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DEVELOPMENT OF DELAY MODEL AT MEDIAN OPENINGS OF ALONG NH-44

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***Abstract:* -- A U-turning vehicle, during merging at an uncontrolled median opening creates the possibility of conflict with approaching through traffic movement and causes traffic congestion which reduces the roadway capacity. The effect of conflicting traffic volume on the U-turning maneuver was also investigated by collecting placement data extremely congested traffic conditions. Compared with turning movements at intersections, U-turn movement at median openings is highly complex and risky. Normally, the speed of conflicting traffic stream is relatively high and the turning vehicle must wait for accepted gap and then turn under low speed level. Therefore, the turning vehicle needs large gap in the conflicting stream before performing the U-turn. In fact, the little studies which contain procedures and models for estimating capacity and delay for different movements at unsignalized intersections do not provide specific guidelines for estimating capacity and delay of U-turn movement at median openings. For this reason, an effort was made to estimate capacity and delay at U-turn median openings.**

In this study, empirical approach is used to estimate capacity of U-turn movement at median openings of divided arterials. The empirical approach using regression analysis was adopted to estimate the best form of the predictive equation for the U-turn capacity and investigate the effect of different relevant factors that might affect the estimated capacity. The results of the approach are presented in this study. A linear model was also recommended as a relationship between the average total delay of the U- turning vehicles and the conflicting traffic flow.

***Keywords* -- Traffic engineering, Capacity, Delay, Conflicting Traffic Flow.**

I.INTRODUCTION

The major purpose of capacity modeling of U-turn median opening is to develop useful relationship between capacity and set of traffic and geometric characteristics. The developed model should be easy for practical applications and predictive under different traffic conditions. It should be mentioned that intersections are provided to facilitate traffic turning movements. As part of traffic management to improve intersection operation, some traffic movements are not permitted at some intersection locations, especially along divided arterial. In most cases, such minor movements are accommodated at separate U-turn median openings. Compared with turning movements at intersections, U-turn movement at median openings is highly complex and risky. Normally, the speed of conflicting traffic stream is relatively high and the turning vehicle must wait for accepted gap and then turn under low speed level. Therefore, the turning vehicle needs large gap in the conflicting stream before performing the U-turn. In fact, the little studies which contain procedures and models for estimating capacity and delay for different movements at unsignalized intersections do not provide specific guidelines for estimating capacity and delay of U-turn movement at median openings. For this reason, an effort was made to estimate capacity and delay at U-turn median openings.

However, the operation can be considered as an interaction of drivers on the minor or stop-controlled turn with drivers on the oncoming approach of the major street in two directions simultaneously. Although the U-turn movement is more complex than right-or left-turning movements at unsignalized intersections, the general concepts and procedures developed for analyzing capacity at priority unsignalized intersections are very crucial in this respect.

The purpose of capacity analysis is to insure that planned highway network could deal with the present and future traffic flows with satisfying quality; Since unsignalized intersections and Median openings are the most common type, their functionality has a great impact on the quality of traffic flows on the urban street network and especially on the suburban and rural highway network (at connections of state and county roads). In the following chapters of this paper, first the development of available capacity methodologies is presented followed by the summary results of conducted capacity modeling using regression analysis.

Problems of U-Turns at Median Openings

In India Due to the wide variation in the operating and performance characteristics of the

Vehicles mixed traffic systems operate very much differently as compared to the homogeneous traffic condition. The traffic in mixed flow is comprised of fast and slow moving vehicles or motorized and non-motorized vehicles. The vehicles also vary in size, maneuverability, control, and static and dynamic characteristics. In the absence of lane discipline and wide variation in sizes of different types of vehicles, they are found to move side by side on the road. Vehicular traffic is increasing very rapidly in recent times giving burden on transportation infrastructure. To meet the demand of vehicular traffic most of the roads now constructed as multilane roads or two lane roads are being widened to multilane roads. Multilane roads are generally constructed with raised median in order to segregate the opposing traffic movements. Median-separated highways provide distinct benefit over undivided roadways (two-lane or multilane roads without medians). Medians segregate opposing traffic, allow space for speed changes and storage of U-turning vehicles, minimize headlight glare, and provide width for future lanes. Median openings are provided at various locations along divided multilane roads to permit vehicles to reach abutting property or reverse their direction of travel. The U-turn movement at a median opening is highly complex and risky compared with turning movements at intersections, firstly because of the high speed and traffic volume and secondly because the turning vehicle has to make a l80̊movement and merge the traffic stream in which it is seeking an acceptable gap. The turning vehicle must wait and then turn under low speed conditions in the face of oncoming traffic and may need to accelerate rapidly to reach the speed of the traffic stream. If there are many turning vehicles that have to wait, then a long queue in the stream cannot be avoided and queue spill-back to block through traffic is possible. This can lead to traffic problems, mainly reduced capacity and level of safety. At these median openings vehicles take U-turn to merge with the approaching traffic.

