# ESTIMATION OF IMPACT OF HIGHWAY CONSISTENCY ON CAPACITY UTILIZATION OF FOUR-LANE -LANE HIGHWAYS USING FRIC

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***Abstract: It is required to take preventive measures in order to improve the overall level of service since the present level of service (LOS) on the road is predicted to drop to "E" and "F" in the near future. In light of this, it is necessary to adopt preventative measures (LOS). Since this road is the principal connecting route between Karnal and the bus terminal, the traffic composition indicates that around 45 percent of the traffic on the road is constituted of autos. The percentage of PCU that is made up by automobiles is given. As a result of this, it has been suggested that an efficient public transportation system be constructed between the bus station in Karnal and the Ghanta Ghar chowk, in order to reduce the number of vehicles that are driven along the particular stretch. The present thesis examines traffic volume, speed, and friction in Karnal. Each side features a four-lane divided road with a 27.5-meter carriageway, a 1-meter median, and a 1-meter shoulder. The study found that the Two-wheelers make up 38% of traffic, followed by cars/jeeps (29%), and other modes (8%). PCUs provide 45% of overall traffic, followed by two-wheelers (22%), cars/jeeps (19%), and others (14%). Only 2% of cars on the road are slow-moving or human-pulled. Fast-moving cars account for 98% of PCU, whereas slow-moving cars account for 1%. The 98th percentile speed is 52 kmph, lower below the IRC speed flow recommendation of 60 kmph. The 85th percentile speed for the route is 39kmph, suggesting the upper safe limit for autos. The 15th percentile speed on the route is 15kmph, indicating the minimum speed needed to avoid traffic congestion. The urban road capacity is established during the design phase and is stated in PCU/hr. However, it may be converted to PCU/day by taking into consideration the peak hour factor of 8%, and it was expected to be 45,000 PCU/day. The four-lane divided stretch of the road is now LOS 'D. By 2018, LOS 'E' will be achieved, and by 2019, LOS 'F will be reached, meaning the road's traffic will exceed its capacity, forcing it to function under forced circumstances. To improve service quality, remedial measures must be taken.***

***Keywords: FRIC, level of service, PCU, transportation, Intelligent Transportation Systems***

## I. INTRODUCTION

Efficient transportation is critical for a country's fast economic development, and road transportation is the only kind of transportation that is self-sufficient in its own right. Consequently, the urban transportation system serves as the backbone of economic activity in all metropolitan settlements across the globe, and as a result, it helps to ensure that the people who live there have a means of subsisting. Rail, rivers, and roadways are all part of the standard urban transportation infrastructure. Roads account for a significant portion of its total area. Because the nation's road construction has not kept pace with the country's transportation demand, the country is experiencing significant traffic congestion, which is leading in a high number of accidents, delays, and irritation on the roadways. Previous thinking was that just increasing road space would be sufficient to address the issue of decreasing capacity. This was shown to be unfounded. This was the primary technique used in the United States of America after the 1960s and 1970s. The lesson learned from this technique is that raising the capacity of a road alone is unsuccessful since it leads to an increase in traffic that outweighs the advantages of expanding the roadway. It is also complicated to do so for a variety of reasons, one of which is that most cities are already developed places, making it impossible to carry out any significant growth projects. In actuality, expanding road capacity alone is not sufficient to achieve a balance between supply and demand on a social or economic level. The adoption of Intelligent Transportation Systems (ITS) has become the most current solution to traffic management operations that has attracted widespread attention (ITS). Such technology aids in the monitoring and management of traffic flow, as well as the reduction of congestion, the provision of other routes to passengers, and the enhancement of safety. These frameworks have achieved notable success in large metropolitan regions of several developed countries in North America, Asia, and Europe, among other places. Despite the fact that most developing-country cities have yet to reap the advantages of urbanization, this is mostly due to economic and technical obstacles.

Both in developing and developed nations, these instruments are very inexpensive and technologically accessible. They may be used in both developing and developed countries. However, despite the fact that they seem to be inexpensive, they are not properly implemented in the majority of poor nations.

