Evaluation Of Drainage Channel Dimension Plan Based On Planned Discharge In Jalan Flamboyan Raya Of Tanjung Selamat Village

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Abstract: In the construction of public facilities and infrastructure, attention should always be given to matters that are directly or indirectly related to the construction of such facilities and infrastructure. As in the construction of drainage, there are several things that affect it, one of which is most often used as a reference in the calculation of drainage channel dimension is maximum rainfall or maximum daily rainfall intensity. Tanjung Selamat is chosen for study because this road is a liaison route for the surrounding community activities and Tanjung Selamat area and Medan city or Pancur Batu District. Therefore, it is necessary a review of the existing drainage channel of rapid development that occurred in Jalan Flamboyan Raya of Tanjung Selamat village both residential areas and places of business. This situation reduces the area of water catchment so that water is often abundant and make the existing drainage channel cannot accommodate it. This research is conducted in several stages, and with Pearson's Log Distribution Method of Type III which aims to determine the magnitude of the peak flood discharge in a particular repetitive period. Based on the results of research and calculations that have been done know that the amount of existing drainage discharge (Q_S)is smaller than peak flood discharge (Q_R)in the area around Flamboyan Road Raya of Tanjung Selamat village. Other causes of the flooding that occurred in the location where the research that the authors do is human behavior that is not friendly to the environment such as littering haphazardly or into the drainage channel, less attention to the maintenance of drainage channels around their dwelling, soil-walled conditions so very vulnerable to changes that affect the ability of the channel to drain the water. Equally important is the development around Jalan Flamboyan Raya of Tanjung Selamat village especially the establishment of various buildings either for residences or for business places resulting in reduced water catchment area. To overcome the problem of puddles / floods with the concept of minimizing or eliminating it in the area around Jalan Flamboyan Raya of Tanjung Selamat village which has an area of water puddle ± 6.839742165 Ha is rearranged the existing drainage network.

Keywords: Dimension, Drainage, Planned Discharge

1 INTRODUCTION

Environmental infrastructur is the basic environment that enables residential environments and orthers to function properly (law N0. 4 of 1992, article 1). One of the equally importen enviromental infrastructur is the channel of rainwater and sewage to centralize and prevent local flooding.. The rain drainage network often referred to as the PUTL Department of Gajah Mada University (1975: 42) (2) is an open and closed water channel to supply surface, groundwater or sewer water. That is, drainage serves to get rid of or remove excess water coming from rain water, household sewerage water, industrial waste water, irrigation, and so forth. Tanjung Selamat Village, in this case, continues to experience considerable developments, especially growth in establishing buildings for residential or business premises. This of course will cause problems / impacts on the hydrological cycle, and common problems that often arise that the occurrence of local water puddles / floods due to increased buildings that are watertight areas. On the basis of this writer interested to write about the drainage system around Jalan Flamboyan Raya. The researcher chose this location because it was the main route connecting the economic activities of the surrounding community in particular, and the Pancur Batu community generally with other districts or cities.

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In planning for the construction of physical facilities, not infrequently problems or certain factors arise that affect it, not to mention the building drainage. The factors that have influence on the planning for drainage buildings, among others, are (3 , 5) :
1. The water from the inside of the channel after the rain falls.
2. The cause of water overflows from drainage.
3. The amount of drainage flow discharge.
4. The cause of silting of the bottom of the drainage channel.
5. Channel dimensions.
6. No drainage maintenance measures.

Given the limited capacity and time of the author, the authors here only address the following issues:
1. Calculation of the dimensions of planned drainage channels.
2. Maximum daily rainfall intensity and area or research location.
3. Take into account the environmental and social circumstances of the planned repeat.

In general, the purpose of this study is to determine the size or capacity of existing and future drainage channels based on repeated periods, and the acceleration of growth or development of the region. The purpose of this research is specifically to determine:
1. The water from the inside of the channel after the rain falls.
2. The cause of the overflow of water from the drainage.
3. The amount of drainage flow discharge.

