Engineering and Technology Journal e-ISSN: 2456-3358

Volume 09 Issue 05 May-2024, Page No.- 4113-4120

DOI: 10.47191/etj/v9i05.30, I.F. – 8.227

Analysis of Handling Flooding on Airport Runways

Acep Hidayat

Department of Civil Engineering, Universitas Mercu Buana, Jakarta, Indonesia

ABSTRACT: The existing drainage conditions on the runway at Halim Perdanakusuma Airport have decreased in service function due to the lack of drainage channel capacity so that it cannot accommodate rainwater, this causes water to invalidate the runway of Halim Perdanakusuma Airport. This drainage system analysis refers to Runway drainage. Hydrological analysis is carried out to obtain the planned flood discharge using HEC-HMS Software, Normal Distribution, Gumbel Distribution, Log Normal Distribution and Log Pearson Type III Distribution. Hydraulics analysis is carried out to calculate the capacity of existing channels using EPA-SWMM 5.1 Software. The capacity of existing drainage channels based on analysis using EPA-SWMM 5.1 Software there are 5 channels out of 11 channels that have an existing discharge smaller than the planned flood discharge. The five channels are C3, C4, C5, CD01 and CD02. The alternative flood inundation management system used in this problem is a detention pond with a pump. The dimensions of the planned detention pond measuring 120m x 114m x 3.5m along with the use of a 2m3/sec pump has a capacity of 47880 m3. Therefore, the flood volume that needs to be accommodated < the storage volume of the pond (46199 m3 < 47880 m3).

KEYWORDS: Airport Drainage; Drainage; Flood Puddle.

I. INTRODUCTION

To improve flight safety, security and comfort, the revitalization of Halim Perdanakusuma Airport includes improving ground and air facilities. Construction on land and in the air will be carried out. This work includes improvements to the runway and taxiway, increasing the capacity of the Naratetama and Naratama aircraft aprons; renovation of the Naratetama and Naratama buildings; improvement of the airport drainage system; and arrangement of other facilities.

II. RESEARCH METHOD

Secondary data is needed to analyze the Halim Perdana Kusuma Airport drainage system. The rainfall station within the airport area, Halim Perdana Kusuma Meteorological Station (06o16'70"LS – 106o53'E), collected rainfall data for 42 years, from 1980 to 2021. Hydrological analysis was carried out with the HEC-HMS v.4.9 program. Catchment area (DTA) delineation is the first step in hydrological analysis. The goal is to determine the distance that rain will flow towards the location to be reviewed. The HEC-HMS v.4.9 application is used to delineate the Cipinang River water catchment area. The delineation process is automated with geographic information system (GIS) features. This process requires DEM (Digital Elevation Model) data, which is used from DEMNAS data.

The HEC-HMS v.4.8 application is used to delineate water catchment areas. To automate this process, geographic information system (GIS) features are included. This process requires DEM (Digital Elevation Model) data, which is used from DEMNAS data.

The results of this delineation will be used in hydrological analysis. In addition, HEC-HMS software can calculate various spatial parameters in the analyzed DTA model.

Meanwhile, delineation of the internal drainage catchment area was carried out using Google Earth Pro. The planned flood discharge for each drainage channel is calculated using the HEC-HMS program. Flood hydrographs are used to calculate flood discharge. Furthermore, the hydrograph is used as a basis for planning the dimensions of the channel system. The dimensions of the drainage system capable of accommodating the planned discharge are generated using the EPA-SWMM 5.1 program and calculated using the Manning formula.

III. RESULT AND DISCUSSION

Hydrological Analysis

Stages for hydrological analysis include:

1. Delineation of Water Catchment Areas (DTA)

At the research location, the Halim Perdanakusuma Airport runway has internal drainage and cross drain due to runoff from the Cipinang River. Therefore, determining the water catchment area for cross drain is carried out separately from internal drainage. In delineating the Cipinang River catchment area, the HEC-HMS v.4.9 application was used. The data needed in this process includes a DEM (Digital Elevation Model) map, which in this case uses DEMNAS data.

