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# DRAINAGE REDESIGNING OF MANYAR STREET USING THE LOG PEARSON III METHOD

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**ABSTRACT**

In metropolitan settings, the drainage system is crucial. Systems for drainage are designed to release water from hydrological cycles as well as wastewater from homes and public spaces. Effective drainage systems can stop flooding or standing water from interfering with people's daily activities and causing damage to road bodies. The project's objective was to determine the amount of water discharge that could pass through drainage lines to prevent flooding in those lines, which would allow researchers to determine the underlying causes of the flooding in the study area. There are some of the theories and methods used to analyse the study. In addition, the theories are aimed to obtain the direction and insight to support the existing data. The theories and literatures are collected from the several ways such as books and journals related to the topic. Moreover, the supporting data are directed to facilitate all the processes required. The analysis shows that the planned rainfall intensity during the 10 years is 158,302mm with the 10-years time return. Moreover, the result from the existing drainage capacity have the maximum capacity of 1,68 m^3/s which can maintain the maximum planned discharge from the data 0,8952 m^3/s. Based on the topography map, the water from the Manyar street will be transferred to the nearby river located right in front of the street. During the rainy season, water will start to collect and settle at the road, and later the flood happens. There are some factors that affect the flooding of this area, trash, sedimentation, and the height differences of the road.

**Keywords** *:* adsorbtion, capacity, flowrate, waste water

## 1. INTRODUCTION

Drainage comes from the English word "to drain", and has the definition of clearing and dumping water. Drainage is a system that aims the problems related to the excess water, especially the water that is unused. The water can be flowing on the ground or underground. This excess water is produced because of the heavy rainfall, waste water that is too much, or from the household [1]. Not only useful for the housing area, drainage is also very important to all of the construction that is directly contact with the water. Drainage can transport water from the pavement, snow that occur in some certain areas, and from the groundwater. In the drainage designing process, there are lots of factor to be considered, either from the structure and material, or from the volume an capacity of the drainage. Drainage is a water structure that function to collect water runoff in a catchment area, allowing both the area and the infrastructure in the drainage catchment area to function properly [2].

Based on Suripin [3] drainage system is a way to flow the excess water, which can be from the natural or hydrology cycle and waste water, that makes the channel to collect the rainfall that flows on the ground surface, then flows to the bigger system. The smaller collection point can be defined as tertiary, and the bigger system is a primary and secondary system. The water collected by all the system then will be flowed to the rivers, lakes, or seas.

Around the urban area, drainage is used as the sanitation to prevent the water puddle that makes inconvenient to the society [4]. Drainage can also prevent the healthy aspect to the urban area due to its function, flows the waste water. Some waste waters that are not transported by the drainage system can make some diseases. In addition, flood is often happened because of the failure of drainage system to flow water. The water discharge that occurs from the houses is higher than the maximum capacity of the drainage.

Sometimes the worst part is when the drainage is covered by trashes, so the water cannot flow smoothly.

The location of the drainage analysis is located in Indonesia, precisely on Manyar street, Malang. In fact, Malang itself currently being the one of the over populated city in Indonesia. The reasons are because Malang has some of the active universities which made many college students outside the city come and stay, so that the urban area is very crowded and close to each other. Another reason is Malang's infrastructure for the drainage system is quite considered as old and at some areas are not capable of carrying the waste water so that the flood happens.

The drainage analysis place is chosen because in the real condition, flood and puddle is often occur during the rainfall. This drainage in the Manyar has a length of 500m to withstand the waste water. The drainage have two drainage in the left and right side of the road, having square cross sectional area with the depth of 0,8 meter and width of 0,7 meters.

The drainage that is not built adequately can be resulting in flood in the area. In addition, the development of residential area takes major part to the capacity of the drainage. The drainage can no longer withstand the capacity of the housing area when the development of housing area is much bigger than the capacity of drainage [5]. Also the existing drainage must be redesigned or upgraded because the city's population is getting higher by time.

