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RESEARCH PAPER

Scope Criterion of Traffic Impact Analysis in Shanghai

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Abstract: Analysis scope is one of the indexes of traffic impact analysis (TIA). Focusing on the shortcomings of current methods, the paper analyzes some key problems including analysis flow, typical road networks and so on, and proposes an effective method of disseminating analysis scope, which considering three main factors, road traffic surroundings, flows from project, and its direction. Taking Shanghai city as an example, the analysis scope are concluded based on five types area level (A–E) and their thresholds of TIA and level of travel flow. Results indicate that, at level A and thresholds as 200–500, 500–1000, and ≥1000, their analysis scopes are 3, 3, 1 intersections, respectively. 5, 4, 2 are for level B, and 6, 5, 3 are at least for level C, D, E, respectively. The TIA is necessary when the regional traffic status located in level D and E, and the travel volume and TIA scope should meet level C.

Key Words: traffic impact analysis (TIA); analysis scope; equivalent capacity; density ratio; intersection turning

1 Introduction

Defining the traffic impact analysis scope is an important aspect of Chinese TIA work, which involves time cost, economic cost and evaluation effect and is also closely related to the location, nature and size of the project. Usually, the location and areas with relatively significant traffic impact is adopted for the traffic analysis and the analysis result is vague to some extent; therefore, the scope is mostly defined subjectively through project consultations and there is a lack of feasible and scientific method generally suitable for different locations, the types and intensity of development.

In other countries, the American Institute of Transportation Engineers recommends that the TIA scope should include all roads, ramps, intersections and other areas with significant changes of traffic characteristics whose traffic flow generated by the project accounts for more than 5% of the peak flow[1]. Most of the foreign methods are subjective more or less due to our traffic conditions and traffic composition, and significant differences exist in the traffic capacity of different road sections and intersections. In China, Fan[2] adopt Spherical Extrapolation Method to make analysis on the aspects of significant correlation between the sections saturation and their resistance, and of the easy availability; however, the analyzed result is inconsistent with the actual situation for that the road sections has uniform traffic distribution and the traffic flow does not decrease as the spherical extrapolation, and finally the travel distribution forecast is skipped. As per the Travel Attraction Balance Theory, Xiong *et al*.[3] put forward the category attraction ratio method for defining TIA scope and regard the attraction distance as the range of influence, but the defined range is always too large. Wang *et al*.[4] adopt the plume models to determine the maximum distance influenced by the surrounding road networks, viz. maximum influenced range. Xiong *et al*.[5] adopt the time quantitative method to determine the impedance function of the road, but relatively big error exists in both models and actual practice, and the computation time is relatively long. Besides, there is the targeted research of commercial district[6,7]. Therefore, the establishment of a feasible and practical method for defining TIA analysis scope is of great significance to the implementation of TIA work[8].

Based on the specific traffic situation of Shanghai, this paper makes analysis and research to propose a feasible and practical method for defining TIA scope.

2 Basic problems on defining TIA scope

2.1 Flows

The TIA scope is defined as the area of the road section and intersection having the long-term and short-term traffic

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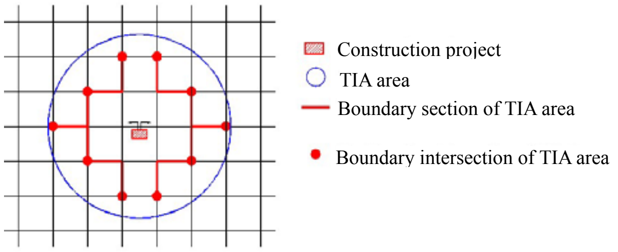

