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Study on the Influence Caused by Opening Different Types of Community on Surrounding Traffic

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Abstract

In February of 2016, China formally promulgated and pointed out that the new communities should promote the block system. This new policy sparked heated debate. To demonstrate the rationality of this decision, the article studies on the problem that the influence on surrounding traffic causing by the opening of different types of community. The result shows that there is a big difference of the influence on surrounding traffic between opening different types of communities. So the decision of opening communities should fully consider the particularity of communities and adjust measures according to local conditions.

Keywords: traffic capacity of road, community, improvement

1. Introduction

As the economy in China develops, the size of urban becomes bigger and bigger and the number of vehicles is sharp increase, which sets a higher demand on the urban traffic networks. In February of 2016, “The central committee of the communist party of China on the management of the state council on further strengthening the construction of urban planning several opinions” formally promulgated and pointed out that the new housing should promote block system. This new policy sparked heated debate.

In China, influenced by traditional living model, urban land is divided into blocks. Road network is sparse and the traffic flow focuses on the trunk road, causing the traffic jam. Originally government wanted to reduce traffic jam by widening the road and increasing the number of road but the effect of this method is not ideal. Reducing traffic jam becomes important problem of government. Scholars emphasis on urban spatial structure to research the method of reducing traffic jam. Cao and Gu pointed out the disadvantage of closed communities and proposed to open communities gradually. Mei putted forward idea of opening communities which will make the communities road network and the urban road network integrated. Li, using traffic analysis theory and Braess Paradox, evaluated and compared the traffic condition under communities opening or not. Wang realized a series of evaluated route, which comes from the network performance analysis, intersection signal timing scheme optimization, traffic organization optimization, intersection highly channelizing design scheme design to form a complete set of traffic engineering facilities, using simulation technology. In recent years, study of “subtle circulation”, which close contact to opening communities, also gradually rise. Some scholars made optimal study on existing urban subtle circulation. Zhang analyzed and optimized the microcirculation system from three sides of the road network system, traffic organization, residents living environment of the street. Zhong designed bi-level optimized programming model and used Genetic Algorithm to optimize the microcirculation system. Lu using TOPSIS whiten pattern and designing Grey Integer TOPSIS grey solving model made further study on the planning method of the microcirculation of the urban. Wang discussed principle and method of the optimization of the urban traffic microcirculation system basing on Multi-objective decision.

From what has been discussed above, China has a wide study range of opening the community and urban traffic microcirculation, which established the foundation of the policy. But there is no studying about the influence causing by opening different communities on surrounding traffic. This problem has important significance to the opening community policy effectively implemented.

Therefore, the article sets up reasonable evaluation index system to evaluate the effect causing by opening communities on surrounding traffic firstly. Then the article compares the difference influence on surrounding traffic when communities have different shapes, different road network structures and different sizes. Finally, making some advises basing on study result about the exciting policy of opening the communities.

2. Evaluation Indexs

To study the influence of communities opening, the article studies the change of index to study the influence on surrounding traffic causing by opening communities. Therefore, the article sets up scientific and reasonable evaluation system and then ensure the weight of every index by AHP. The article uses comprehensive traffic index to measure the influence on surrounding traffic causing by communities opening.

In this system, the index of road network structure includes the increase in road network density and the reduction of nonlinear coefficient and the increase in connectivity index. The index of traffic efficiency includes the reduce time of intersection delay and the reduce time of straight section's delay. The evaluation system is showed in Figure 1.

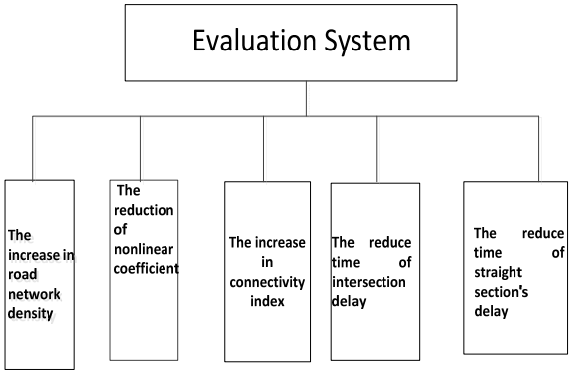


Figure 1. Evaluation system

2.1 Increase in Road Network Density ρ

The road network density is the specific value of total length of road and regional land use area. It is an important index to evaluate traffic microcirculation system of the area and it impacts the accessibility of street. The road of community can't become part of the regional public road. But it becomes part of the regional public road after open the community. The increase in road network density is:

$$\rho = \frac{\sum_{a=1}^{m}\sum_{b=1}^{n} L_{ab}}{S}$$

where L_{ab} is length of the first article b road in a community. Assuming that there are m communities in this area and there are roads in a community. S is the area of this region.