Based on the description above, it is necessary to carry out further research regarding the purpose (1) to measure the water discharge that can be hold by the drainage channel, (2) to find some factors occur due to the flood happened in the decided area.

## 2. METHODOLOGY

### 2.1 Research Location

The observation will be taken place at the Manyar Street that is located in Malang, East Java, Indonesia. This location is selected as the observation place because during the big raining time, flood mostly happen on the area. This location is also observed because there are some there are some uncommon natural factor, sedimentation that occurs on the channel. Also, during the hard rain that occurs mostly on the raining season, not only Manyar street, but some areas of Malang city is flooded by water.

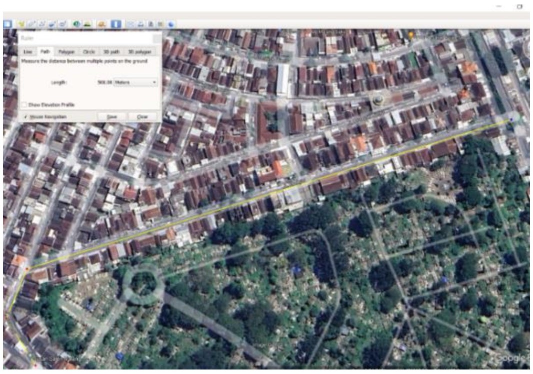

**Figure 1.** Observation length place

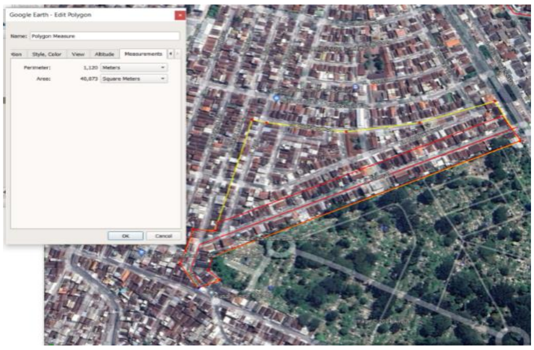

**Figure 2.** Observation area

### 2.2 Collecting Data

From this observation, there are some data that require to be collected. Redesigned data is collected directly to the existing channel of Manyar Street, Malang and from the guidance of literature books and journals to solve and determine the steps of solution. There are two data that requires to be fulfilled:

1. Primary Data, This primary data is obtained from the direct observation of the channel, interview and direct people's point of view and opinion about the observation's problem. By examining and asking the neighborhood's opinion, it will result on a factor that can change the result. The primary data needed for the observation are (1) existing drainage condition of the Manyar street, (2) existing drainage's size of the Manyar street, and (3) width and length of the Manyar street.
2. Secondary Data, The second phase of collecting data is obtained from the direct observation, media, or indirect observation such as searching to the previous existing data, such as published data or the unpublished data. The required data for the observation are (1) rainfall data from the 2011 to the 2020, which can be obtained from the nearest water station, Sukun water station in Malang, (2) contour data or the topography data, which can be obtained trough the google map-pro, which is used to determine the rainfall catchment

area, and (3) maps data to determine the location and street plan to calculate the length and catchment area. This data can be obtained from the google maps-pro.

2.2.1 Rainfall Data

**Table. 1** Maximum Rainfall of Each Year

| STA Sukun | Max Rainfall |
|---|---|
| 2011 | 101 |
| 2012 | 125 |
| 2013 | 101 |
| 2014 | 134 |
| 2015 | 170 |
| 2016 | 122 |
| 2017 | 132 |
| 2018 | 94 |
| 2019 | 135 |
| 2020 | 144 |

