A new analysis and prediction model of road traffic based on open community

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Abstract. This paper aims to optimize the road network structure of open residential areas in China. Firstly, the nonlinear coefficient $R_0 = t_3/T$ is used to study the road condition, using Matlab programming to calculate road network saturation LOS, establish a reasonable evaluation index system of community opening. Then the theoretical model of road resistance function is established, the influence coefficient $\eta$ of each factor is determined, the traffic influence degree model is established, and the vehicle passing model is obtained. Finally, three different types of community A, B and C are constructed, and then traffic simulation is carried out according to Vissim software. The conclusion is that the degree of road traffic pressure relief is the largest in one type of community, and the least degree in type B community.

1. Introduction

In 2016, the State Council issued several opinions on Further Strengthening the management of urban planning and construction, of which Article 16 on promoting the block system has aroused extensive concern and discussion. One point of view is that the closure of the residential area destroys the network structure of the city, which is easy to cause traffic jams. Another point of view is that although the number of passable roads has increased after the opening of the community, the number of vehicles entering and leaving the intersection of the main road around the community has also increased, which will affect the traffic speed of the main road.

2. COMMENT INDEX SYST

In this part, we will establish an evaluation index system to evaluate the impact of community opening on the surrounding road traffic. Then a comprehensive evaluation model is established and analyzed with basic data.

For the main factors affecting road traffic, we can consider from two aspects: the internal situation of the community and the external situation of the community. The internal situation of the community is affected by the scale of the community, the internal road condition and the location of the community; the external situation of the community is affected by the intersection of the main road and the community, and the traffic operation level of the road network.

2.1. Community scale

Closed residential area management is adopted. According to the data, the traffic congestion on the boundary roads of small square administrative districts is more serious than that of large square
administrative districts. The more easily the urban road network is cut off, which hinders the development of the city along the original road network.

2.2. Road condition
When evaluating the rationality and convenience of the road in the community, the non-linear coefficient

\[ R_n = t_3/T \]  

(1)
is used as the index, where, \( t_3 \) represents the actual time or cost of two nodes (cells) on the road, and \( T \) represents the imaginary time or cost of two nodes (cells) on the road. Then the non-linear coefficient of the route of the cell is less than or equal to 1.41, that is, the route can not have reverse detour, and it is better to control it at \( 1.15 \sim 1.2 \).

2.3. Community location
Closed residential management is adopted. The community is located at the traffic hub, which is convenient for the residents in the community, but it is extremely inconvenient for the people outside the community, which has a great impact on the traffic.

2.4. Intersection of main road and residential area
It is inferred from the driving conditions of general intersections, and the ratio of traffic flow to traffic capacity (saturation) is usually used as the evaluation index. Traffic operation status is divided into different service levels according to different saturation.

| service level | Saturation range | Operation status |
|---------------|------------------|------------------|
| A             | <0.6             | Very smooth      |
| B             | 0.6 ~ 0.8        | relatively unobstructed |
| C             | 0.8 ~ 0.9        | accept reluctantly |
| D             | 0.9 ~ 1.0        | blocking         |
| E             | >1.0             | very clogged     |

2.5. Traffic operation level of road network
Generally, the saturation index of road network is used to reflect the service level of road network. Here, \( \text{LOS} = V_1 / C_1 \) is used to represent the road network saturation.

2.6. Closed residential management
Closed residential management is adopted. The community is located at the traffic hub, which is convenient for the residents in the community, but it is extremely inconvenient for the people outside the community, which has a great impact on the traffic.

3. TRAFFIC MODEL
When the community is open, the factors that affect the road traffic include traffic flow interruption (intersection), non motor vehicle (bicycle, electric vehicle), pedestrian and lane width. According to these four factors, we can define:
Table 3: Influencing factors of interference

| $\eta_1$ | $\eta_2$ | $\eta_3$ | $\eta_4$ |
|----------|----------|----------|----------|
| Influence coefficient of traffic flow discontinuity (intersection) | Non motor vehicle (bicycle, battery car, etc.) influence coefficient | Pedestrian influence coefficient | Influence coefficient of lane width |

Considering the impact of non motor vehicles: for urban roads, the impact on vehicle driving also includes the impact of non motor vehicles such as people, bicycles, electric vehicles, etc. after introducing the influence of non motor vehicles, the regression road resistance function in line with the urban road can be established by consulting the data.

$$
t = t_0 \left[ 1 + \alpha_1 \left( \frac{V'}{C} \right)^{\beta_1} + \alpha_2 \left( \frac{V'}{C'} \right)^{\beta_2} \right]
$$

where, $V'$ - non motor vehicle traffic volume; $C$ - capacity of non motor vehicles; $L$ - length of road; $V$ - average speed of road section; $\alpha_1$, $\alpha_2$, $\beta_1$, $\beta_2$, $a$, $b$ - regression coefficient.

