Travel Demand Management Implementation in Bandar Lampung

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Abstract. The high traffic growth of motorcycle (24% per year) and private vehicle (20% per year) in Bandar Lampung is the main factor as the negative impact of congestion. In previous study, the financial losses in Bandar Lampung in term of fuel consumption, time value, and pollution costs Rp 2 Trillion per year. In order to finding a solution to traffic congestion could prevent the massive amount of wasted funding, finally, this paper reviews the range and the scope of possible policy measures aimed at travel demand management to reduce negative impact of traffic congestion. Geometric or physical improvements to roads and intersections have been the traditional response to congestion and only reduce 0.08 degree of saturation flow. Otherwise, motorcycles lanes are one of important strategy for alleviating congestion and reduce 0.3 degree of saturation flow. Further, the addition of new capacity presents an excellent opportunity to combine it with other types of travel demand strategies.

1. Introduction

Traffic congestion is one of the problems that often occur in urban areas, in this case Bandar Lampung. Especially passenger car and motorcycle on several main streets in this city, generally the most traffic occurs in the morning and afternoon which is many people do activities at the same time and in the same destination. The purposes of this research are determining a point of impact of traffic congestion and try to implement travel demand management as one of solution.

Based on data from DISPENDA, motorcycles and passenger cars are growing fast for last ten years. The growth of passenger cars ownership in Bandar Lampung is 20% per year while the motorcycle is 24% per year. The growth of road developments in this city is much slower than the growth rate of vehicle ownership. Until 2016, the government has built five overpass bridges (flyovers) and widening on several roads, but it will only short-term problems solving.

Traffic jam caused financial losses according to the value of time, fuel consumption, and pollution. From previous study, the amount of financial lost based on value of time are Rp 390 billion per year, Rp 797 billion from fuel consumption and Rp 879 billion per year based on pollution cost. The amount of congestion loss in terms of those three variables is Rp 2 Trillion per year. This is a big value of losses and going increase every year. Traffic congestion is one of the chronic problems in most cities and this problem is getting worse year by year. Physical development such as new road or widening cannot solve the problems. After a few years, the new highway will be filled with traffic that would not have existed if the highway had not been built. Similarly, the widened road will be filled with more traffic in a few months. For this reason, the study was conducted to discover and develop concrete steps that can be done by the Government such as travel demand management.

2. Financial Losses in Terms of Value of Time, Fuel Consumption and Pollution

Traffic jam caused financial losses viewed from the value of time, fuel consumption, and pollution. This section will discuss about calculating the financial losses caused of three factors above.

2.1 Financial Losses based on Value of Time

Congestion will cause delays and queues that increase travel time. The value of travel time is the amount of costs incurred someone who is willing to save travel time. Congestion will certainly cause a reduction in travel time savings. This can lead to the increasing of travel costs and losses due to congestion. The previous study [1] was conducted to quantify the cost of losses due to congestion in Bandar Lampung city. This study was carried out during peak hour on Monday, Thursday and Sunday at the intersection of roads along ± 3.7 km. The method used to analyze the value of travel time is The Income Approach Method. This method is used to calculate value of travel time based on two factors, such as Gross Domestic Regional Product (GDRP) and amount of working time per year. The formula of this method is as follows:

$$\lambda = (\text{GDRP/person}) \,/\, \text{amount of working time in one year per person} \qquad (1)$$

Where:

λ = Value of Travel Time
GDRP = Gross Domestic Regional Product

From recent condition in 2017, GDRP of Bandar Lampung is Rp. 57. 4275 Trillion per year, amount of working time in one year for each person is 2,400 and population in 2017 is 1,276,704 people. So, the value of travel time is

$$\lambda = 57{,}4275 \times 10^{12} / (1{,}276{,}240/2{,}400) = \text{Rp. } 18{,}742 \text{ per hour}$$

The amount of losses due to congestion, in terms of time value can be calculated in ways as follows:

$$\text{Cost of Losses} = \text{Traffic volume} \times \text{congestion time} \times \text{travel time value} \qquad (2)$$

The cost of losses due to congestion with The Income Approach Method for one year is 356,519 x 0.12 x 365 x Rp. 18,742 = Rp. 390.223 billion

2.2Financial Losses based on Fuel Consumption

In previous study [2], the influence of travel time is related to fuel consumption level. The longer travel time caused by traffic jam and delay, the biggest value related to fuel consumption resulted in significant losses. Primary data included travel time, traffic jam duration, average speeds of vehicles, travel time for using one liter of fuel consumption, wasted fuel, and traffic volume. The types of vehicles in this case are private car using premium and solar fuel, urban transportation and Bus Rapid Transit (BRT). From survey, we found that 0.875 liter wasted fuel per day per vehicle. The results showed that the highest loss caused by traffic jam obtained from private car with premium fuel. The estimated loss was Rp 797,043,512,920,- at rush hour.

