method.

The following is a summary of the results of calculating the distribution of planned rainfall using the Gumbel, Normal, Log-Normal, and Log Pearson III methods for return periods of 2, 5, 10, 15, and 20 years, which can be seen in table 4.3 below.

Table 4.3 Recapitulation of Planned Rainfall

Return Period T (year)	Dist. Gumbel (mm)	Dist. Normal (mm)	Dist. Normal Logs (mm)	Dist. Pearson III logs (mm)
2	115.3015	123	114.2289	110.7154
5	169.1511	165	157.2558	155.4852
10	204.8069	187.3725	185.9206	189.0529
15	224.8865	196.4600	199,1026	203.6788

20	239.0044	205.5476	213.2192	219.4363

Based on the results of the Chi-Square Test and the Smirnov-Kolmogorov Test, the type of distribution that meets the theoretical requirements and will be used for further calculations is the Gumbel distribution. Because on the chi-square test value χ^2 calculated, the Gumbel distribution is smaller than the other distributions, and in the Smirnov Kolmogorov test, only the Gumbel Distribution and the Normal Distribution are accepted so that the distribution used for further calculations is the Gumbel distribution.

Rainfall Intensity

In determining the design rain intensity as the input discharge, hourly rainfall data is used. Assuming the rain is uniformly distributed for a certain duration, the design rain intensity. Usually, the intensity of rain is associated with short-term rain duration, for example, 5 minutes, 30 minutes, 60 minutes, and hours. This short-term rainfall data can only be obtained by using an automatic rain logger. If short-term rainfall data is not available, only daily rainfall data is available; then rainfall intensity can be calculated using the Mononobe formula. With the design, rain data used is the maximum rainfall with the Gumbel method.

Maximum Rain Intensity using the Mononobe formula:

$$it = \frac{R_{24}}{24}\left(\frac{24}{t}\right)^{2/3}$$

Information:

It = rainfall intensity for the duration of rain t (mm/hour)

t = duration of rainfall (hours)

R24 = maximum rainfall for 24 hours (mm)

Table 4. 4 Maximum Rainfall of the Gumbel Method

Kala Ulang T (year)	Hujan Rancangan (mm)

2	115.3015
5	169.1511
10	204.8069
15	224.8865
20	239.0044

Calculation of Track Debit

The runoff discharge used uses the Rational Method. The rational method can be seen as the most popular way of estimating runoff because of its simplicity. The nature of simplicity implies the simplification of various natural processes into simple processes; thus, this method has many constraints and limitations in use. This rational method aims to estimate the peak discharge with the equation:

$$Q = 0.00278.CIA$$

Where :

Q = planned discharge with a return period of T years (m3/s)

C = runoff coefficient

I = rain intensity during concentration time (mm/hour)

A = drainage area (Ha)

Table 4. 5 Summary of Design Flood Discharge

No	Kala Ulang T (year)	Debit Rancangan (m^3/s)
1	2	0.07322
2	5	0.10742
3	10	0.32773
4	15	0.35986
5	20	0.38246

Hydraulic Analysis and Existing Discharge Calculation

Existing discharge (Qeks) is the debit obtained from the results of calculations for the existing channels at the research location. Existing canal cross-sections at the study site are box culverts and masonry with the cross-sectional dimensions previously mentioned. Based on the calculation results, the existing box culvert size is obtained with dimensions of 50 x 45 x 100 x 15 cm and stone masonry with a size of 30 x 40 x45 cm.

Table 4. 6 Calculation of Design Channel Dimensions with a Comparison of Design Channel Debit and Design Discharge

B(m)	H(m)	f(m)	H1(m)	Area (A) (m2)	S	n	P(m)	R(m)	V	Q Natural Channel Design (Qd) (m3/sec)	Repeat	Qr= (m3/second)	Control
0.5075	0.2537	0.20	0.4537	0.2303			1.41495	0.1627	1.1923	0.2745	2 years	0.0733	Ok
0.5859	0.2930	0.20	0.4930	0.2888			1.57186	0.1838	1.2929	0.3734	5 years	0.1075	Ok
0.8902	0.4451	0.20	0.6451	0.5743	0.008	0.025	2.18047	0.2634	1.6436	0.9439	10 years	0.3280	Ok
0.9218	0.4609	0.20	0.6609	0.6092			2.24352	0.2715	1.6773	1.0217	15 years	0.3599	Ok
0.9433	0.4717	0.20	0.6717	0.6336			2.28661	0.2771	1.7001	1.0771	20 years	0.3827	Ok

