Feasibility Analysis of Primary Drainage Capacity on Jalan Dr. M. Hatta

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Abstract

The Analysis of the Feasibility of The Primary Drainage Capacity on Jalan Dr. M. Hatta. Drainage is a facility and infrastructure for channeling rainwater from one place to another. The aim of this research is to calculate the drainage capacity of the primary channel on Jalan Dr. M. Hatta, East Baturaja District. The method used is descriptive with a qualitative approach. The research location is on Jalan Dr. M. Hatta, East Baturaja District to provide input and recommendations for the implementation of the drainage system on Jalan Dr. M. Hatta After re-planning the drainage dimensions of the primary channel on Jalan Dr M. Hatta, the channel that has been re-planned is able to carry the planned discharge because Q channel > Q planned. as a result of the channel dimensions being inadequate to channel the flood discharge that occurs. Therefore, re-planning of the channel dimensions is necessary. The proposed design indicates variations in channel width and depth, with T ranging from 3 to 4 m, B from 2.0 to 3.5 m, and h from 1.4 to 1.6 m along Sta. 1–6.

Keywords: Drainage capacity, Primary Channels, Regional Planning.

INTRODUCTION

Water is part of the source of life and is included in the prosperity of humans, although in road construction, water is the main enemy. Water can cause fatal damage to road construction caused by erosion. Therefore, water management must be considered both for surface water and water in the road. The main problem of flooding or inundation in an area is caused by population growth, increased construction, housing and other construction, and forest destruction as a water catchment area that has an impact on the level of groundwater overflow to the surface of the land during seasonal rains, in addition to inadequate drainage systems (Kurniawan dkk, 2021).

Drainage is an infrastructure system designed to convey rainwater from one location to another. Rapid residential development has led to a reduction in rainwater infiltration areas due to the increasing extent of impervious surfaces. This condition shortens the time of concentration, resulting in runoff accumulation that exceeds the capacity of existing drainage systems. In addition, the availability of surface water is quantitatively decreasing, while water demand continues to increase in line with population growth and economic development. Almost every year during the rainy season, rainwater overflows from the drainage channel on Jalan Dr. M. Hatta in Baturaja Timur District, causing waterlogging and even flooding and disrupting community activities. Along with the rapid development on Jalan Dr. M. Hatta, Baturaja Timur District, it can affect the ability of the ground surface to absorb rainwater optimally, the implication of which will cause flooding if the current drainage network is not perfect.

Many studies on drainage analysis have been conducted to serve as a reference in channel management and regional planning. Studies on the drainage system in Buleleng Regency (Pariartha et al., 2023), the feasibility of the drainage capacity of Frans Kaisepo Street, Sorong City (Fauzan and Pristianto, 2017), Flamboyan Street, Sungai Kunjang District, Samarinda City (Ramadhani, 2023), Sudirejo I Village, Medan City District (Aqsha et al., 2022), Kedungwaru Village (Rahadi et al., 2022), Dr. Mansyur Street, Medan Selayang District (Suita and Simorangkir, 2018), the Rambah Village drainage channel (Lubis and Hidayat, 2014) and on Kebun Agung Street, Samarinda City (Suharto, 2020), drainage feasibility in the Bastiong Market area (Soninga, 2024), Jalan Sultan Kaharudin, Sumbawa Regency (Purnama et al.,

2016), drainage planning of Pringsewu City (Aswad, 2021), Jalan Mansyur, Medan Selayang District (Suita, 2018) and on Jalan Rijali, Ambon City (Toisuta et al., 2024). Therefore, it is advisable to re-analyze the drainage channel on Dr. M. Hatta Street, East Baturaja District, which includes hydrological and hydraulic analysis of the channel to improve drainage capacity. The aim of this study is to calculate the drainage capacity of the primary channel on Jalan Dr. M. Hatta, Baturaja Timur District.

METHODS

The method used is descriptive with a qualitative approach. The research location is on Jalan Dr. M. Hatta, Baturaja Timur District to provide input and recommendations for the implementation of the drainage system on Jalan Dr. M. Hatta. Direct observations in the field were conducted to obtain an overview of the drainage in the study area and used secondary data and maps. This initial survey was conducted to observe the drainage system and receive input for determining priority areas for handling.

