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Research Paper

Study of Water Pudding in Sports Stadium Area (Case Study: Semeru Stadium, Lumajang Regency)

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ABSTRACT: *When it rains in the Semeru Lumajang Stadium area, the condition of the water in the channel almost overflows to the outside. So it is necessary to evaluate the condition of the existing drainage channels in the area around the stadium in order to identify the problems that cause puddles. From the results of the study it was concluded that the smallest discharge from the drainage system is located in channel 1, which is 0.89 m3/second, and the largest discharge is in channel 2 which is the estuary channel to the river with a discharge of 1.37 m3/second. The drainage system in the Semeru Lumajang Stadium area has a flow direction that all ends in channel 2 which is to the south of the Stadium and in channel 5 which is on the left of the Stadium and there is no change in the shape of the dimensions of the channel. Meanwhile, if there is an overflow of water caused by a lot of garbage and mud in the channel. To overcome the overflow that occurs with the calculations contained in this case study, it is important to have regular maintenance of each channel for the next 10 years, so that the channel can function properly*

KEYWORDS: *Channels, Drainage, Puddle*

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I. INTRODUCTION

Flood is a very popular word in Indonesia, especially during the rainy season, this happens in every city which in fact is a rapidly growing city. Over the years, Indonesia has witnessed many catastrophic floods that have brought huge losses [1] These events are repeated every year, but still not much has been done by the government as the policy implementer to make decisions. In Indonesia, rainfall for floods and droughts is quite significant. Therefore, government and community efforts are needed to anticipate similar disasters.[2] As well as the rapid rate of population growth which has resulted in changes in land use that have shifted from what used to be water catchment areas such as vacant land into housing. This happens in all cities in Indonesia, especially in big cities. The results of the analysis in the Greater Jakarta area (Jakarta, Bogor, Depok, Tangerang and Bekasi) show that there is a change in land use from vegetation and other land uses to built-up areas with an average accuracy of 78% per year.[3] Changes in land use and land cover can reflect human land use patterns in an area, and play an important role in space and water conservation.[4]

In this situation, there will be big problems if there is more rain than usual. The amount of flood discharge is strongly influenced by the intensity of rain. Rain intensity is the high rainfall during the period when the water is concentrated [5]. This will result in water runoff when it rains and flows heavily on the surface whose conditions do not absorb water, in the end the water will directly enter the drainage channels to then be channeled into the nearest rivers. On the other hand, the condition of the drainage canal is no longer able to accommodate the flow that crosses the channel, and the bad habit of people who litter in these drainage channels exacerbates the situation when the rainfall is high. It is necessary to clean each channel so that there is no garbage that clogs the flow of water in each channel.[6]

When it rains in the Semeru Lumajang Stadium area, the condition of the water in the channel almost overflows to the outside. sometimes even from information from the surrounding community, when it rains heavily, water overflows around the Lumajang Stadium area which causes puddles of water, and disrupts activities. The drainage system in the field must be planned as well as possible so that rainwater that falls can be directly and properly drained, and so that there is no puddle on the field which can cause activities on the sports field to be disturbed.[7] So from these problems it is necessary to evaluate the condition of the existing drainage channels in the drainage system that flows into the main channel in the area around the Semeru Lumajang Stadium so that the problems that cause water overflow are known.

II. METHODOLOGY

Research Site

The research location is in the Semeru Stadium area, Lumajang Regency, the complete location data is presented in Figure 1 below.

.Figure 1 :Research Location

Scope of activity

The scope of activities in this study includes:

1. Field survey to find out the conditions and problems that exist in the study area, both technically and non technically.
2. Studying field conditions and then conducting a literature study to identify existing problems and determine the data needed to solve these problems.
3. Collect primary and secondary data obtained from field surveys and those obtained from relevant agencies.
4. Checking the completeness of the data to find out that the required data is really complete, so that data analysis can be carried out.
5. Data processing is carried out to produce alternative solutions to the problem.
6. From several alternatives, one may be selected based on technical and non-technical considerations.
7. Followed by planning and calculating the selected alternative.

