The Impact of Residential Opening on Road Access

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***Abstract*—This article has carried on the research to the topic which the influence of the opening of the residence community on the peripheral traffic. The opening up of enclosed communities has many implications for the improvement of urban roads. This article focuses on the interpretation of the road capacity, the intersection of road traffic capacity, the concept of road vehicle density and the calculation formula, the establishment and improvement of vehicle traffic mathematical model. This paper presents innovatively that the change of road vehicle density can be used to quantitatively determine the open cell's improvement of surrounding road congestion. The degree of evacuation is defined to describe the influence of open cell on the surrounding road. After summarizing and analyzing the three cell types, we use Visual Studio 2015 and Excel to analyze the data and come to the conclusion that the opening of residential roads cannot play a decisive role in the degree of evacuation and acceptance of traffic jam in the surrounding roads.**

***Index Terms*—community open; design capacity; vehicle density; road congestion**

I. Background

With the continuous increase of urban population and improvement of people's living standards, the growth rate of traffic demand far exceeds the increase in the carrying capacity of urban road networks, resulting in much more traffic pressure. As a result, traffic congestion has become the ordinary state of some cities. Rising traffic congestion is an inescapable condition in large and growing metropolitan areas across the world, from Los Angeles to Tokyo, from Cairo to Sao Paolo [1]. Every city with congestion is making efforts to ease the traffic pressure of the traffic peak, but it still hasn't solved the problem from the root. In order to further ease the traffic jams in the city, some countries have begun to promote the block system and have gradually opened the residential quarters and unit complexes that have already been built. These methods have attracted widespread attention.

This method seems to be very effective. The opening of the community can increase the density of the road network and the road area, however, in the meantime, the number of intersections will increase, which may affect the speed of the major traffic roads or increase the waiting time. A conclusion can be concluded that the impact of open communities cannot be generalized with simple discussion. This article focuses on the size of the impact of opening the cells on relieving congestions and the differences in the ability of different types of cells to relieve congestion after they are opened. This article takes this as a research direction, models and studies the impact of opening of different types of residential areas on road traffic, and proposes to the urban planning and traffic management departments on opening communities rationalization suggestions.

II. Solution to the Problem

A. Evaluation Index of Impact of Residential Opening on Surrounding Traffic

To quantitatively determine the impact of the opening up of the community on the traffic of its surrounding roads, it is necessary to first know the original traffic capacity and conditions of the surrounding roads, and then calculate the traffic conditions of the surrounding roads after the opening of the community and the traffic conditions of the internal roads of the community. Based on this, a model was established.

By collecting information and calculating the traffic volume of a road, which is the traffic volume of a road in the unblocked state, this is the design capacity, which is recorded as N_{max}. Capacity analysis tries to understand how much traffic a given transportation facility can accommodate. And capacity is defined as the maximum

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number of vehicles, passengers, or the like, per unit time, which can be accommodated under given conditions [2]. There are many factors influencing road design capacity in practice, such as lane width, slope, and other uncertainties. It is assumed here that the influence of these factors on the design capacity of the road is linear. The correction coefficient is defined here, the actual traffic capacity of the road is obtained by multiplying the design traffic capacity with the correction coefficient of various factors. Since the correction coefficients of different roads are different from each other, their exact values are difficult to obtain, and in most roads, the correction coefficient is close to 1, which has little effect on the theoretical value of design traffic capacity. Therefore, the actual capacity is approximated as equal to the theoretical value in this passage. N_{max} is an intermediate quantity, because the actual traffic volume is very small when the vehicle is rare or very congested. Therefore, if the actual traffic capacity is compared with the design capacity, the degree of congestion of a road cannot be seen. Since the design capacity is related to the factors such as speed and headway distance, the design vehicle density of a road can be calculated using N_{max}, which is the number of vehicles per hundred meters in the smooth state, this data is recorded as P_b . After investigating the density of vehicles in the actual traffic process of a road and comparing it with P_b, we can better know the congestion condition of a road.

During peak hours, peak-hour traffic congestion rises to meet maximum capacity [3], the density of vehicles on many roads is greater than the design vehicle density of the road which will lead to slow-moving and congestion. Record the actual vehicle density of the road as P_s。 The road design vehicle density P_b has previously been obtained, and the ratio of P_s to P_b is defined as the road congestion degree, which is denoted as Y. When Y is larger, it means that the degree of congestion of the road section is higher at this time. When Y is less than 1, it means that the traffic volume on the road is less than the designed capacity, and there will be no slow running or congestion. When Y is greater than 1, the vehicle may be slow and congested. This article should consider the impact of the opening of the community on surrounding road traffic when there are one or more roads with Y greater than 1.

