**EFFECT OF FRICTION FACTORS ON CAPACITY AND SPEED**

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***ABSTRACT***

The estimation of roadway capacity is essential in planning, designing, and operation of highway facilities. Capacity and speed of road suffers a loss due to various factors such as geometric parameters, environmental parameters, city size factors, side friction factors etc. The environmental parameters include rainy conditions, fog, temperatures etc. The effect of friction factors can cause jam conditions in urban stretches, so need to be investigated and some regression equations need to be established between capacity and friction factor to know impact of friction factors. Better characteristics (geometrics, environmental etc.) of road may lead to higher capacity and higher speed at a certain flow.

The thesis aims at, to develop the speed flow relationship for the four lane urban road and to find out effect of friction factor on capacity and speed of road. Friction factor includes major effects such as pedestrian movements, parking & stopping vehicles, exit/entry vehicles into traffic stream, unmotorized vehicles etc. At high side friction value there is significant difference between actual speed and those without friction i.e. very low friction from side. These capacity values are compared with IRC: 106-1990. At low side friction value, capacity and speed does not affect much but at high side friction losses in capacity and speed are high. Therefore, the optimum dosage of steel fibers was determined to be 3 %.

Keywords:- geometric parameters, unmotorized vehicle, friction loses, steel fibre

**INTRODUCTION**

Efficient transportation is very important for the rapid economic growth of a country and road transportation is the only mode that is complete in itself. The urban transportation framework is the backbone of the economic activities in all urban communities everywhere throughout the world, and consequently sustains livelihood of the people living in them. Normal urban transportation facility involves railways, waterways and roads. Among these, the huge extent comprises of roads. Most planning and research efforts have focused on the road system. In essence, road transportation system is the major player in the economic activities of most urban centers. In recent times, many cities have seen a large increase in road traffic and transport demand, which has consequently, lead to decrease in capacity and inefficient performance of traffic systems. As the road development has not matched the transport demand, the country is facing a problem of severe traffic congestion resulting in large number of accidents, delays and frustration on the roads. In the past, it was thought that in order to resolve the decreased capacity problem it was simply to provide additional road space. This was the main strategy applied in the U.S.A at the wake of 1960's and 1970's. A lesson learnt from this strategy is that increasing capacity of road alone is ineffective because it induces travel growth that negates the benefits of highway expansion. Moreover, there is complexity in so doing for one reason that most cities are already built-up areas; hence it is difficult to carry out any substantial expansion works. In practice, it is neither socially nor economically acceptable to balance supply and demand solely by increasing road capacity Although the expansion of road infrastructure is not absolutely ruled out as the demand may be expected to continue to grow by time, the immediate, most relevant and acceptable strategy to mitigate capacity problems and increase efficiency of the road network is through traffic management applications. The most recent approach that has gained prominence in traffic management operations is the introduction of Intelligent Transportation System (ITS). Such technology helps in monitoring and managing traffic flow, reduce congestion, and provide alternate routes to travelers and increases safety. These frameworks have made noteworthy accomplishment in significant urban areas of many created nations of America, Asia and Europe. For most cities of the developing countries, they have yet to realize these benefits, primarily due to economic and technological constraints.

On the other hand the traditional tools that are applied as traffic and demand management tools to increase the efficiency of the transport system include and not limited to: prioritization of road users (i.e. introduction of truck lanes, bicycle and pedestrian routes etc.), road markings and signs, enforcement devices (i.e.

camera, police patrol, etc.), regulation of parking space, congestion charges, traffic restraints (i.e. limiting entry to city centre etc.), improvement of public transportation, etc. These tools are relatively cost effective and technologically affordable and are applicable both in developing and developed countries. However, much as they may seem affordable, yet they are not effectively implemented in most developing countries.

The estimation and knowledge of roadway capacity are essential in planning. designing, and operation of transport facilities. As per HCM 2000 capacity is defined as "The maximum hourly rate at which are reasonably expected to traverse a point or a uniform segment of the roadway during a given time period under condition of roadway, traffic and control conditions". Capacity is greatly influenced by the roadway, traffic and friction on the road. The roadway conditions include geometric parameters such as type of facility, lane width, shoulder width. horizontal and vertical alignments etc. The traffic parameters include dimensions of vehicles, type of vehicle etc. Side friction factors are defined as all those activities taking place by the sides of road and sometimes within the road, which interfere with the traffic flow on traveled way. Activities likely to disrupt traffic flow include the following:-

Blockage of the travelled way (i.e. reduction of effective width) which include:

1. Public transport vehicles which may stop anywhere to pick up and set down passengers
2. Pedestrians crossing or moving along the traveled way
3. Non-Motorized vehicles and slow moving motor-vehicles

* Shoulder activities

1. Parking and un-parking activities
2. Pedestrians and non-motorized vehicles moving along shoulders

* Roadside activities

1. Roadside accessibility including vehicles entering and leaving roadside premises via gates and driveways
2. Trading activities (i.e. food stalls, vendors), and movement of vehicles and pedestrians depending on land use type.

