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Capacity model of on-ramp merging section of urban expressway

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Abstract: To establish the empirical capacity model of an on-ramp merging section, the Erlang distribution is first selected to define the time headway distribution, and then the gap acceptance theory is applied to develop the basic capacity model of the on-ramp merging section. Since not all the time headways on the shoulder lane can be made full use of by on-ramp vehicles, a modified capacity model is developed, which takes the usage probability of time headway into consideration. Then, a model of capacity discount coefficient ξ is developed. Finally, based on the modified capacity model and the model of capacity discount coefficient, an empirical merge capacity model which contains the shoulder lane volume, critical gap, and the distance from nose to merging point, is constructed. Results show that, compared with other models, the proposed model is more reasonable since it takes merging section geometry into consideration, and it is easy to apply. The merge capacity varies with the shoulder lane volume, the critical gap, the distance between the nose and the merging point, and the design velocity of the shoulder lane and ramp.

Key words: merging section; empirical capacity model; urban expressway; gap acceptance

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With traffic demand continuously increasing, several locations on expressways are becoming more and more congested. There is no doubt that the merge area is the most common bottleneck of recurrent congestion. Furthermore, traffic turbulence will spread to affect the traffic characteristics of shoulder lanes and ramps around the merge area. As recommended in the Highway Capacity Manual[1], the influence area extends to 450 m at the on-ramp downstream.

In the past decades, studies focused on explaining and analyzing characteristics, operations, the capacity of the on-ramp merging section, and identifying the causes of capacity drop related to traffic interference caused by vehicle lane-changing maneuvers at merge areas[2-6]. Nowadays, the method used in the HCM is widely adopted to calculate capacity, and it is an empirical method developed based on field data. Three key steps are required to implement this method. First, we should acquire the flow of Lane 1 and Lane 2. Secondly, the on-ramp merging section capacity is calculated to ensure that it can satisfy the existing traffic demand. Finally, the density within the ramp influence area is determined based on the level of service. The expressway geometry, the shoulder volume, and the critical gap are not considered, but these factors have great influence on the merge capacity.

The gap acceptance theory was developed to explain the merging process on freeways. Kita[7] formulated a gap acceptance problem at the freeway merging section. The binary logit model was used to analyze and explain the problem. Lertworawanich et al. [8] developed a new gap acceptance model by defining expressway capacity. Kim and Son[9] promoted a new on-ramp capacity model by making time headway obey different distributions. However, most of these models are difficult to implement. In these papers, the vehicles on the ramp can make full use of all the appropriate gaps, which is different from reality.

Recently, several studies demonstrated that the expressway capacity is variational rather than immutable and frozen. Some other studies proposed that capacity can only truly be defined as a function of breakdown probability, which is a function of ramp vehicle cluster occurrence[10-11]. Subsequently, a probabilistic model describing the process of breakdown at ramp-freeway junctions was examined. Also, a probabilistic model of breakdown occurrence was put forward. Lorenz et al. [10] proposed a modified capacity definition which took the probabilistic nature of the freeway breakdown process into consideration. Then, preliminary models based on survey data were constructed to describe the probability of breakdown[12].

These studies have provided some useful results, but a generalized empirical capacity model should be established to make the model easier to use[13]. Additionally, some other factors, such as distance from nose to merging point and the design speed, were not taken into consideration in constructing the capacity model. So, this study aims to establish a novel on-ramp merging section capacity model, taking the usage probability of time headway into consideration. First, the Erlang parameter is defined according to the shoulder flow; secondly, based on the gap acceptance theory, the ramp capacity is modeled for each Erlang parameter; thirdly, a model is established to

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calculate the usage probability of time headway and then this utilization probability is used as a discount coefficient to obtain the ramp adjusted capacity. Finally, a regression model of the on-ramp merging section capacity is put forward to make the model more practical.

1 Ramp Capacity Model

At merging areas, when appropriate gaps are available, the entrance ramp vehicles will merge into the shoulder traffic flow by changing lanes, and the merge capacity is determined by this process. The general diagram of the merging area is shown in Fig. 1. The ramp capacity is the maximum volume allowed to merge into shoulder traffic flow. With traffic disturbances changing, the ramp capacity varies.