When Y of one or more roads connecting a community road is greater than one, some vehicles will enter the uncongested roads in the neighborhood of the community and the neighborhood of the community (hereinafter referred to as the open roads), when the congestion degree Y of the open road segment increases to 1, these roads will reach the design capacity. If vehicles continue to enter, the result will be congestion on open roads. It is assumed here that when the Y value of the open road section reaches 1, the vehicle does not continue to enter the road section. At this time, the congestion level Y_s of the original congested road segment is calculated again, and Y_s is subtracted from the original congestion degree Y to obtain the congestion reduction Y_j . Compare the current traffic situation with the original traffic situation, and use Y_j / Y as the open traffic impact of the community on the surrounding roads, which is recorded as the evacuation degree H:

$$H=\frac{Y_j}{Y} \tag{1}$$

H is the evaluation value determined in this paper to evaluate the impact of cell opening on surrounding roads. When Y_s is less than 1, it can be regarded as a cell opening to completely solve the congestion problem of surrounding roads. At this time, H is denoted as 1; when H is greater than 0, the greater the H value is, the greater the ability of the opening of the cell to relieve surrounding traffic pressure. The greater the value, the maximum value is 1. When H is less than 0, it indicates that the cell has not played the role of evacuation after opening up, but it has caused congestion on the already congested road.

B. Establishment and Application of Mathematical Models for Road Traffic around Residential Areas

1) Urban road capacity

In ideal conditions where both roads and traffic are ideal, the ideal traffic flow with continuous driving at the minimum headway from a standard vehicle with the same technical performance, the maximum number of vehicles passing through the road section per unit time is the design traffic capacity. [4]

For the calculation of road design capacity, we assume that the width of each lane of the ideal road should not be less than 3.65m, the remaining width of the side road should not be less than 1.75m, and the longitudinal slope should be relatively flat. The vision is wide, and the road should have good plane lines and road conditions. Under ideal road traffic conditions, it should also be assumed that vehicles driving on the road should be composed of a single standard model car, continuously driving at the same speed on one road, and each vehicle should maintain a minimum safety distance consistent with the vehicle speed conditions, and under ideal conditions, there should be no direction interference.

The formula for designing traffic capacity based on the traffic flow model established is:

$$N_{max}=\frac{3600}{t_0} \text{ [5]} \tag{2}$$

Substitute the road design speed into the formula:

$$\mathrm{N_{max}}=\frac{3600}{\mathrm{t_0}}=\frac{3600}{\mathrm{l_0}/\text{（}\bar{\mathrm{v}}/3.6\text{）}}=\frac{1000\mathrm{v}}{\mathrm{l_0}} \text{ [5]} \tag{3}$$

$\bar{v}$ ——Average vehicle speed (km/h);

l_0——The minimum distance between two adjacent cars (m);

t_0——The minimum time interval (s) between two adjacent cars;

l_c——The average length of the vehicle (m);

l_a——Basic safety distance between vehicles (m);

l_z——The average braking distance of the vehicle (m);

l_f ——The average travel distance of the vehicle within the driver reaction time (m);

a——Braking acceleration (m/s^2);

From the above formula we can get:

$$l_0 = l_f + l_z + l_a + l_c \text{ [5]} \quad (4)$$

While the designed road capacity calculated under ideal conditions is not very persuasive, and the complex conditions in the actual road conditions seriously affect the capacity. Under the conditions of actual roads, the influencing factors of roads and traffic are attributed to a correction coefficient α, and α is a constant between 0 and 1. Based on design capacity, various correction factors are determined based on actual road traffic conditions, and various correction factors are multiplied with design capacity to obtain road capacity under actual road traffic conditions N_s . The following factors are determined to affect the traffic capacity of road traffic:

After analysis and induction, the factors affecting traffic capacity are divided into two major categories, namely road condition factors and traffic condition factors.