Concept of Level of Service at Median openings

LOS category	Service Delay range (s/Vehicle)	Control Delay ranges (s/Vehicle) for TWSC (hcm-2010)
A	0-5	0-5
B	>5-8	>10-15
C	>8-13	>15-25
D	>13-20	>25-35
E	>20-33	>35-50
F	>33	>50

Delay ranges for LOS categories of uncontrolled median openings

Objectives of the Study

The objectives of the present study are mentioned below

- To develop a model for estimating the capacity and Delay at U-turn median opening.
- To evaluate the effect of U-turning vehicles on the capacity of a stretch.
- To evaluate the relation between capacity and conflicting traffic flow.
- To evaluate the relation between delay and conflicting traffic flow.

LITERATURE REVIEW

Location of median openings

The growing number of multilane highways with raised or depressed medians and without access control has created the need to provide median openings, or crossovers, at various locations along such facilities to permit vehicles to reach abut- ting property or reverse their direction of travel. Median openings, however, may also become points of increased congestion and accident exposure.

A committee of the Institute of Transportation Engineers developed a list of factors to consider in locating median openings. These included the potential number of left turnsinto driveways, length of frontage along the street right- of-way line of the property proposed to be served, distance of proposed opening from adjacent intersections or other openings, length and width of the left-turn storage lane as functions of the estimated maximum number of vehicles to be in the lane during peak hours, and traffic control. The committee noted the need to consider circuitous routing and added intersection turns that may be caused by closing a median opening.

Kimber et al. (1980) using the empirical approach, concluded that the capacities of the non-priority streams at T-intersections depend linearly on the flow in the relevant priority streams.

AL-Masaeid (1999) identified specific guidelines for estimating capacity and delay models of U-turn movements at median openings. He found that, the capacity and delay were significantly influenced by the conflicting traffic flow, that the predictive capacity model had linear form, while the delay relationship had an exponential form. A wide difference obtained by AL-Masaeid between the gap acceptance and the empirical approaches for capacity estimation.

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Kyte et al. (2003) listed the three main causes of difference, including headway distribution of major stream, usage of gaps of minor stream, and driver behavior. The arrival of conflicting vehicles on urban arterial sometimes does not follow the random process. In other words, the headways are not negatively exponential distributed. This affects the availability of gaps for the u-turn vehicles. This research considered the headway distribution.

Liu et al. (2007; 2008a; 2008b; 2009) have conducted a series of research relating to capacity of U-turn at median opening. They estimated the parameters (critical headway and follow-up headway) of U-turn movements from the field data. They validated the capacity estimation from the model with the field capacity. The model provides reasonable estimated capacity for U-turn movement at median openings. The HCM 2010 utilizes the values of these parameters of U-turn movement for the capacity analysis in the US. Nevertheless, the critical headway and the follow-up headway need local calibration due to differences in driving style (Vasconcelos et al., 2012). Those parameters also vary according to physical geometry characteristics of the junction (Weinert, 2000). The model capacity can differ from field capacity.

Zhou et al. (2009) studied the gap acceptance behavior of left turning drivers at six unsignalized intersections. Logit models were used for estimating the probability of accepting a given gap. Results showed that the number of lanes on the major road, the presence of left turn lanes and the gender of the driver explained the variation in the gap acceptance probability. It was also found that older drivers generally tended to accept longer gaps.

Tupper et al. (2011) studied the factors that influenced the driver's gap acceptance behavior and had clear impact on safety. Different driver’s age and gender groups were found to have different gap acceptance behaviors. Factors that had the greatest effect on gap acceptance behavior were found to be the presence of a queue behind the driver, the driver’s waiting time and the number of the rejected gaps.

STUDYAREA AND METHODOLOGY

Today the city of Hyderabad, India cover an area of 650 square kilometers (250 sq mi), has a population of 6,809,970 making it the fourth most populous city in India.There are 3,500,802 male and 3,309,168 female citizens. The area under the municipality increased from 170 square kilometers (66 sq mi) to 650 square kilometers (250 sq mi) in 2007 when the Greater Hyderabad Municipal Corporation was created. As a consequence, the total population leaped from 3,637,483 in 2001 census to 6,809,970 in 2014 census, an increase of over 87%. Migrants from rest of India constitute 24% of the city population. Hyderabad city is governed by Greater Hyderabad Municipal Corporation that comes under the Hyderabad Urban Agglomeration, which has a population of 12 million the fourth most populous urban agglomeration in the country, with 3,985,240 males and 3,764,094 are females. A proposal to expand the area covered by the city to make it 721 square kilometers (278 sq mi) by merging the surrounding gram panchayats and around 30 villages is being considered, as of 2009.