2. RESEARCH METHOD

Tanjung Selamat Village of Pancur Batu District has an area of ± 390 Ha with a population of ± 4,182 or 1,066 heads of household (based on survey December 15, 2015). Location Tanjung Selamat village is in the highlands with an average height of ± 86 meters above sea level. Geographically the boundaries of the Jalan Flamboyan Raya area of Tanjung Selamat Village are as follows:

- Bordered by Tanjung Anom Village in the North
- Bordered by Namo Rih Village in the South
- Bordered by Durin Jangak Village in the east
- Bordered by Tanjung Selamat Village in the west.

The study location is one of the flooded areas in Tanjung Selamat village, which is located in the area around Jalan Raya Flamboyan which includes:

1. Jalan Flamboyan Raya
2. Jalan Bunga Raya

The researcher chose this location because it was the main route connecting the economic activities of the surrounding community in particular, and the Tanjung Selamat community generally with other districts or cities. Then based on the rationale of the author, the area around the road will be experiencing rapid development. Therefore, the road must be free or minimized from the problems especially floods resulting from rainwater runoff.

Fig. 2.1. *Research Sites*

The collected data is then arranged in accordance with the needs of analyzes performed. That data consists of secondary data and primary data. Secondary data collection is done by requesting data from agencies such as the Bureau of Meteorology, Climatology and Geophysics of Tanjung Selamat, and the Office of Urban Village of Tanjung Selamat II. Data from the Office of Urban Village of Tanjung Selamat include:

1. Data on human resources.
2. Data on artificial resources (existing drainage structures).
3. Data on location / site of Tanjung Selamat village.

Primary data were collected through a limited survey method by conducting surveys, observations, and direct measurements in the field as well as to match and compare them with secondary data. In the survey, measurements were made at several points of measurement at the study site. The forward arrow in the pop-up tool bar to modify the header or footer on subsequent pages. The surveys carried out produce the following data:

1. Local condition around Jalan Flamboyan Raya

Based on the visual photographs below, it can be seen the condition of the area around Jalan Flamboyan Raya

Fig. 2.2. *Intersection of Jalan Flamboyan Raya of Tanjung Selamat village.*

Fig.2.3. *The condition of Jalan Flamboyan Raya leading to Tanjung Anom.*

Fig. 2.4. *Condition of Drainage.*

Based on research in the field, data on the cross-section of drainage channel in the area around Jalan Flamboyan Raya is obtained as follows:

Table 2.1. *Cross Section of Local Area Around Jalan Kutalimbaru*

No.	Channel name	Channel size			Channel length (m)	Condition of the existing channel
		On (m)	under (m)	**high (m)**		
1	JFRA	1,60	1,35	0,65	464,20	Soil channels
2	JFRB	1,59	0,88	0,55	88,60	Soil channels
3	FRKi	1,00	0,64	0,66	206,00	Soil channels
4	FRKa	1,40	0,63	0,66	141,00	Soil channels

Information: JFRA= Jalan Flamboyan Raya A
JFRB = jalan Flamboyan raya B
FRKi = flamboyan raya Kiri
FRKa = Flamboyan Raya Kanan

2.3. Data Analysis

2.3.1. Relationship of rainfall intensity with duration of rain

Data on rainfall for drainage calculations is used as the largest of every single data for a year and presented in mm / hour. In determining the intensity of rainfall according to the unit of time above, and then first determined the amount of reduce mean and reduce standard deviation. Furthermore, rainfall intensity can be obtained for a preset birthday (25 years). The intensity of this rainfall is used to determine the relationship between rainfall intensity and time unit using Mononobe formula.

2.3.2. Accommodating Coefficient

The accommodating coefficient is influenced by the time of concentration and the time of channeling water in the channel. The concentration time is influenced by a) inlet time, that is the time of flow of rain water flowing above ground level, and b) conduit time, that is the time of rain flow flowing in the channel. The time of concentration and the time of channeling water in the channel are determined according to the Kirpich formula with adjustments to the factors that affect the magnitude. These factors, among others, are: Area of drainage, Length of drainage channel, Slope of drain base, Discharge, and Flow velocity.

2.3.3. Drainage Coefficient

The drainage coefficient is the ratio between the parts of the rain that forms the direct runoff to the total rainfall that occurs. The value of this drainage coefficient has a range from 0 to 1, and is affected by soil type, soil conditions, vegetation type, land use characteristics, land slope, and ground-level construction

2.3.4. Area of Drainage Region

The area of drainage region is the extent to which the falling rainfall in the area enters the drainage network under study. Determination of area of drainage region is done by field observation with respect to slope of land surface. The area of drainage region in this study was measured directly from the map after adjusting to the conditions in the field.

