Traffic Planning for Small Cities: A Basic Approach

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Abstract
Background/Objectives: 21st century is the era of urban growth and transportation development which is the major element of the development of nation. As per the growth of population, the need of transportation system has been increased rapidly. For the better transportation system, better traffic facility is considered as a prime element of it. Objective comprises of the improvements in traffic system by congestion and accident reduction, parking and traffic signal planning and to provide a reliable method for traffic analysis of small cities. Methods/Statistical Analysis: Traffic congestion, parking problem, accidents etc. nowadays are the major problems related to transportation facilities. So, there are certain parameters to cope with the transportation problems such as field study, designing & planning, accident analysis, economic evaluation, regulation, planning and administrative functions. In order to perform the traffic planning, there is need to observe the traffic conditions, traffic demand, vehicular characteristics, origin & destination and accident studies. Findings: It covers vehicle growth statics in the city with analysis and forecasting of the vehicle demand for the future. Reduction in accident is the success of efficient traffic system, so its study helps to identify the black spot which helps in improvement of traffic system and planning to minimize the accidents with proper traffic planning. Applications/Improvements: The method discussed is applicable for the aspects of the traffic and transportation planning for small or mid-sized cities. It helps in analyzing the major elements of the traffic systems. Traffic planning for a mid-sized city is an approach towards formulating the methodologies to cope with the traffic related issues for the development of better transportation facilities.

Keywords: Congestion, Traffic Forecasting, Traffic Planning, Traffic System, Urban Development

1. Introduction

Rapid industrialization, development of technologies, increasing population and the resulting urbanization has conveyed about an unprecedented revolution in the increase of motorized and non-motorized vehicles all over the world. Nowadays, these factors are not only governed in big cities, it is also a big challenge for mid-sized city or small city which is growing with a rapid speed. Such increasing urbanization, united with rise in number of vehicle possession, has led in recent years to an increased demand of traffic planning for both long term and short term period. Traffic analysis is basically the process of intercepting and examining the number of vehicles moving on the road and inferring the pattern of traffic movement. A Traffic survey on the city area of Madhubani has been performed out which comprises calculation of current traffic density and contrast with preceding year data, average velocity of traffic, accident analysis, etc.

The problem of traffic congestion, traffic accidents, travel delay, etc. in the roads of a newly developing cities are being viewed with grave concern in the recent years. The main causes for the traffic congestion, traffic delay and traffic accidents are improper planning of road network and other roadway facilities and poor traffic planning. The functions and duties of traffic engineer units were initially limited to traffic surveys and control devices. But now this branch of engineering has developed considerably and include many other activities like design, regulation, planning and administrative functions.

Providing comfortable journey and safety to the road user or public of city is a precarious objective of the traffic and transport career and in modern ages, growing amount of time have been consumed investigating approaches to diminish the conflicts or significances of conflicts amongst traffic and road users. The appropriate traffic safety measures are to be suggested for enhancing
the traffic circulation of an area. Public safety and parking services to be recommended. Through the government had technologically advanced various plans for recovering traffic system, but the current improvements designate that there is a necessity for additional research to improve a sympathetic of current practices and development of a reliable traffic plan.

2. Objective

Objective of the research is the set of desired findings to be achieved to cope with the traffic related issues. It deals with minimizing traffic congestion and sustaining safe, fast, and easy access/egress, minimizing fuel consumption at all phases together with construction and operation of traffic, provisioning for safer travel by all transportation modes, counting pedestrian, bicycling, transit, and other modes to develop proper parking facilities and traffic signal and prevention and control of traffic related injuries.

3. Methodology And Analysis

The basic steps to follow for the planning of better traffic systems for a small city needs several observations and analysis of the same as represented in the different flow chart shown in Figure 1, Figure 2 and Figure 3.

