The Optimal Equipping Based on M/G/K Algorithm

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Abstract. I develop a model to determine an optimal model to improve the traffic capacity of the toll plaza. My model contains four parts: In the first part, I consider the principles of designing the toll plaza. Then I set out to reach to an optimal model on the basis of the principle above. In the meantime, I take the accident prevention, heavy traffic and the throughput of the toll plaza into consideration. After that, I present the emergency area and portable toll collector in order to deal with emergency situations. Moreover, I analyze the traffic flow in various periods every day, after which I we get the scheme of mixed lanes. Then I get the distribution of toll plaza. Then, I change the numerical value of traffic flow when it at peak to examine the sensitivity of my model. What's more, my model is broad enough to accommodate any optimization problem. The result shows that my model is robust.

Keywords: Lanes Distribution, Traffic Capacity, M/G/K Algorithm.

1. Introduction

With the rapid development of our economy and the increase of traffic demand, convenient and fast highways become people's first choice when they drive out. The traffic growth in highway network brings greater pressure to the toll station. Based on above situation, we are required to determine the shape, size, and merging pattern of the area following the toll barrier in which vehicles fan in from B tollbooth egress lanes of traffic as we are considering a toll highway having L lanes of travel in each direction and a barrier toll containing B tollbooths (B>L) in each direction.

By analysis, we are supposed to solve the following problem:

Propose an optimal strategy. The strategy should satisfy the following conditions: with the least amount of cost and the best merging pattern.

Firstly, for generality, we set the volume of traffic, service time and level of service as variables. Then, we try to model the traffic capacity. On the one hand, the model needs to show the basic traffic capacity. On the other hand, it is required to depict the distribution under the influence of traffic flow increase and decline. Then we can change the inputs to do some simulations. Only using many simulation results can we build a relationship between input and output of the complicated transportation system.

Secondly, we seek to use the relationship getting from our simulation to find the best strategy for keeping the traffic capacity. In our model, "best" doesn't means "the largest toll plaza" but "the most suitable" that put weight on the throughput and the cost.

At last, we try to adjust our model to different initial state such as the traffic flow and the type of vehicle. We also take the electronic toll collection booths into consideration.

2. Optimization Model For Toll Plaza

2.1 The Principles of Designing Toll Plaza.

The ultimate aim of toll plaza design is to maximum to avoid the occurrence of traffic accidents and traffic congestion situation, and make the vehicle through a toll plaza safely after entering the lane to accept service. Of course, vehicles also require enough space for payment and going back to the normal track. In order to providing a safe, comfortable, and efficient work environment for management. The design of the toll plaza should follow the following principles:

Toll plaza should have enough charge lanes and parking space for the use of rush hour traffic.

Toll plaza shall not become an obstacle to the security, and avoiding the toll plaza on the interchange ramp affects the mainline traffic.

Toll plaza should be set as far as possible on the flat and straight line sections, for convenient parking and start of the vehicle.

Toll plaza construction should provide convenient conditions for billed business and management business.

2.2 Mixed ETC and MTC.

Table.1 Service level index of change ETC lane to mixed lane in exit

Number	Time bucket	Arrived quantity		Arrived time		Original use rate of ETC	Increased use efficiency
		MTC	ETC	MTC	ETC		
0	0:00-1:00	80	23	45.18	154.43	2%	1081%
1	1:00-2:00	59	15	60.81	243.24	1%	1265%
2	2:00-3:00	34	6	105.22	622.29	0%	2109%
3	3:00-4:00	27	3	132.33	1287.69	0%	3359%
4	4:00-5:00	25	5	145.61	682.19	0%	1502%
5	5:00-6:00	54	20	66.77	179.23	2%	862%
23	23:00-34:00	119	35	30.18	103.70	3%	1092%

As we can see from the table, the use efficiency increases when the lane is rebuilt. The use efficiency increases by 8 times at least and 34 times at most. So when the number of ETC vehicles is less, we should use shared lanes because the use efficiency of shared lanes exceeds accommodation lanes of ETC.

