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# Analysis of traffic behavior at the toll plazas around Bangalore

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**Abstract -** *The traffic in metropolitan cities, especially in India is very complex. In India, due to heterogeneous traffic conditions, road safety and congestion has become a major issue to both vehicle users and pedestrians followed by lots of delay to moving vehicles. A toll road is a public or private roadway for which a charge is assessed for passage. It is a form of road pricing typically implemented to help recoup the cost of road construction and maintenance, which amounts to a form of taxation. This research is intended to highlight the major problems faced at toll roads. At toll plaza's the delay caused to vehicle users is of prime concern since this delay causes loss of productive time and fuel. Hence 3 typical toll plazas in Bengaluru on three major roads Tumkur –Bengaluru road (Navayuga toll plaza-near the toll office), NICE road – near electronic city (NICE Toll Plaza) and Bangalore-Tumkur road (Navayuga toll plaza-near Parle factory) were considered for the present study. Data was collected by manual observation of parameters. Traffic behaviour in these toll plazas was analyzed through traffic distribution survey, descriptive and parametric analysis on service time delay. Based on the study it was found that truck traffic consumes more service time than other category of vehicles. As per the analysis car traffic consumes very less time comparing it with other classification vehicle. Hence, we can conclude that a separate toll lane can be provided with additional sub divided toll lanes exclusively for car classification.*

***Key Words***: **Delay analysis, MINITAB, Statistical significance, Toll plaza and Service time,**

## 1.INTRODUCTION

With the growth in the number of vehicles, the need for expansive roads catering to thousands of motor vehicles transverse across India has become inevitable. However, the demand for the construction of these roads cannot be met by public fund alone. Government has taken initiative to construct the road through different methods like PPP models etc. This revenue is collected mainly through toll booths. However, considering the present situation the modern toll system has some limitations. Due to the limited number of toll booths and slow collection process, the average waiting time per vehicle is more. This outcomes in loses worth thousands of crores of rupees regarding fuel wastage. In addition, there are various cases of toll plaza accidents which happen due to the sudden lane changing by drivers for quicker clearance.

Toll tax is collected to recover the total capital outlay which includes the cost of construction, repairs, maintenance, expenses on toll operation and interest on the outlay. The new facility thus constructed should provide reduced travel time and increased level of service. In India, most of the highway projects are given on PPP basis, i.e. Public Private Partnership. In this the private organization finances and constructs the facility and recovers the capital from the users in the form of toll tax. This tax is collected for a reasonable period of time after which the facility is surrendered to the public. Of late, toll tax is being levied on parking of vehicles in the urban centers in a move to decongest the streets and reduce the pollution levels. This concept is known as Congestion Pricing. In addition, there are numerous cases of toll plaza accidents which happen due to the sudden lane changing by drivers for faster clearance. The major reason behind this is that, the security at the tolls is insufficient and it is beyond the traffic police's control to manage the vast number of vehicles. We keep hearing of many such mishaps at toll plazas which mostly occur due to negligence either on the people's side or due to lack of control from the government agencies including the police. In case of events, where lives are lost, such losses are a life shattering experience.

As is well known, in such a scenario, the general public is a little hesitant in taking responsibilities of any such mishap. Hence it is incumbent on s the government to come up with an effective plan which bridges the gap between the toll management and the public expectation of the service that they experience. Introduction of an effective toll plaza operation plan by the government, its strict implementation and monitoring which would result in a more efficient and a more responsive and efficient system could be a good option for easing the challenges associated with the existing tolling process.

## 2. LITERATURE REVIEW

**Miss. Sambhavi S et al,** (2016) [(1)] The author carried out studies at toll plaza located in Bangalore to evaluate the level of service of the system. The Conclusions drawn from this literature review was a study on service time delay and it variation on different vehicles was conducted by taking three toll plaza in Bangalore. The variation of service time was observed for four categories of vehicles. It was observed that for all categories of vehicles skewness is positive indicating that most values are below average. For cars except at NICE

Toll Plaza it is observed that the skewness value is more than 3 indicating a peak curve. Truck traffic is observed to consume more service time than other category of vehicles. It is about 32 % more than cars and 13 % more than buses. As the heavier vehicles consumes more service time it is recommended in general to provide at least two bays separately for medium sized (Car, Auto, two wheeler, LCV etc) and large size vehicles (Buses and trucks) to avoid system delay. A service time delay of 15 seconds for cars, 22 seconds for buses and 25 seconds for trucks is recommended to calculate overall system delay of toll plaza. For simulation of toll plaza it is recommended to use Burr (4P) function for cars, Johnson SB for trucks and Rayleigh 2P for service time delay for buses. A level of service criteria was also developed using clustering technique on service time delay. Based on these six levels of service ranges were proposed starting from LOS A (0-9 s) and F (> 80 s).