There are many factors that affect the capacity of road conditions. Considering the factors that have a greater impact, there are the following:

Lane width correction factor α_1;

Lateral headroom coefficient α_2;

Gradient correction factor α_3;

Insufficient viewing distance correction factor α_4;

Road condition correction factor along the road α_5;[5]

The correction of traffic conditions mainly comes from the composition of vehicles, especially under mixed traffic conditions, with numerous vehicles, complex types, different sizes, different road areas, different vehicle performance, different speeds, and large mutual interference, which seriously affect road traffic ability. Combine the above factors into a traffic condition correction factor α_6 。[4] Therefore, the actual road capacity is

$$N_s = N_{max}\alpha_1\alpha_2\alpha_3\alpha_4\alpha_5\alpha_6 \text{ [5]} \quad (5)$$

Among them, the correction factors in the formula must take into account the actual conditions of each road section. For different road sections and time periods, the specific values of the correction factors are constantly changing and cannot be generalized. In the following discussion of this paper, because the correction coefficients of different roads are different and difficult to obtain, the effect of this correction coefficient on N_{max} is not large, and this model is an ideal model, in the discussion after this article, N_s and N_{max} are treated as equivalent data.

2) Intersection Capacity

The flow of traffic in two directions passing through a level crossing is the intersection of traffic flow. The designed traffic capacity of the intersection may be the traffic capacity of the intersection. The traffic capacity of level crossings is not only related to the area and shape of the intersections, but also affected by factors such as the traffic management measures of the traffic flow of the intersecting traffic. Therefore, when determining the capacity, the vehicle at the intersection and operation and traffic management methods must be determined first.

Intersections are generally divided into three categories:

No signal lights, no traffic control Intersections;

The circular intersection of the circular island is set in the center;

Intersections with traffic light.

① Traffic capacity at intersections without signals

Intersections without traffic lights can be roughly divided into two categories: one is an ordinary intersection and the other is a roundabout.

Because there is no traffic management system, the randomness of vehicles passing through two crossroads is very strong, vehicles passing through mainly depends on deceleration and parking. According to the interpolation gap theory, the insertable gap of traffic in the preferential direction is calculated, that is, the number of crossing or insertion gaps in the non-preferential direction, which is the maximum gap amount that can be passed in the non-preferential direction.

The traffic flow on the main road is regarded as a continuous traffic flow. Assuming that the vehicle reaches the Poisson distribution of the probability distribution, the interval distribution between the vehicles is a negative exponential distribution. However, not all bays provide the need for secondary vehicle traffic or insertion. Only if the interval is greater than the critical interval β is there a possibility of passing or inserting. Second, when a pluggable gap occurs, the secondary direction traffic flow can successively pass through the vehicle's time interval γ, and we can get the following basic formula:

$$Q_f = \frac{Q_y e^{-q\beta}}{1-e^{-q\gamma}} \text{ [5]} \quad (6)$$

Q_f ——The amount of traffic that can pass on non-priority roads (vehicles/hour);

Q_y ——Bi-directional traffic (vehicle/hour) with priority through main roads;

q ——$Q_y/3600$(vehicles/hour);

At the roundabout, a center island is set in the middle of the intersection. Vehicles interweave into the ring road and travel around the island in one direction. The roundabout is at the intersection of several intersections, so that the vehicles entering the intersection all circle around the island in the same direction. The operation process generally converges in different directions first, then passes through the same lane, and finally branches out. Avoid direct crossovers, conflicts, and large-angle collisions. The conditions suitable for using circular intersections are that the terrain is open and flat; the intersections are four intersections; the traffic volume of intersecting roads is uniform; the volume of left-turn traffic is large; the total traffic volume of motor vehicles at intersections is not large every hour. When a nonmotor vehicle passes, the traffic volume of the motor vehicle must be reduced. The disadvantage is that it has a large area; the vehicle must be bypassed; the traffic is easy to block when the traffic volume increases; pedestrians are inconvenient in traffic. There are many roundabouts in the UK. Research from the UK Transport and Road Research Laboratory believes that reducing the size of the roundabout can improve traffic capacity. [6]

② Signalized intersection motor vehicle capacity

With the transformation of the signal lights, the traffic rights of the signalized intersections change from one direction to another. Based on the signal cycle length and the length of each signal, the traffic capacity of the intersection can be calculated. The commonly used calculation method is the parking line section method, that is, the parking lane of the entrance lane is used as the base plane, and any vehicle passing through the section is considered to have passed the intersection. The capacity of intersections refers to the sum of the capacity of intersecting roads at the entrance. The capacity of each entrance is divided into three conditions: straight, right, and left. Each lane is divided into special and mixed use. [6] Therefore, the calculation formula for the capacity of imported lanes is different. The following are separately introduced:

The capacity of dedicated straight lanes:

$$N_z = \frac{3600}{T} \times \frac{t_e}{t_j} \text{ [5]} \qquad (7)$$

T: Signal period;

t_j: Average time interval between two cars before and after passing the parking line;

t_e: The effective time when the green light is on eliminated the time loss of the motor vehicle when the green light is on, including start-up and acceleration.

