

## **EVALUATION PASSENGER CAR UNIT FOR MOTOR CYCLE IN INDONESIA HIGHWAY CAPACITY MANUAL**

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### **Abstract**

Value of Passenger Car Unit or commonly known as Pcu value is a value that is given to any vehicle that is classified into heavy vehicles, light vehicles (passenger car) and motorcycles. The value of passenger car unit on Indonesia Highway Capacity Manual (IHCM) set up in 1997 is based on a study conducted from 1980-1990 in several cities in Indonesia. At the time of the study, the traffic conditions are very different to the current traffic conditions. That affects of difference traffic conditions are the composition of traffic, traffic regulations, traffic density, traffic discipline and the presence of mass transit, so that the results of traffic analysis do not always correspond to reality as there are anomalies in the determination of the level of road service (Najid, 2014). As well the incompatibility of the capacity value which is considered due to the incompatibility value of Passenger Car Units (Pcu).

Evaluation Pcu become very important to get the value of traffic parameters into compliance with actually occur. In accordance with the traffic density is higher actually, then it is necessary to study for evaluation against Pcu current value and the need to approach or to get the value of Pcu more in line with current traffic conditions. Data collected at two cities, those are Jakarta and Bandung. Based on analysis found pcu's value that got from survey have difference but not all significantly with pcu value in IHCM.

**Keywords:** Passenger car unit, headway, IHCM.

### **1 BACKGROUND**

As we know that actually the use of private transport is very high, especially motorcycles in almost cities in Indonesia especially Jakarta, according to data for 8 years the number of motorcycles in Jakarta has increased three-fold, namely from 2,212,961 in 2000 become 6,765,723 in 2008, while on some routes passengers of public transport decreased significantly. This shows the displacement of demand from public transport to private transport.

The length of roads in the city of Jakarta to only 6.28 percent of the total area, while the number of vehicles in Jakarta reached 9,993,867 units that show growth of 10.79 percent per year. Based on the fact the last five years increasing the number of vehicles in Jakarta showed increases every day as many as 1,127 new vehicles consists of 236 cars and 891 motorcycles. Even in Jabodetabek daily grows new vehicles as much as 2,027 vehicles consists of 319 cars and 1,707 motorcycles and so the same condition in Bandung.

The high use of private transport that cause in-efficiency of urban transportation, so the level of road service to be down. The fall in the level of road service is an indicator that can be used by the Government in road development planning. The problem is in the analysis of the results obtained often not appropriate like traffic volume is greater than

capacity so that ratio of volume and capacity be more than one. Therefore, the determination of the value of passenger car unit which is the decisive factor in the calculation of traffic volume becomes very important to be evaluated.

The calculation of road capacity in IHCM using passenger car unit that strongly influenced by the condition or characteristics of the vehicle, traffic as well as by the characteristics of the road it self based on its function. So in this research need survey conducted in various road type.

## 2 RESEARCH OBJECTIVES

This research aims to :

- Determining the value of passenger car unit based on survey result.
- Identify relationships between types of road with the passenger car unit values.
- Formulate the magnitude of the mismatch between the value of passenger car unit based on survey and based IHCM.

## 3. PROBLEM IDENTIFICATION AND LIMITATION

- Value of Pcu in IHCM look too optimistic and rude.
- Value of Pcu in IHCM not consider the actual service conditions.
- Pcu value that evaluated and analyzed is pcu value for urban roads.

## 4. REVIEW OF LITERATURE

Directorate General Bina Marga (2010) has recorded the total length of the existing road network in Indonesia, which reached 376176 km consisting toll road 741.97 km (0.20%), non-toll national roads 38 569 km (10.25%), road provinces 48 681 km (12.94%), district road 255 253 km (67.85%) and urban road 32 932 km (8.75%). In-efficiency traffic movement take place on urban roads in everyday.

As stated in the background the growth of private vehicle is cause declining the level of service in the mark with declined travel speed and increased the density of traffic on the road. The calculation of traffic volume is highly influenced by the value of Pcu (Passenger Car Unit). Value of Pcu is the value of equality of another vehicle to vehicle passenger cars were categorized as light vehicle (LV), while other vehicles are motorcycles (MC) and heavy vehicles (HV) including all medium bus and big bus as well as all the trucks.

