IJSEAT International Journal of Science Engineering and Advance Technology

# The Study Exploration towards Side Friction Influences by traffic performance measures on roads

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**Abstract:**

Side friction factors are characterized as every one of those activities identified with the exercises occurring by the sides of the road and infrequently inside the road, which meddle with the movement flow on the voyaged way. They incorporate however not restricted to people on foot, bikes, non-motorized vehicles, parked and stopping vehicles. The individual friction factors through relapse examination were weighted and joined into one unit of measure of friction called 'FRIC'. The impact of "FRIC" on speed-flow bends was broke down. The outcomes demonstrated huge effect on speed for both road sorts. Effect on limit was recognized on two-path two-way roads while field information on four-path two-way roads did not permit this. In the microanalysis approach, impact of individual side friction factors on speed was broke down. The outcomes demonstrated that on two-path two-way roads, every single examined element displayed measurably noteworthy effect on speed, while on four-path two-way roads, just a single component demonstrated the same. Advance suggestions were made that these outcomes ought to be connected to define administration programs looking to breaking point levels of side friction on high portability urban arterial streets avenues with a specific end goal to enhance activity security and operation proficiency.

**Keywords:** Side friction factors, urban road links, speed-flow connections.

## I. Introduction

The urban transportation system is the motor of the financial exercises taking all things together urban groups everywhere throughout the world, and thusly maintains work of the general population living in them. Run of the mill urban transportation offices incorporate railroads, conduits, aviation routes and roads. Among these, the huge extent comprises of roads. Coherently, most arranging and research endeavors have concentrated on the road system. Generally, road transportation system is the significant player in the financial exercises of most urban focuses. As of late, numerous urban communities have seen a huge increment in road activity and transport request, which has subsequently prompt to disintegration in limit and wasteful execution of movement systems. Before, it was felt that keeping in mind the end goal to determine the limit issue it was essentially to give extra road space. A lesson learnt from this system is that including limit alone is insufficient on the grounds that it prompts travel development that invalidates the advantages of parkway extension. Also, there is many-sided quality in this manner for one reason that most urban communities are as of now developed regions, consequently it is hard to complete any significant extension works. Practically speaking, it might be neither socially nor financially adequate to adjust free market activity exclusively by expanding road limit. Despite the fact that the development of road foundation is not totally discounted as the request might be required to keep on growing by time, the prompt, most significant and satisfactory technique to relieve limit issues and increment productivity of the road system is through movement administration applications. The latest approach that has picked up unmistakable quality in activity administration operations is the presentation of Intelligent Transportation Systems (ITS). Such innovations screen and oversee activity flow, decrease blockage, give backup ways to go to voyagers and increment security. These systems have made noteworthy accomplishment in significant urban communities of many created nations of America, Asia and Europe. For most urban areas of the creating nations, they have yet to understand these advantages, principally because of financial and mechanical requirements. Then again, the well-known apparatuses (which are considered conventional) that are connected as movement and request administration instruments with a specific end goal to expand the productivity of the vehicle system incorporate and not constrained to: prioritization of road clients (i.e. presentation of truck paths, bike and person on foot courses, crest paths, and so forth.), road hierachisation (i.e. grouping of road capacity), road markings and signs, implementation gadgets (i.e. camera, police watch, and so on.), direction of parking spot, blockage charges, fuel costs, movement limitations (i.e. constraining section to downtown area, Pedestrization of downtown area, and so on.), change of open transportation, and so forth. These devices are generally financially savvy and mechanically moderate and are pertinent both in creating and created nations. Nonetheless, much as they may appear to be moderate, yet they are not viably executed in most creating nations. A decent case is the way activity administration is executed by utilization of road pecking order directions. A various leveled road system is basic to expand road wellbeing, enhancement and intelligibility and to accommodate all road clients. Every class of road in the system serves a particular arrangement of capacities and is composed as needs be. The outline ought to pass on to drivers the dominating capacity of the road. For instance there is a broad division amongst blood vessel and non-blood vessel (or neighborhood) roads. Fundamentally blood vessel and neighborhood roads make the foundation of most urban road systems. Blood vessel roads are essential transport courses that are intended for high activity volumes and high speeds (i.e. through activity development), while neighborhood roads are basically proposed for availability (low volumes and low speeds). In any case, a long way from this origination, numerous blood vessel roads in many creating nations show disintegrated limit and poor execution. Different reviews have concentrated this issue in some creating nations and set up that in addition to other things, there is frequently a lot of movement on and alongside these roads, which influences the route in which they work. This impedance to the smooth flow of movement is known as "side friction". In activity designing practice, arrangement of roads by "ecological" class is regularly utilized as intermediary for the impacts of side friction, for example, residential, shopping, country, rural, urban etc. Movement exercises, for example, number of turning vehicles, stopping, walker action thus on are utilized for this reason likewise and isolate speed-flow bends or limits are regularly given for every class. At the point when versatility is a need, road connections are typically depicted regarding speed-flow connections, which portray their usefulness as far as the primary operational qualities to be sans specific flow speed and limit. From the exact reviews, for example, those utilized as a part of the Highway Capacity Manual (I-HCM 2010) it is realized that different factors including roadside exercises lessen limit and influence speed-flow connections. By suggestion if these exercises are satisfactorily tended to and oversaw, limit and execution could be enhanced and more prominent monetary advantages could come about because of such approaches. Side friction is characterized as a composite variable depicting the level of cooperation between the movement flow and exercises along the side(s) and now and again over.