2.3Financial Losses based on Air Pollution

Congestion will increase vehicle emissions and cost of air pollution. The previous research [1] was conducted to analyze pollutants concentrations generated traffic emissions in Bandar Lampung. The method that used is the load of emission factors in Indonesia as well as the level of emissions cost generated from greenhouse emissions (GRK). The emission factors of vehicles in this study is limited to pollutants such as Carbon Monoxide (CO), Carbon Dioxide (CO^2), Hydrocarbons (HC), Nitrogen Oxides (NOx), Particulates (PM_{10}), Sulfur Dioxide (SO_2), from the content of vehicle's fuel. In determining emissions from each vehicle can be calculated using several factors such as trip length, emission factor (FE), and traffic volume is as follows:

$$E_{j=} \sum_{i=1}^{n} E_{ij=} \sum_{i=1}^{n} l.P_{i.}V.C_{ij=}\ lV \sum_{i=1}^{n} P_{i.}C_{ij}$$

$$E_i = \sum_{j=1}^{n} VKT_j * FE_{i,j} * 10^{-6} \quad (3)$$

Where:

Ei = Emission from polutan i (ton/year)
VKTj = Total trip length for the type j of vehicle (km.vehicle/year).
FEi,j = Polutan i per km trip length per each j type of vehicle (g/km.veh).
V = total traffic volume in a road segment.

Table 1. Total Vehicle's Emission for Each Pollutant

Total Vehicles Emission E_i(ton/year)					
CO	HC	NOx	PM_{10}	CO_2	SO_2
8,420	2,051	355,477	71,778	1,318,504	20,059

Cost of each pollutant as follow:

$CO_2$and CO = \$ 205/ton = Rp. 2,665,000/ton
SO_2 = \$ 1000/ton = Rp. 13,000,000/ton
HC = Rp. 572,000/ton
NOx = Rp. 12,142,000/ton
PM_{10} = Rp. 41,275,000/ton

Based on a survey and emissions calculation, the financial losses caused by congestion based on vehicle emissions within 1 year is Rp 878,825,000,000.

3. Traffic Jam Solution with Road Widening (Physical Improvement)

This previous study [4] be hold to find out how effective the road widening to reduces traffic congestion and increases the road performance. The data was analyzed based on Indonesian Highway Capacity Manual.

The composition of the traffic flow stating in passenger car units (pcu). All traffic flow values (each direction and total) was converted into passenger car units using passenger car equivalents. Based on IHCM, road capacity can be calculated by reference to the equation:

$$C = Co \times FCw \times FCsp \times FCsf \times FCcs \quad (4)$$

C = capacity (pcu / h).
Co = base capacity (pcu / h).
FCW = lane width factor.
FCsp = separating direction factor.
FCsf = side friction factor.
FCCS = city size factor.

Free flow speed actually used by the following equation:

$$FV = (FVO + FVW) * FFsf * FFVcs \tag{5}$$

FV: free flow speed of light vehicles (km / h)
FVW: effective carriageway width (km / h)
FVO: base free flow speed of light vehicles (km / h)
FFVcs: speed adjustment for the size of the city
FFVsf: side friction factor adjustment and width of shoulder

The degree of saturation can be calculated by the following equation:

$$DS = Q / C \tag{6}$$

DS = Degree of saturation flow
Q = total flow (pcu / h)
C = capacity (pcu / h)

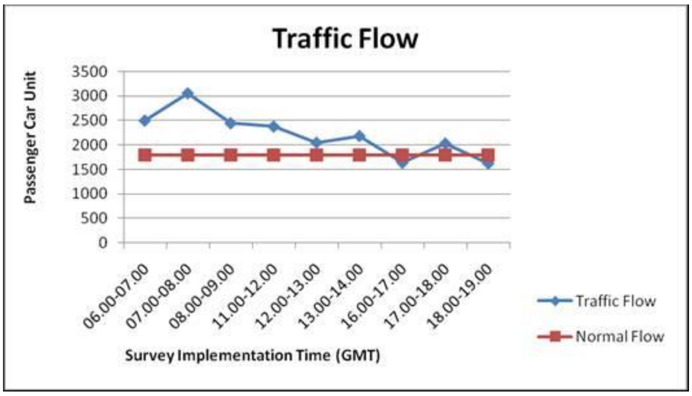

Fig. 1. Traffic Flow in Direction 1

Road capacity
C = (1650 × 2.5) × 0.92 × 1.00 × 0.92 × 0.94 = 3,496 pcu/ hour.