2.3.5. Drainage Capacity

The calculated drainage capacity is divided into two, namely capacity according to existing channel dimension and planned capacity based on rainfall intensity, accommodating coefficient of coefficient of settlement, drainage coefficient, and area of drainage region. These two discharges (Q) are compared, analyzed, interpreted and subsequent conclusions are drawn and recommendations are formulated on the basis of the overall study.

3. RESULTS AND DISCUSSION

a. Data on rainfall

To determine the rain intensity with N year recurrence, it is necessary to know the rainfall data in the research area. Rainfall data in this research is taken from the Bureau of Meteorology, Climatology and Geophysics of Tanjung Selamat Station in Medan, which is complete as follows:

Table 3.1. *Data on Maximum Rainfall from Geophysics Station of Tanjung Selamat.*

Tahun	Curah Hujan Max (mm)	Tahun	Curah Hujan Max (mm)
1987	136	2002	126,8
1988	117	2003	128
1989	84	2004	94
1990	90	2005	106,5
1991	95,5	2006	145
1992	101	2007	117
1993	120,5	2008	98
1994	128,5	2009	76
1995	95,5	2010	190
1996	83	2011	159
1997	76	2012	219
1998	99	2013	83
1999	148,5	2014	86
2000	101,8	2015	106,3
2001	141,5		

Source: *Climatology and Geopysical Meteorology Bodies (1)*

1. Calculation of Rainfall

To calculate the planed rainfall, the calculation is based on information of maximum rainfall from Geophysical Observation Station of Tanjung Selamat by using Gumbel Method:

Table 3.2. *Calculate the Planed Rainfall by using Gumbel Method*

Tahun	x_i	$x_i - \bar{x}$	$(x_i - \bar{x})^2$
2012	219	103,4	1062,76
2013	83	- 32,6	876,16
2014	86	- 29,6	86,49
2015	106,3	- 9,3	
$\sum$	3352,4	00,0	31842,48

Average rainfall($\bar{x}$), calculated by equation (2.2) :

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{N} = \frac{3352,4}{29} = 115,6 \text{ mm}$$

Standard deviation (Sd), is calculated by equation (2.3)

$$Sd = \sqrt{\frac{\sum_{i=1}^{n} (Xi - \bar{X})^2}{(N-1)}} = \sqrt{\frac{31842,48}{(29-1)}} = 33,72286$$

mm

Frequency Factor (K), is calculated by equation (2.4) :

$$K = \frac{Yt - Yn}{Sn}$$

$$Yt = -\left(0,834 + 2,303 \ .\log \ .\log \ {}^{T}\!/_{T-1}\right)$$

$$= -\left(0,834 + 2,303 \ .\log \ .\log \ {}^{25}\!/_{24-1}\right) = 3,19929$$

$$K = \frac{Yt - Yn}{Sn} = \frac{3{,}19929 - 05353}{1{,}1086} = 2{,}40302$$

Based on the description of equation (2.2), (2.3) and (2.4) above, then $x_{25}(R_{24})$ it can be calculated by equation (2.1) :

$$x_{25} = 196{,}63671 \text{ mm}$$

3.3.Calculation of the Planed Discharge

3.3.1. Accommodating Coefficient

The travel time of the water flow above the soil surface to the end of the channel (t_o) is calculated by equation (2.9).

$$t_o = 0{,}0195 \times \left[\frac{L_o}{\sqrt{S}}\right]^{0,77} = 0{,}0195 \times \left[\frac{300}{\sqrt{0{,}001}}\right]^{0,77}$$

$= 22{,}51220$ minute $= 0{,}37520$ hour

The travel time of water flow in the channel (t_d) is calculated by equation (2.10):

$$t_d = \frac{1}{3600} \times \frac{L}{V} = \frac{1}{3600} \times \frac{681{,}6}{0{,}4} = 0{,}47333 \text{ hour}$$