Fig. 1 Definition of TIA scope

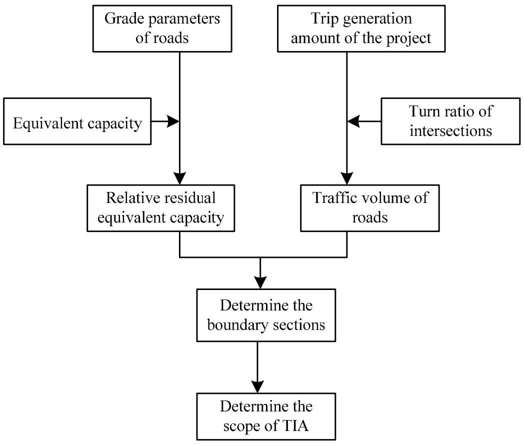

Fig. 2 Flow of determining the TIA scope

situation evaluation in the construction project surroundings with its TIA reaching the threshold[9,10], and its meaning is shown in Fig. 1. The radius of TIA in which is the length of three intersections.

The decisive factors for defining the TIA scope are: (i) the traffic situation in the project area; (ii) travel flow of the project, with its processes shown in Fig. 2; the relative surplus equivalent capacity is inferred from the road grade and the equivalent capacity, and the traffic volume of each section project is inferred from the total travel flow generated from the project and the intersection turning ratio; combine both of these two inferred factors to determine the boundary section, from which the TIA scope will ultimately be defined.

2.2 Key issues

In this paper, the key issues corresponding to the decisive factors of TIA scope are: (i) the criterion for defining the boundary section of TIA scope and (ii) the allocation method of project traffic volume.

As for issue (i), it will be defined by adopting the boundary section defining method based on the relative surplus equivalent capacity ratio, viz. being defined by determining the traffic volume allowable to be added to the city road with various traffic backgrounds.

As for issue (ii), the allocation method of project traffic volume "based on the characteristic of urban intersection turning ratio" is adopted in this paper.

2.3 Typical road network

A typical road network is the premise for the research on the TIA scope. In this paper, mainly the road network with the urban main road and secondary road (mostly one-way three-lane road) in Shanghai is regarded as the typical road network for TIA.

The equivalent capacity C_e of three-lane main (secondary) road is 1800 pcu/h, its equivalent crowding density K_j is 148 pcu/h and the equivalent free-flow speed V_f is 488 km/h[11].

2.4 Relative surplus equivalent capacity percentage *α*

It is defined as the ratio of urban road relative surplus equivalent capacity to road equivalent capacity. It serves just like the relative surplus equivalent capacity to embody the traffic volume allowable to be added under the premise that the existing traffic s does not decrease, and it also serves as a specific index for defining the project TIA boundary section under different traffic situations: Once the ratio of the project traffic volume loaded by the section to the equivalent capacity of this section is less than α value of this section, this section shall be excluded in the project TIA scope; otherwise, it shall be included in the scope.

The α value of three-lane main (secondary) road of the typical road network under various traffic situations (level of service, LOS) is calculate: α=10% for level A, α=5% for level B, α=3% for level C.

2.5 Stability of intersection turning ratio and representative value of straight moving ratio

This paper adopts the flow acquisition system to analyze the flow of approach lanes of 166 intersections in Shanghai during the period from Mar 1, 2005 to Mar 21, 2005, and study on the turning ratio from each entrance to left, straight-through direction and right; two distinct features are found out:

(1) Time stability

The left, straight-through and right turning ratio values are invariable within 24 hours or within 20 continuous days. Take the Northbound at Yixian Road–Handan Road intersection for example, at different period of time on Mar 1, 2005, the left, straight-through and right turning ratio is respectively nearly 0.18, 0.60 and 0.22. A conclusion is drawn on the basis of the 20 days of sample value; these three values are still nearly 0.18, 0.60 and 0.22 respectively, with small changes, as shown in Figs. 3 and 4.

