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Abstract A very high proportion of motorcycles affect the saturated flow and motorcycle behavior in synergy stores in developing countries such as Indonesia. The Indonesian Highway Capacity Manual (IHCM) and previous research have not adopted motorcycle behavior to determine the efficiency of passenger cars in synergy. This study aims to assess PCE based on the behavior of motorcycles in synergy with and without Exclusive Stopping Space for Motorcycles (ESSM). The synergy reservoir's location was a junction with a high motorcycle volume, low side obstacles, and traffic characteristics at an approach width of 3 meters, 5 meters, and 7 meters in Denpasar City. The survey method divides the lane virtually, the size of a motorcycle to determine the headway in the field. At the same time, the saturated flow was analyzed using the discharge headway method of both normal distributed data and log normal. Linear regression analysis was used to determine PCE based on motorcycle behavior on synergy junctions both with ESSM and without ESSM. Based on motorcycle behavior, the highest PCE value is obtained beside flow behavior (0.1-1.2) and the lowest in front behavior of the stop line (0.06-0.8). In determining PCE, it is recommended to adopt the motorcycle's behavior.

Keywords Discharge Headway, Mixed Traffic, Saturation Flow, Signalized Intersection, Motorcycle Behavior, PCE, Exclusive Stopping Space for Motorcycles (ESSM)

1. Introduction

Passenger Car Equivalency (PCE) is the conversion factor of various types of vehicles with light vehicles into reference or becomes the standard where the PCE of light vehicles (LV) is 1. PCE is a unit to convert the unit of the flow of traffic flow units from vehicles/hours into PCU/hour, while the passenger car's unit (PCU) is a unit for traffic flow where the flow of various types of light vehicles (including passenger cars) use the frequency of passenger cars equivalency (PCE) [1]. Traffic flow occurs in the field varies; whereas, the flow of traffic is described as several vehicles on various types and properties form a traffic flow. Each type of vehicle has a diverse geometric, size, and acceleration to create different traffic characteristics for each composition. The Equivalency value of Passenger Cars (PCE) for signalized intersection based on IHCM [1] can be seen in Table 1.

Table 1. PCE value for signalized intersection

Type of Vehicle	PCE for approach type	
	Protected	Resisted
Light Vehicle (LV)	1	1
Heavy Vehicles (HV)	1.3	1.3
Motorcycle (MC)	0.2	0.4

The difference between each type of vehicle determines its effect on overall traffic flow. Therefore, it is necessary to take a concept or magnitude that states the influence of a type of vehicle on the overall traffic flow. PCE or PCU (Passenger Car Unit) is a concept or volume needed to unite the efficiency of influence of each type of vehicle. Discharge headway plays a crucial role in determining saturated flow and synergistic crossing capacity. Motorcycle dominance can affect the value of saturated flow, but an increase in the proportion of heavy vehicles can reduce the effect of motorcycles on their saturated flow [2]. Motorcycles affect saturated flow [[2]–[4]], and certainly affect PCE. There has been many researches [3], [5]–[14] [2], [3], [15], but none of them has yet determined the PCE of a motorcycle by adopting motorcycle behavior in determining PCE, whereas PCE is derived from saturation flow which is the contribution of all vehicles that pass through the synergy store in green time. The determination of PCE by adopting this behavior is essential, considering Denpasar is a city with a proportion of motorcycles 85% [16]. The behavior of motorcycles in synergy can be grouped into several categories, namely, in front of the stop line, beside flow, inside flow [17]. In previous research [2], PCE was partially analyzed for each of the synergistic junctions, but in this study, it combined the reservoirs with the same traffic characteristics. In addition, the difference from previous research is that there has been no research that adopts motorcycle behavior in determining PCE. The study [2] found other factors that affect the saturated flow, namely the behavior of motorcycles, the value of saturated flow based on motorcycles still in the vehicle/hour, not based on PCU/hour, in the study [18] found PCE based on behavior so that saturated flow was obtained in PCE/hour. Therefore, this study analyzed PCE by adopting motorcycle behavior both with and without Exclusive Stopping Space for Motorcycles (ESSM).

2. Materials and Methods

2.1. Passenger Car Equivalent and Saturation Flows

Methods for estimating passenger car equivalent (PCE) at signalized intersections are generally based on saturation flows. However, under mixed traffic conditions, it is not possible to use only the queue of cars to determine the saturation flow rate (passenger car unit/hour). PCE for different types of vehicles is essential to convert heterogeneous traffic flows to homogeneous ones. Thus, the saturated flow becomes interdependent with one another. An alternative to PCE estimation is based on the headway method. Non-lane-based traffic under mixed traffic conditions causes one vehicle to have many other vehicles next, behind, and in front of it. This makes headway measurement for PCE estimation somewhat difficult in mixed traffic conditions [15].

Meanwhile, a regression method is more relevant for PCE estimation at signalized intersections because the calculation is easier and simpler to implement. However, this method relies heavily on accurate analysis of saturation flow which is also a function of determining PCE [15]. A sound understanding of the discharge headway is essential in estimating saturation flows and saturation flow rate because driver behavior is a significant determinant of saturation flows. A past study [19] examined the discharge headway's stochastic properties providing better information to construct the model to estimate saturation flow rates. The discharge headway is a random variable due to differences in driver/rider behavior response times and variations in queue space length. To estimate the saturation headway, the average discharge headway is calculated as follows:

$$\bar{h}_s = \frac{1}{n}\sum_{i=1}^{n} h_{si} \quad (1)$$

where,

$\bar{h}_s$: the average discharge headway (s), which is taken as the estimated saturation headway h;

h_{si}: the discharge headway of vehicle i in the queue, i = 1,2,. . . , n (n is the sample size), consequently, the saturation flow is conventionally determined by the discharge headway

$$S = \frac{3600}{\bar{h}_s} \quad (2)$$

where,

S is the saturation flow (vehicle/hour).

To determine the passenger car equivalent (PCE) and saturation flow, the statistical criteria used are as follows (summarized in Fig.1):

1. If the discharge headway distribution is symmetrical, the average discharge headway calculated by (1) is a good (unbiased) estimate of h, and (2) can be a good estimation for the saturation flow rate [19].
2. However, if the discharge headway distribution is not symmetrical, h_s is not a good estimate and in (2) will give a saturation current level value that is too high (overestimate) or too low (underestimate). Therefore, it is necessary to study the stochastic nature of the time between queued vehicles and analyze the effect of time variation between the estimated saturation flow rates [19].
3. When the average discharge headway is more significant than the median value, and the skewness of the discharge headway is positive, this characteristic indicates that the discharge headway distribution tends to be asymmetrical, and the normal distribution function does not match the discharge headway data [19]. Therefore, the conventional method of estimating the saturation flow expressed in (2) can result in an underestimated value of the traffic flow.
4. If the discharge headway distribution tends to be asymmetrical, then the headway can be modeled with a lognormal distribution [19]. When the random variable

h_s function density is lognormal, ln h_s will follow the normal distribution. It is very relevant, therefore, to use the median value to calculate the saturation flow rate in the following way:

$$S_1 = 3600\, x \frac{1}{h_{med}} \quad (3)$$

where,

S_1: a new estimate of the saturation flow (vehicles/hour);

h_{med}: the estimated median value of the discharge headway(sec).