$$c_2 = a_2 + b_2. \tag{1}$$

1.2.1

2.3 Mobile Toll Vehicle and Portable Toll Collector

We should prepare emergency facility in case the toll systems break down. The design of location as follows: Increase mobile toll vehicles in the plaza, as we can see from Fig.1.
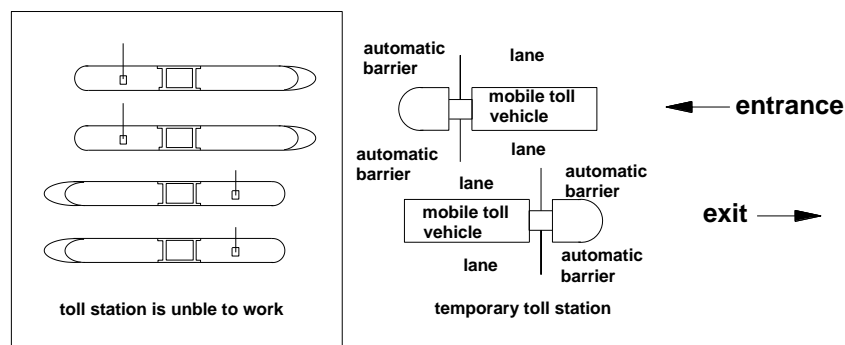

Fig.1 The diagrammatic drawing of mobile toll vehicle

In order to relief the traffic jam at the entrance when traffic flow increases, we set temporary toll facilities. The design of location as follows: Based on the toll system original, increasing portable toll machine in the plaza.
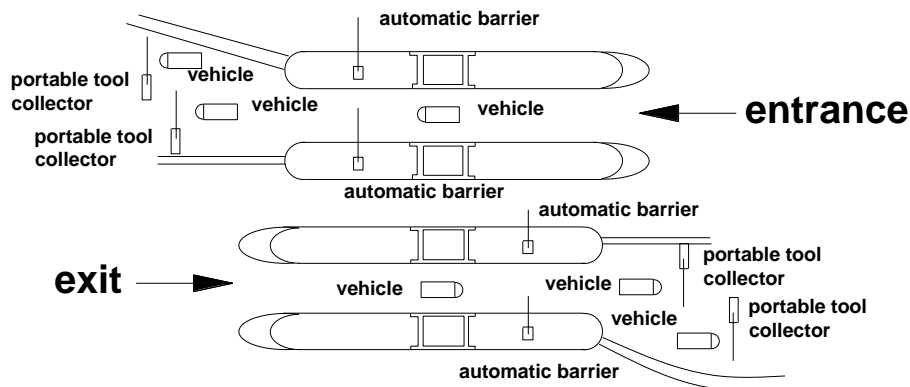
Fig.2 The diagrammatic drawing of added portable toll collector

2.4 Result

After running the program, we get the optimal scale of the toll plaza.

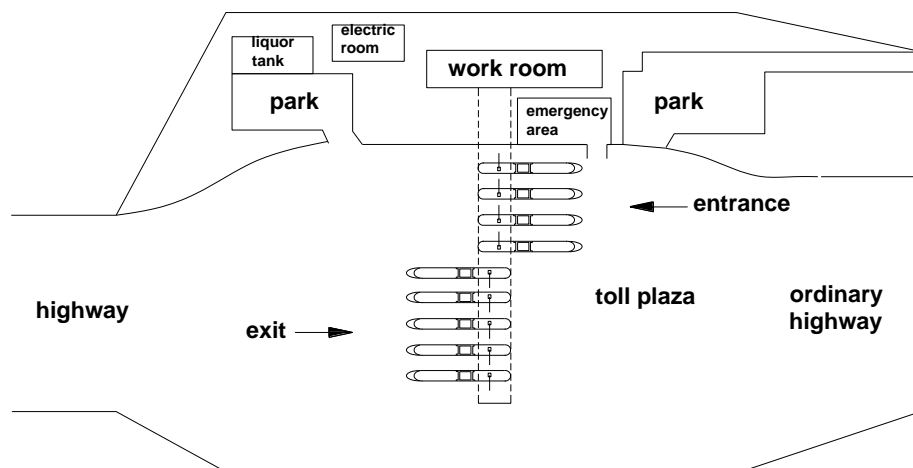The distribution of the toll plaza is presented as fig.3:

Fig.3The diagrammatic drawing of toll plaza

3. Summary

As our team set out to come up with a strategy on what would be the most efficient way to design toll plaza.

Our results are as follows:

We get the lane number and proportion through the analysis of the size of the traffic.

We design the portable charging machine and the emergency area to deal with the situation that is traffic jam or accident.

We change the scheme along with the ratio of cars.

Our design has the graveness and profound meaning in saving construction cost and waiting time. And it is of great significance in ensuring the smooth flow of traffic. This study has reference significance for the design and construction of toll plaza.

In conclusion our team is very certain that the methods we came up with are very stable.

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