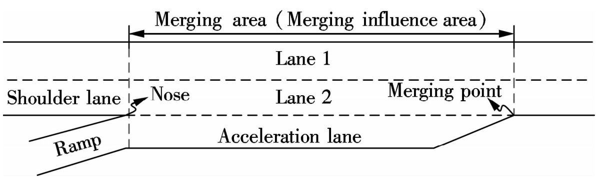

Fig. 1 General diagram of merging area

1.1 Modeling headway distribution

With traffic volume increasing, the headways between vehicles decrease, which will make the interactions between vehicles more intense. When the traffic flow approximates free flow, the interactions between vehicles are weak, and headways are random. When the traffic volume approaches capacity, the traffic flow approximates a saturated state, and headways are regular.

The Erlang distribution can be used to represent various consecutive random distributions by adjusting the parameters. When the Erlang parameter K takes positive integer value from 0 to ∞, the Erlang distribution will be a negative exponential distribution when $K = 1$. As the K value approaches infinity, the headway distribution becomes a constant distribution. So, the Erlang distribution is employed to describe the headway distribution on the shoulder lane. The probability density function of the Erlang distribution is

$$f_k(t) = \begin{cases} \dfrac{\mu^k (\mu k t)^{k-1}}{(k-1)!} & t > 0 \\ 0 & t < 0 \end{cases} \tag{1}$$

where μ is the mean value.

The key step is to establish a calculation model of the parameter K. Hence, the relationship between the shoulder lane volume and K should be defined, and K can be selected according to the volume. Based on the maximum likelihood estimation method, K can be estimated by

$$K = \left(\frac{\bar{t}}{S} \right)^2 \tag{2}$$

where $\bar{t}$ is the mean time headway, s; and S is the standard deviation of the time headway.

Field observation data are used to calculate K in the case that the shoulder volumes take various values. Data sets were collected at Nanhu Road and Yatai Street interchanges in Changchun, China via the video analysis method. The investigation was conducted from 8:00 to 10:00 and 16:00 to 18:00. Due to the variational traffic volumes during these periods, the investigation lasted for 10 d. The average time headway and traffic volumes were acquired every 15 min, and there were 155 average time headways. These sites were composed of three mainline lanes and two ramp lanes.

The vehicle headways at the shoulder lane are recorded to calculate K by using Eq. (2). The shoulder lane volume is selected as an independent variable, and the calculation model of the parameter K is established by regression analysis. As a result of the statistical analysis, the significant coefficient R^2 of the regression analysis is 0.958 5. The calculation model is expressed as

$$K = 1.050\,39 + 0.001\,57 e^{0.003\,43 Q} \tag{3}$$

where Q is the shoulder lane volume, veh/h.

As shown in Eq. (3), K can be calculated by the shoulder volume. K must be a positive integer, so the calculated K values are rounded to the nearest integer. K values are shown in Tab. 1. When $K > 3$, the calculated volume value will exceed 2 200 veh/(h · lane), which is the basic traffic capacity of the expressway. Therefore, $K = 1, 2$, and 3 can represent all the possible shoulder lane volume ranges.

Tab. 1 Ranges of shoulder lane volume by the Erlang parameter

K	1	2	3
Q/(veh · h^{-1})	$0 < Q < 1\,664$	$1\,664 \leqslant Q < 2\,004$	$2\,004 \leqslant Q < 2\,131$

1.2 Modeling ramp capacity model

Before establishing a ramp capacity model, several assumptions are made to simplify the modeling process: 1) The traffic streams on the ramp and shoulder lane are single; 2) There is an inexhaustible queue waiting to enter a shoulder lane; and 3) The ramp vehicles have to select appropriate gaps to merge into the shoulder lane traffic stream.

Several parameters are introduced to describe the merging process: t_c represents the critical gap that can be used to merge into the shoulder lane by a ramp car; and t_h is the headway between two ramp cars. Compared to the headway with the critical gap, the possibility of ramp vehicles entering the shoulder lane is as follows: 1) When $t < t_c$ and t is the shoulder vehicle headway, no ramp vehicle merges; 2) When $t_c < t \leqslant t_c + t_h$, only one vehicle merges; and 3) When $t_c + t_h < t \leqslant t_c + 2t_h$, two vehicles merge.