The degree of saturation flow on the main streets (DS)= 2692/3496 = is 0.77 with a level of service (LOS) C.

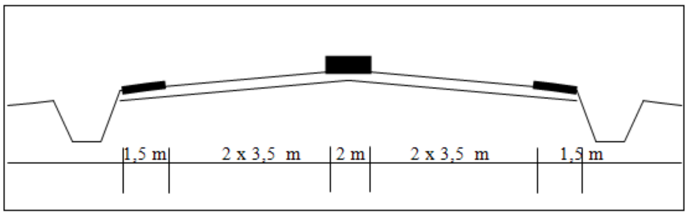

Fig. 2. Cross Section Before Road Widening

After doing 1.2 m road widening, the degree of saturation flow (DS) is 0.76 with the level of service (LOS) C. This is indicated that geometric improvement is not effective to increasing the level of service (LOS) significantly.

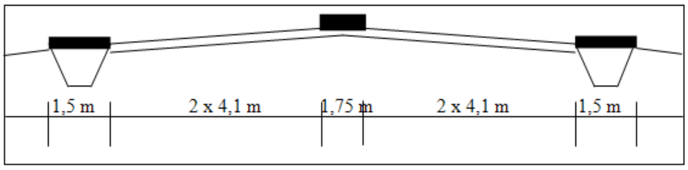

Fig. 3. Cross Section After Road Widening

Furthermore, to determine the level of service (LOS) after doing road widening is shown in Table 2.

Table 2. The Comparison of Before and After Road Improvement

Factor	Before geometric improvement	After geometric improvement
Capacity (C)	2854 pcu/hour	3083 pcu/hour
Traffic Flow (Q)	2208 pcu/hour	2370 pcu/hour
Degree of Saturation Flow	0.773	0.768
Travel Speed	50 km/hour	54 km/hour

Such phenomenon is called by induced demand, neither building new roads nor widening roads are the long-lasting solution to traffic congestion.

4. Traffic Jam Solution with Travel Demand Management

Transportation Demand Management (TDM, also called Mobility Management) is a general term for strategies that result in more efficient use of transportation resources.

4.1 Motorcycles Lane Separation

Motorcycle lanes usually located on the main carriageway for each traffic flow direction. Motorcycle lanes in this scenario obtained from painted lines on existing road.

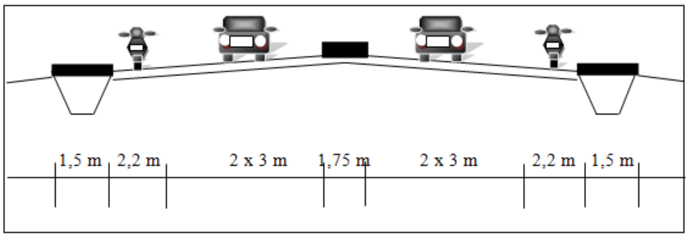

Fig. 4. The Scenario of Separated Motorcycle Lane

Based on problem-solving such as specials separation motorcycles lane scenario, it produces a decrease of DS from 0.77 to 0.595 or increase level of service (LOS) from C to A. It indicates that this scenario more effective than road widening.

Table 3. The Comparison of Before and After Motorcycle Separated Lane Improvement

Factor	Before Motorcycle Separated Lane	After Motorcycle Separated Lane
Capacity (C)	2854 pcu/hour	2711pcu/hour
Traffic Flow (Q)	2208 pcu/hour	1613pcu/hour
Degree of Saturation Flow	0.773	0.595
Travel Speed	50 km/hour	53 km/hour

4.2 The Side Friction Reduction Scenario

Congestion leads to various effects like delay of travel, reducing speed, and reducing capacity. The reason for congestion in Bandar Lampung is not only due to substantial growth of traffic volume but also due to the many activities prevail on the side of the road. They are on-street parking, stop vehicles, pedestrian movement, and others. Side friction used in the calculation is the side friction that occurs when the current peak hour is 07:00 to 8:00 pm. In the interval, there were 99 cases that hour pedestrians (PED), 83 the incidence of vehicles parked vehicles, raising or lowering passengers (PSV), 140 events in and out of vehicles (EEV) and 9 events slow vehicle (SMV). This scenario try to reduce side friction such as on-street parking.