The Directorate General of Highways, Ministry of Public Works in cooperation with the consultant at that time Sweroad of Sweden make traffic's handbook named Indonesian Highway Capacity Manual (IHCM) in year 1997. The manual has been made for determination of the pcu value of vehicles based on traffic conditions and the road conditions. Pcu value of the vehicle is also distinguished in urban areas or in areas between cities. The following Table 4a-4c shows the value for the urban pcu based IHCM 1997:

Table 4a. Intersection

Vehicle Type	Pcu Protected	Pcu Opposed
Light Vehicle (LV)	1	1
Heavy Vehicle (HV)	1.3	1.3
Motor Cycle (MC)	0.2	0.4

Table 4b. Urban Road (Undivided Road)

Road Type	Traffic Flow 2 ways (vehicle/hour)	Pcu		
		HV	MC	
			Road Width, Wc (m)	
			≤ 6	> 6
2 lanes undivided (2/2 UD)	0-1799	1.3	0.50	0.40
	≥ 1800	1.2	0.35	0.25
4 lanes undivided (4/2 UD)	0-3699	1.3	0.40	
	≥ 3700	1.2	0.25	

Table 4c. Urban Road (Divided Road)

Road Type	Traffic Flow/lane (Vehicl/hour)	Pcu	
		HV	MC
2 lanes 1 Way (2/1)	0-1049	1.3	0.40
4 lanes 2 Ways (4/2 D)	≥ 1050	1.2	0.25
3 lanes 1 Way (3/1)	0-1099	1.3	0.40
6 lanes 2 Ways (6/2 D)	≥ 1100	1.2	0.25

The magnitude of the dimensions of the vehicle will affect the value of pcu (Izumi Okura, 2006). Research to determine the value of Pcu been done by some researchers. either on the road section and at signalized intersection or intersection is not signalized. Past research in Surakarta by Rosma in determining pcu at signalized intersections. Value of motorcycle's pcu was determined with linear regression method, result of the research a value of motorcycle's pcu between 0.11 to 0.2. As for bus passengers's pcu between 1.02 to 1.72 (Rosma I, 2003).

## 5. METHODOLOGY

Flow chart showing the systematic study of the prose of this research can be seen in Figure 1 as follow:

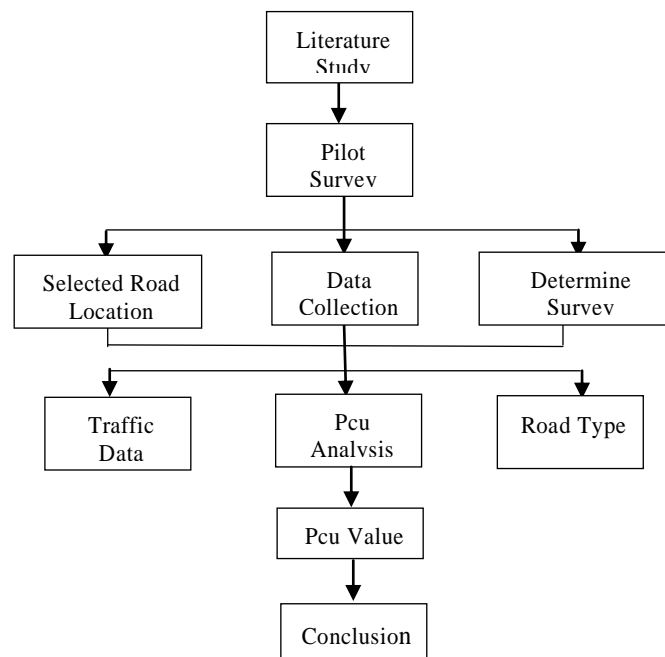


Figure 1 : Methodology

## 6. DETERMINING FACTOR PASSENGER CAR UNIT

To determine Pcu value, be used headway's method (Scraggs, 1964). In this method, Pcu various types of vehicles on the certain condition at certain road type calculated by headway's method. Estimated vehicles 1, 2, 3, ....., i, with the surveyed time of t1, t2, t3 ....., ti, is calculated as the vehicle passed the imaginer line. First Vehicle movement that passed the imaginer line be noted its time and the following vehicle be noted its time too. The difference of time is a headway. Do the same procedure for any following vehicle. The following vehicle consists of passenger car - motor cycle, motor cycle-passenger car, passenger car-passenger car and motor cycle-motor cycle.

$$Pcu = ((HSM-Q) / NSM) / (HCC-Q / NCC) \dots\dots(1)$$

Or

$$PCU.Sm = HAA / HCC \dots\dots\dots(2)$$

with:

HSM = Headway between motorcycle

HAA = Headway between motorcycle and car

HCC = Headway between car

Q = Correction Factor

NSM = total HSM

NCC = total HCC

## 7. DATA COLLECTION

Data collection is done on different types of roads in the city as the following:

At Jakarta

- Hasyim Ashari representing 6/2 D intensive business locations
- KH.Mas Mansyur represent 4/2 UD solid business location
- Ciputat 4/2 D represents a solid business location
- Senopati represent 2/2 UD residential location

At Bandung

- Pasteur 6/2 D represents intensive business location
- Dipati Ukur represent 4/2 UD solid business location
- Juanda represent 4/2 D solid business location
- Tubagus Ismail represent 2/2 UD residential location

### 7.1. Geometric Data Collection

To give an idea of the capacity of each road the following will be explained about the traffic conditions and road geometric conditions.

