

# Evaluation of road drainage capacity to improve optimized road performance in Kebon Pala Area East Jakarta

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## Evaluation of road drainage capacity to improve optimized road performance in Kebon Pala Area East Jakarta

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**Abstract.** Road drainage function as important part that can control a large rainfall that caused puddles that often disturb the comfort of all community activities on the road. Condition of the drainage channel on the road Kebon Pala area, East Jakarta are not qualified due to mistake planning and lack of maintenance. Hence, it is necessary to evaluate the capacity of drainage channel on Road Perindustrian. The purpose of this study is to find the maximum amount of water flow that can be accommodated by drainage channels. Rain intensity was calculated using the Mononobe method, as well as the flow rate is calculated using the Rational method. The existing capacity of drainage dimensions are measured directly in the field using Manning method for calculating flow velocity. The results obtain  $Q_{2\text{yrs}} = 1.27\text{mm/s}$ ,  $Q_{5\text{yrs}} = 1.67\text{mm/s}$ ,  $Q_{10\text{yrs}} = 1.84\text{mm/s}$ , while  $Q_{\text{channel}} = 0.24\text{mm/s}$ . Thus, it can be concluded that capacity of road drainage channel is lower than  $Q_{\text{rain}}$  that can not accommodate the existing rain flow.

### 1. Introduction

Drainage function as important part in regulating water supply to prevent flooding. Drainage means draining, removing, or diverting water. In general, drainage is defined as a series of water structures that function to reduce or remove excess water from certain area in order to make that area can be optimally functioned [1]. Drainage channels also have a central role in supporting a large rainfall that caused puddles that often disturb the comfort of all community activities on the road. Good drainage can improve optimized performance of road [2]. This research was conducted to evaluate the adequate condition of road drainage in based on the rainfall that occurred in recent years [3,4]. Thus, the root cause of flood problem in Jakarta can also be identified. The location of the research was conducted at Perindustrian road Kebon Pala area, East Jakarta, which is a residential area. Over the last 10 years industrial roads has been occurring flooded in rainy season.

Micro drainage system such as channel system function to accommodate and drain water from the rain catchment area, included the channels on the side of the road, rainwater drains around buildings, culverts, city drainage channels and so on. In general, this micro drainage is planned for rain with return period of 2, 5 or 10 years depending on the existing land use [5,6]. The drainage system for residential environments is more likely to be a micro drainage system.

### 2. Methods

The method using for this research consist of several sequence for collecting data as follows:

- Collecting initial data from literature related to drainage channel.
- Surveying the research location on Kebon Pala industrial road, East Jakarta.



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- Collecting secondary data such as periodic last 15 years rainfall from the Meteorology, Climatology and Geophysics Agency of East Jakarta.
- Hydrological Analysis such as maximum average rainfall using the Gumbel method, intensity of rainfall, as well as the planned discharge.

**Table 1.** Monthly rainfall in East Jakarta area.

Year	Monthly Rainfall (mm)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2005	148,0	378,0	361,0	293,0	210,0	40,0	120,0	12,0	21,0	142,0	182,0	277,0
2006	294,0	348,0	381,0	322,0	272,0	54,0	45,0	2,0	0,0	6,0	16,0	226,0
2007	274,9	1.081,4	144,0	310,8	53,1	127,0	6,6	64,8	27,4	168,0	126,4	533,3
2008	273,1	544,8	264,4	386,3	106,7	108,3	6,6	67,0	27,4	168,0	126,4	533,3
2009	398,3	382,0	192,5	271,7	280,4	57,8	46,4	10,2	225,9	64,20	262,9	315,3
2010	403,4	270,2	151,2	109,4	275,4	142,2	83,6	137,0	346,8	519,1	279,7	177,1
2011	130,0	613,9	97,3	72,6	226,9	48,1	12,3	0,0	9,7	72,9	263,3	109,9
2012	560,8	249,9	339,2	155,6	97,9	142,3	0,9	0,0	NA	98,8	269,1	367,3
2013	552,1	282,6	234,7	259,8	270,5	118,7	165,6	27,8	28,0	85,2	387,3	456,4
2014	854,7	456,4	348,3	231,8	181,6	158,6	203,1	95,1	23,5	0,0	40,4	343,7
2015	303,9	400,0	423,0	204,8	62,5	47,4	0,0	2,7	0,0	1,2	126,6	299,8
2016	233,5	516,2	201,8	225,6	211,6	246,0	152,6	171,4	339,8	324,2	358,8	135,6
2017	303,9	400,0	423,0	204,8	62,5	47,4	0,0	2,7	0,0	157,0	126,6	23,5
2018	189,5	379,6	185,8	327,1	100,2	45,0	2,2	0,0	0,0	132,7	352,9	154,8
2019	189,5	379,6	185,8	327,1	100,2	45,0	2,2	0,0	0,0	132,7	352,9	154,8

Source: Meteorology, Climatology and Geophysics Agency of East Jakarta

In the planning of the drainage channel, return period for rainfall discharge depends on the function of the channel and the rain catchment area which are: (a) Quaternary channel use 1 year return period; (b) Tertiary channel use 2 year return period; (c) Secondary channel use 5 year return period; (d) Primary line use 10 year return period.