Therefore, we will take a new idea to establish the theoretical road resistance function model: according to the influence of non motor vehicles [1], the steps to establish the theoretical road resistance function model are as follows: from the traffic flow theory, the road resistance function model is established based on the traffic flow theory, $V_m$ is the free flow speed of the road section. The traffic volume is expressed by $V$, and the speed is expressed by $v$. The blocking density of the road section is $k_m$, and the density $k$ (the number of vehicles per unit length at a certain moment on a lane) meets the following requirements:

$$
v = \frac{k}{v} = \frac{N}{L}
$$

The theoretical model of road resistance function is as follows:

$$
t = \frac{L}{v} \quad v = \frac{V_m}{2} \pm \sqrt{\left( \frac{V_m}{2} \right)^2 - \frac{V_v}{k_m}}
$$

when $V \leq \frac{V_m k_m}{8}$, the traffic flow was normal,

$$
v = \frac{V_m}{2} + \sqrt{\left( \frac{V_m}{2} \right)^2 - \frac{V_v}{k_m}}
$$

when $V \geq \frac{V_m k_m}{8}$, the traffic flow is in a state of congestion and congestion,

$$
v = \frac{V_m}{2} - \sqrt{\left( \frac{V_m}{2} \right)^2 - \frac{V_v}{k_m}}
$$

when $V \geq \frac{V_m k_m}{4}$, If the traffic flow stops, take $V = 0$. 

$$
(3) \quad (4) \quad (5) \quad (6) \quad (7) \quad (8)
$$
According to the interference factors: therefore, the modified formula is: 
\[ V_m = \eta V_s \], where 
\( V_s \) - free running speed, the theoretical blocking density formula is:

\[ k_m = \frac{\eta_1\eta_2\eta_3\eta_4}{t_0+t} \]  

(9)

3.1. Determination of influence coefficient:

1. Determination of influence coefficient \( \eta_1 \) of traffic flow discontinuity (intersection), The influence coefficient \( \eta_1 \) of flow discontinuity (intersection) can be determined by the ratio of the capacity of vehicles at the intersection controlled by traffic lights to the through lane. At the intersection, due to the influence of traffic lights, the calculation formula of capacity \( V_j \) is as follows:

\[ V_j = \phi \frac{3600}{T} \left( \frac{t_s - t_0}{t_s} + 1 \right) \]  

(10)

here \( \phi \) reflects the nonuniformity coefficient of vehicles passing through the intersection. \( t_g \) - green time per cycle, \( t_0 \) - lost time of green light in one cycle, \( t_s \) - average interval time between two vehicles passing through parking line; therefore, the influence coefficient \( \eta_1 \) of vehicle flow discontinuity (intersection) is:

\[ \eta_1 = \frac{V_j}{V} \]  

(11)

2. The determination of the influence coefficient \( \eta_2 \) of non motor vehicles (bicycles, battery cars, etc.) and the influence of non motor vehicles on vehicle movement can be divided into the following three situations:

(1). There is a separation zone between the motorway and the non motor vehicle lane. The influence of non motor vehicles on the vehicle traffic is very small on the road section, and it is advisable to \( \eta_1 = 1 \).

(2). If there is no separation zone between the motorway and the non motorized vehicle lane, and the traffic volume is small, the non motor vehicle has an impact on the vehicle traffic, but the impact is small, so \( \eta_2 = 0.8 \) can be taken.

(3). When there is no separation zone between the motor vehicle lane and the non motor vehicle lane, and the traffic volume is large, the non motor vehicle will occupy the motor vehicle lane, which has a great impact on the vehicle driving. The calculation of \( \eta_2 \) can be determined according to the ratio of the width of the motor vehicle lane occupied by the non motor vehicle to the total width of the motor vehicle lane:

\[ \eta_2 = 0.8 - \frac{V_b}{d_1} \left[ \frac{V_b + 0.5 - d_2}{d_1} \right] \]  

(12)

where, \( V_b \) - non motor vehicle traffic volume, \( \left[ V_b \right] \) - Non motor vehicle capacity per meter, the value is about 800-1000 veh / h [3], \( d_1 \) - vehicle lane width, \( d_2 \) - width of non motor vehicle lane.

3. Determination of pedestrian influence coefficient \( \eta_3 \): pedestrian crossing has a great impact on the interference of vehicles. The influence coefficient \( \eta_3 \) is related to pedestrian flow, road construction and many other factors. In general, it can be divided into six levels, and the recommended values are as follows:
Table 4 recommended values of pedestrian influencing factors at different levels

| Influence level | very serious | serious | more serious | general | small | nothing |
|-----------------|--------------|---------|--------------|---------|-------|---------|
| $\eta_i$        | 0.5          | 0.6     | 0.7          | 0.8     | 0.9   | 1       |

4. Determination of influence coefficient $\eta_4$ of lane width, according to the national road design standard, the standard width of lane is 3.5 meters in order to meet the requirements of vehicle speed and ability. The value can be determined according to the following formula [4].

$$\eta_4 = \begin{cases} 
0.5(d - 1.5) & d \leq 3.5 \\
-0.54 + \frac{1.88d}{3} - \frac{0.16d}{3} & d > 3.5 
\end{cases}$$

(13)

Where $d$—width of motorway.

