Redesign of road drainage system in jalan Banyumas Km 7 Selomerto, Wonosobo with normal discharge method

Nasyiin Faqih, Wiji Lestarini

1,2 Civil Engineering Program Of Universitas Sains Al-Qur’an, Jalan K.H. Hasyim Asy’ari, Km.3 Wonosobo, Indonesia, 53651

Abstract. In the rainy season the condition of the channel on Jalan banyumas Km 7 Wonosobo Regency is not able to accommodate the flow of water so that flooding often occurs. Because of that, it is necessary to redesign new drainage channels. This research is quantitative, the method used is to analyze both hydrologically and hydraulically to get the best drainage building design. From the calculated data, it can be concluded that the drainage channel on the Banyumas km 7 Selomerto road must be expanded or dredged at certain channel points where the expansion must take into consideration the current conditions in the field. For the most discharge (Q) is in the QF section with a discharge of 0.13517 m³ / second and the lowest is in the G7 segment with a discharge of 0.00308 m³ / second. From the calculation results obtained that channels 2, 3, 4, 5, 6 and 7 must be redesigned and made a new building.

1. Introduction

Along with the rapid development of cities in Indonesia, the problem of water has also increased. Increased flooding poses a considerable threat to road infrastructure where flooding can bring about severe obstruction of traffic and costly repair bills. Flooding results from a complex mixture of geological, geomorphological, and hydrological conditions and can cause damage and disruption to people, organisations, industries, and the environment. Modification of natural conditions by human activities, such as road building and forest harvesting, can increase flood. In general, problems about water that cannot be controlled will cause disasters, examples that often arise are problems regarding flooding and inundation.

The problem of flooding should be overcome if the drainage system in the area can be planned properly. Especially in areas with heavy rainfall such as Wonosobo Regency. So from that base, an evaluation study was carried out on the drainage system in Wonosobo Regency, especially Jalan banyumas Km. 07.

After we surveyed directly, we found that the channel dimensions did not meet the standards along the Banyumas 7 km Selomerto road heading to Banjarnegara, that is why the road often flooded during high rainfall. This is certainly very dangerous or disturbing road users and needs to be re-planned.

Drainage is a way of removing excess unwanted water in an area, as well as ways of overcoming the effects caused by the excess water. Urban roads are classified into four categories. These are arterial, sub arterial, collector streets and local road. Design of drainage network requires a clear understanding of drainage problem. In planning the drainage channel, the return period depends on the function of the channel and also the catchment area that will be drained. Changes in the depth,
velocity, and flow area, and Froude number were also calculated for different return periods. Use return periods for channel planning are: Quarterly Channels: 1 year return period, Tertiary Channels: 2 year return period, Secondary Channels: 5 year return period, Primary Channels: 10 year return period.

Diligent efforts are required to estimate these parameters in order to reach the value of runoff coefficient. Flow coefficient is the ratio between the amount of rain water flowing or runoff above the ground surface with the amount of rain water falling from the atmosphere (total rain that occurs). This amount is influenced by land use, type, slope of land and soil conditions. The flow coefficient has an intermediate value, and should the drainage value for analysis use the largest / maximum value.

Liquid substances can be transported from another place by building natural or man-made carriers. Buildings can be either open topped or can also be closed, for which open channels are called open channels and for channels that are closed closed conduits. In an open channel system there is a free surface water where the free water surface is directly affected by outside air pressure.

2. Purpose and Objectives
The purposes and objectives of drainage system planning are as follows:
- Analyze and ensure the dimensions of drainage channels in the field that are not functioning optimally or do not meet standards.
- Re-planning effective drainage channels in accordance with the needs and conditions in the field, so that the Banyumas km 7 road no more flooding.