Study Area

Hyderabad city is the sixth largest metropolitan city in India. The phenomenal increase in population coupled with growth of road vehicles has created considerable traffic problems. It is facing a peculiar problem of combined traffic conditions, where cars, scooters, autos, buses, trucks etc., are operating together. In addition to this the city is facing with the problems of narrow streets and chocked intersections. Compared with turning movements at intersections, U-turn movement at median openings is highly complex and risky. Normally, the speed of conflicting traffic stream is relatively high and the turning vehicle must wait for accepted gap and then turn under low speed level. Therefore, the turning vehicle needs large gap in the conflicting stream before performing the U-turn. So for the modeling of capacity and delay three median openings were chosen in the present study.
To accomplish the objective of this study, three median openings located in Hyderabad City were selected.

- Balaji Hosital
- Kompally
- Bowenpally

Median opening at Bowenpally stretch

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Median opening at Balaji Hospital

Methodology

The study methodology consists of Five phases, through which the corridor management study would be completed for the selected corridor. The Five phases are listed as below:

- Identification of the study Area
- Traffic data collection
- Developing Capacity model for heterogeneous traffic flow
- Developing Delay model for heterogeneous traffic flow
- Evaluation of LOS

To accomplish the objective of this study, Six median openings located in Hyderabad City were selected. These median openings are located along divided suburban arterials and operated at capacity during peak periods. At capacity condition is defined, as the condition in which there is continuous queue of turning vehicles in the approach of the turning lane.

DATA COLLECTION AND ANALYSIS

The data collected at a median opening at Bowenpally and Kompally stretch is shown in the following table

Data collected at a median opening

Capacity of U-turning vehicles (veh/min)	Capacity of U-turning vehicles (veh/hr)	Conflicting Traffic Flow (veh/min)	Conflicting Traffic Flow (veh/hr)	Average Total Delay (sec/veh)
10	600	23	1380	5.9
2	120	70	4200	23.3
4	240	50	3000	13.2
3	180	60	3600	18.1
6	360	36	2160	7.7
4	240	52	3120	13.5
3	180	61	3660	17.37
5	300	43	2580	10.9
2	120	71	4260	24

Development of capacity model

The capacity of U-turning Vehicles is denoted by 'C', Conflicting Traffic is represented as 'q' and the Delay is represented as 'D'.

From the above table

$\Sigma C = 9260$

$\Sigma C^2 = 772400$

Mean of capacity

$$= \frac{\sum \mathbf{C}}{\textbf{no. of observations}}$$

$$= \frac{12260}{50}$$

$\bar{c}$=221veh/hr.

Standard Deviation

$$= \sqrt{\frac{\sum \mathbf{C^2}}{\textbf{no. of observations}} - (\textbf{mean}^2)}$$

$$= \sqrt{\frac{772400}{50} - (221^2)}$$

$$= \sqrt{15448 - 48841}$$

S.D = σ_c= 182.73

CONCLUSIONS

Based on the results of this study, the following points were concluded:

- Capacity and average total delay models for U-turn movements at median openings were found to be significantly influenced by the conflicting traffic flow.
- For Bowenpally and Kompally stretch, Capacity of the U-turning vehicles is inversely proportional to the Conflicting Traffic Flow.
- Capacity model at Bowenpally and Kompally stretch has an R^2 value of 0.9239 i.e., it explains a high percentage of relation between Capacity of U-turning vehicles and conflicting traffic flow.
- The Delay model has linear relationship obtained between the average total delay and the conflicting traffic flow at U-turn median openings.
- Delay model has an R^2 value of 0.924 i.e., it explains a high percentage of relation between Delay and conflicting traffic flow..
- Capacity model at Bowenpally stretch has an R^2 value of 0.911 i.e., the capacity is 91.1% correlated with conflicting traffic flow.
- Delay model has an R^2 value of 0.914 i.e., delay is 91.4% correlated with conflicting traffic flow.
- Capacity model at Kompally stretch has an R^2 value of 0.9014 i.e., the capacity is 90.14% correlated with conflicting traffic flow.
- Delay model has an R^2 value of 0.9066 i.e., delay is 90.66% correlated with conflicting traffic flow.

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