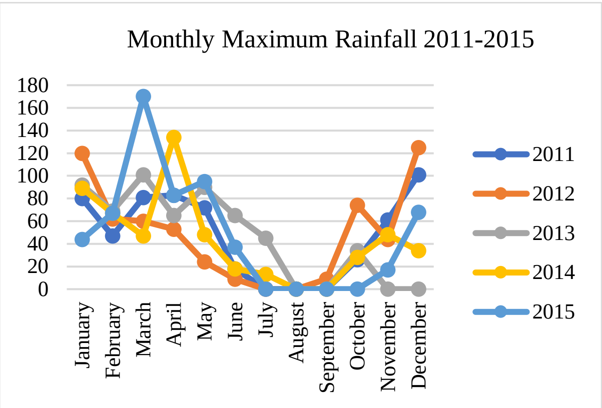


**Figure 3.** Maximum Rainfall Data 2011-2015

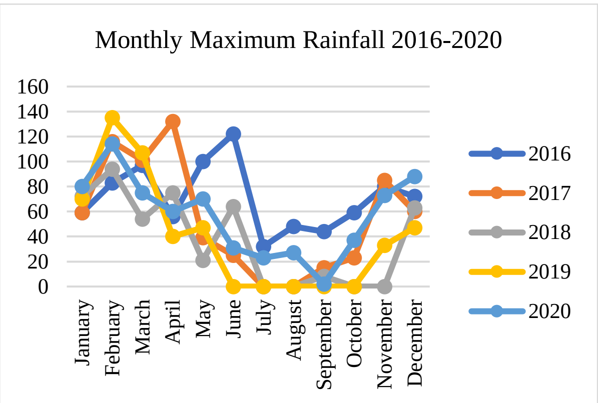


**Figure 4.** Maximum Rainfall Data 2016-2020

2.3 Methods

Methods used on the observation is quantitative method is used in this observation to describe what the observation will be. The observation itself will bring some data about the rainfall and all the calculation steps. In addition, the data will be processed then when the result appeared, further observation is needed to acknowledge more of the problems. In addition, the quantitative method used to acquire the result is the survey method because it can include the large amount of area.

2.3.1 Rainfall Frequency Calculation

1. Normal Distribution

Normal distribution method is mostly known as the Gauss distribution. The method of calculating normal distribution has a formula as stated [2]:

$$X_r = X + K_T s \quad (1)$$

Note:

$X_r$ : Predicted value that is required based on time return T (year)

X : Average value of variation

S : Standard deviation

$X_T$ : Frequency factor, defined as the function of chance or time return, the mathematic model of chance distribution to analyze the chance.

2. Normal Log Distribution

Based on the normal distribution, log of the normal X data is converted into the logarithm of Y = Log X. If the value of Y = Log X is distributed normally, then X can be concluded as the log normal distribution. For calculating the planned rainfall intensity, log normal distribution is using the formula:

$$Y_T = \bar{Y} + K_T s \quad (2)$$

Note:

$Y_T$ : Predicted value that is required upon on time return T (year)

$\bar{Y}$ : Average value of variation

S : Standard deviation

$X_T$ : Frequency factor, defined as the function of chance or time return, the mathematic model of chance distribution to analyze the chance.

3. Gumbel Distribution

For the gumbel distribution method, there are some formulas used by gumbel. These are:

$$X = \bar{X} + S \times K \quad (3)$$

Note:

$\bar{X}$ : Average value of sample

S : Standard deviation

$K$ : Probability factor

Probability factor (K) for the value of gumbel methods can be obtained by:

$$K = \frac{Y_{Tr} Y_n}{S_n} \quad (4)$$

Notes:

$Y_n$ : Reduced mean, which are values that depend on the amount of sample or n

To calculate the value of $Y_n$, it can be seen on the table.

