Quantitative Analysis of Impact of Vehicle-Bicycle Conflict on the Capacity in Urban Mixed Traffic

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ABSTRACT: In order to determine the impact of vehicle-bicycle conflict on the capacity, this interference on the capacity is divided into three states: no interference, weak interference and strong interference, and quantitative analysis of the influence of capacity under the three states. Based on the data about interference of vehicle-bicycle conflict in typical road section in Xi'an, this paper quantitatively analyzes the velocity changing tendency of vehicles under three different interference states, determine the critical value of three different interference state, and the coefficients of interference can be calculated. As a result, the analysis based on the sample data about interference of vehicle-bicycle conflict in typical road section, this sample data shows that the coefficients of interference are significantly different under the different degree of vehicle-Bicycle conflict, not in a fixed value. Therefore, this paper provided a theory basis on capacity computation for condition about different vehicle-bicycle conflict.

KEYWORDS: Traffic engineering, Statistical analysis, Mixed traffic, Capacity, Degree of interference

INTRODUCTION

Mixed traffic flow including motor vehicles, non-motorized vehicles (major bicycles in China cities) and pedestrians, there is a big difference between these types of characteristics of individual traffic, and motor vehicle drivers, cyclists and pedestrians have significantly different behavior. Mixed traffic flow is a major feature of Chinese Urban Transport, this phenomenon makes the traffic flow behavior more complex, increase the severity of vehicle-bicycle conflict, and led to the decline in the efficiency of traffic. The impact of vehicle-bicycle conflict on capacity is related to traffic efficiency, in order to study the interference degree of vehicle-bicycle conflict on traffic capacity, Researchers have been carried out research in this regard.

For the current research between the vehicle-bicycle conflict and the capacity, most scholars expand capacity from the lateral aspect of the interference factor. Among them, literature 2 on the dual carriageway without isolation factors to analyze the impact of the motor vehicle, scholar Jeremy R. Klop and Asad J. Khattak select
North Carolina No isolation facilities dual carriageway as research subjects, situations in different simulation of non-motorized traffic, changes of vehicle operating speed; scholar Mark R. Virkler and Rajesh Balasubram analyzed on a bicycle, rollerblade, jog common traffic flow characteristics; literature 4 depth analysis of signalized intersection in mixed problems, scholar Mr. Li and Mao Bao-hua by simulating in Mixed process, proposed the impact of bicycle traffic capacity and corresponding computational model; scholars You Xiaoqiang and Yan Qipeng introduced the concept of dynamic viscosity of the fluid mechanics, the establishment of non-motorized vehicles motor vehicle friction model channel interference; scholars Zang Xiaodong and Tang Yuanhong analyzed under mixed traffic conditions on the road side obstacles Machine moving vehicle interference, and proposed mathematical model of lateral interference from the driver and vehicle characteristics angle; literature 7 to interference of non-motorized vehicles on the basic sections of the stream for the study, presented the basic analytical sections mixed traffic flow model; scholar Guan Hongzhi and Wang Mingwen for two-way two-lane road, the establishment of a road traffic delay caused by non-motorized traffic due block interference.

Analysis on the research results, in spite of the many theoretical models in Urban Traffic Conflict on interference aspects of capacity, but the lack of actual data collection and quantitative empirical analysis. In view of this, this paper studies the current weakness of the survey program design, field data collection for statistical analysis, simulated disturbance processes Conflict on the operating efficiency of motor vehicles, quantitative analysis of the degree of interference with the capacity of different lateral interference factor.

1. INTERFERENCE TYPE AND STATISTICAL ANALYSIS

1.1 INTERFERENCE TYPE

Non-motorized vehicles with a swing, flexibility features, easy to form groups of riding side by side phenomenon, because of this feature, resulting in adjacent non-motorized vehicles and vehicles in parallel process, due to line interference on adjacent and vehicle speed, effects of vehicle traffic capacity. According to a different number of adjacent non-motorized, produce different degrees of interference, divided into no interference state, the weak interference state and the strong interference state. Among them, the no interference state represents fewer non-motorized and did not have impact on neighboring vehicle speed; the weak interference state represents larger number non-motorized vehicles, lateral approaching motor vehicle lanes, therefore, the vehicle will take slow down measures to ensure traffic safety; the strong interference state represents larger number non-motorized vehicles, and led to non-motorized vehicle occupancy motor vehicle lane, the vehicle will take slow down measures to ensure traffic safety.

1.2 DATA COLLECTION

Different number of non-motor vehicles, different levels of non-motorized vehicles, produce different interference degrees for the vehicle speed, influence capacity. Therefore, the data collection contents main include vehicle speed $v$, number of
non-motorized $n$, non-motorized vehicles operating level $\eta$. Data collection method chosen video, moreover data filtering and sample extraction.