Methode of Collecting Data

The data collected were daily maximum rainfall data for 10 years and water discharge, existing drainage dimensions, water level points, population density and hydraulic data.

Data Processing and Analysis Methods

Data processing and analysis were conducted based on the availability of data obtained during the data collection process.

1. Inventory of the existing drainage system
2. Calculation of the planned discharge
3. Calculation of the existing channel capacity
4. Inventory and identification of flood-prone areas
5. Determination of the planned flood discharge by determining the frequency distribution. Frequency analysis uses probability distribution theory using the Gumbel distribution.
6. Hydrological analysis (rainfall data analysis)
7. Redesigning channel dimensions (if existing Q > planned Q)
8. Flood discharge analysis is conducted using the rational method.

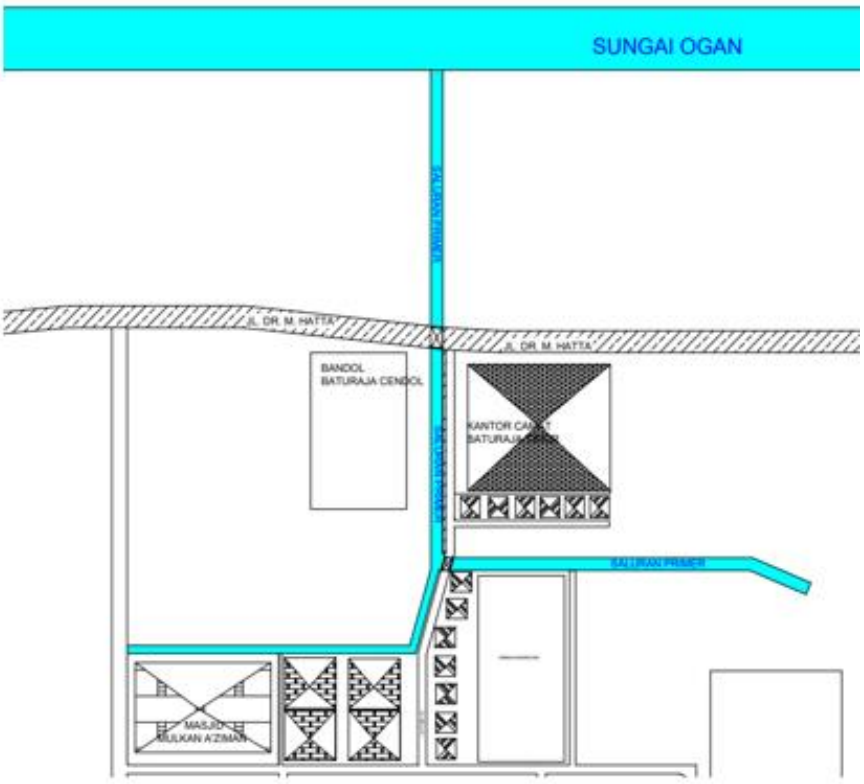

Figure 1. Research Location

The research flow can be seen in Figure 2. As follows.

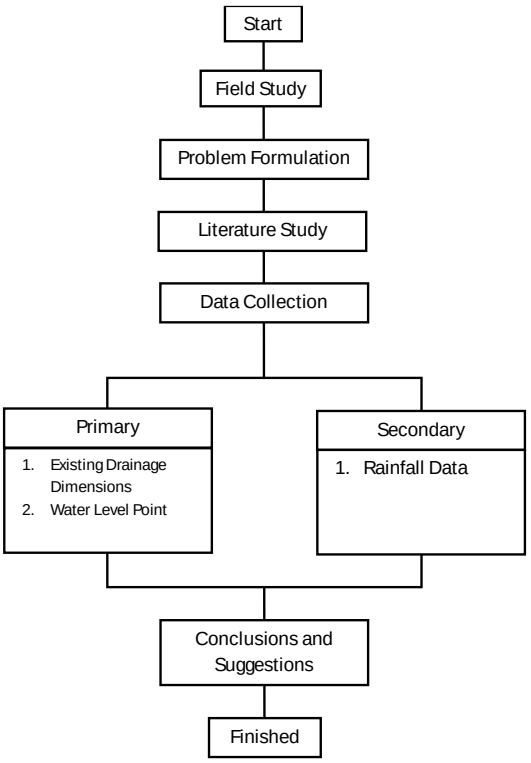

Figure 2. Research flow

RESULT AND DISCUSSION

Maximum Rainfall Analysis

The maximum rainfall analysis data for 10 years is presented in table 1 as follows.

