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DRAINAGE ANALYSIS OF JAKARTA BANDUNG HIGH SPEED TRAIN STATION AT HALIM STATION USING HEC-RASS

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ABSTRACT

Halim Station is the main station in the Jakarta-Bandung High-Speed Train project, playing a crucial role in facilitating travel between the two metropolitan cities. The Halim Station building for the Jakarta-Bandung High-Speed Train is located on the Jakarta - Cikampek Toll Road at KM 0+800, East Jakarta City. Halim Station is the first station for departure and the last stop for journeys using the Jakarta-Bandung High-Speed Train. The area of the Halim Station building is 25,700 m2 with a roof area of 31,100 m2. Each day, the water source to meet operational needs at Halim Station comes from the Regional Water Company (PDAM) with a maximum daily clean water usage limit of 210 m3. The utilization of rainwater in the context of high-speed train stations has significant potential to meet operational sanitation and water needs around the station. With proper rainwater collection, storage, and management systems, rainwater can be processed into a safe and quality water source for various purposes around the station. If there is excess rainwater not needed for the building's operational requirements, the calculation will also include the need for infiltration wells and drainage channels. The utilization of rainwater as an alternative water source for operational needs is expected to completely replace the water source of Halim Station, which previously came from PDAM. Therefore, this could contribute to efforts to reduce environmental impacts and conserve water resources in Indonesia.

Keywords: *Water, Halim Station, Rainwater, Drainage, HEC-RASS*

1. PRELIMINARY

Halim station of Jakarta Bandung fast train, has a very important role in facilitating travel between the two metropolitan cities. As a station with a high passenger flow, maintaining operational sustainability and the convenience of sanitation facilities and maintaining the beauty of the surrounding environment are crucial factors to provide a good experience for service users. The Halim station building of The Jakarta Bandung fast train under study is located on The Jakarta - Cikampek KM 0+800 Toll Road, Halim Perdana Kusumah, Kec. Makassar, East Jakarta City. Halim station of Jakarta Bandung Fast Train is the first station for departure and the last stop for travel using the Jakarta Bandung fast train. The total area of Halim station building is 25,700 m2 with a roof area of 31,100 M2.

Halim station serves as a departure and arrival point for fast trains for passengers traveling between Jakarta and Bandung. Halim station also provides various facilities and services needed by fast train passengers, such as ticket sales areas, waiting rooms, parking areas, restaurants, and other public facilities.

In each day, the source of water to meet operational needs at Halim station is sourced from PDAM with the highest daily usage limit of clean water is 210 m3. However, population growth, increased human activity, climate change, and environmental pollution threaten the available supply of clean water. In Indonesia, one of the abundant natural resources is rainfall that occurs throughout the year. The use of rainwater as an alternative water source can not only reduce dependence on clean water from other sources, but can also have a positive impact on the environment and reduce wastewater loads. The utilization of rainwater in the context of fast train stations has great potential to meet the operational needs of sanitation and water needs for plants around the station. With proper rainwater collection, storage and management systems, rainwater can be processed into safe and quality water sources for various purposes, such as toilets, hand washing, cleaning and watering plants around the station.

2. LITERATURE REVIEW

In the concept of the hydrological cycle, the amount of water in a certain area on the earth's surface is affected by the amount of water that enters (input) and exits (output) in a certain period of time. The faster the hydrological cycle occurs, the more dynamic the water balance level. According to Triatmoodjo (2008) in statistics, several parameters related to data analysis are known which include mean (X), standard deviation (s), skewness coefficient (Cs), kurtosis coefficient (Ck) and variation coefficient (Cv). The statistics are carried out to determine which distribution method to use.

3. EQUATION FORMULA

The calculation of the average rainfall is a good way to use the Algebraic method. The annual maximum rainfall data is summed and divided by the amount of existing data.

$$R = \frac{1}{n}(R1 + R2 + R3 + \cdots + Rn)$$

Where; R = Rainfall value (mm) n = Number of data R1, R2, Rn = Rainfall value (mm)

According to Triatmodjo (2008), the rain measurement station only provides the depth of rain at the point where the station is located, so that rain on an area must be estimated from the measurement point. If in an area there are more than scattered measuring stations, the rainfall recorded at each station may not be the same. In statistics, several parameters related to data analysis are known, including Mean (X), standard deviation (s), skewness coefficient (Cs), kurtosis coefficient (Ck) and coefficient of variation (Cv).

