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Evaluation of Drainage Systems in Sekarbela Area and its Surroundings

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Abstract
Floods that happened in some place of Mataram City in December 2016 at Area of Sekarbela generate many question in society, what becoming cause of that floods, is purification because high rainfall, lack of urban drainage, the stuffing up of drainage effect of garbage or something else. Intention of this research is to calculate run off volume in channel of Sekarbela and its surroundings, and evaluate the condition of drainage channel eksisting in area of Sekarbela and its surroundings. Method the used to calculate run off volume with Rational method and Routing wirh Kinematic Wave manually and use model software of SWMM. Data which used in this analysis for example Intensity Rain, Large of Catchment Area, Condition of Catchment Area, topography or inclination of Catchment Area. Rain intensity the used is 5 Year because channel which in evaluation is secondary channel. Result from this research with calculation manually stream at J-2 with debit 1,79 m3 / s and with SWMM are 2,26 m3 / s while capacities accomodate channel 2,39 m3 / s, so that do not happened overflowing, but it will flooding with 25 years return period.
Keyword: *floods in Mataram,Sekarbela, Kinematic Wave, SWMM.*

Introduction

Floods that occurred at several points in the city of Mataram in December 2016 such as Tanjung Karang, Babakan, and Pagutan Timur Villages raised many questions in the Mataram City Community, what caused the flooding, was due to high rainfall, lack of urban drainage, blockage of drainage due to garbage or other things.

The lack of recharge can also be the causes of flooding, because of the lack of participation of the community in making infiltration wells in their homes, which directly results in drainage without the opportunity to seep into the ground.

Particularly the Sekarbela area and its surroundings is one of the points of flooding, this space is a fairly dense settlement with limited space from a very small drainage area which is added to the drainage channel and a fairly low area compared to the surrounding area.

Because this high rainfall caused flooding in the Sekarbela shopping area of the city of Mataram, water originating from residential settlements which flowed through the drainage canal to Berenyok River overflowed through the road before entering the river.

Based on the explanation above, it is necessary to conduct research on the evaluation of drainage system studies in the sekarbela and surrounding areas.

Formulation of the Problem

Floods or puddles due to rain events in the study area cause material and non-material losses to the surrounding community. So that proper handling is expected to avoid the recurrence of the flood. Some flood handling has been carried out such as the repair of drainage channels, elevation of the Berenyok River talud and the construction of the Loang Balok Park which indirectly became a retention pool to accommodate water runoff from the river, but the results of the handling have not been seen.

Based on the formulation of the problem above, the qualitative descriptive analysis was proposed to be carried out in this study to find out the most dominant causes of flooding in the Sekarbela Region.

Purpose and Benefits of research

Referring to the actual conditions in the field, the objectives and benefits of this research are:

1. Calculate runoff discharge in the sekarbela and surrounding area channels to determine runoff discharge in the sekarbela and surrounding area channels.
2. Evaluate the condition of the existing channel in the Sekarbela area to determine the condition of the existing channel in the Sekarbela Area.

Basic Theory

Flooding is the overflow of water from rivers or channels, which is caused by the inability of existing rivers or channels to channel flowing water (DPU, 2004). In Government Regulation No. 38 of 2011 concerning rivers, floodsis an event of overflow of river water over river troughs.

Some characteristics related to flooding, including:

- Floods can come suddenly with large intensity but can flow immediately
- Floods come slowly but the rain intensity is small
- seasonal flood patterns
- The consequences are inundation, erosion and sedimentation while the other result is the isolation of residential areas and evacuation of the population is needed.

Some researchers who have studied previous floods such as; Waskito (2010) examined the Evaluation of Control of the Cibeet River Flood in Bekasi Regency. Cibeet river control is carried out to overcome and reduce runoff that occurs due to planned 25-year return period (25Q) flood discharge, through alternative structural efforts, including the creation or elevation of flood dikes by using concrete sheet piles due to the already narrow condition of the banks so that it is not possible to handle land use works.