These factors are normally frequent in densely populated areas in developing countries, while they are random and spare in developed countries and consequently there is comparatively little literature about them. Survey has been carried out at congested four lane divided urban road (with high side friction) to analyze the effects of characteristics of urban roads, specially the side friction, in reducing the capacity and speed of traffic.

DISSERTATION PROBLEM AND ITS SIGNIFICANCE

The study entitled "Effect of Friction Factors on Capacity and Speed" aims at collecting and analyzing the speed flow data of four lane urban road in Rohtak city by considering effect of side friction and then comparing with the speed and flow recommended by IRC 106-1990. The study includes finding the composition of traffic, speed, capacity and level of service, amount of disturbance on the road in terms of side friction on the urban road.

Composition of traffic is useful in structural design of pavement, in geometric design and in computing roadway capacity. PCU factor values that suggested by IRC: 106-1990 helps in converting traffic volume of vehicles to PCU in simplified manner. The significance of Capacity and Level of Service is that they help in describing the operational conditions within traffic stream and enable for planning road improvements including future road widening decisions. They also help to know the extent of congestion on the road. Side friction affects the speed of traffic, capacity of road and measures to reduce the effect of side friction and prevent accidents.

Speed flow analysis for the traffic helps in evaluating performance of a road. The traffic flow moving on a road and its analysis is important for understanding the efficiency at which system works. The evaluation of capacity and level of service (LOS) of road helps to know the extent of congestion on the road. Knowing the traffic flow characteristics and the level of service one can easily determine whether a particular section of the road is handling traffic much above or below its design capacity. Traffic flow analysis and level of service evaluation is indicator to improve the transport facilities and is a valuable tool in the hands of transport planners.

In total, study under consideration will be helpful in planning, road improvements, traffic operations and regulations, control of existing facilities and to avoid traffic congestions etc.

OBJECTIVES OF THE STUDY

The study under consideration aims at collecting the Speed flow data of four lane urban road in Rohtak city by video recording technique and side friction data manually recording in notebook. The data thus collected, to analyze the following objectives: -

1. To determine the traffic composition
2. To evaluate the speed distribution of traffic on the road
3. To study the speed frequency curves for different type of vehicle on the road
4. To develop the speed flow relationships on the urban road
5. To evaluate the capacity, level of service and traffic performance of the road
6. To develop the speed-friction relationship having consideration of low and high side friction

SCOPE OF STUDY

The study is limited to Four lane-Two way (with median) sub-arterial road links, with restricted access, located in a straight flat terrain in urban and suburban areas of Rohtak city of Haryana where mobility is the primary function. All road intersections are located far-off from traffic control facilities to avoid controlled interruption in traffic flow. The research was also limited to study four specific side friction factors that includes-

1. Pedestrians (PED/hr per 200 meters)
2. Parking and stopping vehicles (PSV/hr per 200 meters), where there is no specific bus stop.
3. Merging and diverging vehicles (MDV/hr per 200 meters)
4. Unmotorized vehicles (veh/hr)

**LITERATURE REVIEW**

Speed-flow study helps in determining capacity of the road. Capacity and traffic volume analysis is needed to plan, design and operation of roads, and provides the basis for determining the facilities, geometric parameters to be provided at any point in a road network with respect to composition and volume of traffic and to attain the level of service on the road that helps in easy maneuver to the road users. Capacity standards helps for evaluation of investments needed for the future road construction and improvements. Moreover speed flow analysis helps to determine traffic performance of road by evaluating present and future level of service.

CAPACITY OF URBAN ROADS IN PLAIN AREAS

Capacity provides the basis for determining the number of traffic lanes to be provided for different road section regarding volume, composition and other parameters of traffic. IRC has developed the guideline on the capacity of urban roads. These guidelines are based on experience in developed countries and limited studies carried out in India. IRC 106:1990 provides "Guidelines for Capacity of Urban Roads in Plain Areas". These guidelines are applicable for the mid block sections of urban roads but these are not directly applicable for the urban expressways.

Capacity

Capacity is defined as "maximum hourly rate at which persons or vehicles are reasonably expected to traverse a point or a uniform segment of a roadway during a given time period under conditions of roadway, traffic and control conditions". The roadway conditions consist of geometric parameters such as type of facility, lane width, shoulder width, horizontal and vertical alignments, curves etc. Friction on the road also affects the speed and capacity of vehicles.

Speed

Speed is the rate of motion of individual vehicles of the traffic stream. It can be measured in meters per second or generally as kilometers per hour. Two types of speed measurements are commonly used in the traffic flow analysis i.e.

i) Space mean speed

ii) Time mean speed

For the purpose of study space mean speed is preferred over time mean speed. Space mean speed is the mean speed of vehicles in a traffic stream at any instant of time over a certain length (space) of road. In other words, this is average speed based of vehicles to traverse a known segment of roadway based on the average time. Time mean speed is the mean speed of vehicles observed at a point on the road over a period of time. It is the mean spot speed. Space mean speed is slightly less than the time mean speed.

Density

Density (or concentration) is the number of vehicles' occupying a unit length of road at an instant of time. The unit length is generally one kilometer. Density is expressed in relation to the width of the road (i.e. per lane or per two lanes etc.). When vehicles are in a jammed condition, the density is at maximum. It is then termed as the jam density.