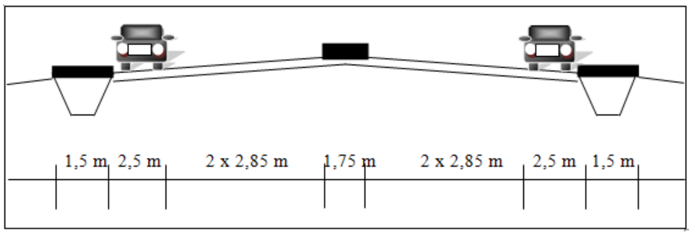

Fig. 5. The Scenario of Side Friction Reduction

This Scenario (side friction reduction) produces DS 0.745 and increase travel speed 56km/hour.

Table 4. The Comparison of Before and After Side Friction Reduction

Factor	Before Side Friction Reduction	After Side Friction Reduction
Capacity (C)	2854 pcu/hour	2711pcu/hour
Traffic Flow (Q)	2208 pcu/hour	2020pcu/hour
Degree of Saturation Flow	0.773	0.745
Travel Speed	50 km/hour	56 km/hour

4.3Bus Rapid Transit Application to Reducing Traffic Jam

Mass transit development is one way to increase the capacity of roads in order to reduce traffic congestion. One of the public transportation that can be applied is BRT (Bus Rapid Transit). In this system, city buses performance will be improved by giving some priority on the road, such as: special bus lanes.

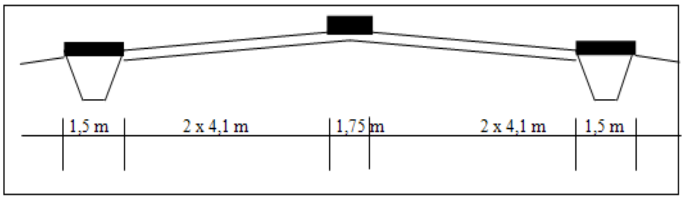

Fig. 6. Sectional Road after Road Widening

In this scenario [3], it is assumed that the width of traffic lane is 8.2 m, consist of the width of BRT lane is 2.2 m and two lanes with 3 m each wide for passenger car.

Table 5. The Comparison of Before and After BRT Lane Implementation

Factor	Before BRT Lane Implementation	After BRT Lane Implementation
Capacity (C)	3496pcu/hour	3076pcu/hour
Traffic Flow (Q)	3056pcu/hour	1759pcu/hour
Degree of Saturation Flow	0.87	0.57
Travel Speed	50 km/hour	56 km/hour

The implementation of BRT lane can minimize the negative effects of congestion. Otherwise on first implementation, it could be not popular regulation because that would reduce the number of traffic lanes for other vehicles.

5. Other Solution

From the results we can see that travel demand management implementation such as special lane for motorcycles, side friction reduction, and BRT Lane implementation are more effective than road widening. Other aspect of travel demand management that could be implemented in Bandar Lampung to reduce traffic congestion; reduce infrastructure investment costs; improve air quality and reduce entire cost of gasoline are parking management; car polling and school polling; travel hour spread; bicycle and pedestrian; congestion pricing; campus action for efficient transportation; car-free planning; kiss and ride; park and ride; intelligent transport system; also transit oriented development.

6. Conclusion

Travel demand management implementation can minimize the negative effects of congestion compared to physical treatment such as widening or built a new road. The entire objective is to ensure that travel demand management principles are considered as a solution for reduce traffic congestion. No single solution for congestion problem solving. It will also inform our transport partners, developers and the public to manage the demand for traveling. Travel demand management is not the sole responsibility of one agency, otherwise it should be delivered by a number of organizations. The following agencies play a key role in managing travel demand.

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[Remarks by Editorial Office] The original manuscript has been replaced by this new manuscript. The minor errors has been corrected by the author and the correct version, i.e., this manuscript, was uploaded on 13 March 2017 based on the author's request.