**Avinash Dubedi et al,** (2012) [2] The main objective of this work is to develop a random utility-based discrete choice model for the toll-booth (lane) choice behavior of drivers approaching a toll plaza. Specifically, a logit model is developed. After initial analysis of the data obtained from three sites, a utility function is proposed for the case when the approaching vehicle is an automobile. The parameters of the utility function are calibrated by using the data on the revealed preferences of drivers (in terms of chosen toll booth) at three different sites (toll plazas). On statistically comparing the calibrated models, it is found that all the data sets can be combined to determine a single set of parameters for the proposed utility function. This is referred to as the generic model for the toll-lane choice behavior of drivers.

**Jack Klodzinsk et al**,(2002) [3] The present study was based on Highway Capacity Manual 2000 and the methodology was as follows:
Volume to Capacity Ratio: The volume to capacity ~V/C! ratio is also not adequate for evaluating the operating conditions at a toll plaza. The capacity is dependent upon the service time, which is dependent on the driver and payment type chosen. Furthermore, no one method for calculating the capacity of a toll plaza has been accepted in practice, however some studies have provided reason-able but somewhat varying methods for determining capacity.
The conclusions drawn from this particular drawn was the LOS hierarchy is defined in term of individual vehicular delay. This hierarchy was concluded after careful inspection of field observations, analyzed data from both toll plazas, and feedback from professionals who have experience with toll plaza operations.

**Feng-Bor Lin et al,** (1994) [4] The purpose of this paper is to describe the performance of toll-plaza operations. Toward this end, the paper will describe the operating characteristics of toll plazas based on field data and simulation as well as discuss the essential features of the methodology.

The conclusions drawn from this particular literature review were, toll collection on a freeway main line can seriously disrupt traffic movement. Not much effort, however, has been made to develop a methodology for the level-of-service analysis of toll plazas. Traffic operations at toll plazas can be affected by vehicle arrival pattern, driver behavior, number and capacities of toll gates, and the geometric designs of plazas. Because of the large number of governing factors involved, analytical models have limited applications in the analysis of toll-plaza operations. Therefore, the meth-odology for level-of-service analysis of toll plazas developed in this project relies heavily on a simulation model. The model, referred to as toll-plaza-simulation (TPS) model, is written in FORTRAN 77 and is intended for personal-computer applications. The Institute of Transportation is in the process of preparing a user manual for public distribution.

Summary of Literature review:

- Many mathematical models like Burr model Rayleigh model etc... or software such as FORTRAN can be used to write programs to simulate the traffic behavior at toll plaza.
- The traffic volume count, speed and delay analysis and service time surveys are required to be carried out to evaluate the Level Of Service of toll plaza