Select Taibai Road of fast road, Fenghui South Road of trunk road, Keji Forth Road of secondary road and Keji Fifth Road of branch road for data collection in Xi'an. Each site collection over 260 effective sample size, and collected 1100 valid samples, determine the relationship between vehicle speed $v$ and non-motorized vehicles operating level $\eta$.

![Fig 1 fast road $v-\eta$ scatterplot](image1)
![Fig 2 trunk road $v-\eta$ scatterplot](image2)
![Fig 3 secondary road $v-\eta$ scatterplot](image3)
![Fig 4 branch $v-\eta$ scatterplot](image4)

2. ANALYSIS of STATE INTERFERENCE

According to the correlation analysis between $v$ and $\eta$, was found the same trend in general, with the non-motor vehicles increase next to the vehicles, the effect of vehicle-bicycle conflict from no interference state gradually transformed into weak interference state, and then transformed into strong interference state, and there are two key points $B_\eta$, $F_\eta$, where $B_\eta$ represents the first point of the interference phase transition occurs, $F_\eta$ represents the second time interference point phase transition occurs. Two key points of this whole process of change into no interference state, weak interference state, strong interference state.
(1) No interference state

No interference state represents the ratio $\eta$ between the $(0, \eta_B)$ range, according to the measured data found that this stage $v$ has not been changed the impact factor $\eta$, $v$ as a constant, only its size and nature of technical grade urban roads, the fast road was about 45km/h, while the brunch road is 25km/h, this speed as the speed of change in the reference value $\bar{v}$, when $v \neq \bar{v}$, is the first time the corresponding $\eta$, The first phase transition called interference point $\eta_B$; when $\eta \geq \eta_B$, with the factor $\eta$ increases, $v$ decreases significantly.

(2) Weak interference state

Weak interference state represents the ratio $\eta$ between the $(\eta_B, \eta_F)$ range, according to the measured data found that this phase $v$ by $\eta$ factor greater impact, with increasing factor $\eta$, $v$ is reduced significantly, the overall trend is similar to the curve. There is a second phase transition point $\eta_F$ in this phase interference, in the process of change $\eta_B \rightarrow \eta_F$, $v$ factor that greatly influence the amplitude $\eta$, to $\eta_F$ points, $v$ weakened by the magnitude of the impact factor $\eta$.

(3) Strong interference state

Strong interference state represents the ratio $\eta$ between the $(\eta_F, 1)$ range, discovery of this phase factor $\eta$ by factor weakening impact of changes based on the measured data, similar trends between the two curves toward, the second phase transition point $\eta_F$ in this phase, was also set up as a non-isolated machine facilities key points.

3 CHARACTERISTIC ANALYSIS AND CALIBRATION COEFFICIENT

3.1 Characteristic Analysis

Under no interference, weak interference and strong interference states, the vehicle speed are quite different, determine the Taibai Road, Fenghui South Road, Keji Forth Road, Keji Fifth Road velocity distribution variation.

From Fig 1 to Fig 4, at the no interference state, the average speed of the motor vehicle is 44.89km/h, 35.91km/h, 29.49km/h, 24.54km/h; at the weak interference state, the average speed of the motor vehicle is 29.39km/h, 23.88km/h, 19.41km/h, 16.23km/h; at the strong interference state, the average speed of the motor vehicle is 16.98km/h, 13.61km/h, 11.15km/h, 9.30km/h.
<table>
<thead>
<tr>
<th></th>
<th>Taibai Road</th>
<th>Fenghui South Road</th>
<th>Keji Forth Road</th>
<th>Keji Fifth Road</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average speed</td>
<td>Standard deviation</td>
<td>Average speed</td>
<td>Standard deviation</td>
</tr>
<tr>
<td>no interference</td>
<td>44.89</td>
<td>2.28</td>
<td>35.91</td>
<td>1.82</td>
</tr>
<tr>
<td>weak interference</td>
<td>29.39</td>
<td>47.45</td>
<td>23.88</td>
<td>42.72</td>
</tr>
<tr>
<td>strong interference</td>
<td>16.98</td>
<td>2.57</td>
<td>13.61</td>
<td>1.86</td>
</tr>
</tbody>
</table>

From Table 1, when the weak interference state and strong interference compared with no interference state, the Taibai Road average speed decreased 34.53% and 62.17%; when the weak interference state and strong interference compared with no interference state, the Fenghui South Road average speed decreased 33.50% and 62.10%; when the weak interference state and strong interference compared with no interference state, the Keji Forth Road average speed decreased 34.18% and 62.19%; when the weak interference state and strong interference compared with no interference state, the Keji Fifth Road average speed decreased 33.86% and 62.10%.

### 3.2 CALIBRATION COEFFICIENT

Due to the speed of the vehicle collected by the technical grade urban roads condition factor, and therefore subject to the formula (1) to speed data surveyed dimensionless treatment, excluding factors influencing the degree of technical grade mixed traffic interference. Where $v$ is the actual vehicle speed acquisition, $\bar{v}$ is different skill level free flow speed road vehicle, $\delta$ is the interference factor.

$$\delta = \frac{v}{\bar{v}} \quad (1)$$

Now the relationship between $v$ and $\eta$ into $\delta$ and $\eta$, the data between the fitting range within each region to determine the boundary changes and the corresponding function parameters constraints.