Figure 1. Methodology.
3.1 Traffic Survey and Analysis
Traffic survey can be done by manually or electronically. By manually, a tally sheet is prepared in which the different class of vehicles are counted with certain time intervals of peak hour as shown in Table 1. Electronically method consists of video graphic method and much more electronic machines. Traffic survey gives us the different analytical results such as traffic volume, road use pattern, future traffic growth, roadway capacity and Level of Service. Some methods have been explained. Figure 4 shows the variation of traffic volume & PCU with time at diff. session. Road use pattern gives the analytical observation of the road section weather the pattern of road use by the motorist in morning peak hours is same of different with the evening peak hours. Pattern identification method gives the result shown in Table 2 of over said traffic data.

Table 1. Motor Vehicle Volume for 1st Session

| Time        | Volume | PCU   |
|-------------|--------|-------|
| 09:00-09:15 | 71     | 38.1  |
| 09:15-09:30 | 79     | 43    |
| 09:30-09:45 | 83     | 43    |
| 09:45-10:00 | 67     | 34.7  |
| 10:00-10:15 | 56     | 28.4  |
| 10:15-10:30 | 70     | 38.6  |
| 10:30-10:45 | 71     | 37.1  |
| 10:45-11:00 | 81     | 40.6  |
| 11:00-16:00 | 90     | 51.8  |
| 16:00-16:15 | 88     | 49.2  |
| 16:15-16:30 | 99     | 47.2  |
| 16:30-16:45 | 83     | 46.5  |
| 16:45-17:00 | 90     | 46.8  |
| 17:00-17:15 | 57     | 46.5  |
| 17:15-17:30 | 100    | 57    |
| 17:30-17:45 | 90     | 49.1  |
| 17:45-28:00 | 89     | 48.2  |

3.2 Accident Record & Forecasting
Accident records have been obtained from the city police station from 2006 – 2015 with the total number of accidents and types of accidents as shown in Table 3 and expressed in Figure 5. Accident forecasting refers to the growth of accident in normal case of present scenario if the proper traffic planning will not be enforced. As per the accident data provided by the city police station from 2006 to 2015 shown in Table 3, it shows that there is not any fatal injury within the city area but there are many major & minor injuries. So, as per the growth of the vehicles throughout the city, the rate of accident will also increase as per the following analysis has been done. Multiple linear regression method is best suited for the analysis of these types of data.

Table 2. Road use pattern

| Road Section         | t-Critical | t-Stat  | Type of Pattern |
|----------------------|------------|---------|-----------------|
| Bata Chowk Road      | 1.9146     | 3.89234 | Different       |

Table 3. Yearly Accident Data

| Year | Number of accidents | Fatal Injury | Major Injury | Minor Injury |
|------|---------------------|--------------|--------------|--------------|
| 2006 | 35                  | 0            | 13           | 22           |
| 2007 | 37                  | 0            | 16           | 21           |
| 2008 | 37                  | 0            | 14           | 23           |
| 2009 | 41                  | 0            | 16           | 25           |
| 2010 | 46                  | 0            | 14           | 32           |
| 2011 | 49                  | 0            | 15           | 34           |
| 2012 | 45                  | 0            | 13           | 32           |
| 2013 | 50                  | 0            | 17           | 33           |
| 2014 | 52                  | 0            | 16           | 36           |
| 2015 | 49                  | 0            | 15           | 34           |
| Total| 441                 | 0            | 149          | 292          |

Figure 4. Variation of Volume & PCU of different session with respect to time.
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MLR general expression: \( Y = a + bX \)

\[
b = \frac{\sum XY - n\bar{X}\bar{Y}}{\sum X^2 - n\bar{X}^2}
\]

\[
a = \bar{Y} - b\bar{X}
\]

By the use of this formula for the data available in Table 3, the regression equations have been found out for the different vehicle classes in Table 4. After inserting the desired year \((X)\), we found the number of different types of estimated accident which may happen if the traffic system will not be improves with respect to time shown in Table 5 & represented in Figure 6.