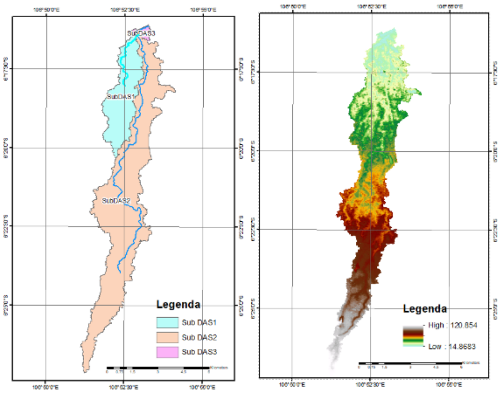

Figure 1.Cipinang River Catchment Area Boundaries
(Source: Researcher, 2024)

Meanwhile, delineation of the internal drainage catchment area was carried out using Google Earth Pro. There were 8 catchment areas as shown in Figure 2 with detailed parameters as in Table 1.

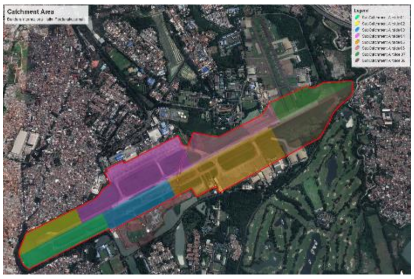

Figure 2. Catchment Area
Halim Perdanakusuma Airport
(Source: Researcher, 2024)

Table 1. Size and Slope of Halim Perdanakusuma Airport Catchment Area

Catchment	A		Slopes
	(m2)	(Ha)	%
AirSide 01	110830	11.0830	0.84
AirSide 02	77525	7.7525	0.49
AirSide 03	108843	10.8843	0.76
AirSide 04	287051	28.7051	1.4
AirSide 05	292246	29.2246	1
AirSide 06	150562	15.0562	0.81
AirSide 07	118145	11.8145	1.4
AirSide 08	195743	19.5743	1.4

(**Source:** Researcher, 2024)

2. Precipitation Plan

In the previous sub-chapter, frequency distribution analysis, distribution suitability testing and distribution selection were carried out. This analysis will be used in determining planned rainfall. A recapitulation of the results of the planned rainfall analysis is presented in Table 2.

Table 2.Determination of Planned Rainfall

Precipitation Plan				
Frequency Distribution Analysis				
Tr (Year)	**Normal**	**Gumbel**	**Normal Logs**	**Pearson Log Type III**
100	263	333	277	354
50	246	298	248	299
25	229	263	223	250
10	203	215	191	195
5	178	178	163	159
2	130	121	121	114

(**Source:** Researcher, 2024)

3. Planned Rain Intensity

Rain intensity is the amount of rain expressed in terms of rain height or rain volume per unit of time. The intensity varies depending on the rainfall area. To analyze rainfall, the Mononobe equation is used. Calculation of Rain Intensity is calculated up to 24 hours with a certain return period using the equation:

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

Table 3. Determination of Planned Rainfall

Distribution Suitability Test				
Chi-Square Test				
X2 Count	*20.00*	*17.67*	*13.00*	*70.67*
X2 Critical	*9,488*	*9,488*	*9,488*	*9,488*
Conclusion	*Not Representing*	*Not Representing*	*Not Representing*	*Not Representing*
Smirnov-Kolmogorof test				
D Count	*0.1978599*	*0.1978599*	*0.1494450*	*0.1494450*
D Critical	*0.206*	*0.206*	*0.206*	*0.206*
Conclusion	*Represent*	*Represent*	*Represent*	*Represent*
Distribution Selection				
Cs	*2.393619*	*2.393619*	*1.072276*	*1.072276*
	Does not meet the	*Does not meet the*	*Does not meet the*	*Fulfil*
Tsk	*10.716946*	*10.716946*	*4.481144*	*4.481144*
	Does not meet the	*Does not meet the*	*Does not meet the*	*Fulfil*
Conclusion	*For planning, take the largest planned rainfall, so that the plan design can anticipate large rainfall in the future and represent the statistics of the data being analyzed. The selected distribution is Log Pearson Type III*			