Standard Deviation (Sd) or Standard deviation is the limit of the frequency value possessed.

$$Sd = \sqrt{\frac{\sum_{i=1}^{n}(.x_i - .\overline{x})^2}{n-1}}$$

Where: = rainfall data (mm) = average rainfall data (mm) = Number of data

Coefficient of Surprise (Cs)

$$Cs = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{(n-1)(n-2)Sd^3}$$

Where: Cs = skewness coefficient sd = standard deviation Xi = ith variant value x̄ = mean value of n variant = amount of data
Coefficient of Curtosis (Ck)

$$Ck = \frac{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^4}{Sd^4}$$

Where: Ck = curtosis coefficient sd = standard deviation Xi = value of the ith variant x̄ = average value of the n variant = amount of data

Coefficient of Variation (Cv)

$$Cv = \frac{Sd}{\bar{x}}$$

Where: Cv = Coefficient of variation sd = standard deviation x̄ = average value of variation

Selection of distribution type. The distribution method can be used to calculate the rainfall of this annual plan.

Tabel 1. Tabel Metode Distribution

No	Metodhs	Qualified		Results
1	Normal	Cs	0	2,26
		Ck	3	63,38
2	Log Normal	Cs	CV^3 + 3CV	2,26
		Ck	5,383	63,38
3	Gumbel	Cs	≤ 1,1396	2,26
		Ck	≤ 5,4002	63,38
4	*Log Pearson* III	Cs ≠ 0		1,56
				6,52

The equation to calculate the intensity of rainfall uses the equation of DR. Mononobe in Suyono S (1999) because the available rainfall comes from the average daily rainfall.

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

Where; I = Rainfall intensity (mm/h) R24 = Maximum rainfall. in 24 hours (mm) Tc = Rainfall time (mm)

$$Q = \frac{1}{3,6}.C.I.A$$

Where; Q = Planned Discharge (m3/s) C = Coefficient (0.75) I = Rainfall intensity (mm/h) A = Watershed Area (km2)

The calculation of drainage capacity aims to find out whether the drainage of the channel is able to accommodate the planned flood discharge. This is also regulated in SNI 02-2406-1991. The equation for calculating drainage capacity uses:

$$V = \frac{1}{n} R^{2/3} S_0^{2/3}$$
$$Q_S = V \times Area$$
$$Q_S = Area \frac{1}{n} R^{2/3} S_0^{2/3}$$

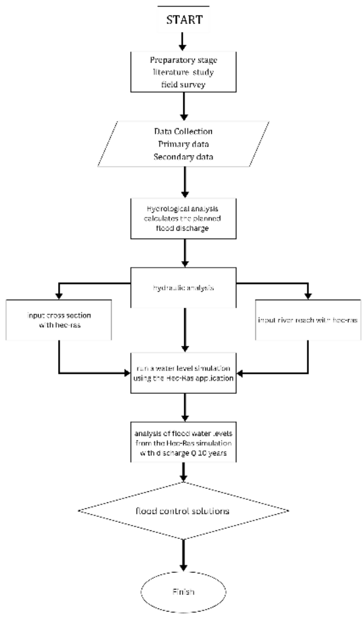
Where: Q_S = Flow discharge (m3/s) V = Average flow velocity (m/s) Area = Cross-sectional area (m) n = Manning hardness coefficient R = Hydraulic radius (m) S = Slope of drainage surface slope.

4. METHODS

The analysis is carried out with the parameters that have been collected and processed to obtain the required analysis. Data processing is carried out sequentially according to the flow as follows:

a. Hydrological analysis with long-term rainfall data using the Gumble method to determine the method to be selected and then an analysis of the suitability of the method with the appropriate data was carried out.
b. Manually calculating operational water needs at Halim Station.
c. Calculate operational water needs that can be met with rainwater catchments.
d. Calculate the volume of the retention pool and the dimensions of the reservoir.
e. Calculate the need for infiltration wells to accommodate the volume of water runoff.
f. Hydraulic analysis of drainage capacity to flood discharge or runoff of design water using the Manning method.
g. Analyze using Hec-ras software to ensure that the drainage capacity can accommodate water runoff.