Hidrology Analysis

Calculating Rainfall Using the Polygon Theissen Method:

$$P = \frac{P1A1 + P2A2 + P3A3}{A1 + A2 + A3} = \frac{\sum_{i=1}^{n} Pi.Ai}{\sum_{i=1}^{n} Ai}$$

With

$P1, P2, ... Pn$ = rainfall is spent in the rain gauge 1, 2, ... n

$A1, A2, ... An$ = areal polygon area 1, 2, n dan n is the number of rain gauge posts.

Analysis of Rainfall Frequency

Normal Distribution

$$PX = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$$

P (X) = Normal chance density function

π = 3,14156

e = 2,71828

μ = average value

σ = value of X deviation

Standard Deviation Variant Value

$$PX = \frac{1}{x\sigma\sqrt{2\pi}} \exp\left[-\frac{(Y-\mu_y)^2}{2\sigma_y}\right] x > 0$$

With:

P (X) = Normal Log Opportunities

X = variant value of observation

σ_y = Standard deviation variant value Y

μ_y = Population Average Value Y

Log – Person III Distribution

Dengan Tahapan :

. 1. Sort data from small to large and change data (X1, X2, …., Xn) in the form of Logaritma (log X1, log X2, …., log Xn).
2. calculate the average value
3. Calculate standard deviation
4. calculate coefficient
5. calculate Logaritma X
6. calculate anti log X

Gumble Distribution

Gumbel distribution is generally used for extreme data analysis which has a double exponential distribution function

Test the level of distribution trust

Chi Kuadrat Test

$$X_h^2 = \sum_{i=1}^{G} \frac{(O_i - E_i)^2}{E_i}$$

X_h^2 = The chi square parameter is calculated

G = Number of subgroups

Oi = Number of observations in sub group i

Ei = Amount of theoretical value in sub group i

Smirnov – Kolgomorov Test

The procedure is as follows : :

- Sort data from large to small or vice versa and determine opportunities for each of these data
- Sort Sort the value of each theoretical opportunity from the data depiction
- From these two opportunity values, determine the difference between observation and theoretical opportunities

  D = maximum {P(Xn) – P'(Xn)}
- Based on the critical value table (Smirnov - Kolmogorov test) specify the price of Do

Calculation of Rain Intensity

Rumus Mononobe $I = \frac{R_{24}}{24} (\frac{24}{t})^{\frac{2}{3}}$

Run Off

Using Rational Method Qp = 0,002778 CIA

With :

Qp = Surface Flow Rate

C = Surface Flow Coefficient

I = rain intenstas

A = area DAS

Search for Floods

Using metode Gelombang Kinematic (Kinematic Wave)

- Equality Kontinuitas

$$\frac{\sigma Q}{\sigma x} + \frac{\sigma A}{\sigma t} = q$$

- Equality Momentum

$$-g(S_0 + S_f) = q$$

- Linear-Scheme Kinematic Wave:

$$Q_{i+1}^{j+1} = \frac{\frac{\Delta t}{\Delta x} Q_i^{j-1} + \alpha\beta Q_{i+1}^{j} \frac{Q_{i+1}^{j} + Q_i^{(j+1)^{\beta-1}}}{2}}{\frac{\Delta t}{\Delta x} + \alpha\beta \frac{Q_{i+1}^{j} + Q_i^{(j+1)^{\beta-1}}}{2}}$$

To look to value α used formula

$$\alpha = [\frac{nP^{2/3}}{1{,}49\sqrt{S_f}}]^{3/5}$$

With:

n= Manning roughness value

P = Wet Circumference

Sf = Channel slope

Because for Kinematic FlowSf = S0

β = 3/5 because of the shape of the Rectangle channel

Channel Storage Capacity

Calculation of the amount of capacity of the drainage canal can be done by calculating the geometric elements of the drainage channel.

Searched for by formula:

$$Q_s = V\ A_w$$

With:

Qs = Chanel Discharge (m3/s)

V = Run off Velocity at chanel (m/s)

Aw = Area of Wet Chanel (m2)

Identification Using EPA SWMM

EPA SWMM is a periodic rainfall runoff simulation model that is used to simulate single events or continuous events with the quantity and quality of runoff from the area being reviewed.