(**Source:** Researcher, 2024)

Table 4. Analysis of Planned Rain Intensity Calculations

t	**R24**					
	R2	**R5**	**R10**	**R25**	**R50**	**R100**
(O'clock)	**114**	**159**	**195**	**250**	**299**	**354**
	Rainfall Intensity (mm/hour)					
0	0	0	0	0	0	0
1	39.61	54.96	67.57	86.73	103.54	122.78
2	24.96	34.62	42.57	54.64	65.23	77.35
3	19.04	26.42	32.49	41.70	49.78	59.03
4	15.72	21.81	26.82	34.42	41.09	48.73
5	13.55	18.79	23.11	29.66	35.41	41.99
6	12.00	16.64	20.46	26.27	31.36	37.18
7	10.83	15.02	18.47	23.70	28.30	33.55
8	9.90	13.74	16.89	21.68	25.89	30.69
9	9.16	12.70	15.62	20.04	23.93	28.38
10	8.53	11.84	14.56	18.69	22.31	26.45
11	8.01	11.11	13.66	17.53	20.93	24.82
12	7.56	10.48	12.89	16.55	19.75	23.42
13	7.17	9.94	12.22	15.69	18.73	22.21
14	6.82	9.46	11.63	14.93	17.82	21.14
15	6.51	9.04	11.11	14.26	17.02	20.19
16	6.24	8.66	10.64	13.66	16.31	19.34
17	5.99	8.31	10.22	13.12	15.66	18.57
18	5.77	8.00	9.84	12.63	15.08	17.88
19	5.56	7.72	9.49	12.18	14.54	17.24
20	5.38	7.46	9.17	11.77	14.05	16.66
21	5.20	7.22	8.88	11.39	13.60	16.13
22	5.05	7.00	8.61	11.05	13.19	15.64
23	4.90	6.80	8.35	10.72	12.80	15.18
24	4.76	6.61	8.12	10.42	12.44	14.76

(**Source:** Researcher, 2024)

The following is an illustration of the IDF curve, which is a tool that can be used to calculate the planned flood discharge needed in planning flood control buildings.

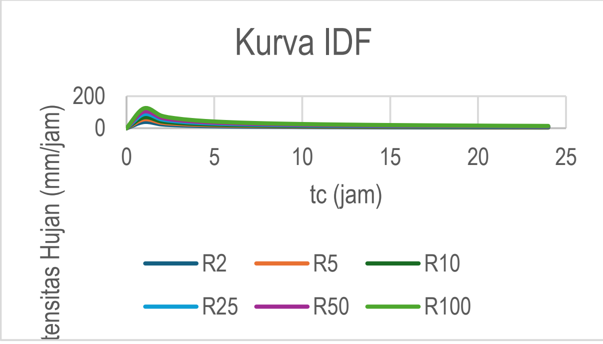

Figure 3.Mononobe Method IDF Curve
(Source: Researcher, 2024)

4. Flood Hydrograph Designed by the SCS Method for the Cipinang River Watershed

The physical representation of water catchment areas and rivers is composed of basin models. Hydrological elements are connected in a network that simulates a surface runoff process. Unit hydrograph modeling has the weakness of large areas, so it is necessary to separate the basin area into several subbasins based on data from the map. The elements used to simulate runoff are subbasin, reach, and junction. The HEC-HMS model for the Cipinang River watershed is shown in Figure 4. below.