#### 7.1.1. Survey in Jakarta

The flow of traffic on all roads are relatively high, especially at rush hour. The following road geometric data for the survey areas in Jakarta:

- Hasyim Ashari road has a total road width of 21.3 m with a median width of 0.5 m and a width of sidewalks on both sides of the road each 2.5 m.
- KH.Mas Mansyur road whole road width is 14.6 m, with a median width of 0.5 m and a width of sidewalks on both sides of the road each 1.5 m.
- Ciputat road in whole width of the road is 16 m, with a median width of 0.5 to 1.5 m and width of sidewalks on both sides of road each 2.0 metre.
- Senopati road whole width of the road is 11 m, without median and a width of sidewalks on both sides of the road each 1.5 m.

### 7.1.2. Survey in Bandung

The flow of traffic on all roads are relatively high, especially at rush hour but still under Jakarta's road condition. The following road geometric data for the survey areas in Bandung:

- Pasteur road has a total road width of 23 metre with a median width of 0.5 metre and width of sidewalks on both sides of road each 2.0 metre.
- Dipati Ukur road whole road width is 10 metre, with a median width of 0.5 metre and width of sidewalks on both sides of the road each 1.5 metre.
- Juanda road in whole width of the road is 26 m, with a median width of 0.5 and width of sidewalks on both sides of road each 2.0 metre.
- Tubagus Ismail road whole width of the road is 9 metre, without median and width of sidewalks on both sides of the road each 1.5 metre.

As comparison population in Jakarta is 10,177,900 person and population in Bandung is 2,470,802 person. From the data survey shows that the number of motorcycles is quite high compared to other type of vehicles.

## 7.2. Data collection for Pcu of Motorcycles

Data collection techniques on the road is use simple tools like the regular stopwatch, pen and note's board. Because many factors can affect the accuracy of the data and usually the human factor is the most decisive. The survey result show on the tables 7.1-7.4 (Jakarta) and 7.5-7.8 (Bandung) as show below:

Table 7.1. Hasyim Ashari Road 6/2D

Period	Ta	Tc	Td	Tb	ta	tb
8.00-8.30	Mb-Mb	Mb-Mt	Mt-Mb	Mt-Mt	Xi-μ	Xi-μ
1	15	3	5	3	0.3	0.5
2	13.5	6	8	2	1.2	0.5
3	14	15	4	3	0.7	0.5
4	15	8	9	2.5	0.3	0
5	16	16	12	2	1.3	0.5
Σ	73.5	48	38	12.5	3.8	2
μ	14.7	9.6	7.6	2.5		
					ta	tb
9.00-9.30	Ta	Tc	Td	Tb	Xi-μ	Xi-μ
1	25	15	11	4	3.8	0.6
2	22	14	15	4	0.8	0.6
3	20	18	13	3	1.2	0.4
4	22	17	14	3	0.8	0.4

5	17	19	13	3	4.2	0.4
$\Sigma$	106	83	66	17	10.8	2.4
$\mu$	21.2	16.6	13.2	3.4		

In Table 7.1 (road 6/2 D) the headway between the car (Ta), car and motorcycle (Tc), motorcycle and car (Td) and motorcycle and motorcycle (Tb) in the morning (peak hour) is smaller than during the day but data deviation is higher, the analysis shows the traffic volume in the morning is higher and unstable than during the day.