METHODS OF DATA COLLECTION

In order to acquire the data on speed-flow and side friction, two different approaches were used:
(i) Manual method

  

Using a manual method, the side friction data on a site was collected by two teams: one for recording the merging and diverging vehicles and another for recording other friction parameters such as parking vehicles, pedestrians, and unmotorized vehicles, which are in lower numbers on the road, which were collected separately. The observations were written down in a format that had been developed ahead of time. It was necessary to register the number of cars in a given category on the format by using tally marks. For the purpose of capturing speed, all of the data collection was done on both sides independently across a span of 200 metres on the road from the centre of a 30 metre stretch chosen for recording speed. Four frictional characteristics are taken into consideration, which are normally significant at most locations. They were as follows:
1, the number of pedestrian movements (pedestrians per hour for every 200 metres).
2 - Parking and halting automobiles, minibuses, and other vehicles on the highway (one vehicle per hour every 200 metres). There isn't a designated bus stop along this stretch of road. As a result, the bus may stop wherever.
3 - Vehicles leaving and entering (vehicle/hour per 200 metres). 4 - Vehicles that do not have motors (vehicle per hour)

COLLECTION OF SPEED FLOW DATA

The actual number of cars seen moving through a site within a certain time frame is referred to as the volume. For time intervals smaller than one hour, the rate of flow reflects the number of vehicles passing a place in the same amount of time represented as an equal hourly rate. Capacity measurements are carried out at intervals ranging from around 2 minutes to one hour to detect daily peaking patterns and to calculate the capacity of facilities (James, 1998).
Approximately 5 minutes is taken into consideration for the purpose of determining highway capacity assessments (Papacostas, 1990). To develop speed-flow correlations in the Road User Cost Study (CRRI, 1982), a five-minute traffic count was utilised to determine the speed of traffic. Another method employed by Kadiyali (1991) to develop speed-flow correlations and calculate the capacity of roadways was the five-minute count. These time intervals are used because they reduce random variation while not unduly obscuring repetitive peaking patterns, which is an important consideration.

Fig. 1: Data Collection by VRT

In the current research, the comparable hourly traffic flow rate was calculated using a five-minute time interval as the time base. To this end, the speed-volume data were gathered at intervals of 5 minutes per time period was used. On paper, the number and type of vehicles, together with their movement directions and speeds, were recorded at each 5-minute interval throughout the length of the research, using a manual data collecting technique. However, there is a very high likelihood of a mistake in the manual recording of speed on the job site. At each five-minute interval throughout the length of the research, data extraction was carried out in such a way that the speed and volume data were obtained in each five-minute interval for the whole period of the study. Five-minute traffic counts are translated to comparable hourly flow rates by multiplying the number of cars by 12 and dividing the result by five. The project makes advantage of the information gathered from the VRT research.

COLLECTION OF SIDE FRICTION DATA

Due to the fact that there are no conventional techniques of measuring side friction, a large number of testings was carried out as shown below:
(i) Stationary manual observation:

It was found that stationary observation was the most desired way, whether it was done with surveyors in the field or with video recording and subsequent observation in the laboratory. The observations were carried out in a continuous fashion and covered the whole portion under consideration.
(ii) Mobile observation:

It was discussed whether to use mobile observation in the form of a floating automobile or roving observers who would note frictional things as they came across them. In essence, a floating automobile is just a moving car that employs an in-vehicle video camera to capture friction events as it travels down the road.

However, it was ultimately chosen to utilise stationary observers since the segments under study were short enough (about 200m) to be monitored by a fixed observer over the whole experiment period. According to this procedure, side friction was recorded manually at the same time, individually for each side of the four-lane two-way roads with two surveyors, and for both sides of the two-lane two-way roads with one surveyor conducting manual records on both sides of the roads.