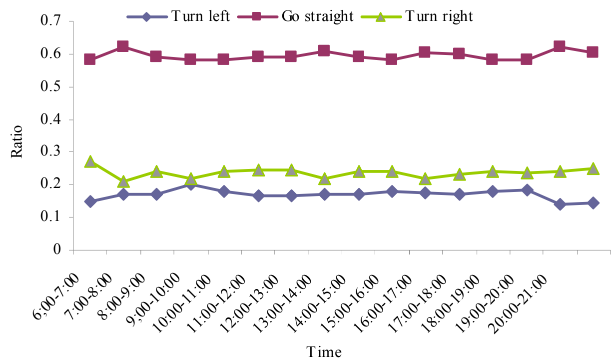

Fig. 3 Turn radios of northbound at Yixian Handan Rd. intersection

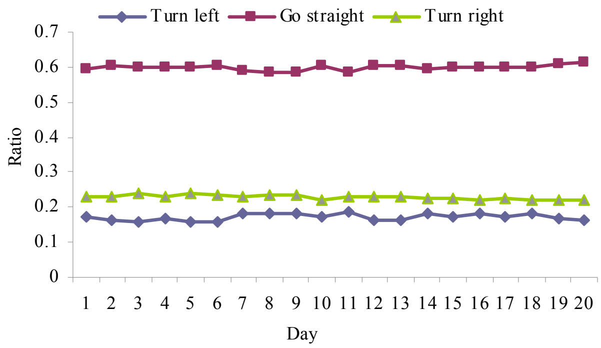

Fig. 4 20-Day turn radios of northbound at Yixian Rd-Handan Rd. intersection

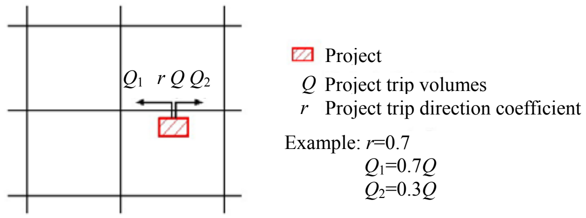

Fig. 5 Nonuniformity of project trip directions

(2) Numerical stability

This value mainly refers to the intersection straight moving ratio (P_s), which is used for allocating the project traffic volume to the least favorable direction during the process of defining the TIA scope index. The straight turning ratio values of all approach lanes of 166 intersections lie within the range of [0.5, 0.7], the mean value 0.6 is obtained in this paper, that is P_s=0.6.

2.6 Travel direction coefficient of project

In this paper, the construction project is simplified as only one entrance/exit and both left and right turning for travel-in and travel-out; due to the nonuniformity of the travel of two directions, the project travel direction coefficient is adopted for representation and this coefficient is defined as the ratio of travel flow of the direction with more travel flow to the total travel flow of this project, indicated by r, as shown in Fig. 5.

Based on the investigation on construction project travel, r=0.7 is taken in this paper, which means one direction's travel flow Q_1 at the entrance/exit of the project accounts for 70% of the total travel flow of the project (0.7Q) and the travel flow for the other direction Q_2 accounts for 30% (0.3Q).

Take Q_1's travel direction, assign Q_1 to the corresponding road section project as per P_s =0.6, and finally determine the TIA scope boundary section as per α value of the section.

3 Defining TIA scope index

3.1 Defining method

The TIA scope is a regular area, for example the areas setting several adjacent intersections or a certain distance as radius, with the project as the center; defining the TIA scope index means to define the radius of this regular area; generally, the radius representing the least favorable and the maximum influenced distance of the project has two kinds of descriptive forms: (I) the number of intersection, (II) the distance. The abroad practice shows that it is more applicable to use the number of intersections to represent the TIA scope index.

Based on the contents in 2.3-2.6 of this paper, four key parameters are obtained: (I) give 1800 pcu/h for the road equivalent capacity C_e of the typical road network; (II) the relative surplus equivalent capacity percentage α and the relative surplus equivalent capacity αC_e; (III) travel direction coefficient r of the project and the allocated project traffic volume rQ; (IV) representative value of the straight moving ratio at the approach lane of intersections, give 0.6 for it.

The specific steps for defining the TIA scope index are:

Step 1: Define the rQ value of the project and its travel direction, the project section is regarded as the first section within the radius of TIA scope (the traffic volume of this section q_1=rQ), and the adjacent intersection is the first intersection within the radius of TIA scope.