Time of water flow concentration (t_c), is calculated by equation (2.8) :

$$t_c = t_o + t_d = 0{,}37520 + 0{,}47333 = 0{,}84853 \text{ hour}$$

Based on the description of equations (2.8), (2.9) and (2.10) above, the accommodating coefficient (C_s) can be calculated by (2.7):

$$C_s = \frac{2t_c}{2t_c + t_d} = \frac{2 \times 0{,}84853}{(2 \times 0{,}84853) + 0{,}47333} = 0{,}78191$$

3.3.2. Drainage Coefficient

Based on field research, it is known that the area of drainage region calculated at the research location is as follows:

Pavement = 464.2 × 2.275 = 1,056.055 m^2
Roadside = 464.2 × 2.16667 = 1,005.76821 m^2
Settlement A = 350 × 100 = 35,000 m^2
Settlement B = 300 × 100 = 30,000 m^2
Cemetery = 95 × 100 = 9,500 m^2
Unused area = 150 × 100 = 15,000 m^2

Thus, drainage coefficient (C) can be calculated by Equation (2.11) as follows:

$$C = \frac{A_1.C_1 + A_2.C_2 + A_3.C_3 + \dots + A_n.C_n}{A_1 + A_2 + A_3 + \dots + A_n}$$

$$C_{kiri} = \frac{(1056{,}055 \times 0{,}95) + (1005{,}76821 \times 0{,}65) + (30000 \times 0{,}40) + (15000 \times 0{,}30)}{1056{,}055 + 1005{,}76821 + 30000 + 15000}$$

$= 0{,}38581$

$$C_{kanan} = \frac{(1056{,}055 \times 0{,}95) + (1005{,}76821 \times 0{,}65) + (35000 \times 0{,}70) + (9500 \times 0{,}25)}{1056{,}055 + 1005{,}76821 + 35000 + 9500}$$

$= 0{,}61277$

$$C_{rata-rata} = \frac{C_{kiri} + C_{kanan}}{2} = \frac{0{,}38581 + 0{,}61277}{2} = 0{,}49929$$

3.3.3. Intensity of Rainfall

The intensity of rainfall (I) during the concentration time is calculated using the Mononobe formula expressed in equation (2.12):

$$I = \frac{R_{24}}{24} \times \left[\frac{24}{t_c}\right]^{2/3} = \frac{196{,}63671}{24} \times \left[\frac{24}{0{,}84853}\right]^{2/3}$$

$= 76{,}05878$ mm/hour

3.3.4. Area of Drainage Region

Based on the measurement at the study site, the area of drainage region is obtained as follows:

$A = \pm$ 68.397,42165 m² = 0,06839742165 km²

3.3.5. The Planed Discharge

Based on the description of equations (2.7), (2.11) and (2.11) above, the planed discharge (Q_R) can be calculated by equation (2.6):

$$Q_R = 0{,}278\ .C_s.C.I.A = 0{,}278 \times 0{,}78191 \times 0{,}49929 \times 76{,}05878 \times 0{,}06839742165$$

$= 0{,}56460\ m^3/dt$

3.4. The channel discharge based on existing dimensions

Based on the measurements at the study sites through several points, the average channel dimensions were obtained as follows:

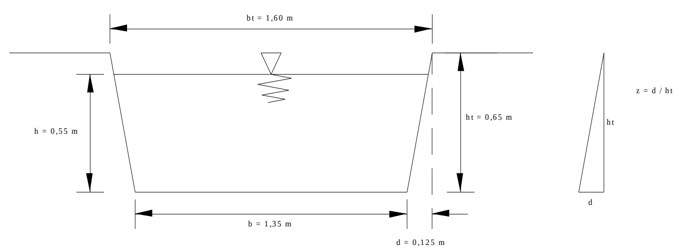

Fig. 3.1. *Diminsion of the Existing Channel*

The slope of lining (z) is calculated by equation (2.13):

$$z = \frac{d}{ht} = \frac{0.125}{0.65} = 0.19231$$

The area of the wet channel cross section (F) is calculated by equation (2.14):