4. Log Pearson type III Distribution

The procedures for utilizing the Log-Pearson III distribution are as follows:

a. The daily maximum rainfall intensity of the certain years is converted into the logarithm.

b. Calculating the average of logarithm with the following formula:

$$Log\ X = \frac{\sum_{i=1}^{n} \sum logX_i - \log \bar{X}}{n} \quad (5)$$

c. Calculate the deviation standard using the formula:

$$S = \frac{n \sum_{i=1}^{n} logX_i - \log \bar{X}}{n} \quad (6)$$

d. Calculating the *Mancegan coefficient* using the formula:

$$Cs = \frac{n \sum_{i=1}^{n} (logX_i - \log \bar{X})^3}{(n-1)(n-2)s^3} \quad (7)$$

e. Calculating the logarithm of planned rainfall intensity using the certain time return, using the formula:

$$Log\ XT = log\bar{X} - \log K_s \quad (8)$$

With the value of G, then the value of $C_s$ can be obtained. Later, the probability of rainfall with the certain periods of time is the antilog of Xt.

Notes:

Log XT : Logarithm of planned rainfall intensity using the certain time return

$\bar{X}$ : Average value of Logarithm

$C_s$ : Asymmetrical coefficient

G : Frequency coefficient

n : number of observation (year)

S : Deviation standard

$k_s$ : Standard variable X, the amount is depended on

2.3.2 Rainfall Intensity Calculation

1. Rainfall intensity using the Mononobe Method (I) [6]:

$$I = \frac{R_{24}}{24} (\frac{24}{t})^{2/3} \quad (9)$$

Notes:

I : Rainfall intensity

$R_{24}$ : Designed rainfall

T : Time concentration (mm/day)

2. Average rainfall intensity ($\bar{x}$):

$$\bar{x} = \frac{\sum_{i=1}^{n} Xi}{n} \quad (10)$$

3. Deviation standard:

$$S = \frac{\sqrt{\sum_{i=1}^{n} x - \bar{x}}}{n-1} \quad (11)$$

4. Variation coefficient:

$$c_v = \frac{S}{\bar{x}} \quad (12)$$

Notes:

n : Number of known data

$\bar{x}$ : The average rainfall intensity (mm)

x : Rainfall intensity (mm)

S : Deviation standard

$c_v$ : Variation coefficient

5. Asymmetrical coefficient ($c_s$)

$$c_s = \frac{n \sum (x_i - x)^3}{(n-1)(n-2)s^3} \quad (13)$$

Notes:

$c_s$ : Asymmetrical coefficient

$\bar{x}$ : The average rainfall intensity (mm)

x : Rainfall intensity (mm)

n : Number of known data

S : Deviation standard

2.3.3 Channel Discharge Calculation

To calculate the capacity of channel, the following formula use is:

$$Q = \propto \times \beta \times I \times A \quad (14)$$

Notes:

Q : Flow capacity ($m^3$)

$\propto$ : Flow coefficient

$\beta$ : Rain spread coefficient

I : Rainfall intensity

A : Flow area

2.3.4 Flow Coefficient Analysis

The formula used to calculate the runoff coefficient is stated as [3]:

$$C_{DAS} = \frac{\sum Ci.Ai}{\sum Ai} \quad (15)$$

2.3.5 Time Concentration

The formula of time concentration [6] can be calculated with the following equation:

$$T_C = t_0 + t_d \quad (16)$$

$$t_0 = \frac{L}{\frac{V_{td}}{3600}} \quad (17)$$

$$t_d = \frac{L}{\frac{V_{td}}{3600}} \quad (18)$$

Notes:

| | | |
|---|---|---|
| Tc | : | Average value of sample |
| $t_0$ | : | Time to reach from the furthest drainage (minutes) |
| $t_d$ | : | Time during the channel with the length of L |
| L | : | Length of channel on the surface (m) |
| V | : | The velocity of the water discharge inside the channel (m/s) |

## 3. RESULT AND DISCUSSION

The data obtained from the Malang water station be rearranged. After arranging the data, the correct order of the data will be shown on the next figure.

