# Research on the Key Technology in the Specification for Traffic Impact Analysis

**Xian-tong Jiang, Hui Xiong and Chang Xu**

**Abstract** With the development of urbanization and mobility, traffic issues have increasingly emerged. Due to the large construction scale and the influence of the development, traffic was generated on the network of roads around the project on the whole city, some development plan schemes and development projects would lead to supply–demand imbalance in the traffic of road nets, aggravating the tense situation of urban traffic and triggering a new and chain of traffic issues. Thus, traffic impact analysis is playing a bigger role in the rational development of urban construction and coordinate development between traffic and land exploration and utilization. According to the research on the national and international specification for traffic impact analysis, the article analyzed real issues in the practices, for one thing. For another thing, the author focused on certain key technology, such as traffic impact analysis type, start threshold, research scope, parking demand prediction, etc. The paper aims to provide a basis and technological support for the establishment of the Specification for Traffic Impact Analysis.

**Keywords** Traffic impact analysis · Specification · Development project
Development plan scheme

## 1 Introduction

When it comes to urbanization rate, it has increased from 36.2%, in 2000, to 57.4%, in 2016, in China. Considering the urbanization rate of 60%, in 2020, and 70%, in 2030, there are 0.24 billion rural Chinese that would shift to the cities, in total. When it comes to mobility development, the total amount of vehicles has grown from 16

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million, in 2000, to 279 million, in 2015, in China. It is estimated that the number would exceed 300 million in 2020. The traffic jams caused by the rapid growth of vehicle numbers have expanded to the medium-sized and even small cities, and there are more than 100 cities with frequent occurrence of traffic jams.

On one hand, land development would definitely lead to higher traffic demand, resulting in greater traffic pressure on the network of urban roads. On the other hand, developers hope to have a safe and smooth transportation environment around their projects to increase the market competitiveness. Therefore, it is necessary to study the inherent link between the projects and the urban traffic demand, reveal the traffic law influenced by the projects nearby, and explore how to coordinate the relations between the two effectively, thus, to promote the cities to develop in a healthy, orderly, and continuous way. Traffic impact analysis is a powerful tool to coordinate the relation between land utilization and urban traffic.

## 2 Traffic Impact Analysis Type

Traffic impact analysis should run through the whole process of land utilization, whether land use planning stage, or in the construction phase of the program, and will have a different impact on the transportation system because of different planning or design. Therefore, the article integrated some provinces and cities of the traffic impact assessment management regulations, taking into account the control plan and the construction of two stages at the same time, but had different priorities on different cities. Considering that “Specification for traffic impact analysis” (Guobiao standards) is applicable to the whole country, it is suggested that the traffic impact analysis can be divided into two types: Development plan scheme and development project.

## 3 Start Threshold

### *3.1 Purposiveness of Start Threshold*

Start threshold is the basis for judging whether the development project needs to carry on the traffic impact analysis, and also determines the necessity of the follow-up work. Different countries or regions have different threshold rules, mainly divided into two categories: one is to divide according to the development project construction scale, that is to say, the traffic impact analysis should be carried out when the scale of the building reaches to a certain extent; the other is the influence degree of road network development projects, that is to say, it is necessary to carry out traffic impact assessment on the degree of traffic impact of different grades of roads.

The first method is simple and easy to control, and it is widely used in the traffic impact analysis of some big cities in China. The second method is to carry out the preliminary traffic assignment for each project, which requires that the basic information is comprehensive and detailed. This method is widely used in foreign countries.

### 3.2 Suggestions of Start Threshold

At present, it is still not mature in China that the threshold method is adopted to produce the influence degree of different grades, because large cities in China have not yet established a complete urban transportation system model to measure the impact of construction projects or planning on the surrounding traffic system. For now, the method to determine the threshold is relatively rough, but the operation is stronger. At the same time, the specified scale of the threshold in a different city is not entirely consistent, therefore, considering similar technical indicators, "Specification for traffic impact analysis" (Guobiao standards) propose requirements only from the perspective of the principle, only from the angle of the principle of the request. More technical parameters and their values will be defined by national or local traffic impact analysis criteria. It is suggested that in the "Specification for traffic impact analysis" (Guobiao standards), the threshold value should be set as follows, to set aside more space for technical standards:

(1) The threshold of traffic impact analysis should be determined based on the plan, the type, scale, and location of the construction project, and the running state of the traffic system.
(2) Traffic impact analysis should be carried out when the scale of the development plan scheme or project reaches the prescribed threshold.