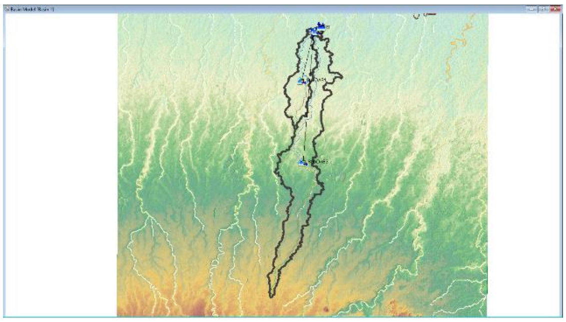

Figure 4 .HEC-HMS Model of the Cipinang River Watershed
(Source: Researcher, 2024)

The hydrological elements in the HEC-HMS model are as follows:

1. Subbasin

The data entered in the subbasin are:

a. Area

Table 5. Sub-watershed area of the HEC-HMS model of the Cipinang River watershed

Sub DTA	Area (km2)
Subwatershed1	8.9753
Subwatershed2	29,774
Subwatershed3	0.6112

b. Loss Method

Table 6.CN and impervious value for land use

No.	Land Use	Impervious(%)	Curve Number(CN)			
			A	B	C	D
1	Thicket	5	68	79	86	89
2	Forest	5	48	67	77	83
3	City	65	89	92	94	95
4	Bare Land	5	77	86	91	94
5	Settlement	15	77	85	90	92
6	Plantation	5	45	66	77	83
7	Farm	5	59	74	82	86
8	Ricefield	5	68	79	86	89
9	Moor	5	65	76	84	88
10	Pond	100	71	80	87	88

(Source: LPPM Undip, 2014)

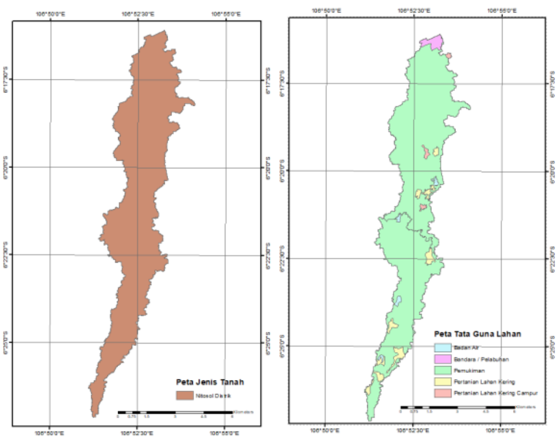

Figure 5. Map of Soil Types and Land Use of the Cipinang River Watershed (Source: Researcher, 2024)

2. Reach

The reaches in the model represent the main rivers. The input data for reach is the Routing method. The method used in this model is the Muskingum method. The required parameters are Muskingum x and Muskingum K. The tracking constants K and x are determined empirically from observations of inflow and outflow at the same time. The x factor is a weighing factor whose magnitude ranges from 0 to 1, usually smaller than 0.5 and in many cases the magnitude is approximately the same as 0.3 and is dimensionless. The K factor itself has a definition that is similar to time of concentration in the time dimension. Considering the limitations of the tool, the K factor is estimated using the lag time equation issued by the USDA. The following is the calculation of routing parameters in the HEC-HMS model of the Cipinang River DAS.

$$Tc = \frac{L^{1.15}}{7700 \times H^{0.38}}$$

$$= \frac{3973.753^{1.15}}{7700 \times (3973.753 \times 0.00177)^{0.38}} = 0.852 \text{ jam}$$

$$Tp = 0.6 \times Tc = 0.6 \times 0.852 = 0.511 \text{ jam}$$

Where:
Tc = Timeconcentration (hours)
L = Lengthmaximum path (ft)
H = Differences in upstream and downstream elevations

Based on the calculation above, the value is obtained
Muskingum K = 0.852 hours
Muskingum x = 0.4

3. Junction

Junctionin the model represents the confluence of rivers or the mouth of a river. Input data at the junction is only downstream or downstream. At the junction it is also necessary to determine where the downstream location is. The downstream in question can be a reach or junction.