**Table. 2** Arranged Maximum Rainfall

| STA Sukun | Max Rainfall |
|---|---|
| 2015 | 170 |
| 2020 | 144 |
| 2019 | 135 |
| 2014 | 134 |
| 2017 | 132 |
| 2012 | 125 |
| 2016 | 122 |
| 2013 | 101 |
| 2011 | 101 |
| 2018 | 94 |

### 3.1 Log Pearson III Calculation

The following is calculation for log pearson III

**Table. 3** Log Pearson III Calculation

| MDRmax (R1) | Log R1 | Log R1 - Log R | (Log R1 - Log R)² | (Log R1 - Log R)³ |
|---|---|---|---|---|
| 170 | 2,230 | 0,137 | 0,019 | 0,003 |
| 144 | 2,158 | 0,065 | 0,004 | 0,000 |
| 135 | 2,130 | 0,037 | 0,001 | 0,000 |
| 134 | 2,127 | 0,034 | 0,001 | 0,000 |
| 132 | 2,121 | 0,027 | 0,001 | 0,000 |
| 125 | 2,097 | 0,004 | 0,000 | 0,000 |
| 122 | 2,086 | -0,007 | 0,000 | 0,000 |
| 101 | 2,004 | -0,089 | 0,008 | -0,001 |
| 101 | 2,004 | -0,089 | 0,008 | -0,001 |
| 94 | 1,973 | -0,120 | 0,014 | -0,002 |

| MDRmax (R1) | Log R1 | Log R1 - Log R | (Log R1 - Log R)² | (Log R1 - Log R)³ |
|---|---|---|---|---|
| 1258 | 20,932 | 0 | 0,057 | 0,000 |

**Table. 4** Rainfall plan

| Time Return | Log R | K | Log R2 | Rainfall Plan |
|---|---|---|---|---|
| 2 | 2,093 | -0,188 | 2,078 | 119,745 |
| 5 | 2,093 | 0,738 | 2,152 | 141,811 |
| 10 | 2,093 | 1,340 | 2,199 | 158,302 |

Rainfall plan using the ten years time return depends on the types of the drainage.

### 3.2 Time Concentration Analysis

Time concentration is the required time for both main channel and the secondary channel to collect and flow the water from the top until the end of the drainage. Based on the calculation, the result of the time concentration are:

| | | |
|---|---|---|
| Main Channel | = | 0,104 |
| Secondary Channel | = | 0,131 |

### 3.3 Rainfall Intensity

Rainfall intensity is the intensity of the rain on the particular area. Calculated Using the time concentration and the rainfall plan of ten years. The value of the rainfall intensity are:

| | | |
|---|---|---|
| Main Channel | = | 0,000069 |
| Secondary Channel | = | 0,000059 |

### 3.4 Catchment Area

Catchment area is the area of rainfall than can be collected by the channel, depends of the terrain and elevation of the soil. The catchment area of the channel are:

| | | |
|---|---|---|
| Primary Channel Area | = | 18500 |
| Secondary Channel Area | = | 21500 |

### 3.5 Runoff Coefficient

Runoff coefficient is the coefficient of the water that is transported by the channel. The value of runoff coefficient on each channel are:

| | | |
|---|---|---|
| Main Channel | = | 0,64 |
| Secondary Channel | = | 0,66 |

### 3.6 Discharge

To calculate the planned discharge, the catchment area must be calculated first. The area is considered as a catchment area using the topography map that shows the elevation and contour of the area. When the water from the higher area flows to the lower area that is still considered as one area. To calculate the discharge plan at Manyar street, the calculation is:

1. Primary channel discharge
   Qrain = C × I × A
   Qrain = 0,64 × 0,000069 × 18500
   Qrain = 0,6913 $m^3/s$
2. Secondary channel discharge
   Qrain = C × I × A
   Qrain = 0,66 × 0,000059 × 21500
   Qrain = 0,7395 $m^3/s$

The calculation shows that the value of planned discharge for the Manyar street channel and the supporting channel is 0,6913$m^3/s$ for the Manyar street and 0,7395 $m^3/s$ for the supporting catchment area channel.

for the existing channel of Manyar street can be seen from the figure above.