Picture 1. Flow chart



The stages of this study began with several stages, namely:

a. Field survey and review of journals related to the title of this study
b. Data collection which includes secondary data and primary data
c. Calculating planned flood discharge within the scope of hydrological analysis
d. The hydraulic analysis stage is the input of cross section and river reach
e. Then, run a water level simulation with the hecras application
f. Water level analysis using 10 years of rainfall data
g. After modeling, the results will be seen through the hecras application
h. The last step, finding flood control solutions

5. RESULTS AND DISCUSSION

a. Rainfall Data Analysis in a span of 10 years using the Gumble method.

Sorting rainfall data obtained from 10 years. The data used came from the Ciliwung Cisadane River Area Center (BBWS). The rainfall data used was taken from January 2013 to December 2022. The data is presented in a table and analyzed for the minimum and maximum values in the annual period. After that, the amount of rainfall in a year is divided by the number of months.

Table 2. Calculation of Average Rainfall in 2013-2022

month	Rainfall Amount (mm)								
	2013	2014	2015	2016	2017	2018	2019	2020	202
January	149	138	67,5	81	30	195	57,5	97	10
February	38,5	89	90	61	175	155	64,5	108	66
March	90,2	74,5	130	48	86	70	30	49	30
April	75,5	78,5	61,5	84	35	57	94	34	55
May	52	35	43,5	56	19	11,5	30	25	75
June	28	47	6,5	71	46,5	11,5	23,5	36	59
July	43	56	0	51	8	9	0	69	62
August	32	58,5	23,5	146	8,5	9	0	49	75
September	6	7,5	0	89	28,5	14,5	0	75	33
October	27	19	2,4	63	72	22	12	51	67
November	100	89	42	83	172	36,5	12	68	76
December	87,5	86	85,2	56	330	19,5	109	49	55
Min	6	7,5	0	48	8	9	0	25	30
Max	149	138	130	146	330	195	109	108	10
Average($\bar{x}$)	60,725	64,833	46,008	74,083	84,208	50,875	36,042	59,167	63,4

Next, calculate the average value of rainfall for 10 years using an Algebraic formula, so as to get the value of daily rainfall.

$$R = \frac{1}{n}(R1 + R2 + R3 + \cdots + Rn)$$

Table 3. Maximum Rainfall Value for 10-year Period

No	**year**	**Maximum Daily Rainfall (mm/day)**
1	2013	149
2	2014	138
3	2015	130
4	2016	146
5	2017	330
6	2018	195
7	2019	109
8	2020	108
9	2021	108
10	2022	94

After that, the average value of deviation, standard deviation, coefficient of variation, coefficient of awkwardness, and coefficient of curtose are searched using the Gubble method.

Table 4. Gumble Method Rainfall Calculation

Tahun	Xi	(Xi - x̄)	(Xi - x̄)^2	(Xi - x̄)^3	(Xi - x̄)^4
2013	149,00	-1,70	2,89	-4,91	8,35
2014	138,00	-12,70	161,29	-2.048,38	26.014,46
2015	130,00	-20,70	428,49	-8.869,74	183.603,68
2016	146,00	-4,70	22,09	-103,82	487,97
2017	330,00	179,30	32.148,49	5.764.224,26	1.033.525.409,28
2018	195,00	44,30	1.962,49	86.938,31	3.851.367,00
2019	109,00	-41,70	1.738,89	-72.511,71	3.023.738,43
2020	108,00	-42,70	1.823,29	-77.854,48	3.324.386,42
2021	108,00	-42,70	1.823,29	-77.854,48	3.324.386,42
2022	94,00	-56,70	3.214,89	-182.284,26	10.335.517,71
Total	1.507,00	0,00	43.326,10	5.429.630,76	1.057.594.919,74
Rerata (x̄)	150,70	0,00	4.332,61	542.963,08	105.759.491,97

Frequency Analysis Calculation

Calculate the standard deviation value (Sd) whose data is obtained from table 4 :

$$Sd = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

$Sd = 69{,}380$

The standard deviation value (Sd) obtained was 69.380.

Next is to calculate the awkwardness coefficient (Cs).

Calculate the value of the coefficient of astonishment (Cs) whose data is obtained from table 4.2.

$$Cs = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{(n-1)(n-2)Sd^3}$$

$$Cs = 2{,}258$$

The Cs score obtained was 2,258.

After that, calculate the curtosis coefficient (Ck).

$$Ck = \frac{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^4}{Sd^4}$$

$$Ck = 63{,}380$$

The value of coefieisn kurtosis (Ck) obtained was 63.380.

