# Passenger car equivalents of becak bermotor at road segment in Medan

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**Abstract.** The road traffic systems, travel patterns and other traffic characteristics are different for each country due to differences in the geometric patterns, available transport facilities for commuters, proportional and type of the vehicle itself and so on. In Indonesia, the standard of pce (Passenger Car Equivalent) value found on IHCM (Indonesian Highway Capacity Manual) published in 1997. IHCM stated that the value of pce for heavy vehicles and motorcycles are 1.3 and 0.5 respectively. On these day, regarding Medan as a third biggest city in Indonesia, there have been lot of changes with regarding to the composition of the vehicle, as well as variations of the type of the vehicle itself. Becak bermotor (motorized tricycles) is a vehicle which is widely available in the city of Medan. Data from Medan City Transportation Department stated that there are more than 20,000 motorized motorized tricycles vehicles operating in the city at these day. Pce value of these rickshaws will be calculated based on observations at road and intersections in Medan. The calculation result shows that the pce value of motorized rickshaw is more than 1. This value will make the calculations regarding the performance of the traffic can be performed more accurately.

## 1. Introduction

For Planning of road transport infrastructure in Indonesia, the Highway Capacity Manual (MKJI) was used as one of its references. The equivalence of passenger cars (pce) is a factor that indicates the effect of various types of vehicles compared to light vehicles on speed, ease of use, dimensions of light vehicles in traffic flow (for passenger cars and light vehicles of similar chassis pce = 1.0).

The value of the determination of the equivalence of passenger cars in MKJI is taken from the results of research in certain areas. This causes the value of the equivalent of passenger cars is not necessarily able to represent the characteristics of traffic that exists throughout Indonesia. Based on these conditions it is necessary to review the provisions of the existing passenger car equivalence to be adjusted to the conditions and characteristics of current in each region in Indonesia.

In a road plan, the types of vehicles expected to cross the road are heavy vehicles, light vehicles and motorcycles. Motor vehicles are an important means of land transportation for the community to facilitate the mobility of people and goods. Along with the increasing need for movement of people and goods, the number and volume of motor vehicles increases rapidly, this will result in among others; Congestion, frequent accidents and air pollution is detrimental to health. Road segment will be

congested if the capacity of the road is not sufficient to accommodate the volume or current through the road, in other words the traffic volume exceeds the existing road capacity.

One of the important problems in the city of Medan is a motorized rickshaw. This vehicle in the city of Medan is a vehicle used to transport people from one place to another. The existence of motor rickshaws is currently experiencing a very significant growth number, this will certainly affect the speed of other vehicles in a road, because this motor vehicle pedicab has a low acceleration and deceleration.

For that reason, it is necessary to carefully influence the effect of pedicab motor vehicles on the traffic performance and need to study the equivalence value of passenger cars for motor tricycles vehicles, related to their role as part of the traffic on the road segment. The study was conducted on Gajah Mada Street in Medan city which is a 4 lane road 2 direction without median. The selection of the location is based on the volume of pedicab motor vehicles in the location.

## 2. Passenger Car Equivalent

In the Indonesian Road Capacity Manual (MKJI) 1997 [1], the value of traffic flows reflects the composition of traffic, stating the flow of traffic in units of passenger cars (pcu). All traffic values (per direction and total) are converted to units of passenger cars (pcu) using pce irically derived passenger cars (pce) derived for the following types of vehicles:

- *Light vehicles (LV) including passenger cars, minibuses, pik-ups, small trucks and jeeps.*
- *Heavy vehicles (HVs) including trucks and buses*
- *Motorcycle (MC).*

The equivalence of passenger cars (pce) for each type of vehicle depends on the type of road and the total traffic flow expressed in the vehicle / hour. All pce values for different vehicles are shown in Table 1 bellow.

**Table 1.** Passenger car equivalent (pce) for undivided road (UD)

| Road Type | Total Traffic for all direction (veh/hour) | pce | | |
|---|---|---|---|---|
| | | HV | MC | |
| | | | Width of lane, Wc(m) | |
| | | | ≤ 6 | >6 |
| Two Lane Undivided (2/2UD) | 0 to 1800 >1800 | 1,3 1,2 | 0,5 0,35 | 0,4 0,25 |
| 4 lane undivided (4/2UD) | 0 to 3700 >3700 | 1,3 1,2 | 0,4 0,25 | |

Source:  Manual Kapasitas Jalan Indonesia, 1997 p. 5-38

Passenger Car Equivalence (pce) is a factor that indicates the effect of different types of vehicles compared to light vehicles on speed, ease of use, dimensions of light vehicles in traffic flow (for passenger cars and light vehicles of similar chassis pce = 1.0) [1].