2.2 Reduction of Nonlinear Coefficient φ

The nonlinear coefficient is the specific value of the actual distanceand the spatially linear distance between the two points. Generally, the bigger nonlinear coefficient is, the greater actual distance between two points is and the worse surrounding traffic jam are. Because the road in the community has exclusiveness, vehicles can't run across the community and only can adopt the method of round to reach destination. The existence of closed community make the actual distance of vehicles running bigger than the spatially linear distance between the two points. The formula of nonlinear coefficient is

$$C = \frac{L_a}{d}$$

where C is the nonlinear coefficient, La is the actual distance between two points, d means the spatially linear distance between the two points.

The reduction of nonlinear coefficient equals the errand of nonlinear coefficient between opening and closing

$$\varphi = C_{AB} - C_{AB2} = \frac{L_{ab} - L_{ab2}}{d}.$$

2.3 Increase in Connectivity Index λ_R

The connectivity index reflects the developed degree of the traffic network. It is the index of describing the number of nodes and edges in the rode network. The higher connectivity index is, the less end breaking road existing in the road network is, confirming that net rate higher. In contrast, it confirms that net rate lower. The formula is:

$$J = \frac{2P}{Q}$$

Where J is the connectivity index. P is the number of nodes in the road network. Q is the number of edges in the road network.

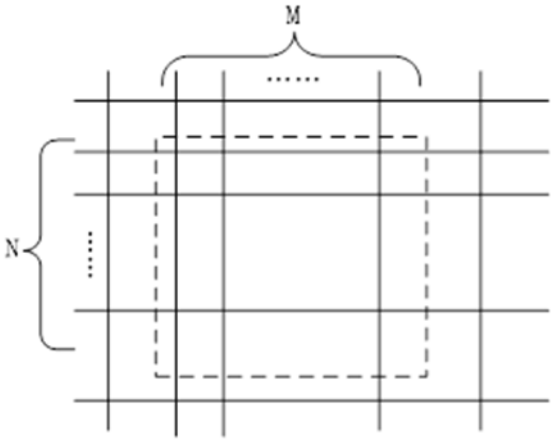


Figure 2. Network of closing community

As shown in the Figure 2, if a close community have M axial roads and N horizontal roads connects with urban road, the rectangle community will increase MN nodes and [M(N+1)+N(M+1)] edges when the community opens. The increase in connectivity index λ_R is

$$\lambda_R = J_1 - J_2 = \frac{2\times[M(N+1)+N(M+1)+2(M+1)+2(N+1)]}{MN+2M+2N+4} - \frac{2\times[2(M+1)+2(M+1)]}{2M+2N+4}$$

$$\lambda_R = \frac{MN-4}{MN+2M+2N+4} + 1(M,N \in P).$$

2.4 Reduction Time of Intersection Delay D_1

The article used traffic impact analysis (T-TIA) based on time to do analysis of delay. The reduce time of intersection delay reflects level of delay causing by traffic jam at intersection. Generally, the higher delay level is, the longer delay time is, confirming that the intersection has lower traffic capacity. In contrast, the intersection has better traffic capacity. The article use the reduce time of intersection delay to reflect traffic capacity of intersection. Assuming that the primary vehicles (along the dotted line in the Figure 4) blocked because close community and round the edge of community. The reach of vehicles follows *Poisson Distribution*; all the intersection have signal light and vehicles turning right have accommodation lane. The formula of the reduce time of intersection delay is:

$$D_1 = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} T_{i,j}$$

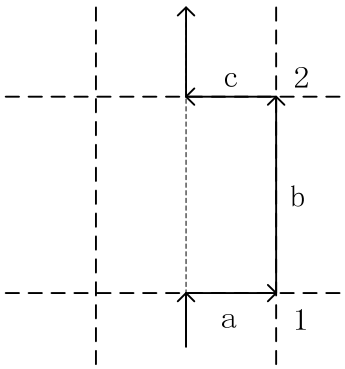


Figure 3. The analysis graphics of the reduce time of intersection delay

Where T_{ij} is the time of intersection delay causing by closing community(s) equal to the saved time causing by opening community, T_{ij}'s formula is:

$$T_{ij} = 0.38T_c\left(\frac{1-y}{1-xy}\right) + 173x^2\left[(x-1) + \sqrt{(x-1)^2 + \frac{16x}{c}}\right],$$

where $x = \frac{Q_\mu}{q_0}$, T_c is signal cycle, y is the split of intersection, x is the road saturation, q_0 is the biggest volume traffic at entrance equal to the per unit time through road a cross-section of the maximum number of vehicles (pcu/h, the number of vehicles per hour), Q_μ is the volume of round traffic (pcu/h); C is the partition coefficient of volume traffic at entrance.

2.5 Reduction Time of Straight Section's Delay D_2

The reduce time of straight section's delay reflects the level of delay causing by traffic jam at straight road. Generally, the higher delay level is, the longer delay time is, confirming that the straight road has lower traffic capacity. In contrast, the straight road has better traffic capacity. We use the reduce time of straight section's

delay to reflect traffic capacity of straight road. Assuming that the primary vehicles (along the dotted line in the Figure 4) blocked because close community and round the edge of community. The reaching of vehicles follows *Poisson Distribution*. The formula of the reduce time of straight section's delay is $D_2 = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} S_{ij}$ where , S_{ij} is the time of straight section's delay causing by closing community(s) equal to the saved time causing by opening community. The formula of S_{ij} is:

$$S_{ij} = \frac{3600L}{v(1+\frac{\alpha Q_0}{V_0})^{\beta}},$$

Where V0 is the biggest volume traffic. α, β are retardation factors and α=0.15, β=4, v is speed of this road; L is the distance of road. We can get the reduce time of straight section's delay $d_2 = \frac{D_2}{m}$ between every pair of points, m is the number of points pair. Basing the evaluation system, the article uses AHP to ensure the weight of every index. Limited to the space not go into here. Finally we got the evaluation formula of the influence on surrounding traffic causing by communities opening $E=0.2495\rho+0.5806\psi+0.0643\lambda_R+0.4243D_1+0.1414d_2$, E is the index of traffic capacity.

3. Calculation and Analysis of the Influence Caused by the Policy

Influences of opening community impacted by the shape of communities and the surrounding road network structure and the size of communities. Due to geographic, political, economic, social, cultural and other factors, the kinds of community in China shows the characteristics of the homogeneity and diversity coexist. From the shape of communities, the common shapes in China are square, triangle and trapezoid. From the surrounding road network structure, there are mesh structure, tree structure and the main street structure; besides the size of the community is also difference. This unite analyze the difference of the influence on surrounding traffic causing by opening communities.

3.1 Analysis of the Influence of Opening Different Shapes Communities

Because of the city planning problems, shapes of communities are different, which results different road structure in communities. There is difference between influences of opening different shape communities. Now the common community shapes in China are square, triangle and trapezoid. Most of communities are square, analyzing the influence causing by opening square communities on surrounding traffic have representativeness and actual meaning. Therefore, the article chooses the square community as the base of study and compares with triangle community to evaluate the influence causing by opening different shape communities.