It was essential to conduct several measurements of numerous variables at the same time in order for the chosen approach to be successful in its application (Stationary manual observation). As previously stated, the primary techniques used to collect data for the fundamental measurements of speed, flow, and side friction were video and manual observation across a lengthy base study segment or section, as mentioned above.

## II. TRAFFIC ANALYSIS

### DATA REDUCTION

For the most part, data reduction is concerned with the logging of relevant events that are not directly measured in field conditions, the creation of combined files containing all relevant data for a site, and finally the reduction of the data to obtain traffic flow statistics, vehicle types and friction events.

TRAFFIC ANALYSIS REQUIREMENTS

It is possible to do a traffic study in terms of daily and hourly fluctuation, as well as its composition, to assist the designer in determining the most acceptable traffic values for the design of road geometrics and pavement. It also aids in the design of the numerous amenities along the road system. Peak hour traffic on the road is taken into consideration while determining regulatory measures for traffic management.

The traffic on a road is made up of a diverse range of vehicles, ranging from the simplest bicycle to the most complex automobile and large commercial vehicles, each of which has an impact on the performance of the road in a different manner. A basic volume count that does not differentiate between different kinds of vehicles is only of limited use. As a result, it is common practice to categories vehicles into different types of transportation.

Vehicles are primarily divided into two types: passenger cars and trucks.

i) Vehicles that move quickly

ii) Vehicles that move slowly

i. Fast Moving Vehicles: - Automobiles, jeeps, automobiles, buses, trucks, motorbikes, scooters, light commercial vehicles, and tractor-trailers, among other types of vehicles, are included in this category. They usually go at a speed of more than 20 kilometres per hour on the road.

ii. Slow Moving Vehicles: - Cycles, cycle rickshaws, horse pulled vehicles, and bullock carts are all examples of vehicles that are manually or animal propelled and fall under this category of vehicles. They normally go at a speed of less than 20 kilometres per hour on the road.

Table 1 and Table 2 indicate the composition of traffic in terms of frequency and per capita unit (PCU) for each kind of vehicle, respectively. Ordinarily, pie charts are used to depict the composition of traffic flows. Figures 4.2 and 4.3 depict the various pie charts based on the frequency of vehicles driven and the number of PCUs used.

Table 1 Vehicle composition in number/hr for four lanes for peak hour

| Sr.no. | | Type of vehicle | Frequency (no.) | % Age frequency |
|---|---|---|---|---|
| 1 | Fast moving vehicle | 1. Cars, jeeps | 604 | 24.55 |
| | | 2. Two wheelers | 940 | 38.21 |
| | | 3. Autos | 704 | 28.62 |
| | | 4. Buses | 120 | 4.88 |
| | | 5. Trucks | 28 | 1.14 |
| | | 6. Tractor Trailer | 12 | 0.49 |
| 2 | Slow moving vehicle | 1. Cycle | 34 | 1.38 |
| | | 2. Cycle Rickshaw | 18 | 0.73 |
| | | Total | 2460 | 100 |

Table 2 Vehicle composition in PCU/hr for four lanes for peak hour

| Sr.no. | | Type of vehicle | PCU/hr | %Age PCU |
|---|---|---|---|---|
| 1 | Fast moving vehicle | 1. Cars, jeeps | 604 | 19.28 |
| | | 2. Two wheelers | 705 | 22.51 |
| | | 3. Autos | 1408 | 44.95 |
| | | 4. Buses | 264 | 8.43 |
| | | 5. Trucks | 62 | 1.98 |
| | | 6. Tractor Trailer | 48 | 1.53 |
| 2 | Slow moving Vehicle | 1. Cycle | 14 | 0.45 |
| | | 2. Cycle Rickshaw | 27 | 0.86 |
| | | Total | 3132 | 100 |

According to the data in tables 1 and 2, the total number of vehicles on the road section is 2460 vehicles per hour during the peak hour, and the total number of vehicles in PCU is 3132 vehicles per hour. Because the data shown above pertains to the study's peak hour, which is from 12:30 PM to 01:30 PM on the chosen stretch of road, the daily traffic volume may be estimated as 39150 PCU/day using a peak hour factor (PHF) of 8% based on the data presented above.