Step 2: Based on the project traffic volume q1 of the first section, use the representative value of straight moving ratio Ps to implement the straight moving allocation on the first intersection, and therefore the project traffic volume of the second road section q_2 (q_2=P_s·q_1) can be obtained.

Step 3: Inspection: Determine the α and αC_e values of the second section as per its traffic LOS. If $q_2 < \alpha C_e$, no allocation of project traffic volume shall be carried out, which means the first section shall be defined as the boundary section of TIA scope and the first intersection shall be defined as the furthest intersection in the analysis scope, so the TIA scope shall be defined as the regular area distant from the first intersection in all directions; if $q_2 > \alpha C_e$, the further allocation shall be carried out in the same way as described in Step 2, and the project traffic volume of the third road section q_3 (q_3= P_s·q_2= P_s·P_s·q_1) can be obtained.

Step 4: Inspect q_3 as per the method described in Step 3; carry out the proper operation as per the inspection results by analogy.

When $q_i < \alpha C_e$, stop the allocation and define the TIA scope; otherwise, continue with the allocation, as shown in Fig. 6.

At last, the TIA scope can be obtained. In Fig. 7, $q_3 < \alpha C_e$, which means there are two intersections included in the TIA scope radius of the project. If $q_3 < \alpha C_e$, then TIA area is the area enclosed by the circle. Solid circles and the thick lines are the intersections and roads analyzed.

3.2 Project trips grade

The TIA scope is defined on the aspect of one certain type of project, such as the project with its travel flow generated within a certain range under a certain grade of traffic situation, rather than the aspect of the project with different conditions.

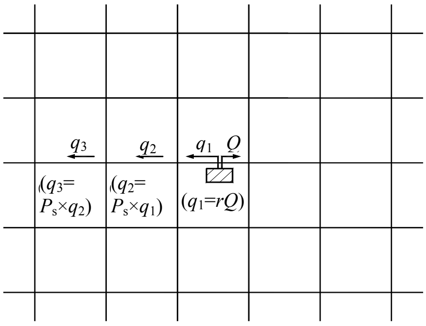

Fig. 6 Scheme of determination for TIA scope boundary

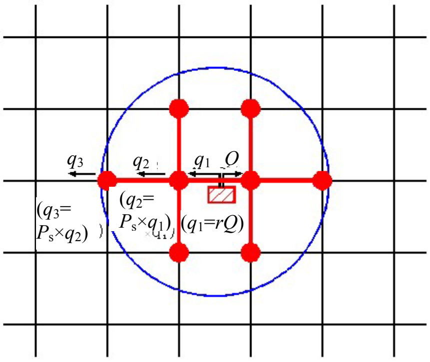

Fig. 7 Scheme of TIA scope

As shown in Table 1, under each regional traffic LOS (A, B and C), all the projects meeting the TIA thresholds are classified into three grades, viz. 200–500, 500–1000 and ≥1000 based on the travel flow. The TIA scope index is focused on each trips grade.

In this paper, as for two trips grades of 200–500 and 500–1000, their mean values (350 pcu/h and 750 pcu/h) are adopted respectively for their representative values of travel flow; as for the trips grade of ≥1000, because the 1000 pcu/h is already a large travel scope, it is suggested to set 1000pcu/h as the representative value of travel flow of this grade. In the process of defining the TIA of each grade, the representative value of trips is regarded as traffic travel volume of project Q.

3.3 Defining research scope

Based on the aforesaid indexes, the TIA index of Shanghai construction project can be defined, as shown in Table 2. In this study, the number of intersection is adopted for the descriptive form of this index. When the regional traffic LOS is defined as A and the TIA trip grades are 200–500, 500–1000, ≥1000, the TIA scopes are respectively 3, 3 and 1 intersections for each grade, and they are respectively 5, 4, 2 and 6, 5, 3 under LOS B and C; when the regional traffic LOS is D or E, the traffic impact analysis must be made, and the typical trips grade and TIA scope should meet the requirements of LOS C at least, and they shall be specifically defined as per different projects.