3.1.1 Calculation of the Influence Causing by Opening Community

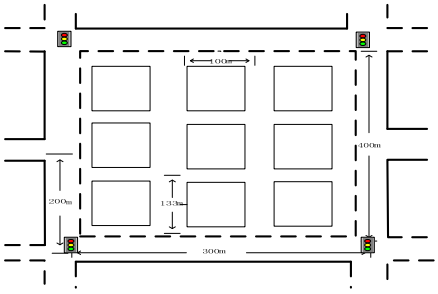


Figure 4. Closed square community

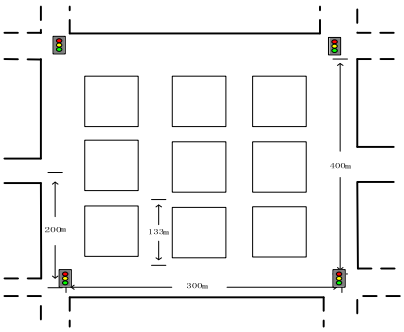


Figure 5. Opened square community

As shown in the Figure 4, it is a diagrammatic drawing of a square community. In actual life, community is in commonly 10 hectares. To simplify the calculation, the article assumes that this community is 400 meters long, 300 meters wide. It covers an area of 12 hectares. The vertical distance of two nodes inside the village is 133 m and the horizontal distance is 100 m. The surrounding road structure is the main street structure which is popular in China and surrounding roads are one-way street. Due to the size of the traffic flow has nothing to do with the moving direction and the total traffic flow is the sum of all directions of traffic flow, the article only studies one direction of traffic flow. Namely vehicles enter into the area from the left side and leave the area on the right side. Vehicles can't enter into the community and only round the edge rode when the community closed. The detour road length is 0.63 km. Assuming that volume of traffic at the community surrounding roads is 600 pcu/h, the biggest volume of traffic is 1200 pcu/h, the road saturation is 0.5, the partition coefficient is 0.5, the retardation factors α=0.15, β=4, the average velocity speed is 50 km/h. There are 4 signal lights at intersections and the cycle of a signal lights is 60 seconds, the split is 1/4. As the basal community of analyze, the article thinks that these parameters can reflect the most of communities in China.

After the community opened, as shown in Figure 5, the fence of the community disappeared and the road in the community connected with the urban road. Two transverse and longitudinal internal transport networks connected with urban, and forms a complete the network traffic in this area.

The article takes the parameters into the evaluated model, using MATLAB to calculate the index of road network structure and the index of traffic operation efficiency showed in Table 1.

Table 1. The index of opening square community

The increase in road network density (km/km^2)	The reduction of nonlinear coefficient	The increase in connectivity index	The reduce time of intersection delay (s)	The reduce time of straightsection's delay (s)
0.012	0.88	1	688	60.57

Take the normalized number to formula (1), gaining the comprehensive index of traffic capacity is 0.4915.

3.1.2 Calculation of the Influence of Triangular Community

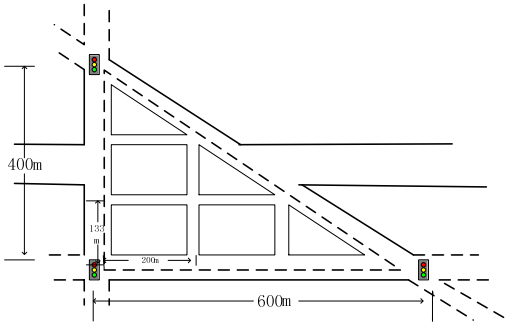


Figure 6. Closed triangular community

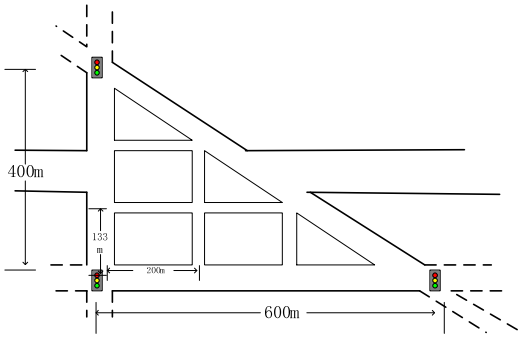


Figure 7. Opened triangular community

As shown in the Figure 6, it is a diagrammatic drawing of triangular community. Because the article only compares the influence of opening different shape communities, it assumes that this community is 600 meters long and 400 meters wide. It covers an area of 12 hectares. The vertical distance of two nodes inside the village is 133 m and the horizontal distance is 200 m. The surrounding roads are one-way street. The article also studies one direction of traffic flow. Namely vehicles enter into the area from the left side and leave the area on the right side. Vehicles can't entrance the community and only round the edge rode when the community closed. The detour road length is 0.86 km. The other parameters are same with 3.1.1 to analyze the difference. As shown in Figure 7, after opened community, the fence of the community disappeared and the road in the community connected with the urban road. Two transverse and longitudinal internal transport networks connected with urban and forms a complete the network traffic in this area.

The article takes the parameters into the evaluated model, using MATLAB to calculate the index of road network structure and the index of traffic operation efficiency showed in Table 2.

Table 2. The index of opening triangular community

The increase in road network density (km/km^2)	The reduction of nonlinear coefficient	The increase in connectivity index	The reduce time of intersection delay (s)	The reduce time of straight section's delay (s)
0.0083	0.58	0.57	516	82.69

Take the normalized number to formula (1), gaining the comprehensive index of traffic capacity is 0.3656.