Dedicated right-turn lane capacity

$$N_r = \frac{3600}{t_r} \text{ [5]} \qquad (8)$$

t_r: The time interval between two consecutive right-turn vehicles passing through the parking section line in sequence.

Dedicated left-turn lane capacity

$$N_l = \frac{3600}{t_l} \text{ [5]} \qquad (9)$$

t_l: The time interval between two consecutive left-turn vehicles passing through the parking section line in sequence.

Capacity of straight and left mixed traffic lanes:

When there are going straight and turning left vehicles in the same lane, the distractions of each other are very serious and may even result in stoppages. Considering the previous method of calculating actual road capacity, select an appropriate interference factor K. According to a large amount of data and practical experience, the left-turn vehicle transit time is greater than the straight-through vehicle transit time, which is usually 1.75 times the straight travel time. Therefore, n_l is set as the percentage of left-turn vehicles. And we can get the following formula:

$$N_{zl} = KN_z\left(1 - n_l + \frac{7}{4}n_l\right) = KN\left(1 - \frac{3}{4}n_l\right) \text{ [5]} \qquad (10)$$

Capacity of straight and right mixed traffic lanes:

The straight and right mixed roads are the same as the above calculation method in terms of principle and model. Based on experience and field observations, the time taken for a right-turn car is generally 1.5 times the travel time of a straight train. n_r is set as the percentage of left-turn vehicles. And we can get the following formula:

$$N_{zr} = K'^{N_z\left(1-n_r+\frac{3}{2}n_r\right)} = K'^{N_z}\left(1 - \frac{1}{2}n_r\right) \text{ [5]} \qquad (11)$$

Using the road traffic capacity proposed above, the traffic conditions of urban roads can be measured to some extent. However, in actual calculations, the above-mentioned capacity still cannot accurately describe the actual road conditions. Consider two scenarios to illustrate:

The vehicles on road A are sparse, the number is small, the roads are unobstructed, and motor vehicles can pass at a relatively high speed; The road B is densely populated with numerous vehicles and the road is relatively congested. The average speed of motor vehicles passing through the road is slow. Both of the above situations may occur in urban roads. Although they are two distinctly different traffic conditions, the traffic volumes of roads A and B may be equal or similar. Therefore, the use of road capacity alone to describe the road blockage is not perfect because it does not take into account the actual number and density of vehicles on the road. The simple traffic flow and road capacity have very limited significance. For this reason, this paper introduces the concept of traffic density.

3) Road vehicle density

Road vehicle density (P)：The number of vehicles per 100-meter road is called road vehicle density. This vehicle density is derived from the density of a single lane vehicle multiplied by the number of lanes.

Design road vehicle density (P_b): In ideal conditions where roads and traffic are both ideal, a standard car with the same technical performance, an ideal traffic flow that runs continuously at the minimum headway, and the number of vehicles in a 100-meter road. m is the number of lanes

$$P_b = \frac{100}{l_0} \times m \qquad (12)$$

Actual road vehicle density (P_s): The number of vehicles in a 100-meter road under actual road traffic conditions. The actual road vehicle density needs to be actually measured.

Road congestion degree Y：The ratio of the actual road vehicle density of a road to the vehicle density of the design road of the road is defined as the road congestion degree of the road.

$$Y = \frac{P_s}{P_b} \times 100\% \tag{13}$$

Calculate that when the evacuation capacity of a cell and its surrounding roads reaches a maximum based on the simplified model above and a program based on C, the road congestion degree is denoted as Y_s, and the original Y value is subtracted from Y_s to obtain Y_j, Y_j, and The ratio of Y is denoted as H. H is an evaluation value determined in this paper that is ultimately used to evaluate the impact of cell opening on surrounding roads. When H is greater than 0, the greater the H value, the greater the ability of the cell to open up to relieve surrounding traffic pressure. The maximum value is 1 When Y_s is less than 1, it can be seen as the opening of the cell to completely solve the problem of congestion on the road. At this time, H is set to 1. When H is less than 0, on behalf of the opening of the cell will not only play an evacuation effect on the surrounding traffic, but will lead to more congestion on the previously congested sections.

