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A Traffic Optimization Model Considering Air Pollution Reduction (Case Study: Sadr Overpass)

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ABSTRACT: Achieving the lowest emission rate of urban air pollutants, requires an effective management of mobile air polluting sources. To address this type of management, not only high quality vehicles should be recruited but also the quality of transportation such as amount, slope, and traffic patterns (i.e., steady vs. interrupted flow) should be considered. Therefore, a number of methods are emerged to control the steadiness of traffic flow through traffic network instruments such as traffic lights or ramp metering schemes. In this study, attempts have been made to model a steady traffic flow on the Sadr Overpass to mitigate the least air pollutants production Modeling the optimized traffic volume entering and leaving the ramps whilst maintaining an acceptable service level using a mathematical linear programming technique is presented. Furthermore, a simulation has been conducted using an IVE model to estimate the amount of emissions. The results indicate that temporary closure of ramps in the east-west direction could lead to a steady flowrate on the overpass which decreases the amount of CO and NOx by %54 and %25, respectively. Similarly, in the West-East direction, deploying a cyclic monitoring of traffic flow in the ramp discharging into Modarres Expressway, results in reduction of CO and NOX by %42 and %41, respectively.

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1. INTRODUCTION

Imposing efficient transportation demand management policies in cities leads to significant effects in un-interrupted traffic flow and air pollution. As an example, by restricting the accesses to Sadr Overpass, as one of the most congested highways in the city of Tehran, can reduce traffic pollutant emissions. Studies in this case show the effect of optimizing stability components of traffic and its patterns in air pollution reduction. For example, in 2018 a study has been conducted to investigate the effects of different ramp metering strategies in air pollutant emissions[1]. In another study a system dynamics model has been used in order to describe the effect of potential TDM policies on long-term environmental costs to the city of Mashhad[2]. In a different study the effect of pricing policy in air pollutant emissions in central area of Tehran is investigated[3]. In 2018 behavior of motorcyclists toward cordon pricing and increasing fuel price policy were investigated in the Central Business District (CBD) of Tehran[4]. Although many recent studies aim at TDM policies effects on air pollution, rare researches have studied optimizing traffic flow parameters to reduce air pollution emissions by TDM policies. Therefore, in this study optimized traffic flow that leads to minimum air pollutant emissions in both west to east and east to west of Sadr overpass is modeled with linear programming method[1].

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2. METHODOLOGY

Entrance and exit ramps of the Sadr overpass have limit of access in some hours of day. Therefore, specific flowrate as a result of traffic demand policies leads to specific vehicle emission rate that is estimated by IVE[2] model. In order to impose TDM policies from an environmental prospective, an optimized traffic model with air pollution reduction approach is developed by a linear programing(LP) method in both sides of Sadr overpass. In this mathematical model flowrate is obtained by different parameters such as maximum allowed speed, level of service and number of lanes in a highway graphed in HCM-2010[5]. The linear programming equations for ramps of Sadr overpass is shown in expressions 1 to 6. These are main equations that are established in a highway with multiple entrance and exit ramps that ensures maintenance of steady traffic flow pattern[6]. The equations are solved with simplex method.

[1] LP
[2] International Vehicle Emission

$$\max x_1 + x_2 + \ldots + x_n \quad (1)$$

$$\max \sum_{j=1}^{n} x_j \quad (2)$$

$$\sum_{j=1}^{n} A_{kj} X_j \leq B_k \qquad k=1,2,\ldots,n \quad (3)$$

$$X_j \leq D_j \qquad j=1,2,\ldots,n \quad (4)$$

$$X_j \geq 0 \qquad j=1,2,\ldots,n \quad (5)$$

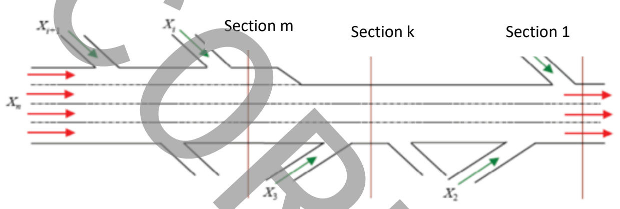

Fig. 1. Schematic view of the multiple ramps of a highway

Table 1. Comparison of flow rate in mathematical linear Model and current flow rate

Direction	Current flow rate(veh/hr)	Flow rate obtained by LP(veh/hr)
East to West	4890	3900
West to East	3490	2795

3. DISCUSSION OF RESULTS

By using the capacity of ramps as maximum demand rates, the results of linear programming equations in peak hours represent optimized traffic flowrate of the Sadr overpass. Table.1 shows the optimized flowrate obtained by LP for both directions of the Sadr overpass in comparison with its flowrate under normal circumstances.

The results of LP equations for entrance ramp of Kaveh Boulevard is obtained zero, which means closure of it in the peak hours can lead to a steady traffic flowrate as well as the lowest air pollutant emissions. The results showed that CO emission is reduced by %54 in this case.

In West to East direction, results showed that the traffic flowrate entered via Modarres Highway should decrease from 692 Vehicle/hr to 478 Vehicle/hr by ramp metering schedules in order to keep steady traffic condition all over the overpass.

Table 2. results of emission rates using IVE model in east to west direction

East to West	Emission rates of criteria pollutants (kg/hr)				
	PM	SO_x	NO_x	VOC	CO
Results obtained by LP	0.13	0.72	0.15	0.23	154.99
Results of modeling current situation	0.21	1.082	27.36	8.01	337.58
Difference value of emission	43	33	25	31	54

Table 3. Results of emission rates using IVE model in West to East direction

West to East	Emission rates of criteria pollutants (kg/hr)				
	PM	SO_x	NO_x	VOC	CO
Results obtained by LP	0.09	0.39	10.56	3.43	114.03
Results of modeling current situation	0.14	0.69	17.94	6.04	197.95
Difference value of emission	35	43	41	43	42

The results further showed that CO emissions in this case can be reduced by %42. The potential lowest emission rate of pollutants in both East to West and West to East direction of Sadr overpass is shown in Table 3.

4. CONCLUSION

The purpose of this study is to minimize the emission rate of air pollutants released by the passed traffic flow on the Sadr overpass of Tehran. The results of this study showed that in order to reach the lowest amount of air pollutant emission from petrol vehicles in East to West direction of the overpass, imposing TDM policies can be effective by restricting Kaveh Boulevard in morning peak hour meanwhile the level of service and the maximum efficiency is optimized. Also, in West to East direction, imposing a specific ramp metering to the entrance flowrate from Modarres Highway could lead to a steady traffic condition on the overpass. In such case PM emissions is decreased by %35 and CO pollutant by %42 as well.

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