3.1.3 Analysis of the Influence of Opening Community Causing by Different Shapes

Table 3. The comparison of the influence of opening community

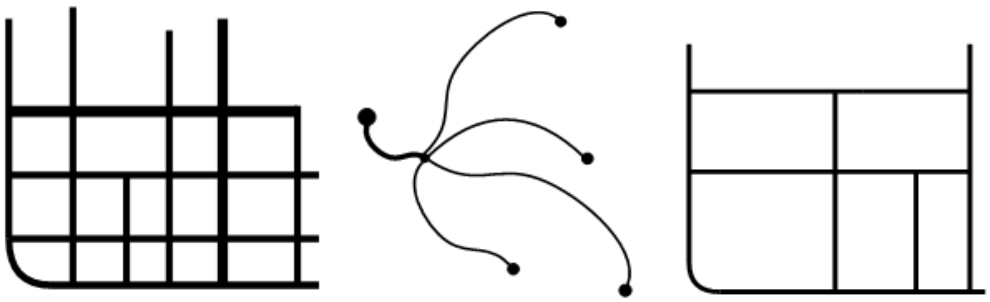
	The comprehensive index	The increase in road network density (km/km2)	The reduction of nonlinear coefficient
Square	0.4915	0.012	0.88
Triangular	0.3656	0.0083	0.58
	The increase in connectivity index	The reduce time of intersection delay (s)	The reduce time of straight section's delay (s)
Square	1	688	60.57
Triangular	0.57	516	82.69

From the comparison, the article finds that the traffic capacity has greatly improvement after opened square community and triangular community when the surrounding road structure is the main street structure. But the comprehensive index of square community is higher than triangular community, confirming that the improvement of surrounding transportation of opening square community is better than opening triangular

community. Comparing these index, the article finds that the reduce time of straight section's delay of opening triangular community is more than opening square community. And it may because that the within road of triangular community is complex. But the actual shapes of communities are not standard square and triangle and we infer that the closer to square, the better influence on traffic capacity. Similarly, the complex community structure like triangle is worse. The other shape community like trapezoid can mirror this method of calculation.

3.2 Analysis of the Influence of Different Surrounding Road Network Structures

There are three kinds of road structure in China, mesh structure, tree structure and the main street structure, as shown in the Figure 8. Among the three kinds of road, the main street structure is used in most cities; some boom cities are mesh structure; but the tree structure is fewer used in cities. This unite analyze the influence of opening community under the main structure and the mesh structure.



Mesh structure Tree structure Main street structure

Figure 8. Basic road structures in China

The surrounding road structure of square community in 3.1.1 is typical main street structure; therefore, the article compares the difference between opening communities when the surrounding structure is the mesh structure and the main street structure.

3.2.1 Calculation of the Influence When the Surrounding Road Structure Is the Mesh Structure

Same as above, the parameters are same with the square community in 3.1.1 besides the surrounding road structure.

The article takes the parameters into the evaluated model, using MATLAB to calculate the index of road network structure and the index of traffic operation effciency showed in list 4.