Table 7. Cipinang River Watershed Design Flood Discharge

Time	**Design Flood Discharge (m3/sec)**					
O'clock	**Q2th**	**Q5th**	**Q10th**	**Q25th**	**Q50th**	**Q100th**
0	0	0	0	0	0	0
1	0.8	1.1	1.5	2	2.4	3
2	6.9	9.8	12.3	16.1	19.4	23.3
3	11	15.9	20	26.3	31.8	38.2
4	15.3	22.5	28.4	37.6	45.6	54.9
5	23.6	34.7	43.9	58.1	70.6	84.9
6	33.5	49.1	62.1	82	99.6	119.7
7	41.8	61.3	77.4	102	123.7	148.5
8	47.9	70.1	88.5	116.5	141.2	169.5
9	52.2	76.2	96.2	126.6	153.3	184
10	54.6	79.7	100.4	132.1	160	191.9
11	54.9	80.1	101	132.8	160.8	192.8
12	54.1	78.9	99.5	130.8	158.4	190
13	53.4	77.9	98.2	129.1	156.3	187.4
14	52.2	76.1	95.9	126.1	152.6	183.1

Time	Design Flood Discharge (m3/sec)					
O'clock	Q2th	Q5th	Q10th	Q25th	Q50th	Q100th
15	50.7	73.9	93.1	122.5	148.2	177.8
16	48.8	71.1	89.6	117.8	142.6	171
17	46.2	67.4	84.8	111.5	134.9	161.8
18	43.2	62.9	79.3	104.2	126.1	151.1
19	40.1	58.4	73.6	96.7	117	140.3
20	36.8	53.7	67.6	88.8	107.4	128.7
21	33.2	48.4	60.9	80	96.7	115.9
22	29.2	42.5	53.4	70.2	84.8	101.7
23	25.1	36.6	46	60.4	73	87.5
24	21.7	31.5	39.7	52.1	63	75.5
25	18.9	27.5	34.6	45.4	55	65.9
26	16.6	24.1	30.4	39.9	48.3	57.8
27	14.6	21.2	26.7	35	42.4	50.8
28	12.8	18.7	23.5	30.9	37.4	44.8
29	11.4	16.6	20.9	27.4	33.1	39.7
30	10.1	14.7	18.5	24.3	29.4	35.2
31	8.9	13	16.3	21.5	26	31.1
32	7.8	11.4	14.3	18.8	22.8	27.3
33	6.9	10	12.6	16.5	20	23.9
34	6	8.8	11.1	14.5	17.6	21.1
35	5.3	7.8	9.8	12.9	15.6	18.6
36	4.7	6.9	8.7	11.4	13.8	16.5
37	4.2	6.1	7.7	10.1	12.2	14.6
38	3.7	5.4	6.8	8.9	10.7	12.9
39	3.2	4.7	5.9	7.8	9.4	11.3
40	2.9	4.2	5.2	6.9	8.3	10
41	2.5	3.7	4.6	6	7.3	8.8
42	2.2	3.2	4.1	5.3	6.5	7.7
43	2	2.9	3.6	4.7	5.7	6.9
44	1.7	2.5	3.2	4.2	5.1	6.1
45	1.5	2.2	2.8	3.7	4.5	5.4
46	1.4	2	2.5	3.3	4	4.8
47	1.2	1.8	2.2	2.9	3.5	4.2
48	1.1	1.6	2	2.6	3.1	3.7

(Source: Researcher, 2024)