## II. Related Work

Since 1930s, maybe starting with the spearheading works of (Greenshields, 1935) an enormous measure of writing has been delivered on the connections between the speed, flow and thickness of activity and the factors influencing these connections. An audit of this writing in full is not justified here, in light of the fact that the prime goal of this exploration is worried with friction, not with expanding information of these hypothetical connections. By and by, some audit of the standard hypothesis is fitting. The fundamental three parameters, which depict continuous movement stream, are Flow, Speed and Density. The summed up representation of their connections, which are the reason for the limit examination of continuous flow offices are appeared in figure 2.1 beneath (I-HCM 2010, Exhibit 7-2). The significance of comprehension the relationship between flow, speed and thickness is irrefutable. From the point of view of plan, information of high flow rate attributes is required for the expectation of thruway limit. From the point of view of activity operations, understanding the whole scope of connections is vital to give satisfactory level of administration. Undertakings, for example, improvement of flow control and incline metering strategies must be founded on these useful interrelationships under high-thickness conditions. Also, any endeavors toward growing new roadway and vehicular innovations with the end goal of enhancing flow attributes will fundamentally originate from a comprehension of the present relations. As a rule, speed-flow-thickness connections are valuable for parkway outline and arranging process as they give quantitative assessments of the adjustment in speed as a component of expected changes in movement request. They are similarly valuable progressively movement control or episode identification in light of changes in activity flow parameters. Throughout the years, the Greenshields display has been recommended to measure the relationship between speed, flow and thickness. It was adjusted and approved utilizing two-path thruway information. It is additionally a solitary administration display. In later later development several models were suggested. The difference is, most of them were calibrated and validated by using freeway data and were two-regime models. These models are reviewed in many publications but among the best known are May (1990), Drake et al (1967) and McShane and Roess (1990) who provide a graphical summary of four key hypotheses, based on Drake et al (1967). These models essentially apply to uninterrupted traffic flow. McShane and Roess describe the Greenshields models as the simplest, with a linear speed-density relationship.

**III. Problem Statement**

The traditional methods for design and operational analysis of highways and urban streets. The procedures and methodologies of this manual evolved from a wide range of empirical research conducted in the USA since the 2000's. Through the years it has evolved to address the needs of a much wider audience including specialists such as environmentalists (i.e. air quality and noise experts). However these procedures were developed for typical conditions found in developed countries where traffic is more homogeneous and regulated. Consequently, they cannot be applied successfully in traffic conditions that are significantly different such as those prevalent in most developing countries. In Mumbai for example, the amount of disturbance to traffic flow from side friction is often considerable and the number of sources of friction is also large. They include: vehicles stopping, parking, loading and unloading (particularly public transport vehicles), non-motorized vehicles (including bicycles), pedestrians walking in the roadway and crossing, street trading, the number of accesses and the number of vehicles using them. In consequence, traffic flow is considerably interrupted, and thereupon diminishing the performance of traffic operations and undermine capacity and functional integrity of the road. Most of these factors are not explicitly addressed by methodologies evolved in developed countries for planning, design and analysis of roadways.