In addition, there are two new estimates for saturated flow levels. [19]

$$S_2 = 3600\, x \exp(-\frac{1}{n}\sum_{i=1}^{n} ln\, h_{si}) \quad (4)$$

$$S_3 = \frac{3600}{\bar{h}_s} x (1 + \frac{\sigma_s^2}{\bar{h}_s{}^2})^{0.5} \quad (5)$$

where,

S2 and S3 are two new estimates of the level of saturated flow (vehicle/hour).

$\sigma_s^2 = [\frac{1}{n} - 1.\sum_{i=1}^{n}(h_{si} - \bar{h}_s)^2]$ It is a variance of the sample time between

5. The regression method is relevant to traffic flow analysis which consists of several vehicles. The queue of each vehicle is calculated and regressed by the saturation flow that may occur during the analysis period. The form of the regression model is given in (4).

$$S\ or\ S_1 = n_{car} + \sum_{j=1}^{k} n_j \,.\, PCE_j \quad (6)$$

where saturation flow $S\ or\ S_1$ is obtained from either (4) or (3) depending on its types of distributions, n_{car} and n_j are the number of cars and the kind of vehicle j, respectively, crossing the stopping line during a specific period.

2.2. Data Collection

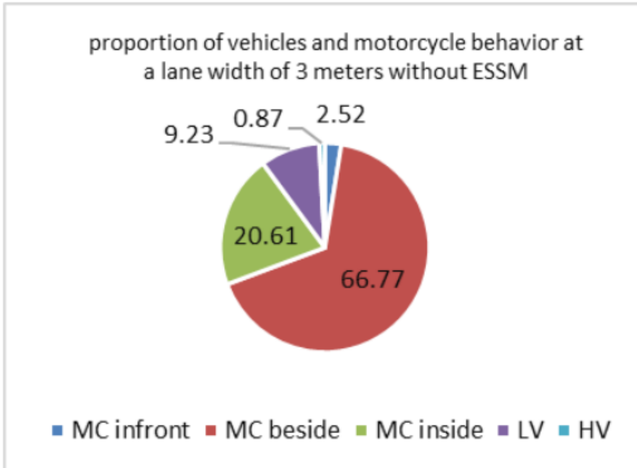
In this study, Denpasar city was chosen because it represents urban areas classified as large cities based on Government Regulation Number 26 of 2008 [20] with a population of more than 500,000 to 1,000,000, where the population of Denpasar City amounted to 947,100 people [16]. Denpasar City was also chosen in this study because it represents urban areas with mixed traffic flow dominated by motorcycles. The proportion of motorcycles in Denpasar City is 82 percent by the ratio of motorcycle ownership rates in Denpasar City.

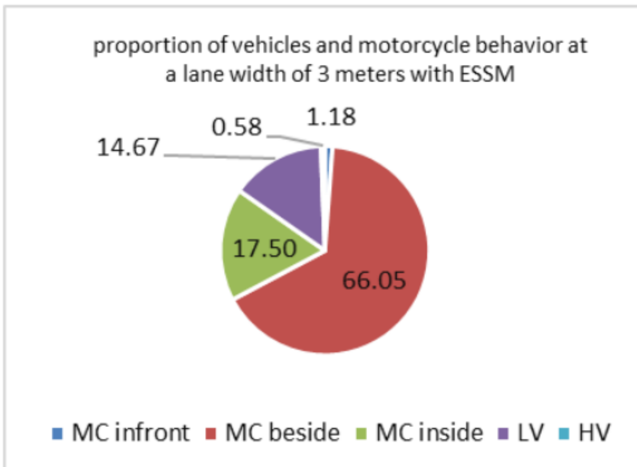
Denpasar City has 66 pieces of synergy, of which there is an exclusive stopping space in 15 synergy stores, and 51 parts of synergy reservoirs do not have an Exclusive Stopping Space for Motorcycles (ESSM). For the analysis, it was selected from four synergy stores that have the volume of vehicles passing through the intersection more or less the same, the same short width and have the same proportion of motorcycles that reflect the same mixed traffic flow conditions between existing ESSM with non-ESSM, Slope to normal intersections, intersections have to be free from bus stops, parked vehicles, pedestrians, movement, and all sorts of side obstacles. Traffic queues should be long and consist of vehicles (heavy vehicles, light vehicles, and motorcycles).

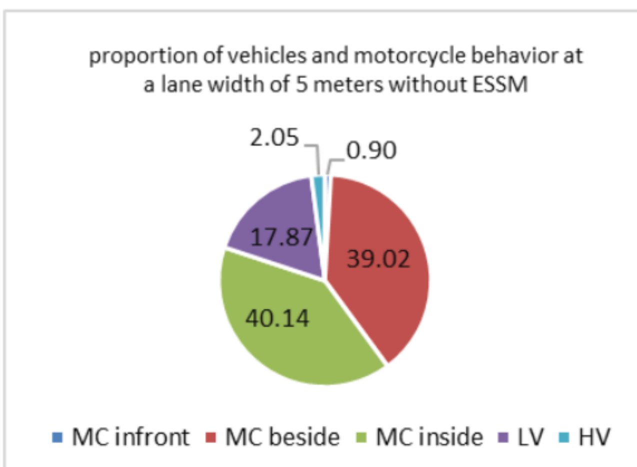
Traffic headway data in Denpasar that is not based on lanes (non-lanes) in heterogeneous traffic conditions, cause one vehicle to have many vehicles behind and in front of it. This makes measuring the headway for PCE estimation quite difficult in heterogeneous traffic conditions [21]. To overcome this, in this study, the measurement of time between was done in the following way: The ATCS camera was directed at an observation point that provides images with high accuracy and better quality. To obtain the headway of each vehicle, the road lane was divided into several routes; each lane that equals to the space is occupied by motorcycles [22]. To eliminate the start-up and acceleration effects on the saturated flow rate, the first five headways of vehicle pairs in each signal cycle were not included as data [19].