**Table 4. Regression equations for accident study**

| Sr.No | Accident Type   | Regression Equation |
|-------|-----------------|---------------------|
| 01    | Major Injury    | \( Y = 13.309 + 0.1515X \) |
| 02    | Minor Injury    | \( Y = 27.80035 + 0.1333X \) |

**Table 5. Future Estimated Accident Statics**

| Year | Major Injury | Minor Injury | Total |
|------|--------------|--------------|-------|
| 2016 | 16           | 30           | 46    |
| 2017 | 16           | 30           | 46    |
| 2018 | 17           | 30           | 47    |
| 2019 | 17           | 30           | 47    |
| 2020 | 17           | 31           | 48    |
| 2021 | 17           | 31           | 48    |
| 2022 | 17           | 31           | 48    |
| 2023 | 17           | 31           | 48    |
| 2024 | 17           | 31           | 48    |
| 2025 | 17           | 32           | 49    |
| Total| 168          | 307          | 475   |

**3.3 DTO Vehicle Record and Future Traffic Study**

District Transport Office is the only governmental...
From DTO, with prior permission of the responsible officer, we get the number of different class of vehicles registered in the district shown in Table 6. This number of vehicle will give an idea of number of vehicles moving in the city. Vehicle growth rate signifies the growth of motor vehicles in the city. The maximum participation of the traffic movement in the city is the vehicle registered with the district transport authority. The significance of the analysis of motor vehicle registered data obtained from DTO is to find the number of vehicles moving on the city road in the upcoming years. It will help in the estimation of the growth of the road network as per the vehicles moving on the road. Multiple regression analysis method best suit for this type of data analysis. Regression equation formed shown in Table 7.

After inserting the year (X) in the different equation for the specific vehicle class, we found the future number of vehicles estimated to be registered with district transport office and will be running on the roads of city shown in Table 8, Figure 7 & Figure 8.

### Table 6. DTO vehicle data record

| Year | Two Wheelers | Three Wheelers | Cars, Jeeps, Vans | Tractors | LMV | Bus/Truck | Total |
|------|--------------|----------------|-------------------|----------|-----|-----------|-------|
| 2011 | 4534         | 12             | 00                | 29       | 00  | 00        | 4575  |
| 2012 | 5988         | 23             | 11                | 37       | 09  | 00        | 6068  |
| 2013 | 7855         | 28             | 19                | 48       | 11  | 00        | 7961  |
| 2014 | 9767         | 37             | 26                | 52       | 15  | 00        | 9897  |
| 2015 | 11322        | 42             | 32                | 63       | 21  | 00        | 11480 |
| Total| 39466        | 142            | 88                | 229      | 56  | 00        | 39981 |

### Table 7. Regression equations for Vehicle growth rate

| Vehicle Class      | Regression Equation |
|--------------------|---------------------|
| Two Wheelers       | \( Y = -14668.3 + 1735.5 \times X \) |
| Three Wheelers     | \( Y = -67.8 + 7.4 \times X \) |
| Cars, Jeeps, Vans  | \( Y = -85.1 + 7.9 \times X \) |
| Tractors           | \( Y = -62.1 + 8.3 \times X \) |
| LMV                | \( Y = -51.2 + 4.8 \times X \) |

### Table 8. Future estimated vehicle record

| Year | Two Wheeler | Three Wheeler | Cars, Jeeps, Vans | Tractors | LMV | Total | Growth Factor |
|------|-------------|---------------|-------------------|----------|-----|-------|---------------|
| 2016 | 13100       | 51            | 41                | 71       | 26  | 13289 | 1.157         |
| 2017 | 14835       | 58            | 49                | 79       | 30  | 15051 | 1.133         |
| 2018 | 16571       | 66            | 57                | 87       | 35  | 16816 | 1.118         |
| 2019 | 18306       | 73            | 65                | 96       | 40  | 18580 | 1.105         |
| 2020 | 20042       | 81            | 73                | 104      | 45  | 20345 | 1.095         |
| 2021 | 21777       | 88            | 81                | 112      | 50  | 22108 | 1.087         |
| 2022 | 23513       | 95            | 89                | 121      | 54  | 23872 | 1.080         |
| 2023 | 25248       | 103           | 97                | 129      | 59  | 25636 | 1.074         |
| 2024 | 26984       | 110           | 105               | 137      | 64  | 27400 | 1.068         |
| 2025 | 28719       | 118           | 112               | 145      | 69  | 29163 | 1.064         |
| Total| 209095      | 843           | 769               | 1081     | 472 | 212260| Av.=1.098     |
3.4 Spot Speed Data & Analysis