**IV. Side friction.**

Activities that give rise to side friction were observed on many streets in Dar- es-salaam. However, their intensity and type depended much on locations such as central area, urban and suburban. Generally these activities were classified as follows:

• Activities happening within the travelled way:

(a) Public mini-buses parking and un-parking to load and unload passengers

(b) Non-motorized vehicles especially push carts and three-wheeled bicycles

(c) Pedestrians and bicycles

(d) Road unworthy vehicles and slow moving vehicles such as tractors

(e) Animals crossing the travelled way i.e. goats, dogs, chicken, cows etc.

• Activities happening on shoulders

(a) Vehicles parking and un-parking especially public mini-buses and taxis

(b) Parked broken-down vehicles

(c) Pedestrians, bicycles and non-motorized vehicles using the shoulders

(d) Street beggars and traders

• Activities happening on the roadsides which essentially generate friction events to shoulders and the travelled way:

(a) Accessibility junctions and driveways to roadside premises such as shops, residences, schools, garages, petrol stations, etc

(b) Trading activities including food stalls, kiosks, vendors, etc.


Figure. Typical side friction factors observed in the field.

***Site Selection***

In the above section, an inventory of traffic facilities and conditions were identified. In this part, specific roads and sites were selected based on those findings. The selection was certainly limited by time and budgetary constraints. This selection was deemed important because the results based on them were expected to represent the whole study area of Mumbai.

Firstly, roads were selected based on the presence of a wide range of traffic flow conditions such as flow intensity (volume/capacity ratio), directional distribution, traffic mix, percentage of heavy vehicles, and levels of side friction. At least places nearby intersections, which are prone to congestion, were avoided because the idea was to observe uninterrupted flow. Secondly, roads were selected based on their physical and geometric quality that could support this kind of study. While selection of roads was generally based on physical, environmental and traffic conditions, selection of the study sites/segments, was based on more specific requirements, which were specified as; straight alignment, with full access control and located in a flat terrain. Based on these, the following roads and sites were selected:

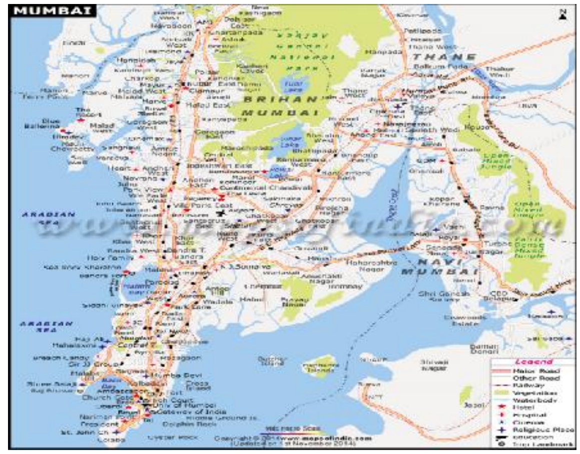


Figure. Location of roads and sites for macroscopic analysis (Mumbai).

**V. Side Friction Factors**

***Identification of site conditions***

*Traffic facilities*

It was identified that Mumbai city is constituted of a radial system of roads. Major highways and arterials of either 4lane-2way or 2lane-2way converge in the city centre where most of the traffic end and originate. Collector and local streets connect to these roads to form the city's road network. In general, it was established that the traffic facilities found in Mumbai could be categorized into four main types: road links, roundabouts, un-signalized intersections, and signalized intersections. This research was concerned only with road links. The following features characterize most of the road links in Mumbai:

1. Kerbs: common on downtown local streets but rare on major arterials

2. Shoulders: mostly potholed and occupied by various activities

3. Sidewalks: exist on many major arterials

4. Medians: exist on all multilane facilities

5. Lane markings: common with major arterials

6. Frontage roads and separators: exist on some four-lane two-way roads (normally called 'service roads')

Urban roads in Mumbai are functionally classified as arterial, collector, or local streets. Arterial roads are designated for major traffic movements with high volumes and high design speed. Collectors are designated for reduced movement function and may be either primary or secondary. Local roads are designated primarily for accessibility. Most of the arterial roads are four-lane two-way facilities with medians separating the two directions of traffic travel, and few are two-lane two-ways with no medians. All collector and local roads are two-lane two-way facilities. The common lane width for arterials is between 3.5m –3.7m and for collector and local roads is between 3.0m – 3.5m. Most of arterial and collector roads have shoulders some of which are unpaved. The width of the paved shoulders range between 1.0m – 2.0m. Speed limits for major arterial range from 50km/h- 80km/h depending on location within the city area while for most collectors is below 50 km/hr, and most local roads are rarely posted with any speed limits. Parking lanes are common on downtown streets, which are local streets and essentially function for accessibility. Many arterials are characterized by sidewalks, which are designated for use by bicycles, pedestrians and non- motorized vehicles. Mostly, collector and local roads outside the central area (CBD) are characterized by unpaved, undesignated walkways. Generally, only part of the observed network especially arterial roads was identified as suitable for this study. Many of the local roads were considered unsuitable due to the deteriorated physical conditions they were in. Moreover, this study was essentially for mobility roads and thus local roads were of less interest.

*Traffic conditions*

Identification of traffic conditions involved primarily two items, which included vehicle composition and directional distribution as explained below:

(a) Vehicle composition

The motor traffic was initially identified to constitute mostly of passenger cars, light vehicles (jeeps, pickups, micro-vans, utility vehicles), mini-buses, and few large buses, big trucks, and motorcycles (two-wheeled and three-wheeled vehicles). Later in this thesis the vehicle types were classified in four major groups based on axle spacing. They included Light Vehicles (LV), Medium Heavy Vehicles (MHV), Heavy Vehicles (HV) and Motorcycles (MC).

(b) Directional distribution

Traffic flow is normally recorded separately for each direction of traffic in the studied section. However, in this study both directions were studied for the two-lane two-way roads and each direction for the four-lane two-way roads.

*Environmental conditions.*

These were defined as all conditions besides geometric and traffic conditions that might have influence on the behaviour of drivers. Environmental data include:

i. Geographical data such as the location of the road within the city

ii. Weather conditions e.g. rain, wind, visibility (e.g. fog, smoke)

iii. Time of day

iv. Pavement conditions (e.g. smooth, degree of damage)

## VI. Results and Discussion

***Assessment of Vehicle characteristics:***

The assessment of vehicle characteristics was intended to identify if different vehicle types portrayed similar operating characteristics in terms of speed so that they could be combined in the analysis. The dominant vehicle types observed in the field were shown as: Light vehicles (LV=67.9%), Medium heavy vehicle (MHV=24%), Heavy vehicle (HV=4.4%), and Motorcycles (MC=3.7%). The composition above suggested the necessity to verify if the operating characteristics of the different vehicle types were or were not statistically different from each other on the studied roads. This was performed by application of analysis of variance method (ANOVA) where the objective was to obtain homogeneity or non-homogeneity in vehicle operational characteristics. For appropriate use of ANOVA method, analysis was performed on equal size samples obtained randomly from the hourly volumes of each vehicle type by means of computer generated random numbers. The results showed that operating characteristics of different vehicle types on the 4lane-2way roads differed significantly at the statistical level of 0.01, while there was no significant difference on the 2lane-2way roads. The results of this analysis are shown in table 8.3. It was thus recommended to include only light vehicles (LV) for further analysis on the 4lane-2way roads and all vehicles on the 2lane-2way roads. However, due to the insignificant presence of the heavy vehicles and motorcycles on all studied roads, it was generally recommended to exclude them from the analysis, implying that only light vehicles and medium heavy vehicles were considered (for two-lane two-way roads).

| ROAD TYPE | (I) Vehicle Type | (J) Vehicle Type | Mean Difference (I-J) | Level of significance | ANOVA F | ANOVA Level of signifi |
|---|---|---|---|---|---|---|
| 4Lane 2Way | LV | MHV | 6.010 | .000 | 31.116 | .000 |
| | | HV | 8.612 | .000 | | |
| | | MC | 7.405 | .000 | | |
| | | | | | | |
| 2Lane 2Way | LV | MHV | -.51837 | .997 | .249 | .862 |
| | | HV | 1.5224 | .927 | | |
| | | MC | -.17347 | 1.000 | | |

Table. Comparison of operating characteristics of different vehicle types.