To find the scattering value, the last must be calculated the coefficient of variation (Cv).

$$Cv = \frac{Sd}{\bar{x}}$$

$$Cv = 0{,}460$$

The value of the coefficient of variation (Cv) obtained from the calculation results is 0.460.

After obtaining the coefficient values, the values are matched to the distribution selection conditions table to continue the rainfall calculation.

Table 5. Selection of Distribution Type

No	Metode	Syarat		Hasil	Keterangan
1	Normal	Cs	0	2,26	Tidak memenuhi
		Ck	3	63,38	Tidak memenuhi
2	Log Normal	Cs	$CV^3 + 3CV$	2,26	Tidak memenuhi
		Ck	5,383	63,38	Tidak memenuhi
3	Gumbel	Cs	≤ 1,1396	2,26	Tidak memenuhi
		Ck	≤ 5,4002	63,38	Tidak memenuhi
4	Log Pearson III	Cs ≠ 0		1,56	Memenuhi
				6,52	Memenuhi

So from the table, it can be concluded that the rainfall calculation uses the Pearson III Log method.

b. Rainfall Data Analysis Using Pearson Log Distribution III

Table 6. Selection of Distribution Type

Tahun	Xi	Log Xi	Log x̄	Log (Xi - x̄)	Log (Xi - x̄)^2	Log (Xi - x̄)^3	Log (Xi - x̄)^4
2013	149	2,173	2,178	-0,004927	0,000024	0,000000	0,000000
2014	138	2,140	2,178	-0,038234	0,001462	-0,000056	0,000002
2015	130	2,114	2,178	-0,064170	0,004118	-0,000264	0,000017
2016	146	2,164	2,178	-0,013760	0,000189	-0,000003	0,000000
2017	330	2,519	2,178	0,340401	0,115873	0,039443	0,013426
2018	195	2,290	2,178	0,111921	0,012526	0,001402	0,000157
2019	109	2,037	2,178	-0,140687	0,019793	-0,002785	0,000392
2020	108	2,033	2,178	-0,144689	0,020935	-0,003029	0,000438
2021	108	2,033	2,178	-0,144689	0,020935	-0,003029	0,000438
2022	94,00	1,973	2,178	-0,204985	0,042019	-0,008613	0,001766
Total	1.507	21,48	21,78	-0,303821	0,237874	0,023066	0,016636
Rerata (x̄)	150,70	2,148	2,18	-0,030382	0,023787	0,002307	0,001664

From this data, the average rainfall was obtained at 150,700 mm.

Frequency Analysis Calculation

$$Sd = \sqrt{\frac{\sum_{i=1}^{n}(log\ x_i - log\bar{x})^2}{n-1}}$$

$$Sd = 0{,}163$$

The standard deviation (Sd) value of the Pearson III Log frequency analysis method is 0.163.

Coefficient of Awkwardness (Cs)

$$Cs = \frac{\sum_{i=1}^{n}(log x_i - log\bar{x})^3}{(n-1)(n-2)Sd^3}$$

$$Cs = 0{,}745$$

The value of the awkwardness coefficient (Cs) from the frequency analysis of the Pearson III Log method was 0.745.

Koefisien Variasi (CV)

$$Cv = \frac{Sd}{\bar{x}}$$

$$Cv = 0{,}001$$

The value of the coefficient of variation (Cv) from the frequency analysis of the Pearson III Log method was 0.001.

Calculating Plan Debit

C = 0,75

I = 61,097

A = 31.500 m^2

Qp = 0,392 m^3/s

The planned or accommodable discharge value is 0.392 m3/s or 33,838,447 m3/day.

a. Operational water needs (Qoperational)

Its daily operational water requirement is 0.00393 m3/s or 339.747 m3/day.

b. Discharge value due to rain that is not used for operational needs (Qlimpas)

Qlimpas = Qp – Qoperasional
Qlimpas = 33.838,447 - 339,747
Qlimpas = 33.498,700 m^3/hari

The Qlimpas value is 33,498.7 m3/day or 0.387 m3/s.

c. Drainage Needs Analysis

Manual Drainage Analysis

Drainage will be designed using a u-ditch channel. Here is the channel data:

A = 0,6 m
B = 0,8 m
Area = 0,480 m2
P = 2,200 m
R = 0,218 m
Upstream = Elevation 0.3 m
Downstream = Elevation -0.15 m
L channel = 473.5 (on the north and south sides of the building)
Slope = 0,1 %
n (manning) = 0,013

Calculating the Water Flow Rate (V)

$$V = \frac{1}{n}\ R^{2/3}\ S_0^{2/3}$$

$$V = \frac{1}{0{,}013}\ x\ (0{,}128\ m)^{2/3}\ (0{,}001)^{2/3}$$

$$V = 0{,}881\ m/detik$$

The V value from the analysis was obtained as 0.881 m/s. This means that the value of V is acceptable because the maximum limit of V permits according to the standard is 1.5 m/s.