3. Methodology
Methodology used in this study is quantitative analysis. The stages of the research are as contained in the following flow chart:

![Flow Chart](image)

**Figure 1:** The stages of the research
3.1. Method of collecting data
The data that will be used in the preparation and preparation of the Final Project Report are as follows:
1. Primary data
   Data obtained through direct observation in the field. These observations produce project data namely; lengthwise and transverse section measurements, elevation, photo documentation, distance, etc.
2. Secondary data
   Secondary data is supporting data obtained indirectly from the field or from other parties. This secondary data must pass through processing first and cannot be directly used. Data collected is rainforest data, topographic data, soil data, literature, graphs and also tables obtained from the relevant official.

3.2. Drainage Planning Survey
The survey is a measurement and retrieval of data that has the purpose of moving the earth's surface conditions measured on paper. Some that must be prepared before conducting a survey are Rainfall data: from Selomerto sub-district, Kab. Wonosobo

3.3. Planning steps in highway drainage
The steps in drainage planning are:
1) field work
2) planning structures such as type, width, thickness, height and channel length
3) planning criteria such as drainage channel classification, characteristics, field conditions, economic considerations and others
4) complementary building planning such as sidewalks, cover buildings, masonry, culverts, retaining walls, etc.

3.4. Site selection, type and size of drainage
The location for the new drainage system was built taking into account the technical, economic, social, environmental and aesthetic impacts. In addition, problems must be taken in relation to land and building acquisition, due to piles that occur in accordance with native land and other problems, cliff stability, river profile, flow direction, river properties, material carried by vertical and horizontal hardening.

4. Analysis and Discussion
From the normal probability distribution table with an area of 0.067 at the end of the graph, then to get the standard value of Z, 0.067 is deducted at the value of 0.5 (area of half the graph) formed by the line the probability. Y-axis and Z-line from the table for area (0.5-0.067) obtained Z = 1.5. From the formula for the standard number [6]

$$Z = \frac{X - \bar{X}}{\sigma}$$

$$1.5 = \frac{X - 101.4}{41.326}$$

$$X = 1.5 \times 41.326 + 101.4 = 163.802 = R_{15} = 164 \text{ mm/day}$$

Where:
1.5 = result of Z
X = 101.4
\(\sigma = 41.326\)
Table 1. Rain Plan Data

| Year | R_{max}(X) | R_{max}^2(X)^2 |
|------|------------|----------------|
| 2011 | 89         | 7921           |
| 2012 | 92         | 8464           |
| 2013 | 78         | 6084           |
| 2014 | 182        | 33124          |
| 2015 | 66         | 4356           |
| Total| 507        | 59949          |

\[ \bar{X} = \frac{\sum R}{n} = \frac{507}{5} = 101.4 \]

\[ \sigma = \sqrt{\left( \frac{\sum x^2}{n} \right) - \left( \frac{\sum x}{n} \right)^2} \]
\[ = \sqrt{11989.8 - 10281.96} = \sqrt{1707.84} = 41.326 \]

R_{max} is taken for the 15th birthday period, so the probability is: \[ \frac{1}{15} \times 100\% = 6.7\% = 0.067 \]

4.1. Calculate the Concentration Time (t_c)

\[ t_c = 0.0195 \cdot L \cdot S^{0.5} \]

Where:

0.0195 = Fixed coefficient

T_c = Time of concentration (minutes)

S = Slope of land ( m)

\( \Delta H \) = Difference in height from the furthest point of flow to the lowest point (m).

L = length of flow path above the land surface (m)

\[ L = 115 + 100 \]

\[ S = \frac{\Delta H}{L} = \frac{596 - 594}{215} = 0.0093 \]

\[ t_{cA} = 0.0195 \left[ \frac{L}{S^{0.5}} \right]^{0.77} = 0.0195 \left[ \frac{215}{0.0093^{0.5}} \right]^{0.77} \]

\[ = 7.381 \text{ minutes} \]

Table 2. Concentration Time Results

| Remarks | Results       |
|---------|---------------|
| A       | 7,381 menit   |
| B       | 6,490 menit   |
| C       | 6,490 menit   |
| D       | 6,473 menit   |
| E       | 7,124 menit   |
| F       | 9,350 menit   |
| G       | 8,676 menit   |