Modeling in EPA SWMM

- **Rain Gage** is rainfall representing modeling that will supply the study area
- **Subcatchment** is one of the hydrological units on the ground that has topography and elements of an internal drainage system that flows surface runoff to one outlet point
- **Junction Nodes (Meeting Point)** is the meeting point of the flow
- **Outfall Nodes (expenditure point)** is the last terminal of the drainage system circuit, describes the end point in the form of an estuary or other output
- **Flow Divider Nodes** is a point that divides some of the flow into another channel
- **Storage Units** is a point where it can provide a water reservoir with a certain volume

- **Conduits** is the connector that flows water from one node to another node in the drainage system in this case can be either an open or closed channel

Surface flow

surface flow Surface subcatchment is defined as a nonlinear reservoir. Water enters through precipitation and subcatchment above. Then the water will flow in several ways including infiltration, evaporation and surface flow. Surface flow per unit area (Q) occurs when the groundwater has reached a maximum and the soil becomes saturated

Infiltrasi

Infiltration is a process where rainwater seeps into the pervious subcatchment area. SWMM provides three options for modeling infiltration namely the Horton infiltration model, the Green-Ampt model and the Curve Number model.

Search for floods

The search for deep floods in SWMM is based on the formula of mass conservation and momentum formula for "varied varied, unsteady flow".

The trace analysis method that can be used is **Steady Flow Routing, Kinematic Wave Routing, Dynamic Wave Routing**

Models in EPA SWMM

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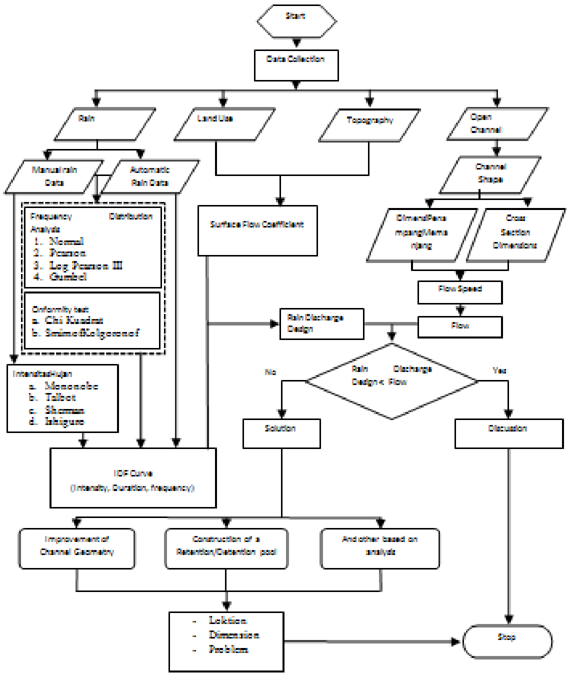
Methodology

The research method describes the stages of the research that will be conducted, including how to collect data, calculations and analysis to answer the problems asked in the research question.

Research Flow Chart



Analysis and Discussion

Data Collection

Data Collection and Processing Phase

In this stage, the data needed include:

- Topographic maps
- Rainfall data.
- Data on the cross-sectional dimensions of the drainage canal both the longitudinal cross-sectional and cross-sectional dimensions at the study site.
- Land Use at the Research Site

Topographic maps for the study area will use the map of the Earth from the Geospatial Agency with a scale of 1: 25,000 and processed with GIS-based software to obtain a larger scale and by combining with the results of measurements of existing drainage channels at the research site.