Table 7.2. KH.Mas Mansyur Road 4/2 D

Period	Ta	Tc	Td	Tb	ta	tb
7.30-8.00	Mb-Mb	Mb-Mt	Mt-Mb	Mt-Mt	Xi- $\mu$	Xi- $\mu$
1	1.43	1.22	1.71	1.41	3.56	0.284
2	1.77	0.34	3.1	2.21	3.22	1.084
3	0.52	0.37	1.11	1.24	4.47	0.114
4	0.59	0.35	0.31	2.12	4.4	0.994
5	4.3	2.52	1.12	0.34	0.69	0.786
6	1.74	1.16	1.25	1.15	3.25	0.024
7	4.06	2.9	1.61	1.32	0.93	0.194
8	2.11	1.74	0.31	0.21	2.88	0.916
9	2.78	1.72	0.46	0.23	2.21	0.896
10	30.6	0.47	3.12	1.03	25.61	0.096
$\Sigma$	49.90	12.79	14.10	11.26	16.34	3.262
$\mu$	4.990	1.278	1.410	1.126		
					ta	tb
9.00-9.30	Ta	Tc	Td	Tb	Xi- $\mu$	Xi- $\mu$
1	1.46	1.71	0.52	0.5	0.733	0.254
2	1.7	1.8	1.45	0.39	0.493	0.364
3	1.88	1.42	0.89	0.67	0.313	0.084
4	1.43	0.32	0.72	0.46	0.763	0.294
5	1.32	1.88	0.52	0.89	0.873	0.136
6	1.77	0.31	0.5	0.63	0.423	0.124
7	1.8	0.98	1.51	0.35	0.393	0.404
8	2.11	1.24	1.46	1.44	0.083	0.686
9	4.27	0.45	1.34	1.62	2.077	0.866
10	4.19	0.8	1.15	0.59	1.997	0.164
$\Sigma$	21.93	10.91	10.06	7.54	3.175	1.132
$\mu$	2.193	1.091	1.006	0.754		

Table 7.2 (road 4/2 D) the headway between the car (Ta), car and motorcycle (Tc), motorcycle and car (Td) and motorcycle and motorcycle (Tb) in the morning (peak hour) is higher than during the day and data deviation is higher too, the analysis shows the traffic too sensitive in the narrow road.

Table 7.3. Ciputat Road 4/2 D

Period	Ta	Tc	Td	Tb	ta	tb
7.30-8.00	Mb-Mb	Mb-Mt	Mt-Mb	Mt-Mt	Xi- $\mu$	Xi- $\mu$
1	3.96	2.76	4.7	3.48	0.012	0.48
2	4.1	3.38	3.28	2.76	0.152	0.24
3	3.88	3.42	4.42	3.08	0.068	0.08
4	5.5	3.38	3.86	1.86	1.552	1.14
5	5.76	3.06	4.66	2.7	1.812	0.3
6	4.54	2.34	4.36	3.1	0.592	0.1
7	4.2	2.6	3.62	2.52	0.252	0.48
8	2.34	3.54	4.42	3.64	1.608	0.64
9	1.82	3.06	4.04	3.2	2.128	0.2
10	3.38	3.68	4.52	3.66	0.568	0.66

$\Sigma$	39.48	31.22	41.88	30.00	3.596	2.24
$\mu$	3.948	3.122	4.188	3		

					ta	tb
9.00-9.30	Ta	Tc	Td	Tb	Xi- $\mu$	Xi- $\mu$
1	3.16	0.84	4.32	2.14	0.882	0.498
2	3.38	5.66	1.02	2.68	0.662	0.042
3	7.2	1.9	2.28	2.8	3.158	0.162
4	2.24	1.96	1.54	2.8	1.802	0.162
5	4.64	2.24	1.04	2.32	0.598	0.318
6	3.14	2	2.28	2.44	0.902	0.198
7	4.38	2.34	2.14	3.4	0.338	0.762
8	4.88	1.2	1.32	2.6	0.838	0.038
9	4.14	1.34	2.82	3.4	0.098	0.762
10	3.26	1.56	2.46	1.8	0.782	0.838
$\Sigma$	40.42	21.04	21.22	26.38	7.102	1.182
$\mu$	4.042	2.104	2.122	2.638		

Table 7.3 (road 4/2 D) just the headway between the car (Ta) is smaller than during the day and the other headway are higher, the analysis shows the motorcycle volume in the morning than during the day.

Table 7.4. Senopati Road 2/2 UD

Period	Ta	Tc	Td	Tb	ta	tb
7.30-8.00	Mb-Mb	Mb-Mt	Mt-Mb	Mt-Mt	Xi- $\mu$	Xi- $\mu$
1	4.65	0.8	1.41	0.76	1.882	0.19
2	2.41	0.73	0.49	0.5	0.358	0.45
3	2.97	1.02	1.62	0.8	0.202	0.15
4	2.58	2.17	1.08	0.94	0.188	0.01
5	2.73	1.62	1.29	0.9	0.038	0.05
6	1.65	0.87	2.81	0.7	1.118	0.25
7	2.77	0.81	2.14	2.35	0.002	1.4
8	3.33	0.97	0.24	1.05	0.562	0.1
9	1.37	1.51	1.42	0.55	1.398	0.4
10	3.22	1.07	3.8	0.95	0.452	1.16
$\Sigma$	27.68	11.57	16.30	9.50	2.668	0.85
$\mu$	2.768	1.157	1.63	0.95		