Tc + half of the width of the road
4.2. Calculate rain intensity during concentration time (I)

Formula: \[ \left[ \frac{R_{\text{max}}}{24} \right] \times \left[ \frac{24}{t_c} \right]^{2/3} \]

\[ = \left[ \frac{R_{\text{max}}}{24} \right] \times \left[ \frac{24}{24} \cdot \frac{24}{7.381} \right]^{2/3} \times 24 \times t_c \]

\[ = 0.01499 \text{ m / hour} \]

| Remarks | Results   |
|---------|-----------|
| A₁      | 0.01499 m/hour |
| B₂      | 0.01634 m/hour |
| C₃      | 0.02129 m/hour |
| D₄      | 0.01636 m/hour |
| E₅      | 0.01535 m/hour |
| F₆      | 0.01280 m/hour |
| G₇      | 0.01346 m/hour |
| A₈      | 0.02159 m/hour |
| B₂      | 0.02942 m/hour |
| C₃      | 0.02942 m/hour |
| D₄      | 0.02626 m/hour |
| E₅      | 0.02787 m/hour |
| F₆      | 0.02794 m/hour |
| G₇      | 0.03900 m/hour |
| A₈      | 0.01045 m/hour |

4.3. Calculating Area (A)

Using the manual method, the results are as follows:

\[ A = (\text{length} \times \text{width}) \text{ (m}^2\text{)} \text{ to find the area of a rectangle} \]

\[ A = \frac{a \times t}{2} \text{ (m}^2\text{)} \text{ to find the area of triangle} \]

\[ A = \frac{\text{number of sides parallel} \times t}{2} \text{ (m}^2\text{)} \text{ to find the area of the trapezoid} \]

\[ A = \frac{(115 + 105) \times 100}{2} \]

\[ = 11000 \text{ m}^2 \]
### Table 4. Results of Area

| Remarks | Formula | Results   |
|---------|---------|-----------|
| A       | 11000 m²|           |
| B       | 11787.5 m²|          |
| C       | 8925 m² |           |
| D       | 9360 m³ |           |
| E       | 12852 m²|           |
| F       | 23992.5 m²|         |
| G       | 10395 m²|           |

**Side East Road**

| Remarks | Formula | Results   |
|---------|---------|-----------|
| A_1     | L × 4   | 400 m²    |
| B_2     | L × 4   | 460 m²    |
| C_3     | L × 4   | 340 m²    |
| D_4     | L × 4   | 312 m²    |
| E_5     | L × 4   | 288 m²    |
| F_6     | L × 4   | 420 m²    |
| F_7     | L × 4   | 180 m²    |

**Side West Road**

| Remarks | Formula | Results   |
|---------|---------|-----------|
| A_8     | L × 4   | 2400 m²   |

### Table 5. C results

| Street | C     |
|--------|-------|
| A      | 0.85  |
| B      | 0.95  |
| C      | 0.95  |
| D      | 0.95  |
| E      | 0.95  |
| F      | 0.85  |
| G      | 0.85  |
| A_1    | 0.95  |
| B_2    | 0.95  |
| C_3    | 0.95  |
| D_4    | 0.95  |
| E_5    | 0.95  |
| F_6    | 0.95  |
| G_7    | 0.95  |
| A_8    | 0.95  |

### 4.4. Calculating Plan Discharge (Q)

\[ Q_A = 0.0278 \times C \times IA \times AA \]