There are several ways or methods that can be used to estimate the equivalence value of passenger cars, depending on the characteristics and conditions of traffic. The way or method that can be used to find or estimate the equivalence of passenger car (pce) are:

### 2.1. Capacity base

The pce counting method based on the capacity according to Chang Chen (1978) in Murtiono ES [2], is a method of modal mode comparison, modified and adapted to the research conditions of survey results obtained from various modes of transport. With these various combinations can be searched the

equivalence value of passenger cars from motorized tricycles with multiple linear regression which formulates as follows

$$Q = b_1\, qlv + b_2\, qhv + b_3\, qmc + b_4\, qbck \tag{1}$$

Where:
Q             = Traffic Volume (pcu/hour)
b             = Coefficient
qlv           = Number of Light Vehicle
qhv           = number weight of vehicle
qmc           = number of motorcycle
qbck          = number of becak  motor/motorized tricycles
which  $b_1$ = pce for lv = 1 ;

$b_1\, qlv = Q - b_2 qhv - b_3 qmc - b_4 qbck$

From the equation, the coefficient generated on each vehicle type is the pce value of the vehicle type.

*2.2. Speed Basis*
Pce calculation method with base speed according to Van Aerde and Yagar (1984), that is by knowing relation of velocity (v) and traffic volume (q) by using multi linear regression.
The linear model of velocity and volume relationships is chosen because in practice the relationship between volume and velocity is close to linear. Multiple regression models of the relationship of speed and volume are:

$$V = a - b_1\, qlv - b_2\, qhv - b_3\, qmc - b_4\, qbck \tag{2}$$

Where:
V = average speed (km/h)
a = free current velocity (km/h)
b = coefficient
qlv = number of light vehicles
qhv = number of heavy vehicles
qmc = number of motorcycles
qbck = the number of motorized tricycles

To determine pce vehicles other than passenger cars the coefficient of each vehicle is divided by the coefficient of passenger car (lv) and can be formulated:

$$pce_i = \frac{b_i}{b_1} \tag{3}$$

Where:
bi = vehicle type coefficient i
b1 = passenger car coefficient (lv)


3. Analysis and Discussion
The result of regression analysis of motorbike proportion relation to traffic flow velocity, ploted in graph form as shown in Figures 1 and 2:
From the analysis survey result in front of gas station (location 1), at interval of vehicle volume 1448-1872 pcu/hour, got relationship between proportion of motorized tricycles with speed of traffic (r) -0.143. This shows that there is a very low relationship. While the direction of the relationship is negative, it indicates that the larger the motorized tricycles proportion the smaller the speed of traffic at that location.

From the analysis results in front of LP3i (location 2), simple correlation (r) obtained, at the vehicle volume interval 1475-1930 pcu / hour obtained between the proportion of motorized tricycles with the traffic speed is (r) -0.304. This shows that there is a low relationship between the two parameter. While the direction of the negative relationship, indicating that the greater the proportion of the pedicab, the speed of traffic in the location will be smaller.
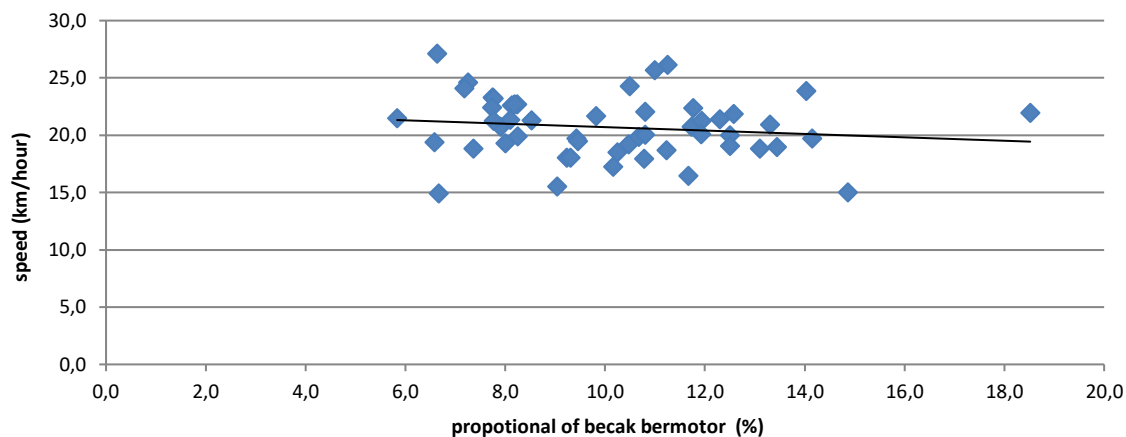