Table 1. Rainfall Data

No	Years	Maximum Rainfall (mm)
1	2011	293
2	2012	367
3	2013	439
4	2014	402
5	2015	355
6	2016	357
7	2017	357
8	2018	449
9	2019	354
10	2020	327

One of the secondary data needed for drainage planning is maximum rainfall data (Ramadhani, 2023) in the study area, obtained from the Meteorology, Climatology, and Geophysics Agency (BMKG) station in Baturaja City. The rainfall data ranges from 2011 to 2020.

Frequency Analysis
The average daily maximum rainfall that has been obtained is sorted from largest to smallest, then analyzed based on the distribution that has been selected to obtain rainfall for a certain return period as in Table 2 below.:

Table 2. Calculation of maximum rainfall distribution

Years	Xi	X'	Xi-X'	$(Xi - X')^2$	$(Xi - X')^3$	$(Xi - X')^4$
2011	293	370	-77	5929	-456533	35153041
2012	367	370	-3	9	-27	81
2013	439	370	69	4761	328509	22667121
2014	402	370	32	1024	32768	1048576
2015	355	370	-15	225	-3375	50625
2016	357	370	-13	169	-2197	28561
2017	357	370	-13	169	-2197	28561
2018	449	370	79	6241	493039	38950081
2019	354	370	-16	256	-4096	65536
2020	327	370	-43	1849	-79507	3418801
Amount	3700			20632	306384	101410984

From the calculation above, Cs = 1.9379 and Ck 4.1517222 are obtained, so the value of Cs = 1 and the value of Ck = 5 in the analysis using the Gumbel distribution. Furthermore, the results of the calculations with a return period of 5 years and 10 years can be seen in Table 3 below.

$$Gumbell\ Distribution$$
$$X_T = \bar{x} + K\sigma_x$$
$$X_T = \bar{x} + \frac{Y_T - Y_n}{S_n} - \sigma_x$$

Table 3. Gumbell distribution

PUH	Reduced Variate (Y_t)	Rainfall Return Period
2	0.3065	368.625
5	1.4999	377.321
10	2.2504	382.790

Rain Intensity (I)
The results of the calculation of the rainfall intensity of the channel for the 5 year and 10 year periods can be seen in Table 4. As follows.

Table 4. Rain intensity

Return Period	R (mm)	So (m)	Tc (hour)	I (mm/s)
T2	368.62	0.003558719	0.168555842	418.811
T5	377.32	0.003558719	0.168555842	428.691
T10	382.79	0.003558719	0.168555842	434.905

Flow Coefficient (C)
The flow coefficient values throughout the research area are presented in Table 5. As follows.

Table 5. Flow coefficient

No	Location	Wide scale m^2	Grade C
1	Kampung baru	2228038	0,95
2	Kampung baru dan bakung	2565060	0,95
3	Bakung	2226565	0,95
SUM		7019663	

Plan Debit (Q)

The calculation results for the 5-year and 10-year return periods can be seen in table 6 below:

Table 6. Calculation of the planned discharge for the primary drainage channel on Jalan Dr. M. Hatta, Baturaja Timur District

Return Period	Intensity (I)	Floww Coefficient (C)	A (m^2)	Plan Debit
T2	418.81	0.95	7019663	77.643
T5	428.69	0.95	7019663	78.474
T10	434.91	0.95	7019663	80.626

After calculations were carried out with the collected data, the dimensions of the existing channel on Jalan Dr. M Hatta were obtained, which are presented in Table 7 as follows.

Table 7. Existing Primary Channel Drainage Data on Jalan Dr. M. Hatta at each observation station

Station	L	S	Channel Dimensions		
			T	B	H
STA 1	57	0.3	2.3	2	0.7
STA 2	200	0.022	2	2.1	0.77
STA 3	25	0.022	2.4	2.2	0.8
STA 4	125	0.022	3.7	3.3	1.2
STA 5	90	0.022	3.8	3.4	1.3
STA 6	65	0.022	3.8	3.4	1.6

Existing Channel Capacity Calculation

Based on field calculations on the existing channel on Jalan Dr. M. Hatta, the data and calculation results obtained using hydraulic analysis are presented in Table 8 as follows.