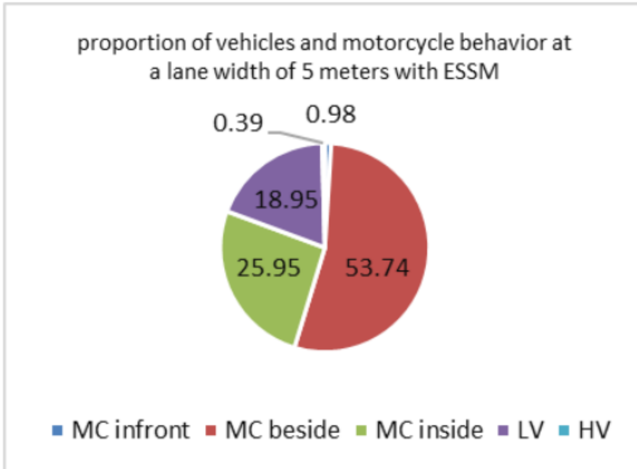
3. Result and Discussion

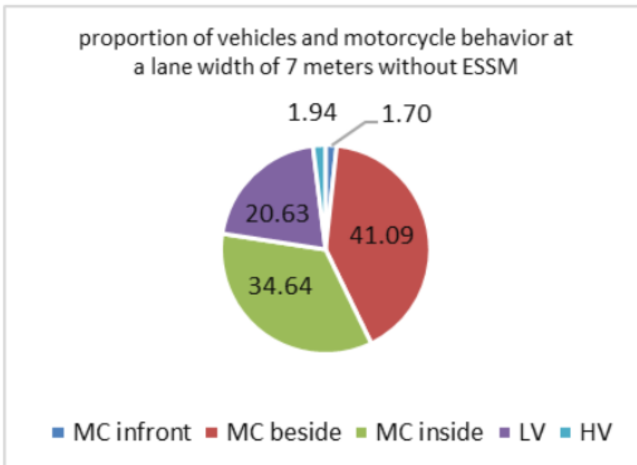
The proportion of vehicles is dominated by motorcycles with behavior beside flow both ESSM and without ESSM unless approaches with a lane width of 5 meters without ESSM. For the number of inside flows to two, both ESSM and without ESSM, except the width of the column 5 meters without ESSM. The third order is LV with a percentage proportion almost the same between approaches with ESSM and without ESSM with a 1-3% difference. The number of percentages of the minor proportion of vehicles is HV which is 0.39%-1.94. Motorcycles dominate the movement on the road in Denpasar city. Motorcycles prefer beside flow behavior. The motorcycle is faster to maneuver in the beside flow position without being blocked by other vehicles. The proportion of vehicles and motorcycle behavior can be seen in Figure 1.


proportion of vehicles and motorcycle behavior at a lane width of 3 meters without ESSM
2.52
0.87
9.23
20.61
66.77
MC infront
MC beside
MC inside
LV
HV


proportion of vehicles and motorcycle behavior at a lane width of 3 meters with ESSM
1.18
0.58
14.67
17.50
66.05
MC infront
MC beside
MC inside
LV
HV


proportion of vehicles and motorcycle behavior at a lane width of 5 meters without ESSM
2.05
0.90
17.87
39.02
40.14
MC infront
MC beside
MC inside
LV
HV





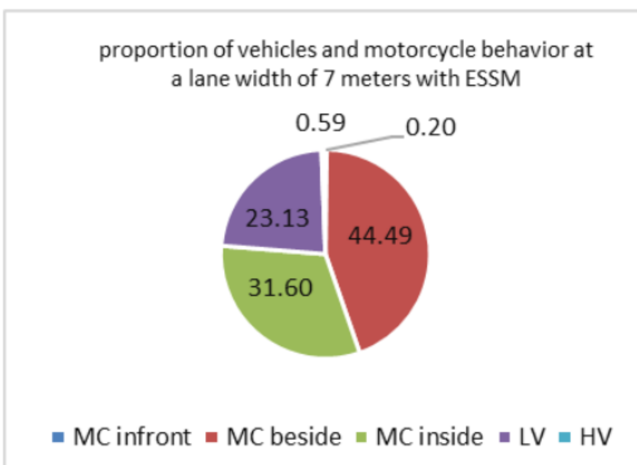
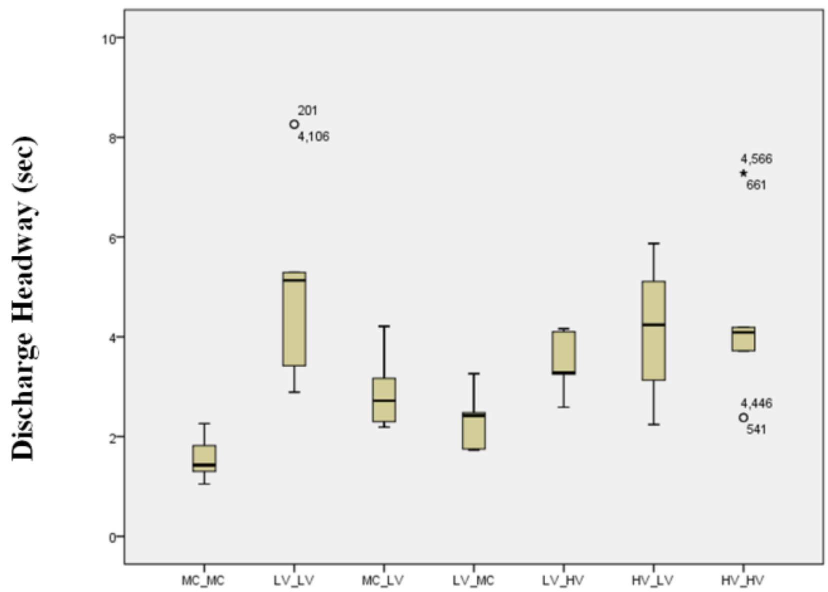


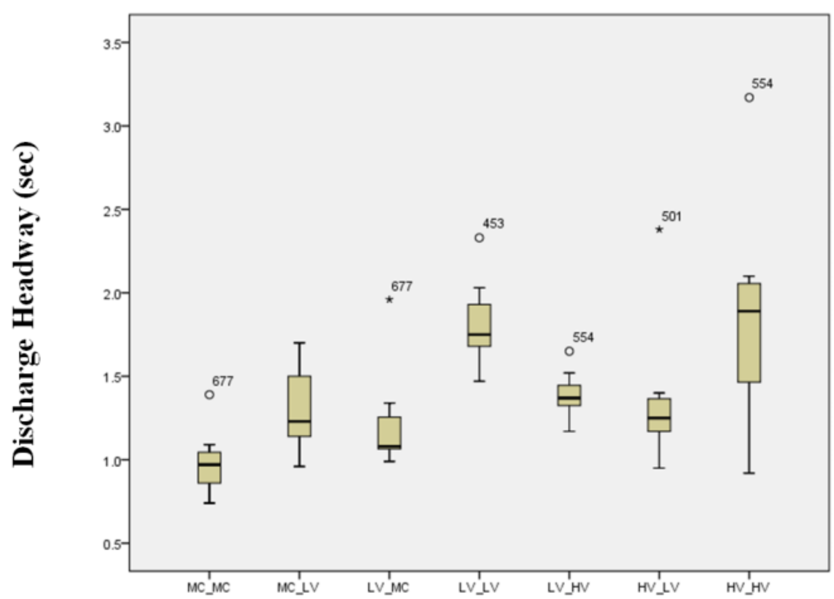
Figure 1. Percentage proportion of vehicles and motorcycle behavior at each width effectively with and without ESSM