Therefore, the ramp volume entering the shoulder lane per second becomes

$$C_R = 3\,600q\sum_{i=0}^{\infty}(i+1)P[t_c+(i-1)t_h < t \leqslant t_c + it_h] \tag{4}$$

where $P[t_c+(i-1)t_h<t\leqslant t_c+it_h]$ is the probability of i vehicles merging into the shoulder lane; C_R is the maximum ramp volume, veh/h; and q is the shoulder lane volume, veh/s.

When $K=1$, the headway distribution in the shoulder lane obeys the negative exponential distribution, and the cumulative distribution function $P(h\leqslant t)$ can be expressed as

$$P(h\leqslant t) = 1-e^{-qt} \tag{5}$$

The maximum ramp volume entering the shoulder lane per second for $K=1$ becomes

$$C_R = 3\,600q\sum_{1}^{\infty} nP(t_c+(n-1)t_h < t \leqslant t_c+nt_h) = \frac{3\,600qe^{-qt_c}}{1-e^{-qt_h}} \tag{6}$$

When $K=2$, the cumulative distribution function $P(h\leqslant t)$ can be expressed as

$$P(h\leqslant t) = 1-e^{-2qt}(1+2qt) \tag{7}$$

In the same way, the maximum ramp volume merging the shoulder lane per second for $K=2$ becomes

$$C_R = 3\,600q\sum_{1}^{\infty} nP[t_c+(n-1)t_h < t \leqslant t_c+nt_h] = \frac{3\,600qe^{-2qt_c}}{1-e^{-2qt_h}}\left(1+2qt_c+\frac{2qt_h e^{-4qt_h}}{1-e^{-2qt_h}}\right) \tag{8}$$

Finally, when $K=3$, the cumulative distribution function $P(h\leqslant t)$ can be expressed as

$$P(h\leqslant t) = 1-e^{-3qt}\left[1+3qt+\frac{(3qt)^2}{2}\right] \tag{9}$$

In the same way, the maximum ramp volume merging the shoulder lane per second for $K=3$ becomes

$$C_R = \frac{3\,600qe^{-3qt_c}}{1-e^{-3qt_h}}\left[1+3qt_c+4.5q^2t_c^2+\frac{3qt_h(1+6qt_c)e^{-3qt_h}}{1-e^{-3qt_h}}+\frac{9q^2t_h^2(1+e^{-3qt_h})e^{-3qt_h}}{(1-e^{-3qt_h})^2}\right] \tag{10}$$

C_R can be calculated by Eqs. (6), (8) and (10). When calculating the maximum ramp volume, t_c is an essential parameter, so t_c is set to be 2 s for convenience. For different critical gap t_c, the relationships between the maximum ramp volume C_R and the shoulder lane volume q are shown in Fig. 2

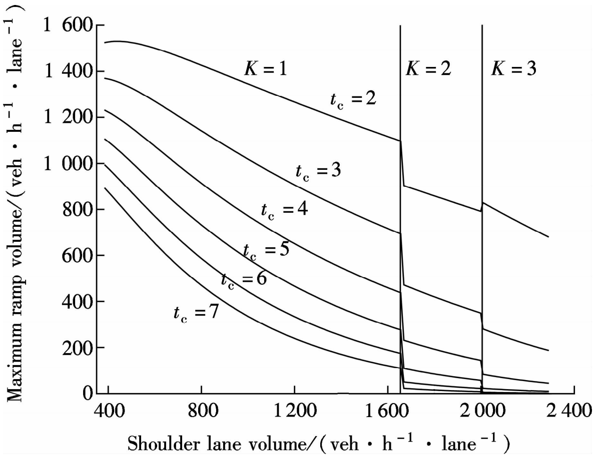

Fig. 2 Maximum ramp volume defined by shoulder lane volume

As shown in Fig. 2, with the same t_c, the maximum ramp volume decreases when the shoulder lane volume increases.

2 Modeling Empirical Merge Capacity

The ramp capacity is calculated by three different formulas for different shoulder lane volumes. It is unfeasible for use in practice. It is necessary to develop an empirical model to simplify the merge capacity calculation. Before establishing the objective, independent variables affecting merge capacity have to be selected, such as shoulder Q and t_c.