Data Collection

Data collection techniques for Flood Management efforts at Semeru Lumajang Stadium are carried out as follows:

1. For data related to non-technical planning and technical planning obtained from relevant agencies and surveys or direct observations in the field.
2. The assumptions of the approach are determined by reviewing the results of the field survey.
3. According to the method of obtaining data used for Flood Management, it can be divided into two, including:
   a) Primary Data
      Primary Data is data obtained by conducting a survey or direct observation in the field. The review was carried out with several observations, including:
      - Location and condition of existing Flood Control buildings.
      -. Condition of the channels in the study area.
   b) Secondary Data
      Secondary Data is data obtained by contacting agencies related to construction planning. In this Flood Management Effort at Semeru Lumajang Stadium requires secondary data as follows:
      - Map of the regional situation in the Semeru Lumajang Stadium area.
      - Map of Drainage Network in the Semeru Lumajang Stadium area.
      - Map of land use in the area of Semeru Lumajang Stadium.
      - Watershed Map (DAS).
      - Rainfall data.

Data Analysis

This is the stage where data processing is carried out, both primary data and secondary data. Data processing includes accumulation activities followed by grouping based on data types and then carried out analytically. While the analysis carried out is on the data:

1. Hydrological Analysis

This hydrological analysis was carried out to determine the planned flood discharge due to rainfall in the watershed in the Semeru Lumajang Stadium area.

2. Hydraulic Analysis
   Hydraulics analysis to analyze and evaluate the existing canals and any flood control structures that will be built to cope with the flooding.

III. RESULTS AND DISCUSSION

Rainfall Analysis

Supirin 2004, the actual way to get the average maximum rain is by determining the maximum rain obtained using the Thiessen polygon method.[8] From the location of the rain station that affects the research location, by using three rain gauge stations, namely the Tempeh rain station, Sukodono rain station and Yosowilangun.

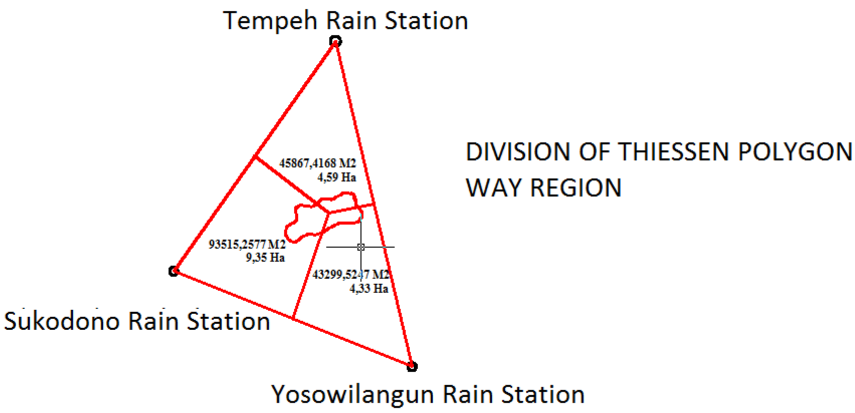

Figure 2. Thieseen polygon weighing area division

The results of the calculation of the average maximum rain, frequency analysis and distribution of rainfall using the Log Persun III method on words 2, 5, 20, 25, 50 and 100 years, the design rain is shown in Table 1 as follows.

Table 1 Rainfall Plan

No.	Return period (years)	Rainfall (mm)
1	100	192.77
2	50	178.42
3	25	163.60
4	10	142.91
5	5	125.56

Source: Calculation Results

Estimating Planned Flood Discharge

Based on the drainage area of less than 300 Ha, it is estimated that the planned flood discharge uses the Rational Method with a return period of 2.5, 10, 25, 50, 100 years. The use of this method is due to its high accuracy. The results of the accuracy evaluation using indicators of volume error, waveform error and peak discharge error for the Rational Method are 48.185%, 14.100% and 5.808%,[9]

- **Calculation of Concentration Time (tc)**

Calculation of concentration time can be calculated by the following formula.

$$Tc = 0{,}0195 \left(\frac{L}{\sqrt{S}}\right)^{0{,}77}$$

With :

Tc = Concentration time

L = Length of distance from the farthest place in the flow area to the place flood observation in Channel 1 (360m)

H = The difference in altitude between the farthest place and the observation point channel A

S = the ratio of the difference in height between the farthest place and the place observation of L, i.e. H : L, or equal to the slope mean of the flow area.