According to Fig. 1, the traffic in terms of vehicle numbers is composed of 24.55 percent car/jeep/vans, 38.21 percent two-wheelers, 28.62 percent automobiles, 6.51 percent heavy vehicles (buses, 1.14 percent tractor trailer, 0.49 percent tractor trailer), 1.38 percent cycles, and 0.73 percent cycle rickshaws, respectively. The number of animals pulled vehicles on the road is tiny in comparison to the overall traffic flow. LV category vehicles account for roughly 91 percent of all vehicles on the road, with maximum two-wheelers accounting for 28.62 percent of all vehicles. traffic in terms of PCU is composed of 19.28 percent cars, jeeps, and vans, 22.51 percent two-wheelers, 44.51 percent automobiles, 11.94 percent heavy vehicles (buses 8.43 percent, trucks 1.98 percent, tractor trailer 1.53 percent), 0.45 percent cycles, and 0.86 percent cycle rickshaws. It has been shown that automobiles provide the most contribution to PCU out of all types of vehicles, accounting for 44.51 percent.

## III. SIDE FRICTION ANALYSIS

SIDE FRICTION

Side friction is defined as the activities on the road that cause a disruption in the ability to man oeuvre on the road. These activities may be caused by the geometric characteristics of the road or by the traffic on the road, and they can occur for a variety of reasons. The impact of these operations on the speed and capacity of the traffic stream is shown in the following discussion of traffic flow speed and capacity. Some of the activities that contribute to road friction are addressed in detail in Section 2.3.

  

SIDE FRICTION ON FOUR LANE DIVIDED URBAN ROAD

The primary goal was to determine whether or not friction variables were responsible for any variations in vehicle speed and capacity on the route under investigation. In our research, we looked at four-lane highways.

A part of urban highway For the purpose of determining the overall side friction on the road, four frictional components were taken into consideration. They were as follows:
(1) Pedestrian movement (number of pedestrians per hour per 200 meters)
(2). Parking and halting cars on the roadway (one vehicle per hour for every 200 meters).
(3) Vehicles leaving and entering (veh/hour per 200 meters).
(4) Unmotorized vehicles (veh/hour per 200 meters);
The side friction data was collected at the same time as the speed flow data, and both were collected at the same time span as the peak flow. The side friction data was manually entered in a spreadsheet for each 5-minute period, and the speed flow data was obtained using a video recording approach. For each five-minute period, the data on side friction, as well as information on speed and traffic volume on the road, is shown in Table 3.