2.1 Modified ramp capacity model

The merge capacity is defined as the sum of the maximum ramp volume and shoulder lane volume. However, the maximum ramp volume should be multiplied by a discount coefficient because not all of the headways can be made use of by ramp vehicles to merge into the shoulder lane. This section describes the discount coefficient model. Vehicles enter the merging section from the ramp and shoulder lane, respectively, and the ramp vehicles can merge into the shoulder lane anywhere in the acceleration lane rather than merging only at the ramp entrance. Ramp vehicles utilize headway to merge by estimating whether the shoulder lane headway is acceptable.

As we know, when calculating the capacity by using the gap acceptance theory, the vehicles waiting on the branch road will take advantage of every appropriate gap to cross the main road traffic flow; however, this is not true in merging areas. In contrast, when an appropriate gap appears on the shoulder lane, the ramp vehicles have a chance to use it to merge into shoulder lane traffic flow. If the ramp vehicles enter the merging area at the same time or later than the shoulder vehicles, and the ramp vehicle velocity is lower than shoulder vehicle velocity, the acceptable headway on the shoulder may not be made full use of by the ramp vehicles. This wastes the appropriate gap and reduces the ramp capacity. To make the ramp capacity model more logical, the established ramp model above should be multiplied by a discount coefficient, which is caused by the waste of the appropriate gap.

For the ramp and shoulder lane vehicles entering the merging section at the same time, the shoulder vehicles will drive out of the merging section first because they have higher speed. The merging area's travel time difference between ramp vehicles and shoulder vehicles is represented by Δt. That is to say, the sum of the time headways of the ramp vehicles overtaken by the shoulder vehicle is equal to Δt, which can be calculated by

$$\Delta t = \frac{L}{V_1 - V_2} \tag{11}$$

where L is the distance from nose to merging point on the acceleration lane; V_1 is the shoulder design velocity; and V_2 is the ramp design velocity.

The general diagram of this process is shown in Fig. 3.

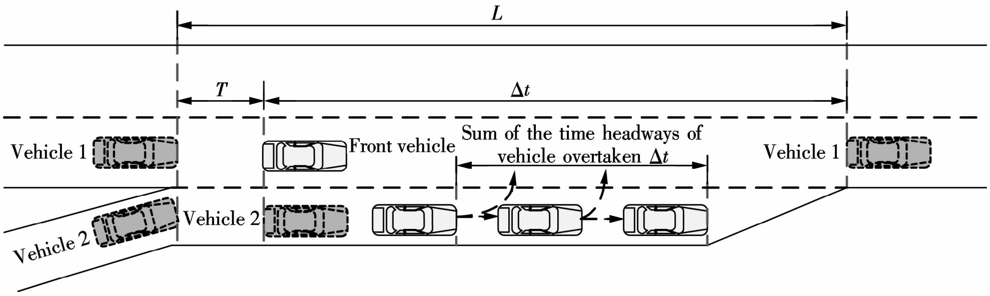

Fig. 3 General diagram of the parameter Δt

As shown in Fig. 3, all the ramp vehicles entering the merging section in Δt before Vehicle 2 entering the merging section can make use of the time headway T between Vehicle 1 and the front vehicle; hence, the discount coefficient is equal to the probability of the ramp vehicle arrivals within $\Delta t + T$, and T can be used by the ramp vehicles to merge into the shoulder lane.

First, we calculate the probability of the headway utilization. T obeys the Erlang distribution, and when $K = 1$, it obeys the negative exponential. The probability density function $f(t)$ can be expressed as

$$f(t) = \lambda e^{-\lambda t} \tag{12}$$

So, when $\gamma = \Delta t + T$, the probability density function of Y is

$$g(y) = \lambda e^{-\lambda(y - \Delta t)} \tag{13}$$

The probability distribution function of Y can be expressed as

$$G(y) = P(Y \leqslant y) = \int_{\Delta t}^{y} g(y)\mathrm{d}y = 1 - e^{-\lambda(y-\Delta t)} \tag{14}$$

In the case of $Y = y$, the probability of n vehicles appearing on the ramp is

$$P(N = n/Y = y) = \frac{(\lambda_2 \Delta t)^n}{n!} e^{-\lambda_2 \Delta t} \tag{15}$$