Based on the above correction of resistance function and influence coefficient, it can be concluded that the modified impedance mode is:

$$\begin{aligned}
    l &= \frac{L}{v} \\
    v &= \frac{v_m}{2} \pm \sqrt{\left(\frac{v_m}{2}\right)^2 - \frac{Vv_m}{k_m}} \\
    v_m &= \eta_1\eta_2\eta_3\eta_4v_s \\
    k_m &= \eta_1\eta_2\eta_3\eta_4\eta
\end{aligned}$$

(14)

Therefore, when the community is open, the number of road sections where vehicles travel increases. Compared with before, the accessibility of vehicles will be increased, which can alleviate the congestion caused by the excessive density of vehicles. While the open community will correspondingly increase the number of intersections, which will cause certain obstacles to the passage of vehicles. Therefore, the opening of the community will cause obstruction to the surrounding roads.

4. DIFFERENT TYPES OF COMMUNITY

Building different types of residential areas: from the area of the residential area, the road conditions inside the community, the surrounding areas of the community, the intersection of the main road and the community, the traffic operation level of the road network, and the traffic flow.

The following figure can be obtained by quadratic fitting with MATLAB.

![Figure 1](image)

Figure 1 speed and flow chart of two lane traffic in residential area
Figure.2 flow chart of multi lane traffic speed

Figure.3 type A community

Figure.4 type B community

Figure.5 type C community

Table.5 different cell types

| type | area covered | location of community | road condition of residential area | Intersection of main road and community | traffic operation level of road network | peak traffic |
|------|-------------|-----------------------|------------------------------------|----------------------------------------|----------------------------------------|--------------|
| A    | 60000       | central transportation hub | two lane                          | cross-bonding                          | the saturation level is 0.9             | 1100 vehicles / h |
| B    | 30000       | areas with moderate traffic | multi Lane                       | o-shaped                               | 0.7 saturation level                   | 800 vehicles / h  |
| C    | 20000       | suburb                | multi Lane                        | t-shaped                               | 0.5 saturation level                   | 600 vehicles / h  |
For type A community: when the management of the community is closed, the intersection between the community and the main road is a cross road, and the vehicles in the community are easy to get out. The saturation of the road network around the community reaches 0.9, and the surrounding roads are congested. The roads are often blocked in the peak period, which affects the road traffic. Suppose that type a community is open: there are four intersections between the main road and the community, and vehicles in all directions can pass through the community. Through the traffic simulation, the traffic flow before the closure is greater than that after the closure, so the open community greatly reduces the traffic congestion.

For type B residential area: when the residential area is closed, according to the evaluation index system, the location of the community is in the area with general traffic; when the community management is closed, the intersection between the community and the main road is O-shaped, which makes it difficult for vehicles to get in and out of the community; the road network saturation around the community reaches 0.7, which indicates that the surrounding roads are a little crowded; congestion still occurs in peak period. Assuming that there is only one intersection in the B-type residential area, the traffic flow of the surrounding road is almost unchanged no matter whether the residential area is in the closed or open state. Therefore, the closed or open state of the community has little impact on the surrounding road traffic.

For the community of class C: according to the evaluation index system, the location of the community is in the suburb, according to the data, there are not many vehicles around the community; when the management of the community is closed, the intersection between the community and the main road is a T-shaped road, which makes it easier for vehicles to get in and out of the community; the saturation of the road network around the community is less than 0.6, indicating that the roads around the community are very smooth; The traffic simulation shows that the traffic flow before and after the closure is greater than that after the closure, which improves the traffic around the community.

To sum up, the degree of relieving road traffic pressure by opening type residential area is the largest, and that of type B community is the least.

5. CONCLUSION
For the impact of community opening on road traffic, our analysis is based on the obtained data, and the results are more reasonable; in the vehicle model, the use of traffic simulation overview can be very accurate analysis, evaluation, optimization of the traffic network and design scheme; in the evaluation of the rationality and convenience of the road in the community, the non-linear coefficient is used as the index, It can reflect the situation represented by the data more vividly. The improvement of the relevant facilities in the traffic open community is to create a good traffic environment for habitation after the traffic opening of the community. Therefore, it is suggested to ensure the width of multiple vehicles at the entrance and exit of the residential area, so as to facilitate the residents and vehicles in the residential area. An underground parking lot can be established in the residential area. During the construction, separation measures should be taken to separate the motor vehicles and non motor vehicles and pedestrians in the North-South passage of the residential area. Some separation facilities should be set up in the weaving area, and the traffic management department should severely punish the illegal vehicles at the entrance of the residential area, to ensure the safety of residents in the community. Due to time, many factors can not be taken into account, and the prediction results may be biased.

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