- Example calculation :

  S = 1/360 = 0,0028

  $T_c = 0{,}0195\ (\frac{360}{\sqrt{0{,}0028}})^{0{,}77}$

  T_c = 17,48090851 minutes = 0,291348 hours
-

The results of the calculation of the concentration time (tc) for each channel vary depending on the length of the channel and the difference in the height of the bottom of the channel. The results of the calculation of the concentration time (tc). The results of this calculation can be seen in the channel table in the concentration time table on the next page.

Table 2. Concentration Time (tc)

No	Channel name	L (m)	Upstream elevation	Downstream elevation	Δh (m)	S	Tc(minutes)	Tc(hours)
1	Channel 1	360	300	299	1	0,0028	17,48090851	0,291348
2	Channel 2	200	300	299	1	0,0050	8,86592915	0,147765
3	Channel 3	45	299	298,5	0,5	0,0111	2,06724340	0,034454
4	Channel 4	45	299	298,5	0,5	0,0111	2,06724340	0,034454
5	Channel 5	50	299	298,7	0,3	0,0060	2,84219115	0,047370

Source: Calculation Results

- **Average Rain Intensity**

  Rain intensity (mm/hour) can be derived from empirical daily rainfall data (mm) using the mononobe method, rainfall intensity (I) in a rational formula can be calculated based on the formula [10]

$$I = \frac{R24}{24}\left(\frac{24}{t}\right)^{2/3}$$

With :

I = rainfall intensity (mm/hour)

R24 = local design rainfall

- Example calculation:

  10-year design rainfall = 142.91 mm

  T = duration of rainfall (0.291 hours)

$$I = \frac{142{,}91}{24}\left(\frac{24}{0{,}291}\right)^{2/3}$$

= 112.401mm/hour

The calculation method uses the mononobe method. Which calculates the intensity with the channel return period ranging from 2 years to 100 years, can be seen in table 3 below.

Table 3. Average Rain Intensity

Channel name	return period (yr)	Rainfall plan	Tc (hr)	Intensity (I)
Channel 1	2	98.21	0.291	77.242
	5	125.56	0.291	98.759
	10	142.91	0.291	112.401
	25	163.60	0.291	128.677
	50	178.42	0.291	140.330
	100	192.77	0.291	151.616
Channel 2	2	98.21	0.148	121.399
	5	125.56	0.148	155.217
	10	142.91	0.148	176.658
	25	163.60	0.148	202.238
	50	178.42	0.148	220.554
	100	192.77	0.148	238.292
Channel 3	2	98,21	0,034	320,147
	5	125,56	0,034	409,329
	10	142,91	0,034	465,871
	25	163,60	0,034	533,330
	50	178,42	0,034	581,632
	100	192,77	0,034	628,409
Channel 4	2	98,21	0,034	320,147
	5	125,56	0,034	409,329
	10	142,91	0,034	465,871
	25	163,60	0,034	533,330
	50	178,42	0,034	581,632
	100	192,77	0,034	628,409
Channel 5	2	98,21	0,047	258,980
	5	125,56	0,047	331,124
	10	142,91	0,047	376,863
	25	163,60	0,047	431,434
	50	178,42	0,047	470,507
	100	192,77	0,047	508,347

Source: Calculation Results

- **Land Use Coefficient**

Based on the land use function, the land use coefficient in channel 1 is as follows.
Rice fields = 0.7
Housing = 0.65
Vacant land = 0.15

- **Planned Flood Discharge**

The equation of the Rational Method with an example of calculation on channel 1, namely:
- Example calculation:
  Q = Maximum flood discharge (m3/s)
  C = coefficient of drainage/land use runoff = 0.650
  I = average rainfall intensity (mm/hour)
  10 year design rainfall intensity = 112.401 mm/hour
  A = area of drainage area (km2) area of watershed
  channel 1, A = 0.021 km2
  Q = 0.2778 . C . I . A
  = 0.2778 . 0.650 .112.401 .0.021
  = 0.460919945 m3/s

Then for the flood discharge, the channel plan is added to the water requirements used in the stadium, namely: 3 liters/passenger/day, so that it can be 0.0347 Q(m2/sec). Then look at the table flood discharge plan, as follows.