| 4LANE 2WAY ROADS | | | | | 2LANE 2WAY ROADS | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Factors compared | Sample size | Average speed | ANOVA F | ANOVA Level of Sig. | Factors | Sample size | Average speed | ANOVA F | ANOVA Level of Sig. |
| NO SF | 136 | 60.6 | 1.6 | 0.206 | NO | 212 | 57.7 | 8.9 | 0.003 |
| PED | 136 | 59.2 | | | PED | 212 | 54.3 | | |
| | | | | | | | | | |
| NO SF | 136 | 60.2 | 3.20 | 0.075 | NO | 66 | 57.4 | 6.8 | 0.010 |
| BIC | 136 | 58.0 | | | BIC | 66 | 52.3 | | |
| | | | | | | | | | |
| NO SF | 50 | 60.5 | 3.18 | 0.078 | NO | 124 | 57.8 | 15.9 | 0.000 |
| NMV | 50 | 56.8 | | | NM | 124 | 51.3 | | |
| | | | | | | | | | |
| NO SF | 37 | 60.7 | 6.3 | 0.014 | NO | 50 | 57.8 | 23 | 0.000 |
| PSV | 37 | 54.3 | | | PSV | 50 | 47.8 | | |

TABLE. Friction factors' impact on free-flow speed by 'average speed method'.

***Graphical demonstration of the impact of friction factors on free- flow speed***

• The average speed method:

A study period of one hour during which data were recorded was examined, and 'free-flow vehicles' were analyzed. Assumption was made that this period of time all conditions remained uniform and that the only condition that affected speed was the event of friction factors. 'Free-flow vehicles' that interacted with a given type of a friction factor were tracked through the study section and their average speeds computed. They were sorted in groups of the friction factors of which they interacted with (i.e. PED, BIC, NMV, PSV) and compared with the same size sample of those 'free-flow vehicles', which did not interact with any friction factor (NO SF). The plot was such that on the x- axis was recorded passage times noted as the 'free-flow vehicle' exited the study section, and on the y-axis was their respective average speeds. The results demonstrated how potentially the different friction factors could affect traffic speed on different road types. The linear models simply indicate the trend within the one-hour study period but do not necessarily predict long-term behavior. The intention of these plots was to demonstrate the trend of the effect of the individual side friction factors on speed within the one-hour study period. It is noted that the impact was not constant over time. The plots are supplementary to the numerical results, which basically depict corresponding results in average terms.

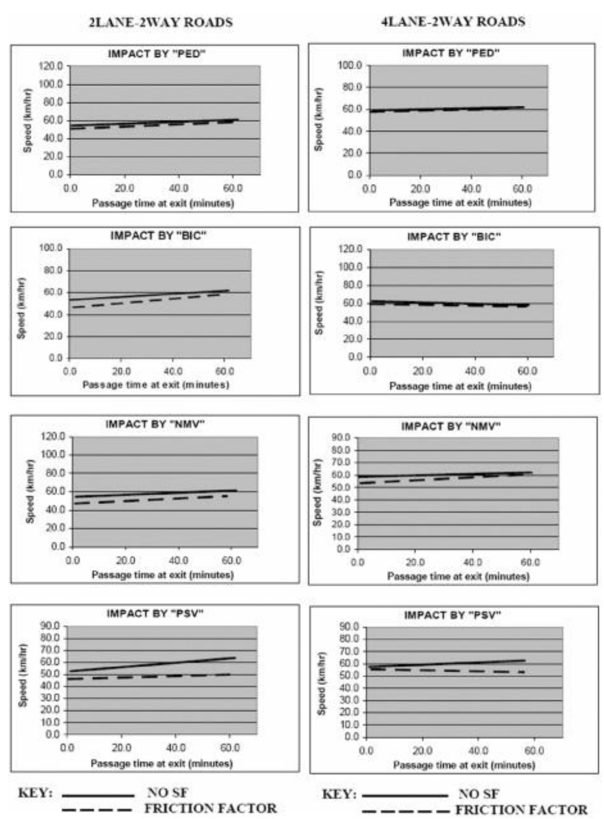

Figure. Impact of friction factors by 'average speed' method.

• Spot-speed method.

Similarly for this method, a study period of one hour was examined. Spot- speeds of 'free-flow vehicles' that interacted with a particular friction factor were measured at the entry point and the exit point of the study section. These two were compared. The plot was such that the vehicles were recorded in terms of numbers sequentially on the x-axis and their respective speeds were plotted on the y-axis. The results demonstrated the impact of each friction factor as shown in figure below.