Table 8. Field Hydraulic Analysis

Return Period	I	C	A (m^2)	Q Plan
T2	418.81	0.95	7019663	77.643
T5	428.69	0.95	7019663	78.474
T10	434.91	0.95	7019663	80.626

A Channel (Trapezium)

The existing calculation of trapezoidal channels at each station for a 2-year period is presented in Table 9. As follows.

Table 9. Calculation of Existing Stations of Trapezoidal Channel A for a 2-year period

Station	Z	A	P	R	V	Q	Q 2 Years Plan	explanation
STA 1	0.82	1.80	5.07	0.35	10.24	18.46	77.64	Overflow
STA 2	0.65	2.00	5.06	0.39	5.36	10.73	77.64	Overflow
STA 3	0.75	2.24	5.36	0.41	5.55	12.44	77.64	Overflow
STA 4	0.77	5.07	7.29	0.69	7.77	39.43	77.64	Overflow
STA 5	0.73	5.66	7.53	0.75	8.18	46.27	77.64	Overflow
STA 6	0.59	6.96	7.95	0.87	9.05	63.02	77.64	Overflow

After analyzing the existing channel, the cause of the flooding on Dr. M. Hatta Street was due to the channel dimensions being inadequate to channel the floodwater discharge, so repairs or re-planning of the channel dimensions were required. Furthermore, the existing channel A trapezoidal channel for a 5-year period is presented in Table 9.

Table 9. Calculation of Existing Stations of Trapezoidal Channel A for a 5 Year Period

Station	Z	A	P	R	V	Q	Q 25 years plan	explanation
STA 1	0.82	1.80	5.07	0.35	10.24	18.46	78.47	Overflow
STA 2	0.65	2.00	5.06	0.39	5.36	10.73	78.47	Overflow
STA 3	0.75	2.24	5.36	0.41	5.55	12.44	78.47	Overflow
STA 4	0.77	5.07	7.29	0.69	7.77	39.43	78.47	Overflow
STA 5	0.73	5.66	7.53	0.75	8.18	46.27	78.47	Overflow
STA 6	0.59	6.96	7.95	0.87	9.05	63.02	78.47	Overflow

After analyzing the existing primary channel on Jalan Dr. M. Hatta, the channel dimensions from station 1 to station 6 cannot accommodate the planned flood discharge, therefore there must be repairs and re-planning of the channel dimensions at station 1 to station 6. The calculation of the trapezoidal A channel for a 10-year period can be seen in table 10. As follows.

Table 10. Calculation of Existing Stations of Trapezoidal Channel A for a 5 Year Period

Station	Z	A	P	R	V	Q	Q 2 years plan	Explanation
STA 1	0.82	1.80	5.07	0.35	10.24	18.46	80,62	Overflow
STA 2	0.65	2.00	5.06	0.39	5.36	10.73	80,62	Overflow
STA 3	0.75	2.24	5.36	0.41	5.55	12.44	80,62	Overflow
STA 4	0.77	5.07	7.29	0.69	7.77	39.43	80,62	Overflow
STA 5	0.73	5.66	7.53	0.75	8.18	46.27	80,62	Overflow
STA 6	0.59	6.96	7.95	0.87	9.05	63.02	80,62	Overflow

Channel Dimension Replanning

The calculation of the trapezoidal A channel in the re-planning of the primary channel dimensions for 10 years is presented in Table 11. As follows.