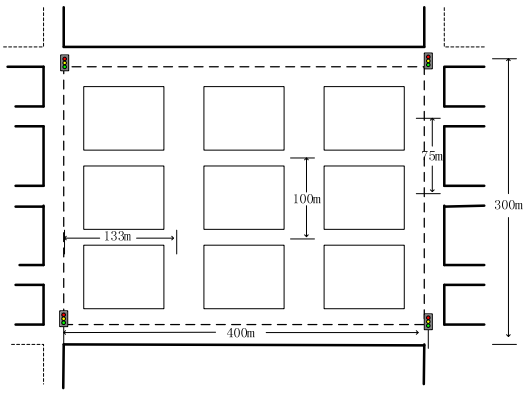


Figure 9. The closed community

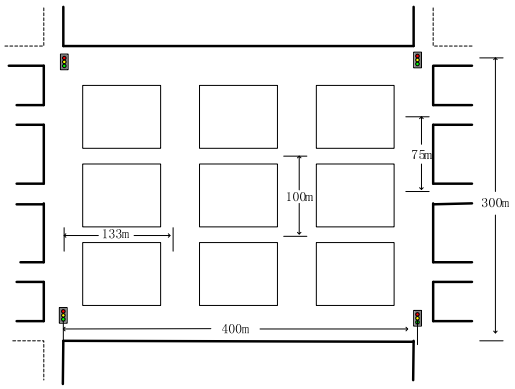


Figure 10. The opened community

As shown in the Figure 9, it is a diagrammatic drawing of square community under the mesh road structure. The article assumes that this community 400 m long, 300 m wide. It covers an area of 12 hectare. The vertical distance of two nodes inside the village is 133 meters and the horizontal distance is 100 meters. The surrounding roads are one-way street. The article also studies one direction of traffic flow. Namely vehicles enter into the area from the left side and leave the area on the right side. Vehicles can't entrance the community and only round the edge rode when the community closed. The detour road length is 0.63 km. The other parameters are same with 3.1.1. As shows in Figure 10, after the community opened, the fence of the community disappeared and the road in the community connected with the urban road and formed dense traffic network.

Table 4. Index of opening square community under the mesh road structure

The increase in road network density (km/km^2)	The reduction of nonlinear coefficient	The increase in connectivity index	The reduce time of intersection delay (s)	The reduce time of straight section's delay (s)
0.012	0.5	1	688	60.57

Take the normalized number to formula (1), gaining the comprehensive index of traffic capacity is 0.3870.

3.2.2 Analysis of the Influence of Opening Community Causing by Different Road Structures

Comparing with the index in 3.1.1, the article gets the Table 5.

Table 5. Comparison of the influence of opening community under different road structure

	The comprehensive index	The increase in road network density (km/km2)	The reduction of nonlinear coefficient
The main street	0.4915	0.012	0.88
The mesh street	0.3870	0.012	0.5
	The increase in connectivity index	The reduce time of intersection delay (s)	The reduce time of straight section's delay (s)
The main street	1	688	60.57
The mesh street	1	688	60.89

From the comparison, the article finds that the traffic capacity has greatly improvement after opened community under the main street and the mesh street. But the comprehensive index of opening community under the main street is higher than that of the mesh street, confirming that the improvement of traffic capacity of opening community under the main street is better than opening under the mesh street. Although the index in closely, there is still exists some difference. The reduction of nonlinear coefficient under the mesh structure is fewer than

the main street; the reduce time of straight section's delay is also shorter. And it may because that when the road structure is the mesh structure, the external road network density is big and the influence on the road network is not obvious; reduce of round road is also limited. Therefore, when the surrounding road structure is the mesh structure, the influence is not better than the main structure although it improves the traffic capacity at a certain extent. Combined with the actual, the influence of policy will effective because the main street structure is the most common in China.

3.3 Analysis of the Influence of Community Size

The population density in China is large and the clustering characteristics are obvious, so the community scale in China is also large about 10 hectares. But there are also some small communities influenced by territory, population and economy. This unite analyze the different influence causing by community scale on surrounding traffic capacity. Comparing the 10 hectares community with the 3 hectares community.

The square community in 3.1.1 is 12 hectares community, which closes to the regular size of community and compare with the small community.

3.3.1 Calculation of the Influence Causing by Opening Small Community

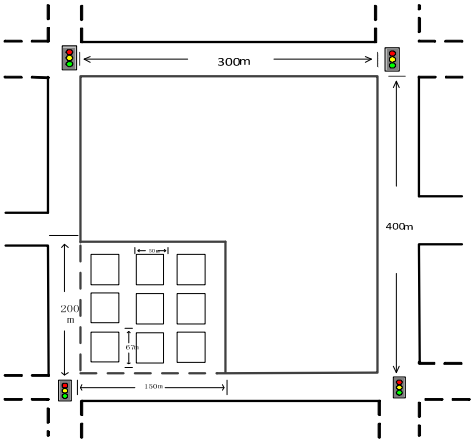


Figure 11. The closed small community

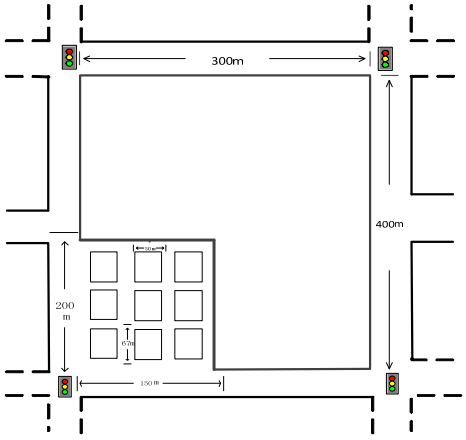


Figure 12. The opened small community

As shown in the Figure 11, it is a diagrammatic drawing of small community. Assuming that this community 200 meters long, 150 meters wide, covers an area of 3 hectares and the vertical distance of two nodes inside the village is 67 meters, the horizontal distance is 50 m. The surrounding road structure is the main street which common in China and surrounding roads are one-way street. Due to the size of the traffic flow has nothing to do