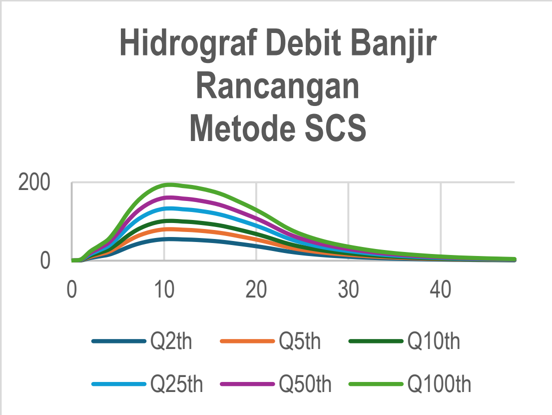

Figure 6. Flood Discharge Graph for Cipinang River Watershed Design SCS Method
(Source: Researcher, 2024)

Hydraulic Analysis

Hydraulic analysis was carried out using EPA SWMM 5.1 software with input data based on the results of hydrological analysis and field measurement data. The object being modeled is the Halim Perdanakusuma International Airport area which includes all buildings, land and the existing drainage network. The land of Halim Perdanakusuma International Airport has an area of 1340945 m2 based on calculations and digitization from Google Earth.

Figure 7. Halim Perdanakusuma Airport Land Area
(Source: Researcher, 2024)

Table 8. Halim Perdanakusuma International Airport Drainage Channel Data

No	Junction ID	Inflow	Inverted Elevation (m)
1	J01	NO	24.7
2	Cipinang01	NO	22.7
3	J02	NO	25.5
4	Cipinang02	NO	22.5
5	J03	NO	24.7
6	JCD01	YES	20.81
7	J04	NO	25.5
8	JCD02	NO	18,815

9	J05	NO	26.15
10	J06	NO	25.5
11	JCD03	NO	18.2
12	J07	NO	25.27
13	Sunter02	NO	22.6
14	J08	NO	26.3
15	Sunter01	NO	23.7
16	Cipinang03	NO	17,102

(**Source:** Researcher, 2024)

Junction JCD01 acceptsinflowaddition of the Cipinang River. This needs to be modeled on the drainage hydraulic system of Halim Perdanakusuma International Airport.

a. Rainfall

The rainfall intensity data used in EPA SWMM 5.1 is based on the results of previous hydrological analysis, namely using a return period of 10 years.

Table 9. Rainfall during the 10 year return period

t (hours)	Time	P
1	1:00	22,387
2	2:00	122,786
3	3:00	31,915
4	4:00	17,823

(**Source:** Researcher, 2024)

Based on the results of the channel capacity analysis of the existing drainage system at Halim Perdanakusuma International Airport, there are 5 red sections where the red color indicates that the channel capacity is fully filled and overflowing.

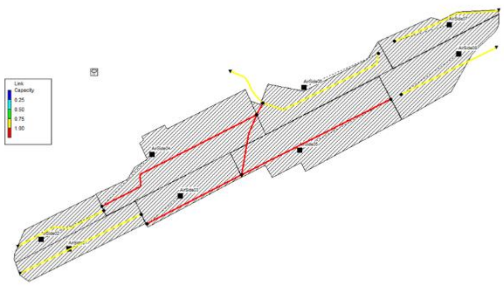

Figure 7. Existing Condition Drainage Channel Capacity (Source: Researcher, 2024)

1. Detention Pool and Pump with Flood Routing

In a flood management system, a detention pond is planned at the downstream drainage point before entering the collector channel. Therefore, the pool volume must be able to accommodate flooding from nodes JCD01, JCD02, and JCD03. The following is the calculation of detention pond dimensions using the flood routing method.