5. CONCLUSIONS AND RECOMMENDATIONS

From the results of the identification of the existing canal at the Pramuka Street Location, Bajarbaru City, the dimensions of the existing box culvert are 50 x 45 x 100 x15, and the masonry dimensions are 30 x 45 x 40. The calculated design discharge is obtained Qr 2 years = 0.0733 m3 /second, Qr 5 years = 0.1075 m3/second, Qr 10 years = 0.3280 m3/second, Qr 15 years = 0.3599 m3/second and Qr 20 years = 0.3827 m3/second. Box culvert cross sections and stone masonry are obtained with a more economical size which is calculated based on daily rainfall from BMKG data from 2002-2021. With a discharge capacity with a box culvert size of 50x45x100x15, it is 0.4098 m3/second, and a discharge capacity with a masonry size of 30x40x45 is 0.4496 m3/second.

It is advisable that in planning for the manufacture of drainage, an in-depth hydrological analysis can be carried out in order to obtain a drainage size that can accommodate flow discharge with a more economical size. Then the cross section should be planned uniformly to facilitate implementation, both conventional drainage, and precast drainage.

BIBLIOGRAPHY

Asdak, C. (2007). *Hidrologi dan Pengelolaan Daerah Aliran Sungai*. Yogyakarta: Gadjah Mada University Press.

BSNI. (2003). SNI 03-6966-2003. *Spesifikasi Saluran Air Hujan Pracetak Berlubang untuk Lingkungan Permukiman*. Jakarta: Badan Standardisasi Nasional.

BSNI. (2017). SNI 8456-2017. *Sumur dan Parit Resapan Air Hujan*. Jakarta: Badan Standardisasi Nasional.

Falah, R. E. (2019). *Analisis Biaya Pekerjaan Drainase Berdasarkan Metode Konvensional dengan Metode Pracetak U Ditch*.Yogyakarta: UII Press.

Halim Hasmar, H. (2012). *Drainase Terapan*. Yogyakarta: Penerbit UII Press.

Herliana. (2016). *Desain Sistem Drainase Kawasan Lebak Perkotaan Kecamatan Landasan Ulin Kota Banjarbaru*. Banjarbaru: Cerucuk.

Khotimah, N. (2008). *Diktat Hidrologi.* Yogyakarta: Jurnal Geomedia.

Maryono, A. (2003). *Konsep Ekodrainase Sebagai Pengganti Drainase Konvensional*. Jakarta: PT. Kompas.

Maryono, A. (2007). *Eko-Hidrolik Pengelolaan Sungai Ramah Lingkungan*. Yogyakarta: Gajahmada University Press.

Muliawati, D. N. (2015). *Perencanaan Penerapan Sistem Drainase Berwawasan Lingkungan (Eko-Drainase) Menggunakan Sumur Resapan di Kawasan Rungkut*. JURNAL TEKNIK ITS Vol.4, No.1.

Peraturan Menteri Pekerjaan Umum Nomor : 12/PRT/M/2014 Tentang Penyelenggaraan Sistem Drainase Perkotaan

Seyhan, E. (1995). *Dasar-Dasar Hidrologi*. Yogyakarta: Gadjah Mada University Press.

SK SNI M-18-1989-F. (1989). *Standar Metode Perhitungan Debit Banjir.* Bandung: Yayasan LPMB Departemen PU

Sosrodarsono, S. (1977). *Hidrologi Untuk Pengairan*. Jakarta: Pradnya Paramita.

Suripin. (2004). *Sistem Drainase Perkotaan yang Berkelanjutan*. Yogyakarta: Penerbit ANDI.

Triatmodjo, B. (2008). *Hidrolika Terapan*. Yogyakarta : Beta Offset.

Yulianti, E. (2018). *Perancangan Drainase Kawasan Perkantoran Rantau Baru Kabupaten Tapin*. Banjarbaru : Cerucuk.

Jealani, jaenal.(2014). *Evaluasi Teknis Sistem Drainase Di Kawasan Kampus Universitas Islam "45" Bekasi.* Bekasi

This page is intentionally left blank