with the moving direction and the total traffic flow is the sum of all directions of traffic flow, the article only studies one direction of traffic flow. Namely vehicles enter into the area from the left side and leave the area on the right side. Vehicles can't entrance the community and only round the edge rode when the community closed. The detour road length is 0.63 km. Assuming that volume of traffic at the community surrounding roads is 600 pcu/h, the biggest volume of traffic is 1200 pcu/h, the road saturation is 0.5, the partition coefficient is 0.5, the retardation factor α=0.15, β=4, the average velocity speed is 50 km/h. There are 4 signal lights at the intersection and the cycle of signal lights is 60 seconds, the split is 1/4. As the basal community of analyze, we think that these parameters can reflect the most of communities.

After the community opened, as shown in Figure 12, the fence of the community disappeared and the road in the community connected with the urban road. Two transverse and longitudinal internal transport networks connected with urban and forms a complete the network traffic in this area.

The article takes the parameters into the evaluated model, using MATLAB calculate the index of road network structure and the index of traffic efficiency showed in Table 6.

Table 6. Index of opening small square community

The increase in road network density (km/km^2)	The reduction of nonlinear coefficient	The increase in connectivity index	The reduce time of intersection delay (s)	The reduce time of straight section's delay(s)
0.00875	0	1	688	67.31

Take the normalized number to formula (1), gaining the comprehensive index of traffic capacity is 0.2203.

3.3.2 Analysis of the Influence of Opening Community Causing by Different Community Sizes

Comparing with the index in 3.1.1, the article gets the Table 7.

Table 7. Comparison of the influence of opening community under different community scale

	The comprehensive index	The increase in road network density (km/km2)	The reduction of nonlinear coefficient
The main street	0.4915	0.012	0.88
The mesh street	0.2203	0.0058	0
	The increase in connectivity index	The reduce time of intersection delay (s)	The reduce time of straight section's delay (s)
The main street	1	688	60.57
The mesh street	1	688	67.31

From the comparison, the article finds that the traffic capacity have greatly improvement after opened big and small community. But the comprehensive index of opening big community is higher than opening small community, confirming that the improvement of traffic capacity of opening big community is better than opening small community. Although the index is similar, there is still some difference. The reduction of nonlinear coefficient opening small community is zero; the reduce time of straight section's delay is 67.31s. The increase in road network density is also small. And it may because that the round distance is long when the community is small. The shortest distance from one point to another without change, only increased the road number. Although opening communities improved the surrounding traffic capacity, the influence of small is not good compared with big community. The small community in China is few and government can think partial open or not open small communities.

4. Conclusions and Suggestions

The article sets up reasonable evaluation index system and establish the comprehensive index of traffic effciency to evaluate the influence of opening different community, using the AHP to ensure the weight of index. From the above analysis, all kinds of opening community will improve the traffic efficiency of surrounding roads but there are large differences of different kinds opening.

The improvement of traffic effcienty causing by opening square community is better than opening triangular community. Actually, the square community is common in China and the traffic effciency is obviously improved after the policy implementation effect. Some communities are triangular which can be partly opened based in actual.

When the surrounding road structure is different, the improvement of opening community is also different and from the study the article makes a conclusion that the improvement of opening community under the main road structure is better than that of the mesh road structure. Combining with the truth, the road structure in China consists of the main structure and the mesh structure. To reduce the traffic jam at the same time reduce the cost of opening, governments can choose open community whose surrounding road structure is the main structure.

Generally, the influence of opening the big community is better when the other conditions are same. Considering our national conditions, government can choose to open some large community and partly open some small community. They can also choose not open considering the impact of safety, costing.

In conclusion, the improvement of opening large square community whose surrounding road structure is the main street is the most obviously. In fact, considering the impact of improvement of opening, costing and safety, the implementation of opening policy should avoid "cutting" and adopt the differentiation policy. Carrying out the period time of open and the pilot open transforms people's concept, which promote the implementation of opening policy and reduce the traffic jam in China.

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