					ta	tb
9.00-9.30	Ta	Tc	Td	Tb	Xi- $\mu$	Xi- $\mu$
1	1.62	0.92	2.01	0.29	0.065	0.679
2	0.6	1.43	1.49	1.21	1.085	0.241
3	1.65	1.74	0.57	0.9	0.035	0.069
4	1.93	0.67	1.47	0.38	0.245	0.589
5	1.28	0.73	0.42	1.49	0.405	0.521
6	1.91	0.63	0.45	0.73	0.225	0.239
7	1.9	2.04	0.5	0.77	0.215	0.199
8	2.03	1.12	1.63	1.31	0.345	0.341
9	1.9	1.9	1.93	0.27	0.215	0.699
10	2.03	0.56	1.11	2.34	0.345	1.371
$\Sigma$	16.85	11.74	11.58	9.69	1.835	2.099
$\mu$	1.685	1.174	1.158	0.969		

Table 7.4 (road 2/2 UD) the headway car and motorcycle (Tc), motorcycle and car (Td) and motorcycle and motorcycle (Tb) in the morning (peak hour) is rather similar than during the day except Ta, the analysis shows the traffic volume in the morning is not significantly different with during the day.

Table 7.5. Dipati Ukur Road 2/2 UD

Periode	Ta	Tc	Td	Tb	ta	tb
7.30-8.00	Mb-Mb	Mb-Mt	Mt-Mb	Mt-Mt	Xi- $\mu$	Xi- $\mu$
1	2.63	1.1	1.41	1.14	0.504	0.029
2	2.21	1.23	1.49	1	0.084	0.111
3	2.07	1.02	1.62	1.2	0.056	0.089
4	1.58	2.17	1.08	1.16	0.546	0.049
5	2.33	1.62	1.29	1.1	0.204	0.011
6	1.61	1.07	2.81	1.05	0.516	0.061
7	2.27	1.11	2.14	1.1	0.144	0.011
8	2.03	0.97	1.24	1.07	0.096	0.041
9	2.31	1.51	1.42	1.12	0.184	9E-03
10	2.22	1.07	3.8	1.17	0.094	0.059
$\Sigma$	21.26	12.87	18.3	11.11	1.394	0.289
$\mu$	2.126	1.287	1.83	1.111		
9.00-9.30	Ta	Tc	Td	Tb	ta	tb
					Xi- $\mu$	Xi- $\mu$
1	2.47	1.38	3.02	1.04	0.90	0.13525
2	2.40	2.15	2.24	1.82	0.84	0.64475
3	2.60	2.61	1.26	1.35	1.04	0.17975
4	1.00	1.01	2.21	1.07	0.56	0.10025
5	1.12	1.10	1.16	1.14	0.44	0.03275
6	1.09	0.97	1.08	1.10	0.469	0.07525
7	1.09	3.06	1.18	1.16	0.469	0.01525
8	1.45	1.68	2.45	0.99	0.109	0.18525
9	0.99	2.85	2.90	1.05	0.569	0.12025
10	1.40	1.04	1.67	1.01	0.162	0.16025
$\Sigma$	15.62	17.83	19.13	11.70	3.785	1.09275
$\mu$	1.562	1.783	1.91	1.17		

Table 7.5 (road 2/2 UD) the headway car and motorcycle (Tc), motorcycle and car (Td) and motorcycle and motorcycle (Tb) in the morning (peak hour) is rather similar than during the day except Ta and Tc, the analysis shows the traffic volume in the morning is not significantly different with during the day.

Table 7.6. Juanda Road 4/2 D

Periode	Ta	Tc	Td	Tb	ta	tb
7.30-8.00	Mb-Mb	Mb-Mt	Mt-Mb	Mt-Mt	Xi- $\mu$	Xi- $\mu$
1	6.98	1.20	2.12	1.14	2.823	0.285
2	3.62	1.10	0.74	0.75	0.537	0.675
3	4.46	1.53	2.43	1.20	0.303	0.225
4	3.87	3.26	1.62	1.41	0.282	0.015
5	4.10	2.43	1.94	1.35	0.057	0.075
6	2.48	1.31	4.22	1.05	1.677	0.375
7	4.16	1.22	3.21	3.53	0.003	2.1
8	5.00	1.46	0.36	1.58	0.843	0.15
9	2.06	2.27	2.13	0.83	2.097	0.6