![Figure 5. $\delta \cdot \eta$ scatterplot.](image1)

![Figure 6. $\delta \cdot \eta$ Strong interference curve fitting stage.](image2)
As can be seen from Fig 5, $\delta \cdot \eta$ scatter plot, $\eta$ phase change front when interference occurs between $\left(0, \eta_B\right)$ range, for operational level of motor vehicles did not have a significant impact, that reduction coefficient of the vehicle running speed is 1; when $\eta=\eta_F$, operational level of motor vehicles achieve lowest level, also set the basis for machine non-isolated facilities; when $\eta$ variation between $\left(\eta_B, \eta_F\right)$, conflict on the vehicle speed reduction factor will be a variable value, this stage is the main stage, wherein $\delta \cdot \eta$ curve fitting between seen in Fig. 6, model fitting between the two visible formula (2).

$$\delta=-4.74\eta^3+8.15\eta^2-5.39\eta+1.69 \quad (2)$$

When $\delta=1$, $\eta=\eta_B \rightarrow (0.16 \ 0.20)$; when $\delta=0$, $\eta=\eta_F \rightarrow (0.84 \ 0.87)$.

So in conflict on the vehicle running speed interference coefficient $\delta$ characterize the degree of capacity reduction, the actual capacity to determine the degree of interference of phase stages.

$$\begin{cases}
\delta=1 & \eta \leq 0.167 \\
\delta=-4.74\eta^3+8.15\eta^2-5.39\eta+1.69 & 0.167 < \eta < 0.86 \\
\delta=0 & \eta \geq 0.86
\end{cases} \quad (3)$$

According to the above formula can be drawn, when $\eta \leq 0.167$ stage before the phase of the interference, the conflict-stage machine is not obvious, yet on the capacity of the motor vehicle lanes interference; when $0.167 < \eta < 0.86$ as strong interference phase stage, the stage of channel capacity vehicle disturbance is not a constant, but varies by the change $\eta$; when $\eta \geq 0.86$ based on the interference phase after phase, which is the most serious conflict-machine, causing the vehicle to run stagnation, the stage is set machine non-isolated facilities.

4. DISCUSSION

(1) By collecting fast road, trunk road, secondary road, branch road vehicle operating speed $v$, number of adjacent non-motorized $n$, non-motor vehicle travel path $l$, non-motorized vehicles operating level $\eta$ as sample data. Based on this
analysis between $v$ and $\eta$ correlation, and further obtain the relationship between $\delta$ and $\eta$, and the whole evolution process is divided into $\eta \leq \eta_B$, $\eta_B \leq \eta \leq \eta_F$, $\eta \geq \eta_F$ three scenarios;

(2) When $\eta \leq \eta_B$, according to the measured data found at this stage $v$ have not been affected change factors $\eta$. The speed $v$ is related to the hierarchical nature of the urban road technology, as a constant value. That is, at this stage $\delta=1$, does not the vehicle speed, road capacity vehicle impact; When $\eta_B \leq \eta \leq \eta_F$, according to the measured data found that this phase $v$ change influenced by factors $\eta$, with the $v$ decreases $\eta$, $v$ is a variable value, that is the stage $\delta$ for a change in value by the size of the impact factor $\eta$; When $\eta \geq \eta_F$, according to the measured data found that the most serious conflict-stage machine, there will be stagnation vehicle running scene, that is, $\delta=0$ indicates that $\eta \geq \eta_F$, you must set the machine non-isolated facilities can guarantee the normal operation of a motor vehicle;

(3) By fitting the sample data, you can determine $\eta_B$, $\eta_F$ two key positions critical point threshold range, which $\eta_B$ belongs to the range of between 0.16 to 0.20, which $\eta_F$ belongs to the range of between 0.84 to 0.87. Thus, when $\eta \leq 0.16$, the vehicle to protect free flow speeds, traffic capacity and will not affect; when $\eta \geq 0.87$, roads need to set the machine non-isolated facilities in order to protect the normal operation of the vehicle; when $\eta$ range is between 0.16 to 0.87, consider the capacity of the road vehicle interference coefficient extent size.

5. CONCLUSION

The actual data analysis based on four typical road in Xi’an, the interference degree for vehicle-bicycle conflict are divided into non-interference, weak interference, strong interfering three state interference, analysis the speed trendence in each state interference, determining phase transition critical point, and calculating the interference degree of vehicle operating speed about weak interference state and strong interference state, at different technical level road. And then further identified
the interference of vehicle traffic capacity about vehicle-bicycle conflict. By the above analysis, under different number of non-motor vehicles conditions, the interference degree is significantly different, these analysis results can promote establish the theoretical model.

REFERENCES