C. A Quantitative Comparison of the Effects of Opening up Different Types of Residential Areas on Surrounding Roads

1) Residential Community Classification

Cell connecting one lane:

Even if this kind of community is open, there will not be any cars entering this kind of community in order to drive to other roads, so this kind of community has no obvious effect on the evacuation of traffic.

Figure 1. Cell connecting one lane [7]

Cell connecting lanes:

There are mainly three kinds of cells connecting lanes as following pictures.

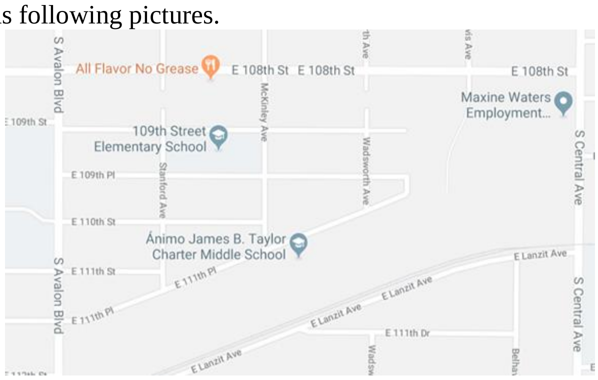

Figure 2. Cell connecting only two lanes [7]

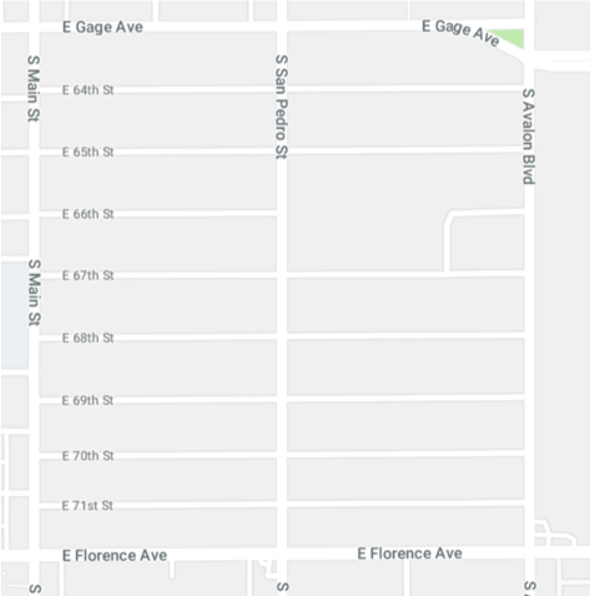

Figure 3. Cell with treelike roads [7]

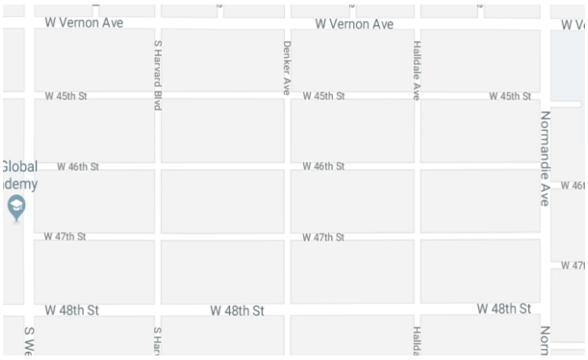

Figure 4. Cell with latticed roads [7]

2) Simplification of Residential Community Models

For the first type of cell that only connects one path, we do not analyze it. For the remaining three types of cells, we need to simplify the individual road because of its high complexity.

Since the ultimate goal is to examine the impact of the community on the surrounding traffic conditions, it is not necessary to analyze the situation of all roads within the community. Therefore, in order to simplify the calculation, these types of cells can be simplified as a typical type, that is, each road corresponds to one entrance, either an input or an output. The roads within the community that pass through are gathered on a main road in the community.

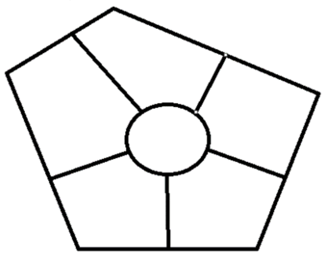

Figure 5. The final simplification

3) Calculation Based on Model

By using the model established in Ⅱ.B, the data in the tables (see appendices 1, 2, 3, and 4) was calculated, and the changes in traffic conditions before and after the opening of the community were obtained, as shown in the following table.