Calculating the Water That Can Be Accommodated by Drainage Channels (Qs)

$$Q_S = V \times Area$$

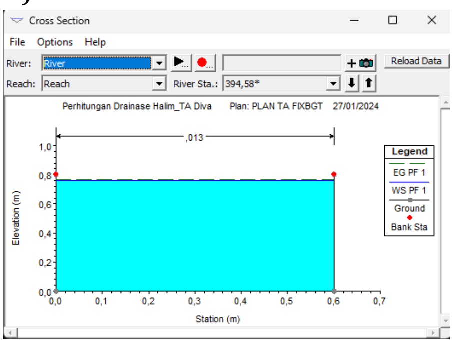
$$Q_S = 0{,}881\,\frac{m}{detik}\,x\ 0{,}48\ m2$$

$$Q_S = 0{,}423\ m3/detik$$

The Q value of the channel or Qs should be greater than the Q value of runoff, so that the drainage is able to accommodate the overflowing water. The Qs value was obtained at 0.423 m3/s and the runoff Q value was 0.387 m3/s. This means that the u-ditch type drainage with a cross section of 600 x 800 mm along 473.5 on the north and south sides of the building can accommodate overflowing water coming from the roof of the building.

d. Drainage Channel Needs Analysis Using HEC-RAS

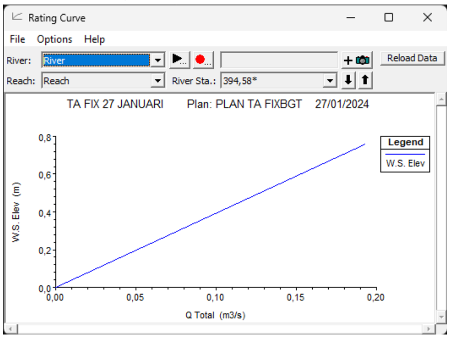
1) Cross Section



Picture 2. Cross Section Analysis Results

From the results of the analysis, it can be seen that the drainage channel measuring 600 x 800 mm is able to accommodate water runoff from the catchment area (station roof).

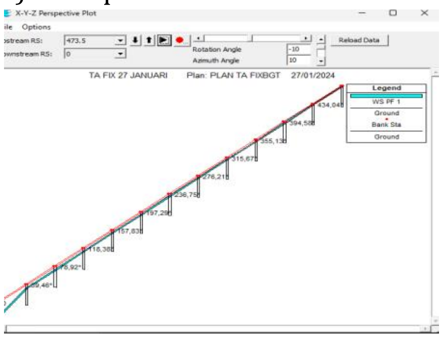
2) Rating Curve



Picture 3. Rating Curve Analysis Results

The rating curve will display the relationship between the stage (river surface) and the river flow (discharge) in addition to showing the sediment boundary load based on flow.

3) Perspective Plot



Picturw 4. Results of Perspective Plot Analysis

Using the perspective of plot XYZ, it is possible to see how the elevation of the river and topographic conditions change along the river, as well as how the flow of water will respond to changes in the elevation and geometry of the river. This helps engineers and planners in making better decisions regarding the design and management of rivers.

6. CONCLUSION

Based on the results of the analysis that has been calculated in the previous chapter are as follows :

a. Average rainfall in Halim is 150,700 mm.

b. The water discharge that can be accommodated using the catchment area in the form of the roof of Halim Station of 31,500 m2 is 0.392 m3/s.

c. The operational water requirement of Halim Station is 339,747 liters/day.

d. The efficiency of using rainwater as a substitute water source for the operational needs of Halim Station is 100%. The efficiency of using rainwater as a substitute water source for the operational needs of Halim Station is 100%.

e. In addition to making infiltration wells, overflowing water can also be channeled with drainage channels measuring 600 x 800 mm along 473.5 on the north and south sides of the station.

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