10	4.83	1.61	5.70	1.43	0.678	0.16
$\Sigma$	41.52	17.355	24.45	14.25	4.002	1.275
$\mu$	4.152	1.7355	2.445	1.425		
9.00-9.30	Ta	Tc	Td	Tb	Xi- $\mu$	Xi- $\mu$
1	3.24	1.84	4.02	1.58	0.13	0.278
2	1.2	2.86	2.98	2.42	2.17	0.562
3	3.3	3.48	1.14	1.80	0.07	0.058
4	3.86	1.34	2.94	0.96	0.49	0.898
5	2.56	1.46	1.84	2.98	0.81	1.122
6	3.82	1.26	0.9	1.46	0.45	0.398
7	3.8	4.08	1	1.54	0.43	0.318
8	4.06	2.24	3.26	2.62	0.69	0.762
9	3.8	3.8	3.86	1.54	0.43	0.318
10	4.06	1.12	2.22	1.68	0.69	0.178
$\Sigma$	33.7	23.48	24.16	18.58	3.67	2.918
$\mu$	3.37	2.348	2.416	1.858		

Table 7.6 (road 4/2 D) the headway between the car (Ta), car and motorcycle (Tc), motorcycle and car (Td) and motorcycle and motorcycle (Tb) in the morning (peak hour) is smaller than during the day but data deviation is higher, the analysis shows the traffic volume in the morning is rather similar with during the day.

Table 7.7. Tubagus Ismail Road 2/2 UD

Periode	Ta	tc	td	Tb	ta	Tb
7.30-8.00	Mb-Mb	Mb-Mt	Mt-Mb	Mt-Mt	Xi- $\mu$	Xi- $\mu$
1	2.7	4.8	4.6	1.6	1.78	0.18
2	4.4	3.8	2.4	1.3	0.08	0.12
3	7.8	6.2	7.2	1.4	3.32	0.02
4	4.8	3.2	4.8	1.2	0.32	0.22
5	3.8	5.2	7.4	1.2	0.68	0.22
6	4.9	5.2	6.6	2.1	0.42	0.68
7	6.2	4.6	8.4	1.4	1.72	0.02
8	4.8	8.2	4.4	1.2	0.32	0.22
9	2.2	3.6	5.2	1.3	2.28	0.12
10	3.2	4.2	2.8	1.5	1.28	0.08
$\Sigma$	44.80	49.00	53.80	14.20	6.18	0.76
$\mu$	4.48	4.9	5.38	1.42		
9.00-9.30	Ta	tc	td	tb	Xi- $\mu$	Xi- $\mu$
1	3.24	1.84	4.02	0.58	0.13	1.358
2	1.20	2.86	2.98	2.42	2.17	0.482
3	3.30	3.48	1.14	1.80	0.07	0.138
4	3.86	1.34	2.94	0.76	0.49	1.178
5	2.56	1.46	0.84	2.98	0.81	1.042
6	3.82	1.26	0.90	1.46	0.45	0.478
7	3.80	4.08	1.00	1.54	0.43	0.398
8	4.06	2.24	3.26	2.62	0.69	0.682

9	3.80	3.80	3.86	0.54	0.43	1.398
10	4.06	1.12	2.22	4.68	0.69	2.742
$\Sigma$	33.70	23.48	23.16	19.38	3.67	4.198
$\mu$	3.37	2.348	2.316	1.938		

Table 7.7 (road 2/2 UD) the headway between the car (Ta), car and motorcycle (Tc), motorcycle and car (Td) and motorcycle and motorcycle (Tb) in the morning (peak hour) is higher than during the day, the analysis shows the traffic volume in the morning is not different significantly with during the day.

Table 7.8. Pasteur Road 6/2 D

Periode	Ta	tc	td	Tb	ta	tb
7.30-8.00	Mb-Mb	Mb-Mt	Mt-Mb	Mt-Mt	Xi- $\mu$	Xi- $\mu$
1	6.98	1.20	2.12	1.14	2.823	0.285
2	3.62	1.10	1.74	0.75	0.537	0.675
3	4.46	1.53	2.43	1.20	0.303	0.225
4	3.87	3.26	1.62	1.41	0.282	0.015
5	4.10	2.43	1.94	1.35	0.057	0.075
6	2.48	1.31	4.22	1.05	1.677	0.375
7	4.16	1.22	3.21	3.53	0.003	2.1
8	5.00	1.46	0.86	1.58	0.843	0.15
9	2.06	2.27	2.13	0.83	2.097	0.6
10	4.83	1.61	2.70	1.43	0.678	2.22E-16
$\Sigma$	41.52	17.36	22.95	14.25	4.002	1.275
$\mu$	4.152	1.7355	2.295	1.425		