Table 4. Plan Flood Discharge

Channel name	Return period (years)	C_{DAS}	I(mm)/jhours	A(km2)	Q(m³/second)
Channel 1	2	0,650	77,242	0,021	0,292898631
	5	0,650	98,759	0,021	0,374490719
	10	0,650	112,401	0,021	**0,460919945**
	25	0,650	128,677	0,021	0,487937591
	50	0,650	140,330	0,021	0,532128746
	100	0,650	151,616	0,021	0,574923738
Channel 2	2	0,650	121,399	0,021	0,460342011
	5	0,650	155,217	0,021	0,58857841
	10	0,650	176,658	0,021	**0,704580041**
	25	0,650	202,238	0,021	0,766880239
	50	0,650	220,554	0,021	0,836334456
	100	0,650	238,292	0,021	0,903594357
Channel 3	2	0,650	320,147	0,006	0,34685352
	5	0,650	409,329	0,006	0,443475696
	10	0,650	465,871	0,006	**0,539433969**
	25	0,650	533,330	0,006	0,577820629
	50	0,650	581,632	0,006	0,630152242
	100	0,650	628,409	0,006	0,680830505
Channel 4	2	0,650	320,147	0,006	0,34685352
	5	0,650	409,329	0,006	0,443475696
	10	0,650	465,871	0,006	**0,539433969**
	25	0,650	533,330	0,006	0,577820629
	50	0,650	581,632	0,006	0,630152242
	100	0,650	628,409	0,006	0,680830505
Channel 5	2	0,650	258,980	0,00462	0,216050144
	5	0,650	331,124	0,00462	0,276234728
	10	0,650	376,863	0,00462	**0,349091638**
	25	0,650	431,434	0,00462	0,359916284
	50	0,650	470,507	0,00462	0,392512904
	100	0,650	508,347	0,00462	0,424079676

Source: Calculation Results

Drainage Channel Evaluation

• Channel Basic Lighting

Comparison of the difference in height between the farthest place (ΔH) and the observation point to the length of the channel (L), namely H / L. Determination of the slope of the channel bottom is attempted to follow the slope of the surface of the soil contour in the design area. Example of calculation on channel 1 with the following data:

- Example calculation:

L = 360 m ; ΔH = 1 m

$$I = \frac{\Delta H}{L} = \frac{1}{360} = 0,00278$$

After calculating the slope of the channel as in the equation above, it can be tabled in the table of the slope of the channel base as follows:

Table 5 Calculation of Planned Flood Discharge for return period is 25 years

No	Channel name	L (m)	ΔH (m)	I (mm/hour)
1	Channel 1	360	1	0,00278
2	Channel 2	200	1	0,00500
3	Channel 3	45	0,5	0,01111
4	Channel 4	45	0,5	0,01111
5	Channel 5	50	0,3	0,00600

Source: Calculation Results

- **Channel Planning**

Then the above equation can be tabled in the Existing Square Dimension Planning table

Table 6 Manning Coefficient Price

No	Material	Manning Coefficient
1	Cast Iron in layers	0,014
2	Glass	0,010
3	Concrete channel	0,013
4	Mortar coated stone	0,050
5	Cemented stone couple	0,025
6	Clean earth channel	0,022
7	earth channel	0,030
8	Channel with stone and grass bottom	0,040
9	Channels in rock excavations	0,040

- **Square Channel Dimension Planning**

In evaluating the drainage network in this area, it is necessary to first determine the maximum discharge that can be accommodated by the existing channels. If the maximum discharge of the existing channel is less than the design discharge. To calculate the maximum discharge in the channel, look at the direction of flow from the channel, then when a stream gets another channel flow, the flow rate of the previous channel is added first From the results of the calculation of the maximum discharge of the dimensions of the existing channel, it can be seen that there are many that are not able to accommodate the 10-year planned flood discharge.