Spot speed method is beneficial for the traffic planning as it gives the different allowable speed limits for the different class of vehicles moving on the particular road. Here is the sample data shown in Table 9 graphical represented in Figure 9 with its analysis shown in Table 10, Figure 10 and Figure 11.

Using the values of mid-speed and cumulative frequency %, cumulative speed distribution curve is plotted and from that graph the following results are obtained:

- Upper speed limit for regulation = 85th percentile speed = 52 kmph
- Lower speed limit for regulation = 15th percentile speed = 27 kmph
- Speed to check design elements = 98th percentile speed = 62 kmph
Figure 11. Cumulative speed distribution.

Table 9. Data for Spot Speed on Kotwali Chowk – Thana Chowk road

| Route: Kotwali Chowk – Thana Chowk | Date/Time: 4th June 2015/10:30 – 11:00 am |
|-----------------------------------|------------------------------------------|
| Speed Range (KMPH)               | No. of vehicles observed                  |
| 0 – 10                           | 8                                        |
| 10 – 20                          | 10                                       |
| 20 – 30                          | 38                                       |
| 30 – 40                          | 62                                       |
| 40 – 50                          | 66                                       |
| 50 – 60                          | 46                                       |
| 60 – 70                          | 5                                        |

4. Results and Discussion

Traffic survey gives us several aspects of traffic planning to formulate a better plan. During traffic survey, it had been observed that most of the traffic volume flow is between 09 am to 11 am and 04 pm to 06 pm. The road use pattern had been identified on road sections between the above said peak hours. It gives the analysis of the usability of road during the both peak hours. So, road use pattern gives the result that the pattern is different, i.e., the traffic volume demand and traffic movement on the both peak hours are different. So, we will consider the maximum traffic volume demand period for deciding the design features. Accident forecasting is an important element of better traffic system. The result of the analysis shows that if there is not proper improvement of traffic system, then accident statistics will increase. DTO vehicle record have been analyzed to generate the future traffic demand and it shows that there will be huge traffic demand in future. So, it will be helpful for traffic design methods. Spot speed study enforced the speed limits of the vehicle and results obtained shows that there is over speeding at some places and there is under speed vehicles at some places.

Table 10. Spot Speed analysis of Kotwali Chowk – Thana Chowk Road

| Speed Ranges (kmph) | Mid Speed (kmph) | Frequency | Frequency % | Cumulative Frequency % |
|---------------------|------------------|-----------|-------------|------------------------|
| 0 – 10              | 5                | 8         | 3.40        | 3.40                   |
| 10 – 20             | 15               | 10        | 4.26        | 7.66                   |
| 20 – 30             | 25               | 38        | 16.17       | 23.83                  |
| 30 – 40             | 35               | 62        | 26.38       | 50.21                  |
| 40 – 50             | 45               | 66        | 28.09       | 78.30                  |
| 50 – 60             | 55               | 46        | 19.57       | 97.87                  |
| 60 – 70             | 65               | 5         | 2.13        | 100                    |
| Total               |                  | 235       | 100.00      |                        |
5. Conclusion

This research is an approach towards the planning of better traffic system of a small or mid-sized city. The result gives the statistics of several analysis that is very useful for the traffic planning and management strategies. The above explained analysis is not much more sufficient for the planning of a better traffic system but it is a motivation towards the further research on traffic planning.

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