So the probability of n vehicles appearing on the ramp can be expressed as

$$P(N = n) = \int_{\Delta t}^{\infty} p(N = n/Y = y)\mathrm{d}G(y) = \int_{\Delta t}^{\infty} \frac{(\lambda_2 \Delta t)^n}{n!} e^{-\lambda_2 \Delta t}\mathrm{d}G(y) \tag{16}$$

The discount coefficient ξ is equal to the probability of the ramp vehicle arrivals during $\Delta t + T$ and it is represented by

$$\xi = P = \sum_{n=1}^{\infty} P(N = n) = \sum_{n=1}^{\infty} \frac{(\lambda_2 \Delta t)^n}{n!} e^{-\lambda_2 \Delta t} = 1 - e^{-\lambda_2 \Delta t} \tag{17}$$

In the same manner, when $K = 2, 3$, the discount coefficient model is expressed as

$$\xi = P = 1 - e^{-\lambda_2 \Delta t} \tag{18}$$

where λ_2 is the ramp lane flow rate, veh/s.

Eqs. (17) and (18) suggest that the headway distribution has no influence on the discount coefficient.

After being modified, the model is finally expressed as

$$C_{\mathrm{RM}} = \xi C_{\mathrm{R}} \tag{19}$$

where C_{RM} is the modified ramp capacity.

The next section develops a generalized merge capacity model using the modified ramp capacity model and addresses the ramp flow effect on the merge capacity.

2.2 Definition of independent variables

According to Eqs(6), (8) and (10), the maximum ramp volume, that is, the ramp capacity, is determined by the shoulder lane volume, so the shoulder lane can be selected as one variable. The ramp capacity is determined when the shoulder volume is determined. As shown in Fig. 2, when the critical gap takes different values from 2 to 7, the correlation curves of the ramp capacity and the shoulder lane volume approximate to linear, which demonstrates the tendency that the ramp vehicles merge the shoulder lane with more difficultly with the shoulder lane volume increasing. Fig. 2 shows that when the critical gap is 2, 826 ramp vehicles can merge into the shoulder lane per hour in the case that the shoulder volume is 1 896 veh/(h · lane)$^{-1}$. However, only 11 vehicles can merge into the shoulder lane when the critical gap is 7. According to Tab. 1, Fig. 2 is divided into 3 regions when $K=1$, 2, 3.

Fig. 4(a) shows the calculated merge capacity when the ramp capacity takes different values. After regression analysis, Fig. 4(b) shows the fitted exponential curve of the merge capacity for each critical gap value. It is clear that the merge capacity decreases with the increase in the ramp capacity. Furthermore, the merge capacity also decreases rapidly as the critical gap value increases. When the critical gap value is 7, a small change in the ramp capacity will result in a larger change in the merge capacity. Compared with that of $t_c=2$, the merge capacity decrease is more dramatic when $t_c=7$.