TABLE I—RESULTS CALCULATED BASED ON MODEL

v(km/h)	v(m/s)	l_0(m)	P_b(vehicles/100m)
10	2.78	8.288	12.07
15	4.167	10.89	9.18
20	5.56	13.5	7.4
25	6.94	16.78	5.96
30	8.33	20.54	4.86
35	9.722	24.79	4.03
40	11.11	27.59	3.65

The specific calculation method is as follows:

If the surrounding roads of a community need to be opened for clearing, it is inevitably confirmed that road congestion exists. That is, the congestion degree Y is greater than 1, and other roads within the community and surrounding the community must be in a clear state, that is, the congestion degree Y is less than 1, assuming that Vehicles on congested roads will flow through the roads in the community to other non-congested roads. When the congestion level of one of the original non-congested roads becomes 1, the vehicle stops flowing in, and the Y of the original congested road is calculated at this time.

III. CONCLUSION

A. Results Found

It is not difficult to see in the three sets of data in Appendix 2, 3, and 4 that after the opening of the community, the problem of congestion was not solved fundamentally (the congestion Y after opening was still greater than “1”). The reason is that some of them are due to internal problems in the community; others are not enough to meet the demand.

From this we can see that the successful relief of traffic pressure has a high demand for the community. Taking into account the “evacuation degree” data, the community has indeed contributed to the relief of traffic pressure. Under the premise of light traffic congestion, the opening of the community can complete the task of traffic grooming. However, once it is not possible to completely divert congested vehicles, these vehicles will block the capillaries of the city, which will not only adversely affect the residents but will also make the situation complex and changeable and not conducive to ease. To sum up, it is difficult to rely on open communities to ease traffic pressure. This not only poses a huge challenge to the community, but also has high requirements for the surrounding traffic conditions.

B. Advice for City Planning and Traffic Management

As mentioned above, after analyzing the data, we can see that the opening of the community can relieve traffic pressure to some extent under certain circumstances, but in other cases, not only external traffic pressures are not relieved, but also traffic jams will happen in the community.

As a key factor, the design density and flow of roads within the community are the key factors. If the number of cars that can be accepted on an external, relatively unobstructed road segment is much smaller than the number of excess cars on congested roads, even if the community is open, it will not relieve traffic pressure. Since traffic congestion in the general situation is not the status quo but rather the presence of the network has a certain range, and the area is small, that is, the opening of the communities where the entrances and exits cannot jump out of the congested area does not play a significant role, so if the traffic to the surrounding area is congested from the mitigation effect, the community must be large, and the entrances and exits of the community must connect the main roads. This has extremely high demands on the location and area of the community.

The internal conditions of the community are also important factors, namely the internal road structure of the community. If there is a high number of motor vehicles in the community, there is no underground parking space inside the community. All the owner’s private cars are parked on the ground, which has a great influence on the smoothness of the road in the community. Or it is not easy to open the road because of the small design density of roads in the community. If the community satisfies one of the two above, even if it crosses a congested area, it will be difficult to achieve open traffic. In addition, the residents' quality, safety awareness, and their willingness are also important criteria for investigation.

To sum up, the number of cells that can contribute to traffic is very limited. Due to the relatively high demands on the community, the opening up of the community remains to be considered.

C. Advantages

When establishing a vehicle traffic model, multiple models were selected for evaluation. First, according to the types of roads and intersections and the complexity, the vehicle capacity of each road and intersection is analyzed in turn, and the formula is given. In addition, due to the uncertainty of the location of the roads in time and space, the actual road traffic capacity is different for the same road capacity. To this end, the concept of road vehicle density is further introduced. Describe in detail the density of vehicles in each lane of the corresponding road. According to the dual standards of road capacity and density of road compartments, the vehicle operation status of specific roads is determined. In the study of the effects of open communities, the amount of change in the density of surrounding road vehicles after the opening of a residential area was specifically studied, and the ratio of the change in the density of road vehicles to the original road traffic density was defined as the degree of influence of road traffic, and the number of open communities was determined. The influence of the surrounding roads.