Based on drainage simulations using EPA SWMM 5.1, the following data were obtained:
Concentration time (tc) = 8,212 minutes
Td = 7,153 minutes
Qmax = 4,116 m3/second (located at the downstream junction)
Flood duration = 126 minutes
Flood volume that must be accommodated
= JCD01 + JCD02 + JCD03
= 27074 + 13561 + 5564
= 46199 m3
With a retention pond depth of 3.5 m, it can be calculated:
Retention pond area
= ((Maximum Volume)/(Pool Depth))
= (47617.023/3.5)
= 13604.864 m2
Planned:
Detention pool width = 120 m
So it can be calculated:
Detention pool length
= 13604.864 m2 / 120 m
= 113.374 m≈ 114 m
Check the capacity of the detention pool
Vpool ≥ Vflood
120 m x 114 m x 3.5 m ≥ 46199 m3
47880 m3 ≥ 46199 m3 (OK)
So, the flood volume that needs to be accommodated < the volume of the pool storage (46199 m3 < 47880 m3). This means that the detention pond is able to accommodate flooding that occurs with a pump capacity of 2m3/second.

IV. CONCLUSIONS

Based on the analysis and discussion in this study, the following conclusions can be drawn:

1. Operational performance of Trans Metro Pasundan Corridor 2: The highest load factor was recorded at Poll B at 15:30 (94.07%), while the lowest was at Poll A at 15:30 (23.79%). The longest travel time occurred at Poll B at 15:30 on May 23, 2023 (91.55 minutes) due to heavy traffic. Some load factors do not meet the World Bank standards, for example, at Poll A at 06:30 on March 23, 2023. However, travel time complies with the standards for distances of 21 km and 23 km (10-12 km per hour). Headway between 5-13 minutes meets the standard (10-20 minutes).
2. Perceptions of passenger satisfaction and expectations for Trans Metro Pasundan Corridor 2 based on attributes with scores below 80% include: provision of facilities at shelters/stops, availability of Polls, provision of information boards, comfort, cleanliness, ticket machine availability, garbage bins, waiting seats, city maps, route maps, shelter availability, number of shelters, ease of use of the Bus Friend application, and waiting time between

buses. Attributes in quadrant I are the top priority for improvement, including facility provision, waiting seats, city maps, route maps, ticket machines, information boards, shelter availability, Poll availability, number of shelters, ease of use of the Bus Friend application, comfort, and garbage bins. These 12 attributes have a significant impact on passenger satisfaction and must be improved.

3. Evaluation of service conditions based on the Customer Satisfaction Index value for Trans Metro Pasundan Corridor 2 services is 73.078, which falls within the interval of 66.00-80.99, indicating that passengers are "Satisfied" with the performance of Trans Metro Pasundan Corridor 2 services.