Table 3 Data reduction process of peak hour

| | Time 12:30 PM- 01:30 PM | | | | | |
|---|---|---|---|---|---|---|
| 5 min no. | 5 min flow (No of vehicle) | Vehicle Type | Vehicle composition (no.) | Speed (kmph) | Side friction (Measured per 200m) | |
| | | | | | Type | Free |
| 1 | 156 | Cars | 44 | 44.71 | PED | 7 |
| | | Two-wheelers | 55 | 47.46 | PSV | 8 |
| | | Autos | 38 | 28.79 | Merging | 21 |
| | | Buses | 12 | 43.26 | Diverging | 32 |
| | | Trucks | 3 | 29.28 | Non-motorized | 2 |
| | | Cycles | 4 | 16.58 | | |
| 2 | 180 | Cars | 52 | 33.59 | PED | 18 |
| | | Two-wheelers | 65 | 31.43 | PSV | 11 |
| | | Autos | 42 | 27.79 | Merging | 26 |
| | | Buses | 17 | 27.13 | Diverging | 16 |
| | | Trucks | 4 | 32.24 | Non-motorized | 6 |
| | | Cycles | | | | |
| 3 | 143 | cars | 39 | 40.37 | PED | 11 |
| | | Two-wheelers | 52 | 31.32 | PSV | 8 |
| | | Autos | 35 | 38.76 | Merging | 23 |
| | | buses | 11 | 32.44 | Diverging | 16 |
| | | Trucks | 3 | 32.64 | Non-motorized | 2 |
| | | Cycles | 3 | 20.46 | | |
| 4 | 130 | cars | 35 | 39.42 | PED | 6 |
| | | Two-wheelers | 47 | 46.23 | PSV | 11 |
| | | Autos | 33 | 25.47 | Merging | 12 |
| | | buses | 10 | 46.69 | Diverging | 14 |
| | | Trucks | 2 | 27.64 | Non-motorized | 4 |
| | | Cycles | 3 | 6.49 | | |
| | | cars | 49 | 41.23 | PED | 11 |
| 5 | 165 | Two-wheelers | 59 | 29.73 | PSV | 13 |
| | | Autos | 40 | 40.23 | Merging | 17 |
| | | buses | 14 | 29.49 | Diverging | 8 |
| 7 | 185 | | | | | 1 |
| | | Autos | 44 | 35.67 | Merging | 22 |
| | | buses | 18 | 23.45 | Diverging | 24 |
| | | Trucks | 4 | 34.56 | Non-motorized | 3 |
| | | Cycles | | | | |
| 8 | 180 | cars | 51 | 33.59 | PED | 11 |
| | | Two-wheelers | 65 | 31.43 | PSV | 13 |
| | | Autos | 43 | 27.79 | Merging | 24 |
| | | buses | 17 | 27.13 | Diverging | 13 |
| | | Trucks | 4 | 32.24 | Non-motorized | 6 |
| | | Cycles | | | | |
| 9 | 187 | cars | 52 | 39.74 | PED | 6 |
| | | Two-wheelers | 68 | 38.46 | PSV | 11 |
| | | Autos | 44 | 24.24 | Merging | 21 |
| | | buses | 18 | 32.7 | Diverging | 26 |
| | | Trucks | 5 | 31.47 | Non-motorized | 4 |
| | | Cycles | | | | |
| 10 | 168 | cars | 48 | 49.24 | PED | 4 |
| | | Two-wheelers | 60 | 50.44 | PSV | 12 |
| | | Autos | 41 | 37.43 | Merging | 16 |
| | | buses | 15 | 25.22 | Diverging | 31 |
| | | Trucks | 4 | 23.43 | Non-motorized | 8 |
| | | Cycles | | | | |
| 11 | 190 | cars | 60 | 35.43 | PED | 7 |
| | | Two-wheelers | 76 | 50.47 | PSV | 8 |
| | | Autos | 54 | 37.44 | Merging | 31 |
| | | buses | | | Diverging | 14 |
| | | Trucks | | | Non-motorized | 5 |
| | | Cycles | | | | |
| 12 | 155 | cars | 52 | 46.24 | PED | 6 |
| | | Two-wheelers | 58 | 29.73 | PSV | 6 |
| | | Autos | 45 | 36.74 | Merging | 16 |
| | | buses | | | Diverging | 12 |
| | | Trucks | | | Non-motorized | 4 |
| | | Cycles | | | | |

ANALYSIS OF SIDE FRICTION DATA

The most effective method of performing side friction impact analysis was to combine the individual frictional components into a single unit of measure. As a result, it is simpler to determine whether friction was considerable or negligible on a specific location in terms of a single unit of measure rather of dealing with separate components. The decision to consolidate the separate friction elements into a single unit of measure was made on the basis of the benefits discussed above. This unit was given the designation of 'FRIC.' The name of the research was chosen at random in order to fit the concept of the investigation. The term 'FRIC' is just a shortened form of the word 'friction.'

In the equation 6.1, side friction is calculated from the observed value of the number of frictional parameters, which is then translated into a numerical value using the equation 6.2.

FRIC = A*PED + B*MDV +C*PSV + D*UMV (eq. 6.1)

Where, PED= Pedestrians (No. /200m)

  

MDV=Merging and Diverging vehicles (No. /200m) PSV= Parking and stopping Vehicles (No. /200m) UMV=Un-motorized Vehicles (No. /200m)
A, B, C, and D are the unit side friction coefficients for each of the four categories of friction.