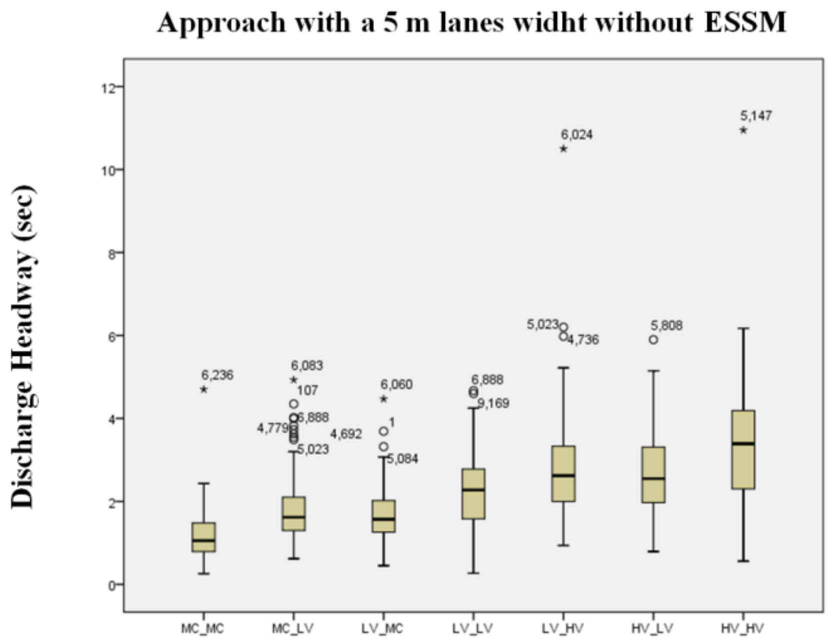
The headway data obtained is divided into pairs of vehicles such as Motorcycles following motorcycles (MC-MC), Light vehicles following motorcycles (MC-LV), Heavy vehicles following motorcycles (MC-HV), motorcycles following light vehicles (LV-MC), light vehicles following light vehicles (LV-LV), Heavy vehicles following light vehicles (LV-HV), motorcycles following heavy vehicles (HV-MC), light vehicles following heavy vehicles (HV-LV), Heavy vehicles follow heavy vehicles (HV-HV). Furthermore, the data is combined to get information set per type based on approach widths 3, 5, and 7, with ESSM or without ESSM.

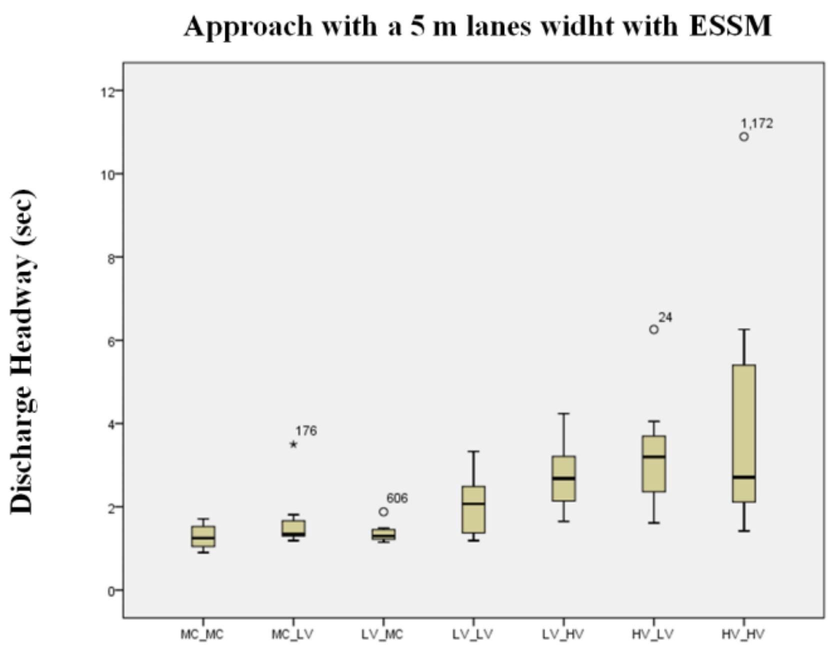
Approach with a 3 m lanes widht without ESSM



Approach with a 3 m lanes widht with ESSM




Approach with a 5 m lanes widht without ESSM
Discharge Headway (sec)
0
2
4
6
8
10
12
6,236
6,083
107
4,779
6,888
5,023
4,692
6,060
1
5,084
6,888
9,169
6,024
5,023
4,736
5,808
5,147
MC_MC
MC_LV
LV_MC
LV_LV
LV_HV
HV_LV
HV_HV


Approach with a 5 m lanes widht with ESSM
Discharge Headway (sec)
0
2
4
6
8
10
12
176
606
24
1,172
MC_MC
MC_LV
LV_MC
LV_LV
LV_HV
HV_LV
HV_HV

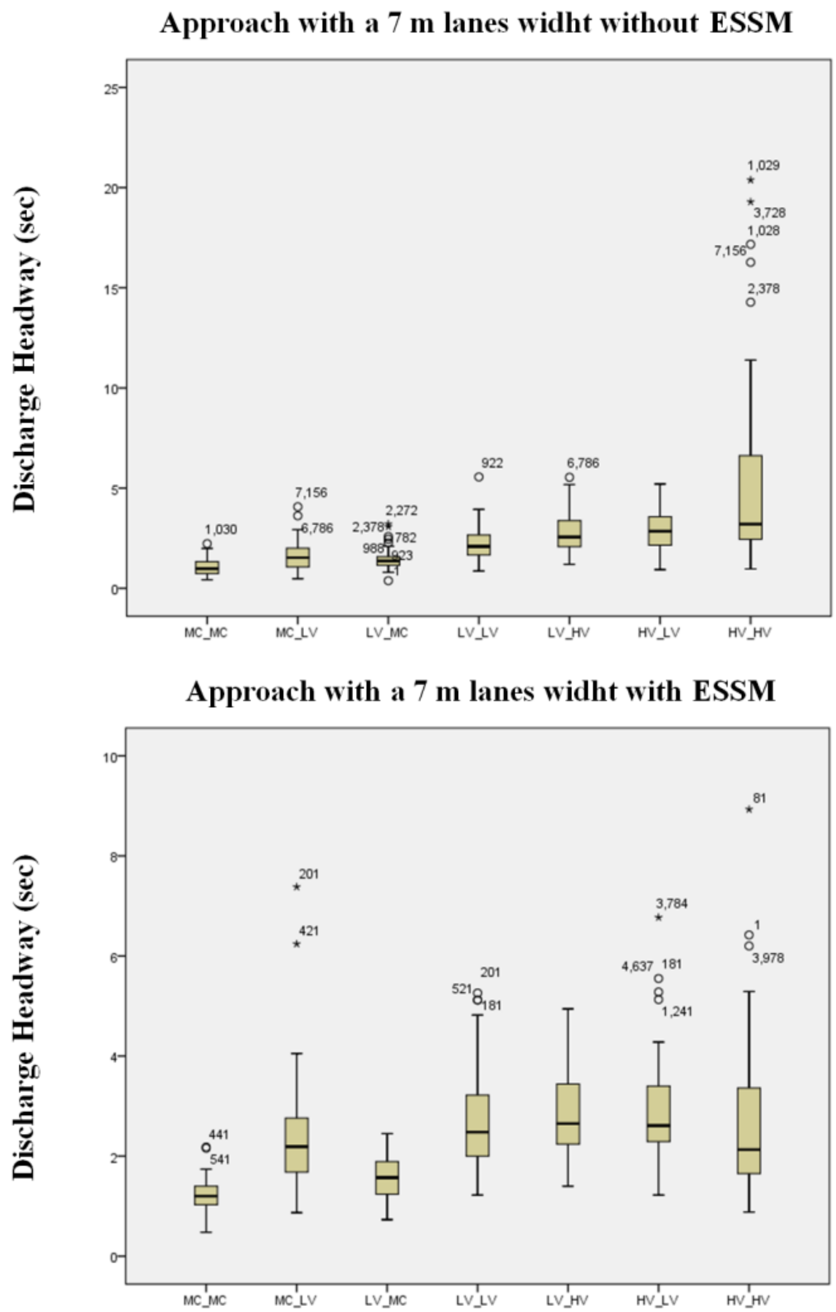


Figure 2. Vehicle Types and Discharge Headways

Headway data on the approach with an effective width of 3 meters Non-ESSM based on a boxplot graph varies, visible from the shape and position of different boxplots between vehicles. Boxplot on motorcycle composition following the motorcycle (MC-MC) shows the lowest position compared to boxplot composition of other vehicles. This suggests that the MC-MC describes a lower headway value compared to other vehicles. The distribution of heavy vehicle headway values following heavy vehicles (HV-HV) tends to be homogenous, indicating the smallest boxplot size compared to other boxplot vehicle compositions. The composition of HV-LV vehicles is the most significant compared to other vehicles, followed by LV-LV. The distribution of TH data in each vehicle shows a noticeable variation from the median position on the boxplot, where MC-LV and HV-LV tend to have a balanced proportion of time headway distributions at higher and lower time headway values. Data distribution in the LV-MC group tends to cluster at a time headway lower than the median value while LV-HV tends to press at a time headway higher than the median value.