Table 11. Recapitulation of 10-year Primary Drainage Channel Dimension Replanning

Stasiun	Z	A	P	R	V	Q	Q 10 Years Plan	Explanation
STA 1	0.54	3.85	6.08	0.63	22.03	84,83	80,62	Safe
STA 2	0.54	3.99	6.18	0.64	22.32	89,05	80,62	Safe
STA 3	0.54	4.13	6.28	0.65	22.59	93,31	80,62	Safe
STA 4	0.71	6.02	7.61	0.79	25.54	153,75	80,62	Safe
STA 5	0.67	6.75	7.94	0.84	26.77	180,72	80,62	Safe
STA 6	0.63	7.20	8.09	0.88	27.60	198,75	80,62	Safe

The drainage system in the Dr. M. Hatta Street area needs to be optimized to handle larger volumes of rainwater, especially during periods of heavy rainfall. This is because the capacity of the existing drainage channels is insufficient and the water catchment area is still below the technical standards set by the government. This is in accordance with Fajra (2012) who stated that actions that can be taken are to increase drainage capacity by repairing and expanding existing drainage channels, building new drainage channels, and increasing the water catchment area in the area. These actions can reduce the risk of flooding.

So that the channel dimensions are obtained which are.

a. Station 1 = Upper width (T) = 3 m, Lower width (B) = 2 m, and channel height (h) = 1.4 m
b. Station 2 = Upper width (T) = 3 m, Lower width (B) = 2.1 m, and channel height (h) = 1.4 m
c. Station 3 = Upper width (T) = 3 m, Lower width (B) = 2.2 m, and channel height (h) = 1.4 m
d. Station 4 = Upper width (T) = 4 m, Lower width (B) = 3.3 m, and channel height (h) = 1.4 m
e. Station 5 = Upper width (T) = 4 m, Lower width (B) = 3.5 m, and channel height (h) = 1.5 m
f. Station 6 = Upper width (T) = 4 m, Lower width (B) = 3.5 m, and channel height (h) = 1.6 m

Channel Cross-section Image

After redesigning the dimensions of the primary drainage channel on Jalan Dr. M. Hatta, the redesigned channel was able to drain the planned discharge because the Q channel > Q plan with a trapezoidal shape. This is in accordance with research revealed by Oktavia and Rulhendri (2023) which stated that with the requirement of a capability ratio of Qs ≥ Qr, the trapezoidal shape meets these requirements.

a. Existing Channel Conditions

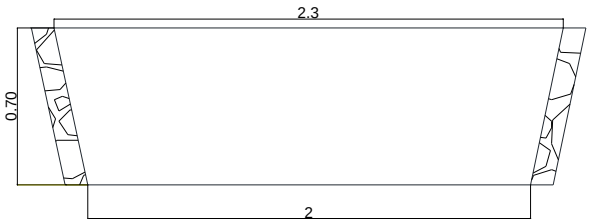

Figure 3. Existing channel condition

b. Condition of the channel that has been re-planned for the next 10 years

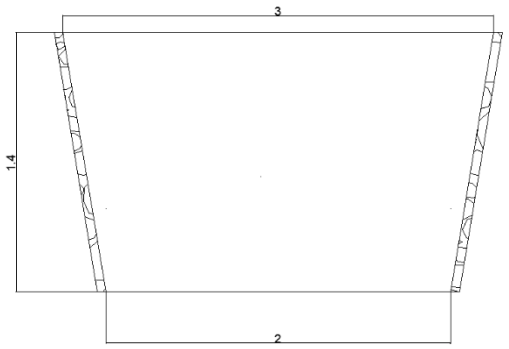

Figure 4. Condition of the planned channel

CONCLUSION

After analysis and calculations, the cause of the flooding on Jalan Dr. M. Hatta, Baturaja Timur District, was determined to be the inadequate dimensions of the channel to handle the floodwaters. Therefore, repairs or redesign of the channel's dimensions are necessary. With the results obtained are So that the channel dimensions are obtained, Station 1 = Top width (T) = 3 m, Bottom width (B), = 2 m and channel height (h) = 1.4 m, Station 2 = Top width (T) = 3 m, Bottom width (B), = 2.1 m and channel height (h) = 1.4 m, Station 3 = Top width (T) = 3 m, Bottom width (B), = 2.2 m and channel height (h) = 1.4 m, Station 4 = Top width (T) = 4 m, Bottom width (B), = 3.3 m and channel height (h) = 1.4 m, Station 5 = Top width (T) = 4 m, Bottom width (B), = 3.5 m and channel height (h) = 1.5 m, Station 6 = Top width (T) = 4 m, Bottom width (B), = 3.5 m and channel height (h) = 1.6 m.

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