1. Width of the primary channel = 0,8 m
2. Depth of the primary channel = 0,7 m
3. Width of the supporting channel = 0,6 m
4. Depth of the supporting channel = 0,7 m
5. Velocity of the water = 1,5 m/s

The area of primary channel is:

A = 0,56 $m^2$

For the primary channel in Manyar street, the existing channels are consisted of right and left side of the road. So, the channel area will be multiple by two, equals to the area of 1,12 $m^2$.

The area of secondary channel is:

A = 0,42 $m^2$

For the supporting channel in other streets that have the same catchment area to the Manyar street, the existing channels are consisted of right and left side of the road. So, the channel area will be multiple by two, equals to the area of 0,84 $m^2$.

So, the discharge of the primary channel is:

$Q_s$= 1,68 $m^3/s$ > 0,6913 $m^3/s$ (Adequate)

So, the discharge of the supporting channel is:

$Q_s$= 1,26 $m^3/s$ > 0,7395 $m^3/s$(Adequate)

The calculation shows that all the channels in Manyar street, both the main channel and the supporting channel are adequate to the planned discharge of the area. The result shows that if the water discharge is lower than the capacity, then the flood will not happen in the area [7].

3.7 Factors of Flood

From the flooding that occurs at the Manyar street, there are some factors that took a major part of flood. Some of the factors are:

1. Elevation of the road.
   During the maintenance of the road, when the condition is getting poorer and weaker by time, the maintenance of Indonesian government is not the best when it comes to handling road. Instead of redoing the asphalt work, scrape the old and crushed asphalt and keep the road elevation the same, the asphalt work is just to cover all the old road with the new asphalt, so the elevation of the road keeps getting higher and higher. The asphalt work will also make the water that flows on the surface of asphalt go inside the house yard.
2. Elevation of the nearby river.
   The water collected from the catchment area will be flowed to the nearby river, which is located nearby the road. But the factor that makes the flood happen is the elevation of the river now is higher than the channel elevation.
   This problem occurs naturally when the water flowed on the river contains mineral, rock, soil, or mud so the depth of water slowly got shallow. So, that the channel will not flow the water to the river,
   but keep the water settle and keep collecting the waste water from the household. This case will make problem when the rainfall occurs, the drainage capacity will be not adequate and the overflow of the water from the channel will make the flood happens. Despite of the flood, the settled water from the drainage will also make diseases for the household.
3. Depth of the channel.
   The drainage of Manyar street has the similar condition of the nearby river which is shallowing. The condition is called sedimentation, which is occurs mostly on the household area and river. The source of problem is also similar, by flowing the soil or mud, and also moss that produced inside the channel, make the channel got less depth and make the capacity of drainage less. When the rainfall occurs, the drainage will not capable to hold and flow the water to the river entirely.
4. People behavior of putting trash.
   From the research results, the drainage channel has a channel capacity that is able to accommodate rainwater and household waste, but what causes flooding is that the channel is blocked, because the rubbish around the area is not cleaned up by local residents.
5. Drainage system.
   The last factor of the flood is that the channel is not built properly, when the drainage was built it did not create the drainage system that should have been there, which is the cause of flooding. The following are things in the drainage system:

a. Gutters
b. Rainwater retention pon

## 4. CONCLUSION

Based on the research conducted, the following are the conclusions drawn from this study:

1. From the calculation process, the value that are obtained for the drainage existing capacity can still adequate to hold the water discharge from the catchment area because the value of the existing drainage capacity is bigger than the planned discharge during peak rainfall. Based on the channel capacity is 1,68 $m^3/s$ comparing to the water discharge that 0,6913 $m^3/s$. Also for the existing supporting channel in the same catchment area has the value of 1,26 $m^3/s$ larger than the rainfall water discharge at 0,7395 $m^3/s$. It can be concluded that the drainage of Manyar street is still save at holding and flowing the rainfall water from the catchment area.
2. The factors that make the flood occurs at the Manyar street are the sedimentation on the nearby river and Manyar street channel, the elevation of the road which is higher at some point of the houses, the people behavior of littering that makes the channel clogged.

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