Time headway on approach with an effective width of 3 Meters with ESSM based on boxplot graphics varies visible from the shape and position of different boxplots between vehicles. The boxplot on THE MC-MC shows the lowest position than another vehicle boxplot. This suggests that the MC-MC describes a lower headway value compared to other vehicles. The distribution of LV-HV headway values tends to be more homogeneous compared to other vehicles, shown to be the smallest boxplot size compared to other vehicle boxplots. The variety of HV-HV vehicles is the most significant compared to other vehicles, followed by the MC-LV. The distribution of TH data in each vehicle shows a visible variation from the median position on the boxplot, where the MC-MC and HV-LV tend to have a balanced proportion of time headway distributions at higher and lower time headway values. Data distribution in the LV-MC group tends to cluster headway which is higher than the median value.

Time headways on approach with an effective width of 5 meters Non-ESSM based on boxplot graphics tends to show a more similar distribution than other intersections. The boxplot on the MC-MC still shows the lowest position compared to another vehicle boxplot. This suggests that the MC-MC describes a lower headway value than other vehicles. The distribution of MC-MC headway values tends to be homogeneous, indicating the smallest boxplot size compared to other vehicle boxplots. The variety of HV-HV vehicles is the most significant compared to other vehicles. The distribution of TH data in each vehicle shows variations seen from the median position on the boxplot. It remains the same; the variation in each vehicle tends to be the same, where all vehicles tend to have a balanced proportion of time headway distributions at higher and lower time headway values.

Time headway on approach with an effective width of 5 meters with ESSM based on boxplot graphics varies visibly from the shape and position of different boxplots between vehicles. The boxplot on THE MC-MC shows the lowest position than another vehicle boxplot. This suggests that the MC-MC describes a lower headway value than other vehicles. The distribution of LV-MC headway values tends to be homogeneous, indicating the smallest boxplot size compared to other vehicle boxplots. The variety of HV-HV vehicles is more significant than other vehicles, followed by the LV-LV. The distribution of TH data in each vehicle shows a noticeable variation from the median position on the boxplot, where the MC-MC and LV-HV tend to have a balanced proportion of time headway distributions at higher and lower time headway values. Data distribution on MC-LV and HV-HV tends to cluster at time headways higher than the median value.

Time headway on approach with an effective width of 7 meters Non-ESSM based on boxplot graphics varies visibly from the shape and position of different boxplots between vehicles. The boxplot on the MC-MC shows the lowest position compared to another vehicle boxplot. This suggests that the MC-MC describes a lower headway value than other vehicles. The distribution of LV-MC headway values tends to be homogeneous, indicating the smallest boxplot size compared to other vehicle boxplots. The variety of HV-HV vehicles is more significant than other vehicles. The distribution of TH data in each vehicle shows variations. However, it is still similar, seen from the median position on the boxplot, where almost all vehicles tend to have a balanced proportion of time headway distribution at a time headway value that is higher and lower than the median. Only HV-HV vehicles whose data distribution tends to cluster at a time headway higher than the median value.

Time headway on approach with an effective width of 7 meters with ESSM based on boxplot graphics varies visible from the shape and position of different boxplots between vehicles. The boxplot on THE MC-MC shows a lower position than another vehicle boxplot. This suggests that the MC-MC describes a lower headway value than other vehicles. The distribution of MC-MC headway values also tends to be homogeneous, indicating the smallest boxplot size compared to other vehicle boxplots. Vehicle variations on MC-LV, LV-LV, LV-HV, and HV-HV are pretty similar. The distribution of TH data in each vehicle shows a balanced proportion of time headway distributions at higher and lower than median time headway values.

The data analysis was done in SPSS descriptively while perceiving the form of data distribution. This analysis aimed at observing the pattern of data distribution, whether it was normal or not. The form of data distribution can be realized through statistical calculations with the Shapiro-Wilk or Kolmogorov Smirnov approach. Fewer than 50 used Shapiro Wilk's approach, while more than 50 used Kolmogorov-Smirnov. The data was said to be normally distributed if the Sig value. The test statistic was greater than 0.05.

Normal-distributing data was then calculated by the saturated flow with equation (2), while the abnormal data would be calculated by equation (5).

After the value of S3 was obtained based on the various criteria above, regression was further performed to determine the PCE value as in tables 1-6, for each approach with a width of 3, 5, 7 with and without ESSM. So the value of S3 and PCE value obtained can be seen in Table 2-7.

Table 2. PCE & Saturation Flows at approach with a 3 m lanes width without ESSM

Time	Infront	Beside	Inside	LV	HV	S3
07.00-08.00	38	1189	509	113	7	3063,82
07.10-08.10	35	1346	537	126	8	3272,08
07.20-08.20	33	1415	526	144	8	3369,01
07.30-08.30	29	1419	494	156	9	3381,23
07.40-08.40	26	1369	440	158	10	3451,99
07.50-08.50	29	1316	372	161	10	3353,91
08.00-09.00	40	1242	339	163	11	3285,04
12.00-13.00	41	1140	309	131	25	3179,17
12.10-13.10	40	1058	292	132	24	3077,09
12.20-13.20	45	974	295	135	22	3080,14
12.30-13.30	50	923	293	140	18	2999,63
12.40-13.40	52	898	275	153	17	2945,12
12.50-13.50	47	884	272	156	19	2943,71
13.00-14.00	48	864	265	151	20	3010,67
16.00-17.00	47	861	258	170	14	2957,37
16.10-17.10	48	864	239	148	13	2916,08
16.20-17.20	43	876	222	143	13	2875,64
16.30-17.30	42	814	203	142	12	2838,64
16.40-17.40	36	780	207	139	10	2843,93
16.50-17.50	32	860	210	142	11	2884,12
17.00-18.00	36	921	240	144	9	3037,37
R2 = 95.80%; Adjust R2= 94.7%; pce (mc infront) = 0.02; pce (mc beside) = 1.2; pce (mc inside) = 0.2; pce (hv) = 0.1; pce (lv) = 1.00						