To determine the dimensions of the existing channel 1 in the form of a square, among others:

1. The width of the bottom of the channel (b) is the width of the base of the existing channel = 0.3 m,
2. Flow depth (y) is the vertical distance from the lowest point on a channel cross section to the free surface = 0.5.
3. The peak width (T) is the cross-sectional width of the channel on the free surface, because the channel is square so the value of T = b = 0.3
4. Wet area (A) is the cross-sectional area of the flow perpendicular to the flow direction.
   $A = b \times y$
   $= 0{,}3 \times 0{,}5$
   $= 0{,}15\ m^2$
5. Wet circumference (P) is the length of the line of intersection of the wet surface of the channel with the cross-sectional plane perpendicular to the flow direction.
   $P = b + 2y$
   $= 0.3 + 2 \cdot 0.5$
   $= 1.3\ m$
6. Hydraulic radius (R) is the ratio of wet area to wet circumference
   $R = \frac{A}{P}$
   $= \frac{0{,}15}{1.3}$

= 0,12 m

7. According to the existing data the channel wall uses concrete with unfavorable conditions, then the manning roughness coefficient value is n = 0.013
8. In evaluating the drainage system in the channel 1 stadium area, the flow velocity uses the manning method with the following equation:

   V = Speed of flow in the channel (m/s)
   n = Manning roughness coefficient = 0.025
   R = Hydraulic radius = 0.240
   S = Channel base slope = 0.0310

   $$V = \frac{1}{n} \, x \, R^{2/3} \, x \, S^{1/2}$$

   $$= \frac{1}{0{,}013} \, x \, 0{,}240^{2/3} \, x \, 0{,}01310^{1/2}$$

   = 3,40 m/s
9. To determine the type of flow is the ratio between the gravitational force and the inertia force, which is expressed by the Froude number (Fr). Froude number [11] is defined as follows:

   V = flow rate (m/s)
   y = flow depth (m)
   g = acceleration due to gravity (m/s)

   $$F_r = \frac{V}{\sqrt{g \cdot y}}$$

   $$= \frac{3{,}40}{\sqrt{9{,}81 \, .0{,}5}}$$

   = 1.534
10. Determine the debit of each channel with the formula:

   A = Wet cross-sectional area = 0.48 m2
   V = Flow velocity in channel = 1.77 m/s
   Q = V x A
   = 0.48 x 1.77
   = 0.85 m3/s

So from the equation above, it can be concluded that there is no change in the shape of the channel dimensions. Meanwhile, if there is an overflow of water, it is caused by the amount of garbage and deflection in the channel. There is no change in the shape of the dimensions of the channel as a result of the channel being able to accommodate the planned flood discharge for the next 10 years

IV. CONCLUSIONS AND SUGGESTIONS

Conclusion

The following conclusions can be drawn from the evaluation of the drainage system in the Semeru Lumajang Stadium area:

1. The smallest discharge from the drainage system is located in channel 1 which is 0.89 m3/second, and the largest discharge is in channel 2 which is the estuary channel to the river with a discharge of 1.37 m3/second.
2. The drainage system in the Semeru Lumajang Stadium area has a flow direction that all ends in channel 2 which is to the south of the Stadium and in channel 5 which is to the left of the Stadium.
3. There is no change in the shape of the channel dimensions. Meanwhile, if there is an overflow of water, it is caused by the amount of garbage and deflection in the channel. The absence of changes in the dimensions of the channel is due to the channel being able to accommodate the planned flood discharge for the next 10 years.

Suggestion

To overcome the overflow that occurs with the calculations contained in this case study, it is important to have regular maintenance of each channel for the next 10 years, so that the channel can function properly.

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