D. Challenges Still Existed

With the specific calculation of the application model, the available data is very limited. After obtaining a large amount of data on road lengths, traffic flows, etc., at various levels of the city's roads, inspections can be conducted. When calculating the minimum safety clearance of a vehicle, due to the complexity of the vehicles, the minimum safety distance between cars can only be roughly estimated, and it cannot be applied to a wider variety of vehicles. Moreover, some roads have different road conditions and are difficult to count. No correction factor is added.

We postulated that drivers would select routes to lower their travel time variabilities, just as they would to lower their mean travel times. But this is not exactly the same condition as common traffic conditions which may lead some extend of uncertainty in the model we proposed [8].

Part of the model is based on the simplification of actual traffic conditions which may lead to a little inaccuracy for the final numerical result.

APPENDIX A RESULTS CALCULATED BASED ON MODEL

v(km/h)	v(m/s)	l_0 (m)	Pb(Vehicles / 100 m)
10	2.78	8.288	12.07
15	4.167	10.89	9.18
20	5.56	13.5	7.4
25	6.94	16.78	5.96
30	8.33	20.54	4.86
35	9.722	24.79	4.03
40	11.11	27.59	3.65

APPENDIX B DATA SET 1

Initial situation					
	Design density (vehicles /100 meters)	Actual density (vehicle /100 meters)	Flow (vehicle)	Speed (km/h)	Congestion degree
Input 1 outside	3.65	7.81	1952.5	25	2.14
Input 1 inside	12.07	2.21	331.5	15	0.18
Output 1 outside	7.4	6.32	1390.4	22	0.85
Output 1 inside	12.07	1.81	181	10	0.15
Output 2 outside	4.86	4.45	1335	30	0.92
Output 2 inside	12.07	2.32	162.4	7	0.19
Residential trunk road	12.07	3.81	762	20	0.32
After evacuation					
	Actual density (vehicle /100 meters)	Congest-ion degree			
Input 1 outside	6.32	1.73			
Input 1 inside	3.7	0.31			
Output 1 outside	7.4	1			
Output 1 inside	2.89	0.24			
Output 2 outside	4.86	1			
Output 2 inside	2.73	0.23			
Residential trunk road	5.3	0.43			
Evacuation degree	0.3582				
Adoption degree	1				

APPENDIX C DATA SET 2

Initial situation					
	Design density (vehicles/100 meters)	Actual density (vehicle/100 meters)	Flow (vehicle)	Speed (km/h)	Congestion degree
Input 1 outside	4.03	7	1750	25	1.74
Input 1 inside	12.07	5	500	10	0.41
Input 2 outside	5.96	6.2	1240	20	1.04
Input 2 inside	12.07	4	320	8	0.33
Input 3 outside	5.96	6.8	1020	15	1.14
Input 3 inside	12.07	7	210	3	0.58
Output 1 outside	7.4	6.1	2440	40	0.82
Output 1 inside	12.07	7	210	3	0.58
Output 2 outside	4.86	3.2	1600	50	0.66
Output 2 inside	12.07	2.8	168	6	0.23
Residential trunk road	7.4	3.1	475	15	0.42
After evacuation					
	Actual density (vehicle /100 meters)	Congest-ion degree			
Input 1 outside	4.83	1.19			
Input 1 inside	7.17	0.59			
Input 2 outside	6.02	1.01			
Input 2 inside	4.17	0.35			
Input 3 outside	6.19	1.04			
Input 3 inside	3.81	0.32			
Output 1 outside	7.4	1			

Output 1 inside	8.3	0.69			
Output 2 outside	4.86	1			
Output 2 inside	4.46	0.37			
Residential trunk road	6.06	0.82			
Evacuation degree	0.7309				
Adoption degree	1				

APPENDIX D DATA SET 3

Initial situation					
	Design density (vehicles /100 meters)	Actual density (vehicle /100 meters)	Flow (vehicle)	Speed (km/h)	Congestion degree
Input 1 outside	3.65	5.62	1573.6	28	1.54
Input 1 inside	7.4	7.28	1601.6	22	0.98
Output 1 outside	4.86	1.16	522	45	0.24
Output 1 inside	7.4	7.28	1601.6	22	0.98
Residential trunk road	7.4	7.28	1601.6	22	0.98
After evacuation					
	Actual density (vehicle /100 meters)	Congest-ion degree			
Input 1 outside	5.5	1.51			
Input 1 inside	7.4	1			
Output 1 outside	1.28	0.26			
Output 1 inside	7.4	1			
Residential trunk road	7.4	1			
Evacuation degree	0.0608				
Adoption degree	0.0324				

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