Data Processing

Rainfall data

Rainfall data is obtained from the Metapology and Geophysics Agency Selaparang (BMKG) and the Department of Agriculture of the Province of NTB

Tabel 1 Average rainfall

Years	Rainfall Data		Rainfall Average
	Ampenan	Cakranegara	
	100.968	140.306	
2008	50	55	52.91
2009	180	123	146.85
2010	161	156	158.09
2011	62	70	66.65
2012	72	80	76.65
2013	78	105	93.70
2014	49	77	65.28
2015	58	85	73.70
2016	89	88.2	88.51
2017	159	113.3	132.41

source : calculation result

Frequency Analysis Curah Hujan

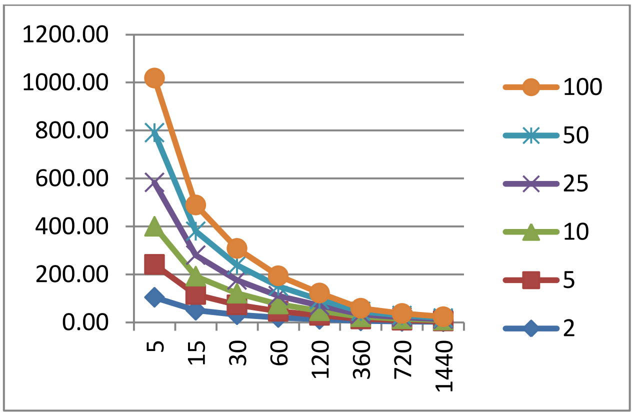
Frequency analysis is done to get rainfall plans for various recurrences. This data will then be used to calculate the planned flood discharge. Rainfall plans are taken for return periods of 5, 10, 25, 50 and 100 years.

Tabel 2 Rain Return Period Data

RAINFALL INTERVAL (t)	RAINFALL PERIODE					
	2	5	10	25	50	100
5	104.18	137.23	159.08	183.02	207.25	227.61
15	50.09	65.97	76.48	87.60	99.64	109.42
30	31.55	41.56	48.18	55.04	62.77	68.93
60	19.88	26.18	30.35	34.58	39.54	43.42
120	12.52	16.49	19.12	21.72	24.91	27.36
360	6.02	7.93	9.19	10.40	11.98	13.15
720	3.79	4.99	5.79	6.53	7.54	8.28
1440	2.39	3.15	3.65	4.10	4.75	5.22

Source : Calculate Result

Gambar 1 Rainfall Return Period Data



Calculate Rain Intensity

Rain intensity is calculated for each block with an interval based on the concentration time (Tc) value for each block. Concentration Time is calculated by the formula:

$$t_c = \left(\frac{0{,}87\ x\ L^2}{1000\ x\ S}\right)^{0{,}385}$$

Tabel 3 Rainfall Intensity

Jam	1	2	3	4	5	6	7	8
2009	4	12	32	5	8	5	1	0.5
2010	0.6	1.1	18.8	1	1	1.7	3.3	
2011	0.7	49.9	3.5	1				
2012	44.7	24.5	15	1	7	1.5	0.6	
2013	15.7	15	17.3	4.8	14.8	0.4	0.4	0.4
2014	32	81.8						
2015	11.7	5.8	5.5	70.1	1.7	3.3	0.1	
Rata2	15.62857	27.15714	15.35	13.81667	6.5	2.38	1.08	0.45
Prosentase	18.97538	32.97275	18.63715	16.77546	7.891953	2.889669	1.311278	0.546366

Land Use

In this study the study area was divided into 152 blocks, the aim of which was to detail the run off flow in the Rain Catchment Area.

Tabel 4 Average Runoff Coefficients of Each Block

Id	Area Of Total Blok	Road Area	C Road	Area of Building	C building	% Impervious	area of open space	C open space	C Run Off
			0.9		0.9			0.15	
1	2	3	4=3x0,9	7	8=7x0,9	SWMM	5	6=5x0,15	9=(4+6+8)/2
1	2.668	0.000	0.000	2.188	1.969	81.985	0.481	0.072	0.765
2	1.384	0.000	0.000	0.855	0.769	61.765	0.529	0.079	0.613
3	3.185	0.000	0.000	1.861	1.675	58.436	1.324	0.199	0.588
4	1.074	0.000	0.000	0.539	0.485	50.211	0.535	0.080	0.527
5	1.301	0.000	0.000	0.729	0.656	56.003	0.573	0.086	0.570
6	1.756	0.045	0.041	0.867	0.781	51.961	0.844	0.127	0.540

Analytical Phase

After all secondary and primary data is available, the next step is to analyze the data. In this study, 2 (two) stages of the study were carried out, namely calculating the capacity of the existing channel, then calculating the design debit (Rational Method, Routing with Kinematic Wave and SWMM).