F = (b + z.h).h = (1.35 + 0.19231 × 0.55) × 0.55
= 0.80068 m^2

The circumference of wet channel (P) is calculated by equation (2.15):

$$P = b + 2.h.\sqrt{1+z^2} = 1.35 + 2 \times 0.55 \times \sqrt{1+0.19231^2}$$
$$= 2.47015 \text{ m}$$

The hydrological channel radius (R) is calculated by equation (2.16):

$$R = \frac{F}{P} = \frac{0.80068}{2.47015} = 0.32414 \text{ m}$$

The slope of the channel bottom (S) is assumed as:

$$S = {}^{1}/_{1000} = 0,001$$

Based on the above description, the channel discharge from the channel dimension in the research location using equation (2.17) is:

$$Q_S = F\,.\,{}^{1}/_{n}\,.R^{2/3}.S^{1/2} = 0,80068 \times {}^{1}/_{0,040} \times 0,32414^{2/3} \times 0,001^{1/2}$$
$$= 0.29869 \; {}^{m^3}/_{dt}$$

3.5. Channel Discharge based on dimensional planning

In dimension planning, the author provides several options that can be selected after calculations based on factors that can be seen in the field, among others:

3.5.1. Channel dimension changed, channel fixed

In this case, the channel dimension is increased but the channel type is fixed, i.e. the ground channel.

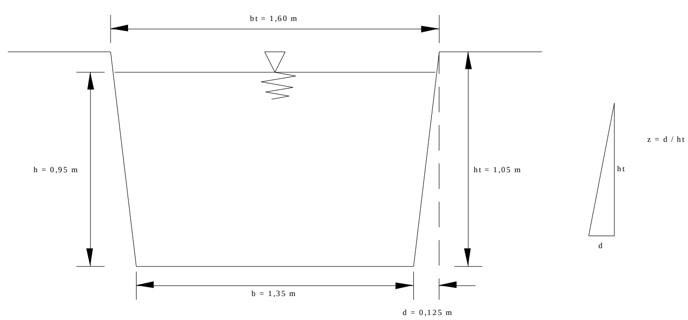

Fig 3.2. *Channel Dimensions.*

Slope of lining:

$$z = \frac{d}{ht} = \frac{0,125}{1,05} = 0,11904$$

Area of wet channel cross-section:

$$F = (b + z.h).h = (1,35 + 0,11904 \times 0,95) \times 0,95$$
$$= 1,38993 \text{ m}^2$$

Circumference of wet channel:

$$P = b + 2.h.\sqrt{1+z^2} = 1,35 + 2 \times 0,95 \times \sqrt{1+0,11904^2}$$
$$= 3,26342 \text{ m}$$

Channel hydrologic radius:

$$R = \frac{F}{P} = \frac{1,38993}{3,26342} = 0,42591 \text{ m}$$

Then the planed channel discharge:

$$Q_S = F\,.\,{}^{1}/_{n}\,.R^{2/3}.S^{1/2} = 1,38993 \times {}^{1}/_{0,040} \times 0,42591^{2/3} \times 0,001^{1/2}$$
$$= 0,62203 \; {}^{m^3}/_{dt}$$

3.5.2. Channel dimension fixed, channel changed

In this case, the channel dimension is fixed but the channel type is converted from the ground channel into a pairing channel of stone with the completion:

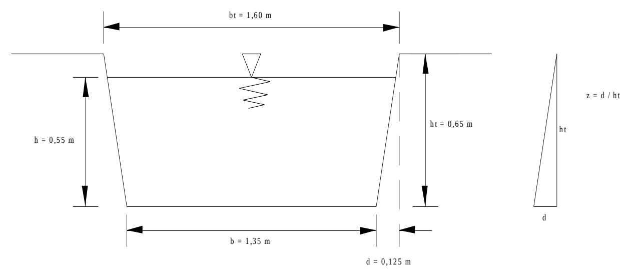

Fig. 3.3. *Channel Dimensions.*

Slope of lining:

$$z = \frac{d}{ht} = \frac{0,125}{0,65} = 0,19231$$

Area of wet channel cross-section:

$$F = (b + z.h).h = (1,35 + 0,19231 \times 0,55) \times 0,55$$
$$= 0,80068 \text{ m}^2$$

Circumference of wet channel:

$$P = b + 2.h.\sqrt{1+z^2} = 1,35 + 2 \times 0,55 \times \sqrt{1+0,19231^2}$$
$$= 2,47015 \text{ m}$$