Determination of the return period is also based on economic considerations, based on the principle of problem solving in society.

The purpose of this research is to find the maximum amount of water flow that can be accommodated by drainage channels [7]. Result of the planned discharge, average maximum rainfall and maximum rainfall using the Gumbel method can be seen in the Table 2 dan Table 3 below:

**Table 2.** Average maximum rainfall in East Jakarta area.

Year	Average Rainfall (mm)	$(X - \bar{X})$	$(X - \bar{X})^2$
2005	150,0	-47,68	2273,38
2006	163,7	-33,98	1154,64
2007	243,1	45,42	2062,97
2008	222,6	24,92	621,00
2009	209,0	11,32	128,14
2010	241,3	43,62	1902,70
2011	138,1	-59,58	3549,77
2012	190,1	-7,58	57,45
2013	239,1	41,42	1715,61
2014	269,8	72,12	5201,29
2015	156,0	-41,68	1737,22
2016	259,8	62,12	3858,89
2017	171,0	-26,68	711,82
2018	155,8	-41,88	1753,93
2019	155,8	-41,88	1753,93

Thus,  $\sum X_{max} = 2965,2$ ;  $\bar{X} = 197,68$ ;  $\sum (X - \bar{X})^2 = 28483,74$ ;  $S_x = 45,10$

**Table 3.** Maximum rainfall using Gumble method

Return Period (years)	$Y_t$	$N$	$Y_n$	$S_n$	$\bar{X}$	$S_x$	Max Rain (mm)
2	0,3665	15	0,5128	1,0206	197,68	45,10	191,21
5	1,4999	15	0,5128	1,0206	197,68	45,10	241,29
10	2,2502	15	0,5128	1,0206	197,68	45,10	274,45

Obtaining maximum rainfall ( $X_T$ ) using this formulae:

$$X_T = \bar{X} + \left[ \frac{(Y_t - Y_n)}{S_n} \right] \cdot S_x \quad (1)$$

Hence,

$X_T$  for return period 2 years:

$$X_T = 197,68 + \left[ \frac{(0,3665 - 0,5128)}{1,0206} \right] 45,10 = 191,21 \text{ mm}$$

$X_T$  for return period 5 years:

$$X_T = 197,68 + \left[ \frac{(1,4999 - 0,5128)}{1,0206} \right] 45,10 = 241,29 \text{ mm}$$

$X_T$  for return period 10 years:

$$X_T = 197,68 + \left[ \frac{(2,2502 - 0,5128)}{1,0206} \right] 45,10 = 274,45 \text{ mm}$$

### 2.1. Rain intensity

Determining rainfall discharge using Rational Method while rain intensity for flood return period of 2 years, 5 years, 10 years using Mononobe formulae as follow:

$$Q = 0,278 \cdot C \cdot I \cdot A \quad (2)$$

Where: Q = rainfall discharge ( $\text{mm}^3/\text{sec}$ )  
 C = runoff coefficient  
 A = coverage area ( $\text{km}^2$ )  
 I = rainfall intensity ( $\text{mm}/\text{hour}$ )

$$\left( \frac{R_{24}}{24} \right) \times \left[ \frac{24}{t_c} \right]^{2/3} \quad (3)$$

R24 = thickness of maximum daily rain (mm)  
 tc = length of rain (hours)

$$t_0 + t_d \quad (4)$$

$$t_0 = \frac{2}{3} \times 3,28 \times L \times \frac{n}{\sqrt{s}} \quad (5)$$

L = channel length (m)  
 m = Manning coefficient  
 s = ground slope

### 2.2. Rainwater discharge and channel capacity

The occurrence of flooding is determined by the intensity of rainfall discharge and the capacity of the road drainage channel in draining, removing, or diverting water. Result of channel capacity can be seen from Table 4:

**Table 4.** Rainwater discharge for channel capacity.

STA	H (m)	L <sub>b</sub> (m)	L <sub>u</sub> (m)	A (m <sup>2</sup> )	bH	H <sup>2</sup>	m	A (m <sup>2</sup> )	h (m)	W (m)	P (m)	R (m)	V (m/s)	Q (m <sup>3</sup> /s)	A (m <sup>2</sup> )
1	1,5	1,1	1,1	1,65	1,65	2,25	0,91	3,69	1,12	0,5	4,86	0,75	0,15	0,55	2,73
2	1,5	1,1	1,1	1,65	1,65	2,25	0,91	3,69	1,12	0,5	4,86	0,75	0,15	0,55	2,73
3	1,5	0,9	0,9	1,35	1,35	2,25	0,75	2,61	1,12	0,5	3,7	0,70	0,14	0,36	2,43
4	1,3	0,9	0,9	1,17	1,17	1,69	0,47	1,96	0,97	0,43	3,04	0,64	0,12	0,23	1,98
5	1,3	0,7	0,7	0,91	0,91	1,69	0,37	1,53	0,97	0,43	2,76	0,55	0,11	0,16	1,72
6	1,2	0,7	0,7	0,84	0,84	1,44	0,25	1,2	0,9	0,4	2,55	0,47	0,10	0,12	1,53
7	1,2	0,7	0,7	0,84	0,84	1,44	0,25	1,2	0,9	0,4	2,55	0,47	0,10	0,12	1,53
8	1,2	0,5	0,5	0,6	0,6	1,44	0,18	1,09	0,9	0,4	2,30	0,36	0,09	0,09	1,29
9	1,1	0,5	0,5	0,55	0,55	1,21	0,09	0,65	0,82	0,36	2,14	0,30	0,07	0,04	1,13
10	1,1	0,5	0,5	0,55	0,55	1,21	0,09	0,65	0,82	0,36	2,14	0,30	0,07	0,04	1,13
11	1,4	1,2	1,2	1,68	1,68	1,96	0,82	3,28	1,05	0,46	3,91	0,83	0,14	0,45	2,62
12	1,4	1,2	1,2	1,68	1,68	1,96	0,82	3,28	1,05	0,46	3,91	0,83	0,14	0,45	2,62
13	1,3	1,1	1,1	1,43	1,43	1,69	0,58	2,41	0,97	0,43	3,34	0,72	0,13	0,31	2,24
14	1,3	1,1	1,1	1,43	1,43	1,69	0,58	2,41	0,97	0,43	3,34	0,72	0,13	0,31	2,24
15	1,3	1,1	1,1	1,43	1,43	1,69	0,58	2,41	0,97	0,43	3,34	0,72	0,13	0,31	2,24
16	1,2	1,1	1,1	1,32	1,32	1,44	0,40	1,89	0,9	0,4	3,03	0,62	0,12	0,22	2,01
17	1,2	0,9	0,9	1,08	1,08	1,44	0,33	1,55	0,9	0,4	2,79	0,55	0,11	0,17	1,77
18	1,2	0,9	0,9	1,08	1,08	1,44	0,33	1,55	0,9	0,4	2,79	0,55	0,11	0,17	1,77
19	1,1	0,9	0,9	0,99	0,99	1,21	0,17	1,19	0,82	0,36	2,56	0,46	0,09	0,10	1,57
20	1,1	0,9	0,9	0,99	0,99	1,21	0,17	1,19	0,82	0,36	2,56	0,46	0,09	0,10	1,57
<b>Average</b>	<b>1,2</b>	<b>0,9</b>	<b>0,9</b>	<b>1,16</b>				<b>0,48</b>						<b>0,24</b>	

From the results above for the planned discharge for 2 years, 5 years and 10 years, it can be concluded that the drainage channel at Perindustrian road Kebon Pala area, East Jakarta inadequate function properly that can be seen in Table 5 below:

**Table 5.** Channel capacity compared to discharge rainwater.

Return Period (Year)	Q plan (m <sup>3</sup> )	Q channel (m <sup>3</sup> )	Remarks
2	1,27	0,24	Not adequate
5	1,67	0,24	Not adequate
10	1,84	0,24	Not adequate

Maximum rainfall discharge is over the discharge capacity of channel. Therefore, in heavy rainy season most of rainwater cannot accommodate in the channel, due to less capacity of channel discharge. This condition will caused puddles that often disturb the comfort of all community activities on the road. For solution , it is necessary to enlarge the dimensions of all these channels so that the channel can accommodate water properly and avoid flooded. Other factor consider to influence capacity of channel are sedimentation in the base of channel and waste material from community that is dumped into the drainage as well.

### 3. Conclusion

From the results of the study and calculations carried out of the evaluation of capacity drainage channels on P road Kebon Pala area, East Jakarta, it can be concluded that maximum rainfall discharge is over the discharge capacity of channel. The existing capacity of drainage dimensions are measured directly in the field using Manning method for calculating flow velocity. The results obtain  $Q_{2\text{yrs}} = 1.27\text{mm/s}$ ,  $Q_{5\text{yrs}} = 1.67\text{mm/s}$ ,  $Q_{10\text{yrs}} = 1.84\text{mm/s}$ , while  $Q_{\text{channel}} = 0.24\text{mm/s}$ . Thus, it can be concluded that capacity



of road drainage channel is lower than  $Q$  rain that can not accommodate the existing rain flow. This condition will caused puddles that often disturb the comfort of all community activities on the road.

#### 4. Recommendation

Based on the results of the flood prevention identification study and the drainage design plan on Kebon Pala area, some suggestions for improving the condition of road drainage are as follow:

- Enlarge the dimensions of the channel to accommodate rainwater.
- Improve existing channels to function optimally
- Clean the drainage channels from sewage material and mud in order to drain water optimally
- Repair and clean openings on the road side to speed up draining the rainwater runoff to the urban drain system
- Provide effective garbage disposal system to prevent garbage dumping into drainage channels.
- Increase society awareness to participate and campaign in maintaining the drainage channels clean without garbage

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