- Debit Design, Debit design will be calculated using conventional methods.
- Rational Method :

Qp = 0,002778 CIA

- Routing Method with Kinematic Wave

$$Q_{i+1}^{j+1} = \frac{\frac{\Delta t}{\Delta x} Q_i^{j-1} + \alpha\beta Q_{i+1}^{j} \frac{Q_{i+1}^{j} + Q_i^{(j+1)\beta-1}}{2}}{\frac{\Delta t}{\Delta x} + \alpha\beta \frac{Q_{i+1}^{j} + Q_i^{(j+1)\beta-1}}{2}}$$

Discussion and Solution

Judging from the analysis using these two methods, Rational Method combined with the Kinematic Wave Method and data processing using SWMM Software using the 5-year Rainy Period, it can be said that the existing channel is capable of accommodating runoff from surrounding settlements that pass through the channel evaluation is carried out but this condition can change due to sedimentation in the drainage channel, if the sedimentation thickness of up to 10 cm has reduced the channel capacity to approach runoff discharge (review points J-2 and J-3) which can overflow the water even if it occurs in the 2-year return period, this sedimentation itself was caused by the generation of waste in the Drainage channel at the study site, so that flooding that often occurs in the research area is caused by garbage in the canal.

From the results of data analysis and discussion can be seen basically Drainage Channels that are evaluated can channel runoff water but changes in channel conditions can affect the channel capacity of the channel which has an impact on the overflow of water from the Drainage channel which causes flooding in the penelittian area so as to maintain continue to hold water according to its capacity, Drainage Channels must be normalized periodically. Whereas for land changes that can occur later due to the development of the City, KDB should not be too high in residential areas because only 50% of land cover can lead to overflow of water on Drainage canals with calculation using the 5-year Rainy Period.

Conclusions

From the results of the research conducted, some conclusions can be drawn, including:

1. Runoff Discharge using the Rational and Kinematic Wave methods produces the highest runoff discharge in the 110th and 115th minutes, that is at J-2 of 1.79 m3 / sec, J-3 of 1.72 m3 / sec, J-4 of 1 , 68 m3 / sec, J-5 is 1.60 m3 / sec, J-6 is 1.56 m3 / sec, J-7 is 1.52m3 / sec, J-87 is 4.71m3 / sec, J- 88 of 4.19 m3 / sec, J-89 of 4.25 m3 / sec, J-90 of 5.85 m3 / sec, J-91 of 6.43 m3 / sec
2. Runoff Debit using SWMM Software produces the highest runoff discharge in the 180th minute, that is on J-2 of 2.26 m3 / sec, J-3 of 2.03 m3 / sec, J-4 of 1.92 m3 / sec , J-5 is 1.68 m3 / sec, J-6 is 1.62 m3 / sec, J-7 is 1.52m3 / sec, J-87 is 3.77m3 / sec, J-88 is 3.79 m3 / sec, J-89 is 3.88 m3 / sec, J-90 is 5.90 m3 / sec, J-91 is 5.90 m3 / sec
3. Calculations to obtain water runoff using the Rational and Kinematic Wave methods compared with calculations using SWMM Software show different results even though the SWMM calculations also use the Kinematic Wave routing method.
4. The condition of the channel in the current research area can still hold water runoff until the return period of 5 years of rain even though it has overflowed for a return period of 10 years of rain.

Recommendation

From the results of this study researchers can give some suggestions, including:

1. Channels located at the research location should be normalized periodically given the lack of public awareness in disposing of garbage;

2. In planning the development of the region, it is best to study the flood problem that can occur in several locations, using SWMM Software, the work becomes easier and faster to do, besides this software is also free, only limited to the area below

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