Table 3. PCE & Saturation Flows at approach with a 3 m lanes width with ESSM

Time	Infront	Beside	Inside	LV	HV	S3
07.00-08.00	6	1216	413	204	6	3382,56
07.10-08.10	7	1357	433	223	8	3492,62
07.20-08.20	6	1462	441	247	7	3662,95
07.30-08.30	7	1450	420	257	8	3707,37
07.40-08.40	8	1467	397	256	10	3702,44
07.50-08.50	10	1413	367	251	13	3658,05
08.00-09.00	10	1355	342	246	15	3603,96
12.00-13.00	10	1268	313	267	14	3506,47
12.10-13.10	13	1197	298	268	14	3377,36
12.20-13.20	19	1120	267	264	16	3303,76
12.30-13.30	27	1036	243	257	14	3151,90
12.40-13.40	31	982	223	268	14	3125,73
12.50-13.50	36	945	233	266	15	3147,10
13.00-14.00	41	959	252	267	12	3162,84
16.00-17.00	42	933	250	248	9	3157,00
16.10-17.10	35	930	261	249	8	3133,48
16.20-17.20	29	939	254	258	9	3140,70
16.30-17.30	28	940	247	249	7	3123,00
16.40-17.40	25	919	227	249	7	3111,92
16.50-17.50	22	950	216	250	6	3190,40
17.00-18.00	19	977	220	251	5	3243,19
R2 = 98.1%; Adjust R2= 97.6%; pce (mc infront) = 0.06; pce (mc beside) = 1.2; pce (mc inside) = 0.2; pce (hv) = 0.1; pce (lv) = 1.00						

The approach of 3 meters without ESSM can be seen in that regression analysis of saturation flow S3 (formula 5) goodness of fit value with R-Square approach of 0.947 which means motorcycle behavior (in front of a stop line, beside flow, inside flow), light vehicles and heavy vehicles contributes 94.7% to saturated flow. And the significance of F of 0.000, means the model built is feasible. In the regression analysis model, it was also found that the larger the HV, the larger the MC and the saturated flow, but the larger the inside MC and the infront MC of the stop line would reduce the saturated flow value. The largest determinant of saturated flow at the width of the column of 3 meters is MC beside because it has a PCE value of 1.19. The largest PCE is a motorcycle beside flow PCE whose value exceeds the PCE of a light vehicle by 1.2 times the light vehicle, because the behavior of the motorcycle beside flow interferes with the movement of other vehicles because of its behavior so that other vehicles cannot maneuver freely. Other vehicles maintain a distance where the area needed for a safe distance from motorcycle behavior beside is 1.2 light vehicles. Unlike the case with the behavior of the motorcycle inside flow, this PCE is 0.2 times the PCE of a light vehicle, because the behavior of inside flow does not interfere with others, so other vehicles maneuver constantly where the area of the behavior of the motorcycle inside is 0.2 times the light vehicle. PCE motorcycle in front of stop line 0.02 times PCE light vehicle because the behavior of the motorcycle in front of stop line does not interfere with other vehicles because the earliest infront motorcycle of stop line maneuvers leaves the intersection. PCE vehicles weigh 0.1 times the PCE of light vehicles because, in addition to the volume of heavy vehicles being very small passing through the junction in 1 hour, heavy vehicles also do not interfere with other vehicles so that other vehicles maneuver regularly with constant where the safe area of heavy vehicles is 0.1 times light vehicles. Previous research [2] also found that the motorcycle PCE in the Gatot Subroto-Kenyeri-Seroja PCE motorcycle is larger than light vehicles and heavy vehicle PCE is smaller than PCE light vehicles which are 1.02 for motorcycle PCE and 0.2 for heavy vehicles.

While from the approach with a lane width of 3 meters with ESSM, regression analysis of saturation flow S3 (formula 5) goodness of fit value with R-Square approach of 0.981 which means motorcycle behavior (in front of a stop line, beside flow, inside flow), light vehicles and heavy vehicles contributes 98.1% to saturated flow. And the significance of F of 0.000 which means the model built is feasible. In regression analysis, it was also found that the larger the infront MC, the larger the MC is also the saturated flow, but the larger the inside MC and HV will reduce the saturated flow value. The largest determinant of saturated flow at the width of the 3-meter column is MC beside because it has a PCE value of 1.2. The largest PCE is a motorcycle beside flow PCE whose value exceeds the PCE of a light vehicle by 1.2 times the light vehicle, is because the behavior of the motorcycle beside flow interferes with the movement of other vehicles because of its behavior so that other vehicles cannot maneuver freely, other vehicles maintain a distance where the area needed for a safe distance from motorcycle behavior beside is 1.2. Unlike the behavior of the motorcycle inside flow, the PCE is 0.2 times the PCE of light vehicles because the behavior of inside flow does not interfere with other vehicles so light vehicles maneuver constantly where the safe area of the behavior of the inside motor is 0.2 times the light vehicle. PCE motorcycle in front of stop line 0.06 times PCE light vehicle because the behavior of the motorcycle in front of stop line does not interfere with other vehicles because the earliest infront motorcycle of stop line maneuvered leaving the intersection. PCE vehicles weigh is 0.1 times PCE light vehicles because in addition to the volume of heavy vehicles is very small through the intersection in 1 hour, heavy vehicles also do not interfere with others so that other vehicles maneuver regularly with constant where the safe area of heavy vehicles is 0.1 times light vehicles. The PCE value of motorcycles beside flow, motorcycles inside flow, and heavy vehicles is the same at an effective width of 3 meters with ESSM and without ESSM. The difference is slight in the PCE of the motorcycle in front of the stop line with a difference of 0.04. The similarity of PCE values indicates that the behavior distribution, proportion of vehicles, and vehicle headways are almost the same at a junction with an effective width of 3 meters with and without ESSM.

Table 4. PCE & Saturation Flows at approach with a 5 m lanes width without ESSM

Time	Infront	Beside	Inside	LV	HV	S3
07.00-08.00	21	906	718	318	40	2192,41
07.10-08.10	24	1048	754	342	37	2387,49
07.20-08.20	22	1198	806	384	43	2543,98
07.30-08.30	32	1261	894	411	52	2789,19
07.40-08.40	32	1329	1002	435	59	3022,74
07.50-08.50	30	1317	1092	447	66	3267,11
08.00-09.00	34	1237	1119	467	68	3220,95
12.00-13.00	34	1179	1136	489	54	3216,83
12.10-13.10	35	1086	1140	491	53	3165,70
12.20-13.20	28	1010	1137	492	55	3087,26
12.30-13.30	27	902	1162	495	62	2912,93
12.40-13.40	26	859	1123	520	65	2686,65
12.50-13.50	24	888	1166	524	65	2720,22
13.00-14.00	23	866	1261	549	68	2645,02
16.00-17.00	17	839	1334	573	52	2571,81
16.10-17.10	17	866	1266	536	55	2518,02
16.20-17.20	17	916	1163	527	60	2410,07
16.30-17.30	19	949	1092	527	60	2336,61
16.40-17.40	18	973	1033	529	56	2261,44
16.50-17.50	16	1146	1078	527	49	2332,20
17.00-18.00	18	1254	1186	509	45	2383,88
R2 = 91,3%; Adjust R2= 89.1%; pce (mc infront) = 0.8; pce (mc beside) = 0.1; pce (mc inside) = 0.3; pce (hv) = 0.2; pce (lv) = 1.00						