	Ta	tc	td	Tb	ta	tb
9.00-9.30					Xi- $\mu$	Xi- $\mu$
1	4.2	1.84	4.02	1.58	0.92	0.658
2	3.8	2.86	2.98	2.42	0.52	0.182
3	4.4	3.48	1.14	1.8	1.12	0.438
4	2.2	1.34	2.94	1.76	1.08	0.478
5	3.8	1.46	0.84	2.98	0.52	0.742
6	3.8	1.26	0.9	1.46	0.52	0.778
7	2.4	4.08	1	1.54	0.88	0.698
8	3.2	2.24	3.26	2.62	0.08	0.382
9	1.4	3.8	3.86	1.54	1.88	0.698
10	3.6	1.12	2.22	4.68	0.32	2.442
$\Sigma$	32.80	23.48	23.16	22.38	4.16	2.498
$\mu$	3.28	2.348	2.316	2.238		

Table 7.8 (road 6/2 D) the headway between the car (Ta), car and motorcycle (Tc), motorcycle and car (Td) and motorcycle and motorcycle (Tb) in the morning (peak hour) is higher than during the day, the analysis shows the traffic volume in the morning is not different significantly with during the day.

## 8. DATA ANALYSIS

### 8.1. Pcu Calculation

The results of calculation of the value Pcu across the road at the morning peak hours and off-peak hours of daylight are presented in Table 8.1 and Table 8.2 below:

Table 8.1 Summary of value Pcu at Jakarta

Metode	Observation Location	Pcu	
		<i>Motor Cycle</i>	
		Peak	Off Peak
Headway	Hasyim Ashari	0,19	0,21
	Mas Mansur	0,16	0,21
	Senopati	0,22	0,19
	Ciputat	0.17	0,22

From the analysis of Pcu obtained from four locations in the Jakarta area Pcu Motorcycles values obtained varied from 0.16 to 0.22 during peak hours and the value of Pcu Motorcycles at peak hours vary from 0.19 to 0.22.

Table 8.2 Summary of value Pcu at Bandung

Metode	Observation Location	Pcu	
		<i>Motor Cycle</i>	
		Peak	Off Peak
Headway	Pasteur	0,28	0,33
	Dipati Ukur	0,22	0,26
	Juanda	0,24	0,33
	Tubagus Ismail	0.18	0,19

From the analysis of Pcu obtained from four locations in the Jakarta area Pcu Motorcycles values obtained varied from 0.18 to 0.28 during peak hours and the value of Pcu Motorcycles at peak hours vary from 0.19 to 0.33.

## 8.2. RMSE Analysis of Pcu Value

Comparisson between data at road of Jakarta and data at road of Bandung on off peak hour use Root Mean Square Error (RMSE) Analysis describe at Table 8.3 below :

ROAD TYPE	PCU VALUE			Difference (RMSE)		
	IHCM	JAKARTA	BANDUNG	2-3	2-4	4-3
1	2	3	4	5	6	7
6/2 D	0.4	0.19	0.33	53%	18%	42%
4/2 D	0.4	0.17	0.33	58%	18%	48%
4/2 UD	0.4	0.16	0.26	60%	35%	38%
2/2 UD	0.4	0.22	0.19	45%	53%	16%
Average	0.4	0.19	0.28	0.54	0.31	0.36

Comparisson between data at road of Jakarta and data at road of Bandung on peak hour describe at Table 8.4 below :

ROAD TYPE	PCU VALUE			Difference (RMSE)		
	IHCM	JAKARTA	BANDUNG	2-3	2-4	4-3
1	2	3	4	5	6	7
6/2 D	0.25	0.22	0.28	12%	12%	21%
4/2 D	0.25	0.21	0.24	16%	4%	13%
4/2 UD	0.25	0.22	0.22	12%	12%	0%
2/2 UD	0.25	0.19	0.18	24%	28%	6%
Average	0.25	0.21	0.23	0.16	0.14	0.1

Pcu value based on survey in Jakarta and Bandung show that at the Off Peak Hour the Pcu value of both cities more different with Pcu based on IHCM compare at the Peak Hour. It means Pcu value version IHCM is more not appropriate when off peak hour condition.

### 8.3. Statistical Analysis of Pcu Value

The statistic test was needed to see the extent of the difference between pcu motor cycle based on IHCM and based on survey. Since the number of road type just 4, so the T-test with 5% significant level that be used and so T Tabel = - 3.182 and 3.182

Hipotesis Formula test is :

$\mu_0$  = motor cycle pcu based on IHCM

$\mu_1$  = motor cycle pcu based on Survey

Ho :  $\mu_1 = \mu_2$

H1 :  $\mu_1 > \mu_2$  atau  $\mu_1 < \mu_2$

$$T = \frac{D-d_0}{Sd/\sqrt{n}} \quad ; \quad Sd^2 = [n \cdot \sum D^2 - (\sum D)^2] / [n \cdot (n-1)]$$