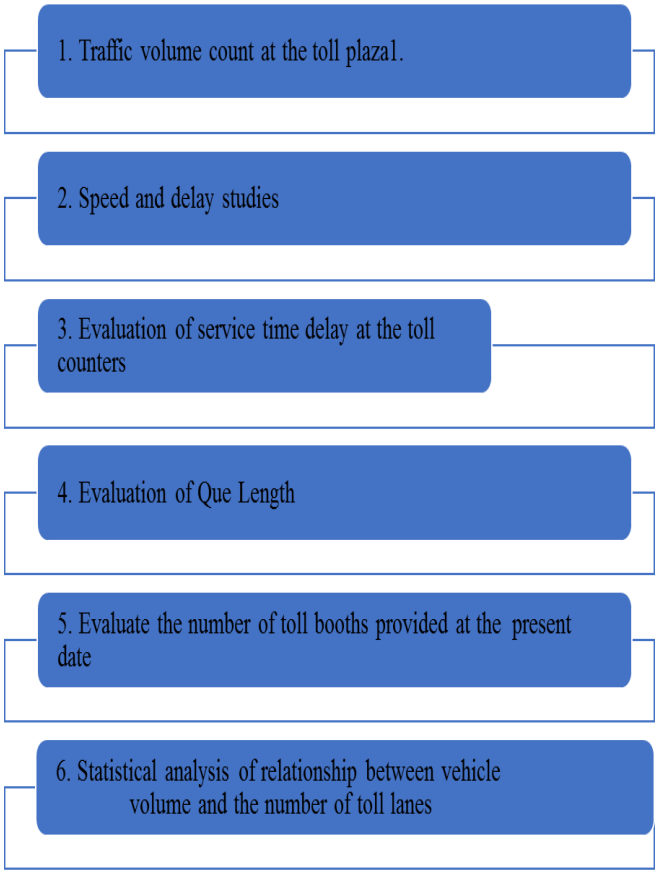


**Fig -1**: Study Methodology

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## 3. ANALYSIS OF TRAFFIC VOLUME COUNT

- As per the traffic volume count and traffic behavior at the Navayuga toll plaza (Parle factory) it has been observed that the peak traffic during the weekdays is at around 8am – 9am and as well in the evening around 4pm – 6pm. Whereas in the weekend the traffic behaviour is constantly varying having a peak hour around 7.30am – 9am and as well in the evening around 5pm- 6pm.
- Similarly, as per the traffic behaviour at the NICE toll plaza it has been observed that the peak hour during the weekdays is around 9am - 11am. Whereas in the
- weekend the traffic behaviour is constantly varying having a peak hour around 9am- 10am and as well in the evening around 5pm - 7pm.
- Similarly, as per the traffic behaviour at the Navayuga toll plaza (near Office) it is been observed that the peak hour during the weekdays is at around 11am to 12 pm and as well in the evening around 5pm to 7pm. Where as in the weekend the traffic behaviour is constantly varying having a peak hour around 5pm to 6pm.

## 4. STATISTICAL ANALYSIS

**Table -1**: Descriptive Statistics for Car

| Description | NHAI Toll Plaza – Parle Factory (Seconds) | NHAI Toll Plaza - Nelamangala(Seconds) | Nice Toll Plaza (Seconds) | Summary (Seconds) |
|---|---|---|---|---|
| Sample Size | 200 | 200 | 100 | 500 |
| Mean | 18.88 | 12.200 | 21.24 | 17.44 |
| Variance | 103.610 | 23.667 | 66.19 | 64.489 |
| STD. Deviation | 10.179 | 4.865 | 8.136 | 7.726 |
| Skewness | -0.285 | -1.416 | -0.126 | -0.609 |
| Excess Kurtosis | -0.024 | 0.332 | -1.282 | -0.324 |

**Table -2**: Descriptive Statistics for LCV

| Description | NHAI Toll Plaza – Parle Factory (Seconds) | NHAI Toll Plaza - Nelamangala(Seconds) | Nice Toll Plaza (Seconds) | Summary (Seconds) |
|---|---|---|---|---|
| Sample Size | 200 | 200 | 100 | 500 |
| Mean | 18.88 | 19.867 | 35.800 | 24.849 |
| Variance | 103.610 | 87.127 | 76.029 | 88.922 |
| STD. Deviation | 10.179 | 9.334 | 8.719 | 9.410 |
| Skewness | -0.2855 | -1.042 | -0.313 | -0.546 |
| Excess Kurtosis | -0.0284 | -0.087 | -0.697 | -0.270 |

**Table -3**: Descriptive Statistics for minibus

| Description | NHAI Toll Plaza – Parle Factory (Seconds) | NHAI Toll Plaza - Nelamangala(Seconds) | Nice Toll Plaza (Seconds) | Summary (Seconds) |
|---|---|---|---|---|
| Sample Size | 200 | 200 | 100 | 500 |
| Mean | 22.8 | 14 | 38.700 | 25.166 |
| Variance | 170.457 | 14.143 | 194.900 | 126.5 |
| STD. Deviation | 13.056 | 6.866 | 13.96 | 11.294 |
| Skewness | -0.486 | -1.046 | -0.256 | -0.425 |
| Excess Kurtosis | -1.16 | -0.671 | -1.393 | -1.074 |