REFERENCES

1. Andriyani, A., Dermawan, W. B., Isradi, M., & Rifai, A. I. (2021). Operational Performance Analysis of Rapid Transit Bus (BRT) Corridor 11 in Pulogebang Bus Station. World Journal of Civil Engineering, 2(2), 71–80. http://world.journal.or.id/index.php/wjce%0AAttribution
2. Ariostar, A., Muttaqin, A. W., Adriadi, A., Andiyan, A., & Irawan, S. (2022). Implementasi Standar Pelayanan Minimal Bus Trans Metro Bandung Koridor 1. Jurnal Komposit: Jurnal Ilmu-Ilmu Teknik Sipil, 6(1), 9–16.
3. Bakar, M. F. A., Norhisham, S., Katman, H. Y., Fai, C. M., Azlan, N. N. I. M., & Samsudin, N. S. S. (2022). Service Quality of Bus Performance in Asia: a Systematic Literature Review and Conceptual Framework. Sustainability, 14(13), 7998.
4. BPS-West Java. (2020). Transportation Statistics of West Java Province 2020. Central Bureau of Statistics of West Java Province.
5. Chikkabagewadi, S., Devappa, V. M., & Karjinni, V. V. (2022). Evaluation of the Bus Service Quality and a Strategy for Improvement Service: Based on Importance Performance Analysis and Customer Satisfaction Index Level. Journal of Pharmaceutical Negative Results, 5441–5453.
6. Dermawan, W. B., Bimantara, F., & Isradi, M. (2021). Passenger Satisfaction Analysis on Bekasi Station Service Performance. IJTI International Journal of Transportation and Infrastructure, 5(1), 36–43.
7. Dwiatmoko, H., Isradi, M., Prasetijo, J., & Hamid, A. (2022). Comparative Study of the Passenger's Satisfaction with Regional Rail Transport in Indonesia and Malaysia. European Journal of Science, Innovation and Technology, 2(2), 32–40. http://www.ejsit-journal.com/index.php/ejsit/article/view/94/81
8. Esmailpour, J., Aghabayk, K., Vajari, M. A., & De Gruyter, C. (2020). Importance–Performance Analysis (IPA) of Bus Service Attributes: A Case Study in a Developing Country. Transportation Research Part a: Policy and Practice, 142, 129–150.
9. Firdaus, H. Y., Isradi, M., Prasetijo, J., & Rifqi, M. (2021). Performance Analysis and Passenger Satisfaction on Trans Jakarta Bus Services (Cibubur Route – BKN). Journal of Science, Technology, and Engineering (JSTE), 1(2), 73–81.
10. Firdaus, H. Y., Isradi, M., Prasetijo, J., Rifqi, M., & Halim, H. (2022). Analysis of Transjakarta Service Performance on the Cibubur-BKN by Servqual Method. European Journal of Science, Innovation and Technology, 2(1), 113–123.
11. Isradi, M., Arifin, Z., Setiawan, M. I., Nasihien, R. D., & Prasetijo, J. (2022). Traffic Performance Analysis of Unsignalized Intersection Using the Traffic Conflict Parameter Technique. Sinergi, 26(3), 397. https://doi.org/10.22441/sinergi.2022.3.015
12. Isradi, M., Farhan, M. N., Rifai, A. I., & Mufhidin, A. (2021). Analysis of Passenger Satisfaction with LRT Jakarta Services Route Velodrome - Boulevard Utara. IJTI (International Journal of Transportation and Infrastructure), 5(1), 26–35.
13. Isradi, M., Molina, P., Rifai, A. I., Mufhidin, A., & Prasetijo, J. (2021). Evaluation of Performance and Services of Integrated Transportation System (Case Study: Connecting Line between MRT Dukuh Atas Station and KRL Sudirman Station). Proceedings of the International Conference on Industrial Engineering and Operations Management, 496–507.
14. Rachmadina, Y., Isradi, M., Prasetijo, J., Negara Dalimunte, A. K., & Mufhidin, A. (2023). Analysis of the Choice of Commuter Line Electric Rail Train (Krl) Modes and Transjakarta Buses for the Bekasi City - East Jakarta Route. Engineering and Technology Journal, 8(08), 2655–2664. https://doi.org/10.47191/etj/v8i8.23
15. Rifai, A. I., Lista, Isradi, M., & Mufhidin, A. (2021). How did the COVID-19 Pandemic Impact Passenger Choice toward Public Transport? The Case of Jakarta, Indonesia. Design Engineering, 2(8), 6816–6824.
16. Sum, S., Champahom, T., Jomnonkwao, S., & Ratanavaraha, V. R. (2019). An Application of Importance-Performance Analysis (IPA) for Evaluating City Bus Service Quality in Cambodia. International Journal of Building, Urban, Interior and Landscape Technology (BUILT), 13, 55–66.
17. Suria, H., Ahmad, F. M., & Siti, N. S. (2019). Bus Service Indicator: The Different Sight of Performance Index Development. Journal of Physics: Conference Series, 1349(1), 12049.

18. Suprapti , Feril Hariati , Acep Hidayat , Nuryanto , Siti Kholifah Syaja'ah (2024) Effectiveness of LID Infiltration Well Model Technology to Reduce Runoff in Bumi Citra Asri Housing Complex, Bogor, Jurnal Komposit: Jurnal Ilmu-ilmu Teknik Sipil Vol. 8 No. 1 (2024) pp. 153-162 DOI: http://dx.doi.org/10.32832/komposit.v8i1.14983