Table 5. PCE & Saturation Flows at approach with a 3 m lanes width with ESSM

Time	Infront	Beside	Inside	LV	HV	S3
07.00-08.00	12	1219	479	385	10	2938,44
07.10-08.10	12	1126	443	382	12	2949,77
07.20-08.20	18	1081	431	380	12	2950,63
07.30-08.30	17	1070	444	392	13	2994,95
07.40-08.40	19	1069	465	385	14	3072,90
07.50-08.50	20	1104	473	399	13	3160,94
08.00-09.00	20	1073	500	381	17	3184,46
12.00-13.00	24	1112	527	409	7	3237,44
12.10-13.10	23	1145	555	430	6	3291,43
12.20-13.20	20	1166	571	444	6	3327,81
12.30-13.30	19	1178	580	434	8	3366,52
12.40-13.40	18	1124	601	428	8	3378,93
12.50-13.50	21	1143	634	435	9	3392,42
13.00-14.00	18	1143	628	420	11	3355,56
16.00-17.00	16	1140	619	421	8	3345,80
16.10-17.10	20	1104	597	395	7	3314,07
16.20-17.20	25	1077	587	374	5	3327,62
16.30-17.30	28	1113	581	357	3	3288,83
16.40-17.40	29	1119	545	348	2	3307,10
16.50-17.50	28	1109	541	356	3	3370,24
17.00-18.00	26	1085	547	332	2	3397,64
R2 = 90,3%; Adjust R2= 87.9 %; pce (mc infront) = 0.36; pce (mc beside) = 0.11; pce (mc inside) = 0.71; pce (hv) = 0.1; pce (lv) = 1.00						

Approach with a lane width of 5 meters without ESSM can be seen that regression analysis of saturation flow S3 (formula 5) goodness of fit value with R-Square approach of 0.89 which means motorcycle behavior (in front of a stop line, beside flow, inside flow), light vehicles and heavy vehicles contribute 89.1% to saturated flow. And the significance of F of 0.000, a model built on the data obtained has been feasible. Regression analysis also found that the larger the HV, MC in front, MC besides, and MC insides, the greater the saturated flow is. The determination of saturated flow at a lane width of 5 meters without ESSM is the MC in front of the stop line because it has a PCE value of 0.8. The PCE of motorcycle in front of stop line is 0.8 times light vehicle, it is because the behavior of the motorcycle in front of stop line interferes with the movement of other vehicles because of its behavior so that other vehicles cannot maneuver freely, whereas other vehicles maintain a safe distance where the area is needed for a safe distance from the behavior of the motorcycle in front of stop line is 0.8 of the light vehicle areas. Unlike the behavior of inside flow and besides flow motorcycles of 0.3 and 0.1 times PCE light vehicles because the behavior of inside flow and besides does not interfere with light vehicles so that light vehicles maneuver constantly where the safe distance area of the behavior of the motorcycle inside flow and beside flow is 0.3 and 0.1 times light vehicles. Vehicles weigh 0.2 times the PCE of light vehicles because, in addition to the volume of heavy vehicles being very small through the junction in 1 hour, heavy vehicles also do not interfere with light vehicles so light vehicles maneuver regularly with constant where the safe distance area of heavy vehicle behavior is 0.2 times light vehicles.

While from the approach with a lane width of 5 meters with ESSM, regression analysis of saturation flow S3 (formula 5) goodness of fit value with an R-Square approach of 0.879 which means motorcycle behavior (in front of a stop line, beside flow, inside flow), light vehicles and heavy vehicles contributes 87.9% to saturated flow. And the significance of F of 0.000 models built on the data obtained has been feasible. In regression analysis, it was also found that the larger the infront MC, the inside MC, and the LV the larger the saturated flow is, but the larger the MC and HV would reduce the saturated flow value. The largest determination of saturated flow at a column width of 5 meters with ESSM is the MC inside because it has a PCE value of 0.79. PCE motorcycle in front of stop line 0.4 times light air, it is because the behavior of the motorcycle in front of stop line leaves the earliest synergy so as not to disturb other vehicles in maneuverable. The area required for a safe distance from the behavior of an in-front motorcycle of the stop line is 0.4 of the light vehicle area. PCE motorcycle beside flow 0.1 times light vehicle, it is because the behavior of the motorcycle beside flow does not interfere with other vehicles in maneuverable. The area required for a safe distance from motorcycle behavior is 0.1 from the light vehicle area. Vehicles weigh 0.1 times the PCE of light vehicles because, in addition to the volume of heavy vehicles being very small passing through the intersection in 1 hour, heavy vehicles also do not interfere with light vehicles so that other vehicles maneuver regularly with constant where the safe distance area of heavy vehicle behavior is 0.1 times light vehicles. Unlike the behavior of motorcycles inside flow 0.7 times PCE light vehicles because the behavior of inside flow interferes with the movement of other vehicles so that other vehicles require a safe area distance of 0.7 times light vehicles.

Table 6. PCE & Saturation Flows at approach with a 7 m lanes width without ESSM

Time	Infront	Beside	Inside	LV	HV	S3
07.00-08.00	19	1195	941	446	31	3321
07.10-08.10	21	1337	961	492	32	3267
07.20-08.20	17	1386	957	508	32	3219
07.30-08.30	20	1422	986	531	35	3096
07.40-08.40	19	1373	961	539	37	3016
07.50-08.50	19	1385	943	545	46	2950
08.00-09.00	20	1367	942	550	54	2854
12.00-13.00	25	1238	956	524	65	2680
12.10-13.10	36	1137	941	512	70	2569
12.20-13.20	41	1003	868	533	73	2555
12.30-13.30	51	932	893	551	72	2494
12.40-13.40	57	825	876	548	73	2407
12.50-13.50	60	753	857	566	74	2380
13.00-14.00	60	770	852	582	73	2569
16.00-17.00	57	808	851	553	48	2679
16.10-17.10	58	826	856	539	47	2727
16.20-17.20	67	829	829	520	41	2843
16.30-17.30	66	820	817	514	38	2983
16.40-17.40	70	780	785	505	37	3115
16.50-17.50	68	876	747	512	37	2953
17.00-18.00	67	981	762	501	32	2918
R2 = 95.7%; Adjust R2= 91.7 %; pce (mc infront) = 0.8; pce (mc beside) = 0.4; pce (mc inside) = 0.3; pce (hv) = 0.9; pce (lv) = 1.00						

Table 7. PCE & Saturation Flows at approach with a 7 m lanes width with ESSM

Time	Infront	Beside	Inside	LV	HV	S3
07.00-08.00	12	1585	1172	556	15	2293
07.10-08.10	11	1723	1200	582	15	2339
07.20-08.20	8	1804	1122	607	16	2381
07.30-08.30	4	1877	1035	637	18	2423
07.40-08.40	4	1856	997	636	19	2420
07.50-08.50	6	1839	952	639	23	2808
08.00-09.00	5	1773	932	646	24	2833
12.00-13.00	5	1658	953	880	24	2826
12.10-13.10	5	1495	1015	897	20	2794
12.20-13.20	4	1356	1086	904	20	2763
12.30-13.30	5	1289	1121	928	23	2751
12.40-13.40	5	1240	1158	932	25	2356
12.50-13.50	6	1210	1182	936	28	2328
13.00-14.00	6	1251	1188	926	27	2334
16.00-17.00	7	1296	1132	832	26	2340
16.10-17.10	9	1343	1096	829	26	2346
16.20-17.20	8	1380	1047	814	23	2674
16.30-17.30	9	1404	1044	816	16	2676
16.40-17.40	9	1452	1037	820	15	2688
16.50-17.50	8	1477	1058	845	13	2682
17.00-18.00	8	1489	1057	869	12	2692
R2 = 76.4%; Adjust R2= 70.5%; pce (mc infront) = 0.2; pce (mc beside) = 0.2; pce (mc inside) = 0.8; pce (hv) = 0.2; pce (lv) = 1.00						