## IV. CONCLUSIONS AND SCOPE OF FURTHER RESEARCH

The current thesis investigates the amount of traffic, the speed of traffic, and the friction factor on an urban stretch in the city of Karnal. Each side of the chosen section has a four-lane split road with a 27.5-meter carriageway, a one-meter median, and a one-meter shoulder. The following are the major results reached as a result of the research:

On the basis of traffic composition, it can be noticed that two-wheelers account for the greatest proportion (38 percent), followed by automobiles (29 percent), cars/jeeps (25 percent), and other modes (eight percent) of transportation.
As for PCUs, the vehicles contribute the most with 45 percent of total traffic, followed by two wheelers with 22 percent, cars/jeeps with 19 percent, and others with 14 percent.
Fast moving vehicles account for 98 percent of all vehicles on the road, with just 2 percent of all vehicles being slow moving vehicles or human pulled vehicles. In terms of PCU, the fast-moving car on the road accounts for about 99 percent of all traffic, whereas the slow-moving vehicle on the road accounts for nearly 1 percent of all traffic.

According to the findings of the speed flow analysis, the 98th percentile speed is 52 kmph, which is lower than the current IRC guideline of 60 kmph for the speed flow. The 85th percentile speed for the route is determined to be 39kmph, indicating that the top safe limit for cars travelling on the road has been reached. According to the findings, the 15th percentile speed on the route is 15kmph, which determines the lowest speed required to prevent traffic congestion on the road.

The model speed for the road stretch is determined to be 29kmph, indicating that the majority of vehicles on the road are travelling at this pace, according to the results.
On the road segment in question, the FFS (free flow speed) was discovered to be 57.5kmph, which corresponds to the average speed of 100 cars travelling at free speed between 9:00pm and 10:00pm on a given night.

The speed flow relationship has been constructed for all vehicles and for each type of vehicle separately by supplying the coefficient of determination value (r2) for each vehicle.

### RECOMMENDATIONS

In light of the current level of service (LOS) on the road, which is expected to decline to 'E' and 'F' in the near future, it is necessary to implement preventative measures to enhance the overall level of service (LOS). According to the traffic composition, about 45 percent of the traffic on the road (PCU) is comprised of automobiles, since the road is the primary connecting route between Karnal and the bus station. Consequently, it is proposed that an effective public transit system be established between Karnal's bus station and Ghanta ghar chowk (Pawan valmiki chowk), in order to limit the number of automobiles on the designated stretch.

### SCOPE OF FURTHER RESEARCH

For plain terrain and straight sections of road, the traffic performance of a four-lane divided section of Karnal city has been developed. The road has a surfaced shoulder and median on both sides to separate the traffic from each other, and the effect of side friction on the speed and capacity of the road has also been considered. Despite the fact that the research includes a wide range of traffic performance characteristics, there is always room for additional development in the study.

The following are a few examples of possibly linked areas for further investigation:
i) It is possible to undertake this research to estimate the impact of curves and slopes on the speed and capacity of an urban road in Karnal city.
(ii) This research may be carried out on a variety of pavements with a variety of pavement characteristics as well as a variety of environmental variables, all of which will affect the speed and capacity parameters on a city road in different ways.
(iii) The four-lane split carriageway stretch is included in the current investigation. There is potential for expanding the research to include undivided roads when vehicles approaching from the front create disruption in the flow of traffic.
iv) It was decided to restrict the scope of the investigation to four different kinds of side friction metrics. The inclusion of additional sorts of side friction factors, such as bicycles riding on shoulders, cars and nonmotorized vehicles that park on shoulders for extended periods of time, accident sites, or any other kind of traffic-calming device, is proposed in future research.
v) In order to account for the influence of the different parameters of side friction separately on the speed and capacity, a microscopic investigation for the friction factors must be carried out. Simulation models must also be developed.

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