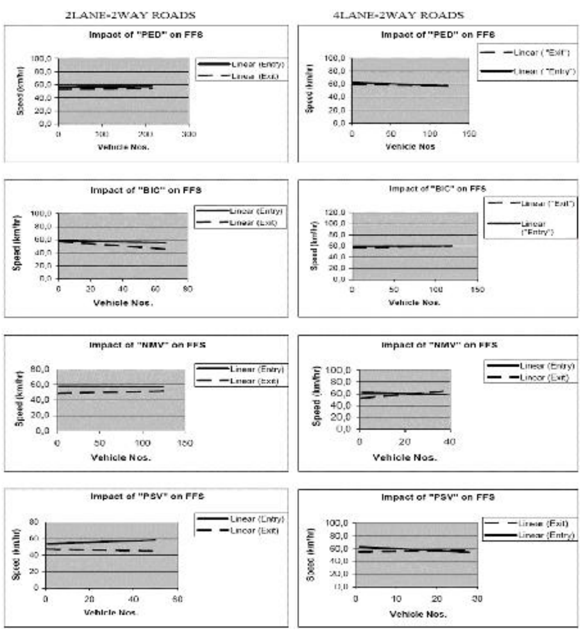


Figure. Impact of friction factors by 'spot-speed' method.

Observation of figure above indicates that most drivers entered the study section at higher speeds, but on interacting with a frictional element in the way they exited at lower speeds. By implication many drivers tended to decelerate on passing friction objects. However not all drivers behaved so, there were some although the minority entered with lower speeds and exited with higher speeds or they accelerated on passing a friction object. The above figure demonstrates the general behaviour, whereas the individual behaviour is explicitly depicted in figure below as exemplified for the case of parked or stopping vehicles (PSV) friction factor.

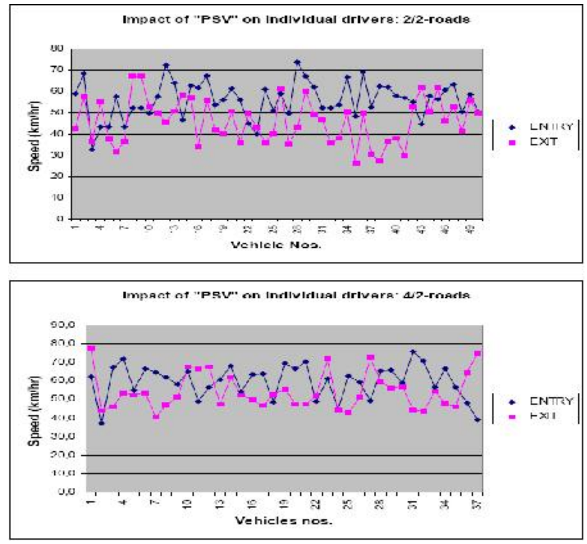


Figure. Impact by PSV on the behaviour of individual vehicles.

## VII. Conclusion

This study was arguably conducted on a small scale. The microscopic study was limited to analysis of only four types of interactions. It is recommended in further studies to include other types of interactions such as pedestrians crossing the road, bicycles riding on shoulders, vehicles stopping momentarily in the travelled way, vehicles and non-motorized vehicles that park on shoulders for longer times. On the other hand, the macroscopic study also included only limited number of friction factors. This was reflected by the explanatory power of the regression models relating speed to flow and friction, which varied from poor to good depending on site. There were clearly site- specific factors in operation that had not been identified or measured. It is thus recommended to conduct this study on a much larger scale including a wider range of all frictional components in order to account for much of the variation in the criterion variable. Similarly, larger scale-study would imply to include wider spectrum of facilities such as intersections, roundabouts, ramps and different terrains. It is likely that the effect of different friction factors would vary for different facilities and different terrains. For high precision results, it is recommended that further work should be on microscopic scale where simulation models can be built and calibrated. This is proposed in the knowledge that at present, there are no simulation models developed to take account of friction factors. Application of simulation will be regarded as a breakthrough in this field. It has been shown that side friction can have effects on speed and capacity in Mumbai, which indicated considerable effects like other commonly used factors in capacity analysis. This leads to the recommendation that highway capacity studies, particularly in the developing world, should include this variable, though in a form suited to their own particular circumstances.

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