Approach with a lane width of 7 meters without ESSM it can be seen that regression analysis of saturation flow S3 (formula 5) goodness of fit value with R-Square approach of 0.917 which means motorcycle behavior (in front of a stop line, beside flow, inside flow), light vehicles and heavy vehicles contribute 91.7% to saturated flow. And the significance of F of 0.000, a model built on the data obtained has been feasible. Regression analysis also found the larger HV, MC in front, MC beside, MC inside the smaller the saturated flow. The largest determinant of saturated flow at a column width of 7 meters without ESSM is HV because it has a PCE value of 0.9. PCE motorcycle beside flow and PCE inside flow value are almost the same which are.4 and 0.3, it is because, on an approach with a lane width of 7 meters without ESSM motorcycle behavior beside flow, inside flow movement is constant so it does not interfere with other vehicles in maneuvering. PCE motorcycle in front of stop line 0.8 times light vehicle, it is because the behavior of the motorcycle in front of stop line interferes with the movement of other vehicles because of its behavior so that other vehicles cannot maneuver freely, other vehicles maintain a safe distance where the area needed for a safe distance from the behavior of the motorcycle in front of stop line is 0.8 of the light vehicle area. PCE vehicles weighing are 0.9 times PCE light vehicles are close to light vehicles because in addition to the volume of vehicles on this approach has started to be many and stable so that the safe area of heavy vehicles is 0.9 times light vehicles.

While from the approach with a lane width of 7 meters with ESSM, regression analysis of saturation flow S3 (formula 5) goodness of fit value with R-Square approach of 0.665 which means motorcycle behavior (in front of a stop line, beside flow, inside flow), light vehicles and heavy vehicles contribute 70.5% to saturated flow. and the significance of F of 0.000 models built on the data obtained has been feasible. In regression analysis also found the larger HV, MC inside, the smaller the saturated flow and the larger the MC beside, the MC in front the greater the saturated flow, The largest determinant of saturated flow at the width of the column 7 meters with ESSM is the MC inside because it has a PCE value of 0.75. Table 7 shows the variation of each PCE based on the behavior of the motorcycle to save with a width of 3.5 and 7 meters without or with ESSM. PCE motorcycle in front of the stop line and beside the flow PCE is the same which is 0.2 times the light vehicle, is because the behavior of the motorcycle in front of the stop line and beside flow does not interfere with other vehicles in maneuverable. The area required for a safe distance from the behavior of the motorcycle in front of the stop line and beside flow is 0.2 of the light vehicle area. Vehicles weigh 0.2 times the PCE of light vehicles because, in addition to the volume of heavy vehicles being very small passing through the intersection in 1 hour, heavy vehicles also do not interfere with light vehicles so that other vehicles maneuver regularly with constant where the safe distance area of heavy vehicle behavior is 0.2 times light vehicles. Unlike the case with the behavior of motorcycles inside flow 0.8 times PCE light vehicles because the behavior of inside flow interferes with the movement of other vehicles so that other vehicles need a safe area of 0.8 times light vehicles.

Table 8. Summary PCE value

Approach width		Multiple Linear Regression Model	PCE				
			MC *Infront*	MC *Beside*	MC *Inside*	LV	HV
3m	without ESSM	*S=-0,02infront+1,2beside-0,2inside+0,1HV*	0,02	1,2	0,2	1	0,1
	ESSM	*S=-0,06infront+1,2beside-0,2inside-0,1HV*	0,06	1,2	0,2	1	0,1
5m	without ESSM	*S=0,8infront+0,1beside+0,3inside+0,2HV*	0,8	0,1	0,3	1	0,2
	ESSM	*S=0,4infront–0,1beside-0,7inside-0,1HV*	0,4	0,1	0,7	1	0,1
7m	without ESSM	*S=-0,8infront–0,4beside-0,3inside+0,1HV*	0,8	0,4	0,3	1	0,9
	ESSM	*S=0,2infront+0,2beside-0,8inside-0,2HV*	0,2	0,2	0,8	1	0,2

From Table 8, it can be seen that in general, the larger the width of the shorter, the greater the PCE value of mc inside flow and HV both with ESSM and without ESSM, it is because the larger the width of the lane, the more significant the volume of mc inside flow and HV. As for other PCE values varying in each approach width, both ESSM and without ESSM, the volume of motorcycles beside flow and in front of the stop line varies in each width of the approach. In general, the PCE value of heavy vehicles is small, and this is because the volume of heavy vehicles slightly passes through the intersection per hour.

4. Conclusions

PCE values differed from each approach observed. PCE values are varied according to vehicle proportions, geometrics, and motorcycle behavior. In synergy with different lane widths, motorcycle behavior is also different because motorcyclists' perception varies in each lane width. Eventually, it relates to how they maneuver to get out of the intersection quickly. With different behaviors, certainly, the value of PCE is different.

Approach with an effective width of 7 meters with ESSM PCE obtained is a PCE motorcycle in front of stop line of 0.2, PCE motorcycle beside flow 0.2, motorcycle inside flow 0.2, light vehicle 1, and heavy vehicle 0.2. The behavior of motorcycles beside flow has a significant PCE value on the approach with an effective width of 3 meters with ESSM or without ESSM and an approach with an effective width of 7 meters without ESSM of 1.2 and 1.4. HV PCE values have low values of 0.1 and 0.2 at effective widths of 3 meters, 5 meters, and 7 meters, both with ESSM and without ESSM. In general, the greater the width of the shorter, the greater the PCE value of mc inside flow is and HV both with ESSM and without ESSM. This is because the more significant the width of the lane, whereas the greater the volume of mc inside flow and HV. As for other PCE values varying in each approach width, both ESSM and without ESSM, the volume of motorcycles beside flow and in front of the stop line varies in each width of the approach. Most of the PCE HV values are very small, namely 0.1 and 0.2 caused by the volume of heavy vehicles that slightly pass through the junction in an hour.

The width of the 3-meter lane with ESSM and without ESSM PCE is relatively the same. It proves that the ESSM is not so influential on the behavior of the motorcycle, it happens because the motorcycle prefers in addition to other vehicles (beside flow) the width of the lane is narrow, so ESSM cannot accommodate the motorcycle, so the MC beside mostly affects saturated flow. At the same time, the MC inside will reduce the value of saturated flow. At a lane width of 5 meters without ESSM, the most influential saturated flow is the MC in front. Meanwhile, at a lane width of 5 meters with ESSM, MC Inside flow is the most significant. At a lane width of 7 meters with ESSM, HV, and all motorcycle behavior reduce the value of saturated flow where the most influential in reducing saturated flow is the amount of HV. As for the width of the column of 7 meters without ESSM, the most significant to reduce saturated flow is HV.

The PCE HV value for all stores is smaller than the PCE value of LV, the PCE value of HV is also smaller than the PCE value of one of the behaviors of a motorcycle except at an approach of 7 meters without ESSM. The reason is that the proportion of HV is tiny. Similar research needs to be done with different methods to determine the most relevant PCE values.

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Determination of PCE Based on Motorcycle Behavior at Signalized Intersections in Denpasar, Bali

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