#### Table 6. Result of Discharge (Q)

| Remarks | Results     |
|---------|-------------|
| QA      | 0.06493 m³/sec |
| QB      | 0.08477 m³/sec |
| QC      | 0.08363 m³/sec |
| QD      | 0.06740 m³/sec |
| QE      | 0.08683 m³/sec |
| Remarks       | Results              |
|---------------|----------------------|
| QF            | 0.13517 m³/sec       |
| QG            | 0.06158 m³/sec       |
| QA₁           | 0.00380 m³/sec       |
| QB₂           | 0.00480 m³/sec       |
| QC₃           | 0.00440 m³/sec       |
| QD₄           | 0.00360 m³/sec       |
| QE₅           | 0.00353 m³/sec       |
| Q₁₆           | 0.00516 m³/sec       |
| QG₇           | 0.00308 m³/sec       |
| Discharge of west road side | 0.01103 m³/sec |

4.5. Calculating Channel Dimensions

**Table 7. Channel Discharge**

| No. Channel |             |
|-------------|-------------|
| S₁ = QA₁    | S₇ = QG7    |
| S₂ = QB₂    | S₈ = QA8    |
| S₃ = QC₃    |             |
| S₄ = QD₄    |             |
| S₅ = QE₅    |             |
| S₆ = QF₆    |             |

\[ S₁ = QA + QA₁ \]
\[ = 0.06493 + 0.00380 = 0.06873 \text{ m}³/\text{sec} \]

Taken \( V = 1 \text{ m} / \text{sec} \) (because the discharge is less than 1)

Square shape, K70

\[ Q = A \times V \]

\[ A = \frac{Q}{V} \]
\[ A = \frac{0.06873}{1} = 0.06873 \]

Using the old channel:

\[ B = 1.00 \text{ m} \]
\[ H = \frac{A}{b} = \frac{0.06873}{1.00} = 0.06873 \]

\[ F = 0.4 \text{ (F taken 0.4 because the discharge value is 0.15 to 0.50, see table)} \]

\[ F + H = 0.4 + 0.06873 = 0.46 \]

So the wall height is taken = 0.5 m

\[ V\text{new} = \frac{Q}{A} = \frac{0.06873}{1.00 \times 0.06873} = 1 \text{ m/dtk} \]

\[ R = \frac{A}{Q} = \frac{1.00 \times 0.06873}{(2 \times 0.06873) + 1.00} = \frac{0.06873}{2.3746} = 0.03 \]

\[ I_{\text{channel}} = \left( \frac{V}{KR^{2/3}} \right)^2 = \left( \frac{1.00}{70 \times 0.03^{2/3}} \right)^2 = 2.2 \]
i_{\text{ground surface}} = 595 - 594 = 1
= \frac{1}{100} = 0.01

= 100 \times 0.01
\Delta H = 0.01 \times 100 = 1

| Remarks | I_{\text{channel}} | I_{\text{ground surface}} | \Delta H |
|---------|-------------------|---------------------------|---------|
| S_1     | 2,2               | 0,01                      | 1       |
| S_2     | 0,00625           | 0,01739                   | 1,9985  |
| S_3     | 0,002             | 0,02352                   | 1,9992  |
| S_4     | 0,0011            | 0,01282                   | 0,999   |
| S_5     | 0,0007            | 0,01388                   | 1       |
| S_6     | 0,0004            | 0,02857                   | 3       |
| S_7     | 0,0003            | 0,022                     | 1       |
| S_8     | 0,00003735        | 0,018                     | 10,8    |

The value of \( \Delta H \) is taken from the largest value of \( I \)

5. Conclusion

Based on the fact that has been obtained and the drainage system analysis that has been discussed previously we can take the conclusions that:

- Flooding occurs on Jalan Anyumas Km. 07 because the dimensions of the old channel are too small and do not meet the qualifications according to the current water flow.
- Based on the field data and our calculations, the channels that did not undergo dimensional re-planning were only on channel 1 and channel 8, but channels 2, 3, 4, 5, 6, 7 had dimension re-planning according to the above calculation.
- From the calculated data, it can be concluded that the drainage channel on the Banyumas Km 7 Selomerto road must be expanded or dredged at certain channel points where the expansion must take into consideration the current field conditions.

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