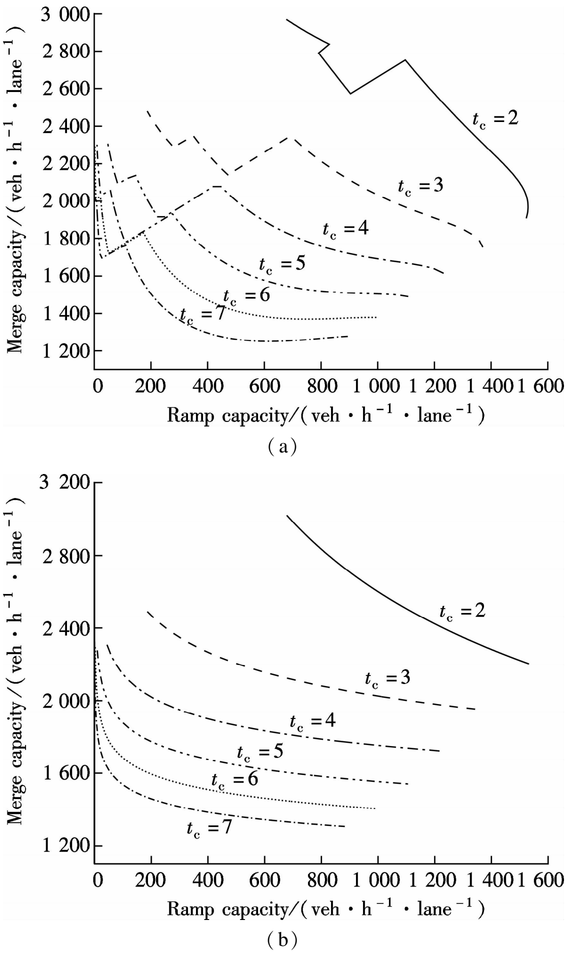

Fig. 4 Relationship between merge capacity and ramp capacity. (a) Observed; (b) Fitted

As described in previous sections, the ramp capacity is determined by the shoulder lane volume because the ramp vehicles will have more difficulty to merge into the shoulder lane as the shoulder lane volume increases. This also causes disturbance in the shoulder lane traffic flow. Fig. 5(a) shows that the calculated merge capacity when the shoulder volume takes different values on the condition that the critical gap value changes from 2 to 7. Based on the regression analysis, Fig. 5(b) shows the fitted linear curve of the merge capacity.

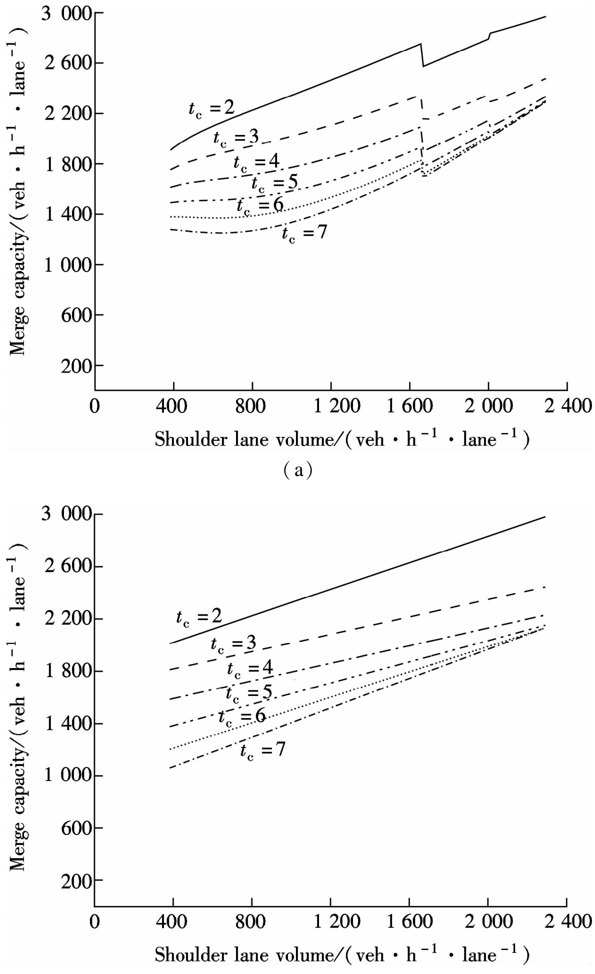

Fig. 5 Relationship between merge capacity and shoulder volume. (a) Observed; (b) Fitted

As shown in Fig. 5, the merge capacity increases as the shoulder lane volume increases. A linear relationship can be used to describe the relationship between the merge capacity and the shoulder lane volume. Since the ramp capacity is determined by the shoulder lane volume, the shoulder lane volume and the critical gap are selected as factors for developing the empirical merge capacity model.

Apart from the shoulder lane volume and the critical gap, Δt is another key factor for developing the empirical merge capacity model, which can be calculated by Eq. (11).

Fig. 6(a) shows the calculated merge capacity when the shoulder volume takes different values under the condition that the distance from nose to merging point changes from 10 to 300 m (Δt changes from 0.9 to 27). After regression analysis, Fig. 6(b) shows the merge capacity fitted linear curve for each Δt, the least R^2 value of 0.88 means that the linear curve is appropriate for illustrating the relationship between the merge capacity and Δt with the fitted curves.