We state  $d_0 = 0.045$

8.3.1. Statistic test of data at survey in Jakarta on off peak hour describe at Table below :

Table 8.5. Off Peak Hour Data in Jakarta

ROAD TYPE	PCU VALUE			
	IHCM	JAKARTA	DIFFERENCE	4 X 4
1	2	3	4	5
6/2 D	0.4	0.19	0.21	0.044
4/2 D	0.4	0.17	0.23	0.053
4/2 UD	0.4	0.16	0.24	0.058
2/2 UD	0.4	0.22	0.18	0.032
Sum	1.6	0.74	0.86	0.187
Average	0.4	0.185	0.215	0.047

$$Sd^2 = (4 * 0.187 - 0.86^2) / (4 * 3) = 0.0007 \quad ; \quad Sd = 0.026$$

$$T = (0.215 - 0.045) / (0.026 * \sqrt{2}) = 3.269$$

Decision : Reject H0 and Accept H1

8.3.2. Statistic test of data at survey in Jakarta on peak hour describe at Table below :

Table 8.6. Peak Hour Data in Jakarta

ROAD TYPE	PCU VALUE			
	IHCM	JAKARTA	DIFFERENCE	4 X 4
1	2	3	4	5
6/2 D	0.25	0.22	0.03	0.001
4/2 D	0.25	0.21	0.04	0.002
4/2 UD	0.25	0.22	0.03	0.001
2/2 UD	0.25	0.19	0.06	0.004
Sum	1.00	0.84	0.16	0.007
Average	0.25	0.21	0.04	0.002

$$Sd^2 = (4 * 0.007 - 0.16^2)/(4 * 3) = 0.0002 \quad ; \quad Sd = 0.014$$

$$T = (0.04-0.045)/(0.014*2) = - 0.179$$

Decision : Accept H0

From the statistical analysis, we got the summary at the off Peak Hour Pcu value based on survey in Jakarta is significantly different 0.045 point from pcu value based on IHCM but at Peak Hour the pcu value based on survey is not different significantly with pcu based on IHCM.

8.3.3. Statistic test of data at survey in Jakarta on off-peak hour describe at Table below :

Table 8.7. Off Peak Hour Data in Bandung

ROAD TYPE	PCU VALUE			
	IHCM	BANDUNG	DIFFERENCE	4 X 4
1	2	3	4	5
6/2 D	0.4	0.33	0.21	0.044
4/2 D	0.4	0.30	0.23	0.053
4/2 UD	0.4	0.26	0.24	0.058
2/2 UD	0.4	0.19	0.18	0.032
Sum	1.6	1.08	0.52	0.079
Average	0.4	0.270	0.130	0.020

$$Sd^2 = (4 * 0.079 - 0.52^2)/(4 * 3) = 0.0456 \quad ; \quad Sd = 0.214$$

$$T = (0.130-0.045)/(0.214*2) = 0.199$$

Decision : Accept H0

8.3.4. Statistic test of data at survey in Jakarta on off-peak hour describe at Table below :

Table 8.7. Off Peak Hour Data in Bandung

ROAD TYPE	PCU VALUE			
	IHCM	BANDUNG	DIFFERENCE	4 X 4
1	2	3	4	5
6/2 D	0.25	0.28	0.03	0.001
4/2 D	0.25	0.24	0.04	0.002
4/2 UD	0.25	0.22	0.03	0.001
2/2 UD	0.25	0.18	0.06	0.004
Sum	1.00	0.92	0.08	0.007
Average	0.25	0.230	0.02	0.002

$$Sd^2 = (4 * 0.007 - 0.08^2)/(4 * 3) = 0.002 \quad ; \quad Sd = 0.042$$

$$T = (0.02 - 0.045)/(0.042 * 2) = - 0.298$$

Decision : Accept H0

From the statistical analysis, we got the summary at the off Peak Hour Pcu value based on survey in Bandung is not significantly different 0.045 point from pcu value based on IHCM and so at the Peak Hour too.

## 9. CONCLUSIONS AND RECOMMENDATIONS

### 9.1. Conclusion

- Value Pcu Motor cycles based on research results on average smaller than the value Pcu based IHCM good at peak hour and off-peak hours.
- At off peak hour the difference between pcu based on survey and pcu based on IHCM greater than at peak hour.
- Pcu value version IHCM is more not appropriate when off peak hour condition.
- The density of traffic significantly influence the Pcu value of motor cycle.
- Result of Statistical Analysis show the pcu value of motor cycle based on IHCM still appropriate use in Bandung but not in Jakarta especially at off peak hour.
- The traffic volume characteristic for same road type is different between Jakarta and Bandung

### 9.2. Recommendation

- Need to look at the relationship Pcu value on the level of service roads on each road
- The studies should be done on a smaller city or town has a population of fewer than Jakarta and Bandung.

## 10. REFERENCES

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