Functional classification of urban roads

Besides the Expressways, urban roads can be classified into the following four main categories:

(i) Arterial (ii) Sub-arterial

(iii) Collector Street (iv) Local Street

Equivalency Factors

Urban roads are having characteristics of mixed traffic conditions. resulting in complex interaction between various kinds of vehicles. To cater this, we need to express the capacity of urban roads in terms of a common unit. The unit generally employed is the 'Passenger Car Unit, (PCU), and each vehicle type is converted into equivalent PCUs based on their relative interference value. The equivalent PCUs of different vehicle categories do not remain constant under all circumstances. Rather, these are a function of the physical dimensions and operational speeds of  respective vehicle classes. In urban situations, the speed differential amongst different vehicle classes is generally low, and as such the PCU factors are predominantly a function of the physical dimensions of the various vehicles.

REVIEW OF CLASSICAL SPEED-FLOW RELATIONSHIP AND FACTORS AFFACTING

Since 1930s, perhaps beginning with the pioneering works of Greenshields (1935) an immense amount of literature has been produced on the relationships between the speed, flow and density of traffic and the factors affecting these relationships.  
  
Yagar and Vanar (1983) list the factors affecting capacity and speed-low relationships for two-lane highways under three headings, as follows;

(i) Geometric factors: grades, bendiness, lane width, lateral clearance

(ii) Traffic factors: vehicle mix, abutting land use etc.

(iii) Weather-surface factors: darkness, pavement roughness and the winter season alone (without adverse weather) all decreased speed.

Bang et al. (1995) under the consultancy of Swedish National Road Consulting AB, SweRoad identified significant effects of geometric factors (i.e. carriageway width, shoulder width, median), traffic and environmental factors (directional split, city size) and side friction factors (i.e. pedestrians, non-motorized vehicles, public transport vehicles) on speed- flow relationships on Indonesian urban/suburban road links and these were included in Indonesian HCM (1997).  
  
Gibreel et al. (1999) studied the relationship between geometric design consistency and highway capacity based on a three-dimensional analysis, considering combinations of vertical and horizontal curves. They have compared the actual service flow rate as determined based on the observed traffic flow data, and the theoretical flow rate as calculated based on highway capacity analysis. The results show that the actual service flow rate is always smaller than the theoretical service flow rate with a ratio of actual to theoretical ranging from 0.74 to 0.98.

Bang and Heshen (2000) developed capacity guidelines for road links and Intersections for Henan and Hebei provinces in China. The side friction class will be used to determine the speed and capacity reductions, i.e. by using these formulas:

(a) For free flow speed

FV = (FVO+FVW) x FFVSF x FFVCS

Where,  
FV = free flow speed (km/hour)

FVO = basic free flow speed (km/hour)

FVW = road width factor (km/hour)

FFVSF = adjustment factor for land use and side friction.

FFVCS = city size factor

(b) For capacity

C=Co x FCW x FCSF × FCCS  
Where,  
C = capacity (pcu/hour)

Co = basic capacity (pcu/hour)

FCW = road width factor.

FCSF = side friction factor

FCCS = city size factor

Chandra and Kumar (2003) investigated the impact of lane width on capacity of two-lane roads in India. They investigated the impact of lane width on capacity of two-lane roads in India. They found that the capacity of two-lane roads in PCU/h increases with total width of the carriageway. and the relationship between the two follows a second-degree curve. The relationship can provide a capacity estimate for two-lane roads with a carriageway width ranging from 5.5 to 8.8 m.

Reddy et al. (2008) studied the effect of on-street parked vehicle on traffic mobility in urban area and found that parking facility with a width of 2.5m and a length of 30 to 40 m, would reduce speed by 10 to 12% in case of motor cycles, autos and cars, and 12 to 15% in case of heavy vehicles.

CONCLUSIONS

In the present thesis traffic volume, speed and friction factor is studied on an urban stretch in the Rohtak city. The selected stretch is four lane divided road with 2×7.5 m carriageway. The following main conclusions were drawn from the study-

1. Traffic study was carried out in the three stretches of 2 hours each i.e. 08:00 AM to 10:00 AM, 12:00PM to 02:00 PM and 08:00 PM to 10:00 PM.
2. From the traffic volume data it is observed that maximum hourly traffic on the road is 2460 vehicles/3132 PCU (12:30 PM to 01:30 PM) and the minimum traffic is 356 vehicles/467 PCU (09:00 PM to 10:00 PM).
3. From the traffic composition it is observed that maximum contribution is of two wheelers with 38% followed by Autos having 29%, cars/jeeps 25% and others 8%.
4. The traffic in terms of PCUs maximum contribution is of autos with 45% followed by two wheelers 22%, cars/jeeps 19% and others 14%.
5. The fast moving vehicle on the road is 98% and 2% vehicle on the road is slow moving vehicle or human drawn vehicles. The fast moving vehicle on the road in terms of PCU is almost 99% and the slow moving vehicle on the road is almost 1%.

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