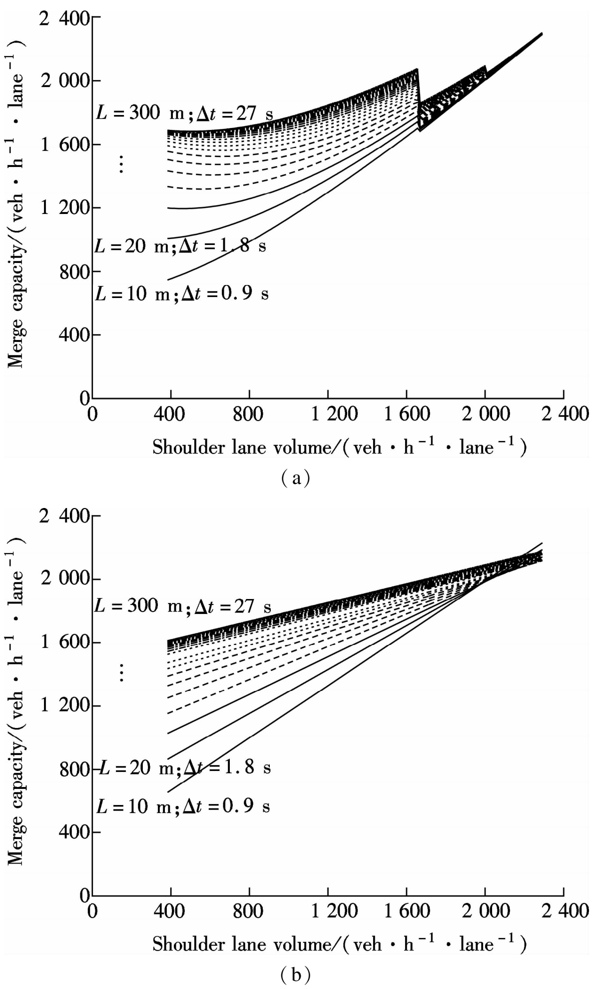

Fig. 6 Relationship between merge capacity and Δt. (a) Observed; (b) Fitted

When $t_c = 4$, the merge capacity increases with the increase in the shoulder lane volume, a linear relationship can be used to describe the relationship between the merge capacity and the shoulder lane volume. Furthermore, the merge capacity also increases as the distance from nose to merging point in the acceleration lane increases (Δt increases) because the longer the distance from nose to merging point is, the larger the probability of the gap used by the ramp vehicle is.

In conclusion, t_c, Q, and Δt should be selected as model independent variables to establish the generalized empirical merge capacity model.

2.3 Establishment of the empirical model

Since the linear relationships can describe all the relationships among the merge capacity, t_c, Q, and Δt, the linear model is chosen to develop the empirical merge capacity model. The high R^2 value is calculated, which is 0.84 for the linear function.

Three parameters are applied to derive the merge capacity empirical model. Δt can be calculated by Eq. (11), and it is also the only parameter representing the merging area's geometry. Using the parameters mentioned above, the generalized empirical merge capacity model is expressed as follows:

$$C_M = 0.468Q - 163.940t_c + 12.0696\Delta t + 1776.753 = 0.468Q - 163.940t_c + 12.0696\left(\frac{L}{V_1 - V_2}\right) + 1776.753 \tag{20}$$

where C_M is the merge capacity, veh/(h · lane).

Generally speaking, when the traffic becomes heavy, not only the shoulder lane vehicles but also the ramp vehicles are not able to accelerate, and the merge capacity decreases when compared to fast moving traffic. The merging vehicles have to take adventure gaps to merge into the shoulder lane; the accepted critical becomes smaller, which directly causes an increase in merge capacity. The empirical capacity model established in this paper considers the dynamic demand for the critical gap at different speeds and volume.

3 Conclusion

In this paper, the established empirical capacity model suggests that the merge capacity varies with t_c, Q, and Δt. Differently from other studies, the analysis results illustrate the phenomenon that the acceptable gap cannot be made full use of for merging into the shoulder lane by the ramp vehicles, and the ramp capacity is discounted. The discount coefficient model is established by the probability theory. After being multiplied by the discount coefficient ξ, the modified ramp capacity is applied to calculate the merge capacity. Finally, to simplify the merge capacity, an empirical capacity model is modeled. The empirical model contains t_c, Q, and Δt. According to the empirical model, the merge capacity is variable rather than a fixed value. This model is more practical because it considers the utilized inadequacy of the acceptable gap. However, the model does not take the effects of the other lanes' traffic conditions into account. If the shoulder and other lane vehicles change lanes in the merge area, with the disturbances in the merging sections becoming greater, the merge capacity will experience a new decrease.