Channel hydrologic radius:

$$R = \frac{F}{P} = \frac{0,80068}{2,47015} = 0,32414 \text{ m}$$

Then the planed channel discharge:

$$Q = F\,.\,{}^{1}/_{n}\,.R^{2/3}.S^{1/2} = 0,80068 \times {}^{1}/_{0,020} \times 0,32414^{2/3} \times 0,001^{1/2}$$
$$= 0,59738 \; {}^{m^3}/_{dt}$$

3.5.3. Channel dimension changed, channel changed

In this case, the added channel dimension and channel type become the stone pair channel with the completion:

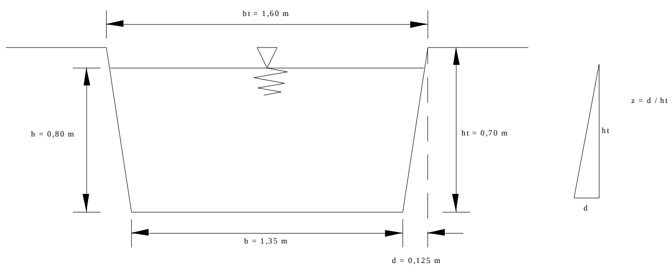

Figure 3.4. *Channel Dimension Changed*

Slope of lining:

$$z = \frac{d}{ht} = \frac{0,125}{0,80} = 0,15625$$

Area of wet channel cross-section:

$$F = (b + z.h).h = (1,35 + 0,15625 \times 0,70) \times 0,70$$

$= 1,02156 \ m^2$

Circumference of wet channel:

$$P = b + 2.h.\sqrt{1 + z^2} = 1,35 + 2 \times 0,70 \times \sqrt{1 + 0,15625^2}$$

$= 2,76699 \ m$

Channel hydrologic radius:

$$R = \frac{F}{P} = \frac{1,02156}{2,76699} = 0,36919 \quad m$$

Then the planed channel discharge:

$$Q_S = F.\frac{1}{n}.R^{2/3}.S^{1/2} = 1,02156 \times \frac{1}{0,020} \times 0,36919^{2/3} \times 0,001^{1/2}$$

$= 0,83125 \ m^3/dt$

CONCLUSIONS

The conclusions obtained in this study, among others, are:

1. The drainage channel planning around the research site is poorly planned. This can be seen from the situation after the rain, the water from the channel almost overflows.
2. Based on the results of research / observation in the field, the cause of the overflow of water from the drainage is because the water is retained due to the waste discharged into the drainage channel, plants that grow almost along the channel causing the value of the roughness of the channel becomes large so that the dimension of the channel is reduced.
3. Based on the calculation results it is known that the drain discharge of drainage channel is $Q_s = 0.29869 \ m^3/dt$, while the peak flood peak quantity $Q_R = 0.56460 \ m^3/dt$. Then the cross section of the drainage channel needs to be changed in dimensions according to the planed discharge. Once redesigned, the channel dimension is $Q_S = 0.83125 \ m^3/dt$, which is greater than $Q_R = 0.56460 \ m^3/dt$, and thus the drainage channel can accommodate runoff water / rainfall.

SUGGESTIONS

The suggestions that can be given based on the results of this study, among others:

1. It is necessary to redesign the drainage channel dimension in order to smoothly discharge the planed discharge.
2. It is expected that the surrounding community can maintain / keep drainage channels clean so that the flow of water is not hampered.
3. If the channel dimension needs to be redesigned, then the selection of the planned dimensions of the calculation results needs to be reviewed based on the needs and conditions in the field. This is because the development that takes place along Jalan Flamboyan Raya is the authority of the Regional Government of Pancur Batu / Regional Government of Deli Serdang, while the Village Government is only tasked to supervise and maintain it.
4. For the maintenance of drainage channels at once to minimize runoff from the channel, the choice of the planed dimensions according to the author is: Dimensions Changed, Channel Fixed. Whereas if it is necessary to build a drainage channel that is steady, durable, and not too affected by the environment, then the choice of the planed dimensions according to the author are: Dimensions Changed, Channel Changed.

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