**Figure 1.** Graph of influence of motorized tricycles vehicle proportion to speed of traffic at location 1 (Jalan Gajah Mada).
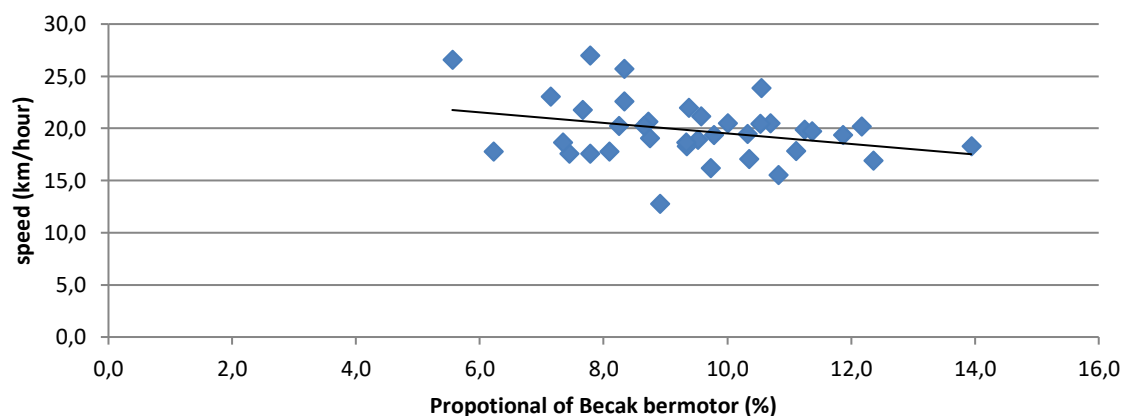


**Figure 2.** Graph of influence of motorized tricycles vehicle proportion to speed of traffic at location 2 (Jalan Gajah Mada ).

In order for the value of pce to be a reference, it is necessary to have an pce value that can represent each type of vehicle. To obtain a representative pce value, the calculated average pce values for both sites were surveyed (Table 2).

**Table 2.** Recapitulation result of pce

| Vehicle Type | pce | | Number of Vehicle | |
|:---:|:---:|:---:|:---:|:---:|
| | Location 1 | Location 2 | Location 1 | Location 2 |
| LV | 1 | 1 | 5470 | 5551 |
| HV | 1.99 | 1.89 | 110 | 83 |
| MC | 0.54 | 0.55 | 13021 | 11912 |
| BCK | 0.84 | 1.13 | 1915 | 1765 |

From the data available in Table 2, we can find the average pce per type of vehicle and compare it to the MKJI as described at Table 3.

**Table 3.** The differences of pce between MKJI and Analysis

| | Total Volume, 2 Way (veh/hour) | LV | HV | MC | BCK |
|:---|:---:|:---:|:---:|:---:|:---:|
| Pce  MKJI 1997 | $\geq 3.700$ | 1 | 1.2 | 0.25 | - |
| pce survey 2016 | $\geq 3.700$ | 1 | 1.95 | 0.54 | 0.98 |

There is a difference between the three pce values, which occur because:
a. pce at MKJI in 1997 is a summary of typical traffic in some cities in Indonesia while pce in survey 2016 is an actual condition in Medan.
b. There is a difference of pce value in the field with the pce value on MKJI because of the difference of initial assumption that "becak bermotor" or BCK value is same as motorcycle (MC).

4. Conclusion
The results obtained from the analysis can be concluded as follows:
1. The proportion of motorized tricycles vehicles has a low effect on the average speed of traffic on Jln. Gajah Mada.
2. Pce values obtained in Jln. Gajah Mada stated that the traffic density had a significant effect on the average speed.
3. From the analysis results obtained pce values for traffic on the road Gajah Mada is LV = 1, HV = 1.95, MC = 0.54, BCK = 0.98.
4. There is a difference of average pce value from Gajah Mada street with pce value on MKJI because of differences in the initial assumption that motorized tricycles value is same as motorcycle, this is done because the proportion of motorized tricycles is still small.

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