References

[1] TRB. *Highway capacity manual* 2010[M]. Washington, DC, USA: Transportation Research Board of the National Academies, 2010.

[2] Cassidy M J, Rudjanakanoknad J. Increasing the capacity of an isolated merge by metering its on-ramp[J]. *Transportation Research Part B: Methodological*, 2005, **39** (10): 896-913. DOI:10.1016/j.trb.2004.12.001.

[3] Laval J A, Daganzo C F. Lane-changing in traffic streams[J]. *Transportation Research Part B: Methodological*, 2006, **40**(3): 251−264. DOI:10.1016/j.trb.2005.04.003.

[4] Chung K, Rudjanakanoknad J, Cassidy M J. Relation between traffic density and capacity drop at three freeway bottlenecks[J]. *Transportation Research Part B: Methodological*, 2007, **41**(1): 82−95. DOI:10.1016/j.trb.2006.02.011

[5] Duret A, Bouffier J, Buisson C. Onset of congestion from low-speed merging maneuvers within free-flow traffic stream: Analytical solution[J]. *Transportation Research Record*, 2010, **2188**: 96−107. DOI:10.3141/2188-11.

[6] Coifman B, Kim S. Extended bottlenecks, the fundamental relationship, and capacity drop on freeways[J]. *Transportation Research Part A: Policy and Practice*, 2011, **45**(9): 980−991. DOI:10.1016/j.tra.2011.04.003.

[7] Kita H. A merginggiveway interaction model of cars in a merging section: a game theoretic analysis[J]. *Transportation Research Part A: Policy and Practice*, 1999, **33**(3): 305−312. DOI:10.1016/s0965-8564(98)00039-1.

[8] Lertworawanich P, Elefteriadou L. A methodology for estimating capacity at ramp weaves based on gap acceptance and linear optimization[J]. *Transportation Research Part B: Methodological*, 2003, **37**(5): 459−483.

[9] Kim S G, Son Y. Development of a new merge capacity model and the effects of ramp flow on the merge capacity [C]//*Proceedings of the* 82*nd Annual Meeting of the Transportation Research Board*. Washington, DC, USA, 2003: 1−19.

[10] Lorenz M, Elefteriadou L. Defining freeway capacity as function of breakdown probability [J]. *Transportation Research Record*, 2001, **1776**: 43−51. DOI:10.3141/1776-06

[11] Brilon W, Geistefeldt J, Zurlinden H. Implementing the concept of reliability for highway capacity analysis[J]. *Transportation Research Record*, 2007, **2027**: 1−8.

[12] Elefteriadou L, Roess R P, McShane W R. Probabilistic nature of breakdown at freeway merge junctions [J]. *Transportation Research Record*, 1995, **1484**: 80−89.

[13] Ci Y S. On-off ramp junction capacity and ramp setting on urban expressway [D]. Harbin: School of Transportation Science and Technology, Harbin Institute of Technology, 2008. (in Chinese)

城市快速路入口交织区通行能力模型

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摘要：为建立快速路入口交织区的经验通行能力模型，首先利用 Erlang 分布来定义车辆车头时距分布，然后采用间隙接受理论模型推导入口交织区基本通行能力模型. 由于并非所有主路车流车头时距都能被匝道车辆充分利用，因此建立了修正的通行能力模型，模型考虑了车头时距被利用的概率. 然后，建立了通行能力折减系数(ξ)模型. 结合修正的通行能力模型和折减系数模型建立了包括主线流量、临界间隙和鼻端到汇合点距离等参数的入口匝道经验通行能力模型. 结果表明，与其他模型相比，所建立的经验模型考虑了交织区几何条件且简单易用，交织区通行能力和主路流量、临界间隙、鼻端到汇合点距离及主线和匝道的设计速度紧密相关.

关键词：交织区；经验通行能力模型；快速路；间隙接受

中图分类号：U491