Table 1 Project trips grade for TIA (pcu/h)

LOS	Trips threshold	Trips grade	Typical value
A	200	≥1000	1000
		500–1000	750
		200–500	350
B	100	≥1000	1000
		500–1000	750
		100–500	350
C	30	≥1000	1000
		500–1000	750
		30–500	350
D	-	-	-
E	-	-	-

Table 2 Indexes of TIA scope in Shanghai

LOS	Trips threshold (pcu/h)	Trips grade (pcu/h)	Traffic Impact analysis scope (Number of Intersections along the radius direction)
A	200	≥1000	3
		500–1000	3
		200–500	1
B	100	≥1000	5
		500–1000	4
		100–500	2
C	30	≥1000	6
		500–1000	5
		30–500	3
D	-	-	-
E	-	-	-

4 Conclusions

In this paper, as for the current situation that most of the TIA defining methods of the construction projects of a number of cities are vague without taking into account of the travel flow of the construction project itself or various shortcomings of the regional traffic of the project, through a further study on defining TIA scope and on the key issues, the following conclusions are made:

(1) Based on the stability of the urban intersection turning ratio, it is suggested that the project traffic volume be allocated as per the random allocation of turning ratio in the TIA work.

(2) The TIA scope defining method comprehensively taking into account of the regional traffic situation and the relative surplus equivalent capacity of road network is proposed and the specific analysis steps are set forth.

(3) Based on the investigation on actually measured data and the simulation analysis, the recommended criterion of construction project TIA scope under different regional traffic situation and the travel scale of Shanghai are defined. When the regional traffic LOS is defined as A and the TIA trips thresholds are 200–500, 500–1000, ≥1000, the TIA scopes are

respectively 3, 3 and 1 intersections for each threshold, and they are respectively 5, 4, 2 and 6, 5, 3 under LOS B and C; when the regional traffic LOS is D or E, the traffic impact analysis must be made, and the specific trips grade and TIA scope should meet the requirements of LOS C at least, and they shall be specifically defined as per different projects.

The TIA defining method put forward in this paper is practical with good feasibility, which establishes a sound theoretical basis for Shanghai to comprehensively carry forward the traffic impact analysis of construction project.

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References

[1] Yi H V. The Guidelines and Requirements of Traffic Impact Analysis in U.S. States And Counties (Cities), California Department of Transportation, California , USA, 1992.

[2] Fan X J, Wang Y Y. Application of spherical extrapolation method to TIA. Traffic and Computer, 2007, 3(25): 137–144.

[3] Xiong H L, Jin B H, P J X. Research on the method of identifying study of traffic impact analysis. Transport Planning and Research, 2004, 4(2): 41–44.

[4] Wang L, Liu X M, Ren F T, *et al*. The application of cloud model in traffic impact analysis. Journal of Highway and Transportation Research and Development, 2001, 6(18): 82–84.

[5] Xiong Q, Liu X M, Wang L. Study on the numerical method based on time about traffic impact area. Journal of Highway and Transportation Research and Development, 2004, 11(21): 78–82.

[6] Shen J W, Liu X J, Chen L C. The traffic impact of large-scale commercial facilities in cities. Journal of Wuhan University (Information Science), 2002, 4(27): 432–435.

[7] Zhou W, Li W D. Research on the identification of the study area boundary of large commercial developments. Journal of Transportation Systems Engineering and Information Technology, 2003, 4(3): 61–68.

[8] American Society of Civil and Engineers. Site Impact Traffic Assessment (problems and solution), Chicago, Hlincis, 1992.

[9] Institute of Transportation Engineers. Trip Generation, 7th Edition., Washington. DC, USA, 2004.

[10] Cheng L, Li Q, Wang J Y, *et al*. Urban street network capacity reliability. Journal of Southeast University (English Edition), 2004, 20(2): 235–239.

[11] Jiang G Y. Technologies and Applications of the Identification of Road Traffic Conditions, Beijing: China Communications Press, 2004.