**Table -4**: Descriptive Statistics for fullbus

| Description | NHAI Toll Plaza – Parle Factory (Seconds) | NHAI Toll Plaza - Nelamangala(Seconds) | Nice Toll Plaza (Seconds) | Summary (Seconds) |
|---|---|---|---|---|
| Sample Size | 200 | 200 | 100 | 500 |
| Mean | 15.8 | 17 | 30.769 | 21.18 |
| Variance | 72.029 | 105.571 | 32.192 | 69.93 |
| STD. Deviation | 8.487 | 10.275 | 5.674 | 8.145 |
| Skewness | -0.616 | 1.034 | 0.511 | 0.309 |
| Excess Kurtosis | -1.083 | 1.588 | -0.787 | -0.094 |

**Table -5**: Descriptive Statistics for 2-Axle

| Description | NHAI Toll Plaza – Parle Factory (Seconds) | NHAI Toll Plaza - Nelamangala(Seconds) | Nice Toll Plaza (Seconds) | Summary (Seconds) |
|---|---|---|---|---|
| Sample Size | 200 | 200 | 100 | 500 |
| Mean | 15.100 | 21.9 | 34.500 | 23.83 |
| Variance | 0.544 | 106.989 | 26.818 | 44.783 |
| STD. Deviation | 0.738 | 10.344 | 5.179 | 5.420 |
| Skewness | -0.166 | -0.716 | -0.094 | -0.325 |
| Excess Kurtosis | -0.733 | -0.262 | -1.18 | -0.725 |

**Table -6**: Descriptive Statistics for semiaxle

| Description | NHAI Toll Plaza – Parle Factory (Seconds) | NHAI Toll Plaza - Nelamangala(Seconds) | Nice Toll Plaza (Seconds) | Summary (Seconds) |
|---|---|---|---|---|
| Sample Size | 200 | 200 | 100 | 500 |
| Mean | 28.9 | 25 | 35.467 | 29.789 |
| Variance | 76.989 | 26.889 | 24.981 | 42.953 |
| STD. Deviation | 8.774 | 5.185 | 4.998 | 6.319 |
| Skewness | -0.073 | -0.861 | 0.496 | -0.146 |
| Excess Kurtosis | -1.598 | -0.223 | 0.035 | -0.595 |

**Table -7**: Descriptive Statistics for Semi Artic

| Description | NHAI Toll Plaza – Parle Factory (Seconds) | NHAI Toll Plaza - Nelamangala (Seconds) | Nice Toll Plaza (Seconds) | Summary (Seconds) |
|---|---|---|---|---|
| Sample Size | 200 | 200 | 100 | 500 |
| Mean | 25.6 | 22.4 | 46.778 | 32 |
| Variance | 33.3 | 11.3 | 72.194 | 38.93 |
| STD. Deviation | 5.771 | 3.36 | 8.497 | 5.87 |
| Skewness | -0.788 | -0.168 | 0.348 | -0.20 |
| Excess Kurtosis | -0.184 | 2.033 | -0.999 | 0.85 |

## 5. CONCLUSIONS

A study on service time delay and its variation on different vehicles was conducted by taking three toll plazas in Bangalore.

- The service time for the car was found to be 17.44 sec, whereas for LCV it is 24.849 sec. Hence, we can say that it has increment of 29.6%.
- The service time for the car was found to be 17.44 sec, whereas for Mini Bus it is 25.166 sec. Hence, we can say that it has increment of 30.6%.
- The service time for the car was found to be 17.44 sec, whereas for Full Bus it is 21.18 sec. Hence, we can say that it has increment of 17.6%.
- The service time for the car was found to be 17.44 sec, whereas for 2-Axle it is 23.83 sec. Hence, we can say that it has increment of 26.8%.
- The service time for the car was found to be 17.44 sec, whereas for Multi-Axle it is 29.789 sec. Hence, we can say that it has increment of 41.5%.
- The service time for the car was found to be 17.44 sec, whereas for Semi-Artic it is 32 sec. Hence, we can say that it has increment of 46%.

Hence as per the analysis carried out car traffic consumes very less time comparing it with other classification vehicle. Therefore, we can conclude that a separate toll lane can be provided with additional sub divided toll lanes exclusively for car classification.

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