## 4 Research Scope

### 4.1 Quantitative Methods of Research Scope

The scope of the traffic impact analysis should be determined by the scope of the traffic generated by the development project, while this range is mainly determined by the traffic generation intensity of the project, the entry and exit of the projects, as well as the surrounding road network structure. Generally speaking, the larger the amount of traffic generated by the development project, the wider the scope of the traffic impact. On the other hand, for the development projects with similar traffic generation, the more foreign channels they connect with the urban road network, the more traffic flows are generated and attracted, thus, the influence distance is smaller in a single direction. Similarly, the greater the density of the surrounding road network is, the more parallel the roads are, more traffic will be diverted from development projects, and thus, the smaller the range it can radiate.

At present, national and international quantitative methods on the scope of the traffic impact analysis can be roughly divided into two types. One is used in traffic planning procedures, through the method of trial presumption study traffic impact range; the other one is the application of relevant theoretical model assumptions in particular, direct method of calculus study traffic impact range.

After comparison, although two kinds of methods have definite quantitative indexes, the first type applies a very mature traffic distribution or traffic assignment process, which fully reflects the impact of the actual road network. The second type might identify the project as a homogeneous area, or do not take into account the differences in the actual spatial distribution of traffic. The theoretical model describing the city and traffic travel is too simple to reflect the actual situation. In this regard, the first type of approach is superior to the second one in principle. However, there are obvious defects in the first method. In order to determine the scope of the traffic, the operation process of traffic planning should be repeated.

Therefore, in most cities of our country, in the process of traffic impact analysis, it is necessary to adopt a practical and simple method to determine the scope of traffic impact.

## *4.2 Determining Method*

(1) **The minimum limit of traffic impact analysis**. The minimum limit of any development project that reaches the threshold of traffic impact assessment is a single-layer rectangular network, each side of which are made by the city sub-road (or two highways) surrounded, based on the development project.

(2) **The maximum limit of traffic impact analysis**. In Beijing, for example, in the urban construction projects, the maximum limit is a network, each side of which is composed of two layers of the parallel urban rapid road based on the development project. For the development project located in the outskirts of the construction area, the maximum limit is the entire satellite city or metro road network, as well as all the road network composed of external contacts.

(3) **The scope of the calculation program of the traffic impact analysis**

   (a) The scope of traffic impact is estimated based on the type of traffic impact analysis. For small-scale development projects, the minimum limit range can be selected; for large-scale construction projects, the project can be expanded to the nearest urban trunk road or urban rapid road, with its enclosed area as the initial impact.

   (b) It is necessary to establish a target year (traffic impact analysis perspective years) for the road network model, including the initial centroid effect within the road network, preliminary impact on the road network, and the calibration of the section of the road resistance function. At the same time,

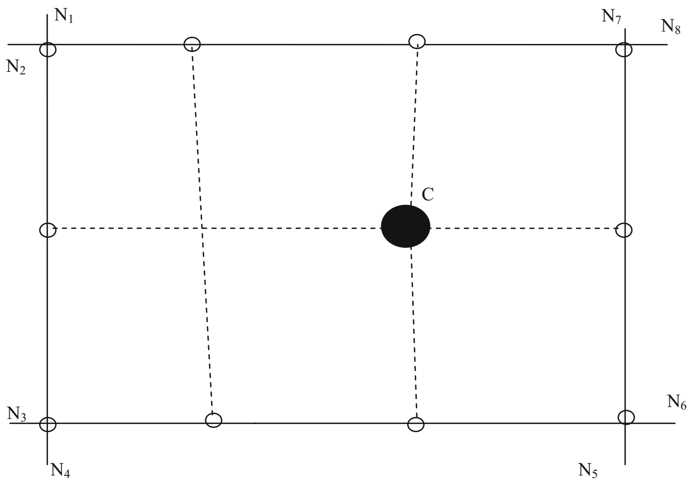


**Fig. 1** Road network model (1)

it is necessary to maintain the openness of the simple road network (in fact, the extension of the road in the model is also extended to the outside of the scope of the original). The scheme is shown in Fig. 1, with C as the centroid of the development project, Ni as road node.

(c) According to the type of development projects, determine the amount of traffic generated based on the relevant standards; determine the proportion of traffic radiation in various directions based on the location.

(d) With the development project as centroid, and endpoint foreign channel network model as a virtual center node, we used the "gravity model" to complete the traffic distribution to obtain the traffic conversion matrix, OD. For Fig. 1, this set of traffic transfer amount is T(C, N1)–T(C, N8), and T(N1, C)–T(N8, C).

(e) Based on this set of traffic OD matrix, traffic assignment is implemented to obtain the traffic volume on each boundary road.

(f) The proportional relation between the traffic generated by the project and the maximum allowable traffic volume at the service level of the road is calculated as follows:

$$R = \frac{V_P}{V_{\max}} = \frac{V_P}{C \cdot r} \tag{1}$$

$V_p$ Project generated traffic;
$V_{max}$ Maximum allowable traffic volume;
$C$ Traffic capacity of the road;
$r$ Specific service level corresponding to the load,which is the ratio of $V/C$.

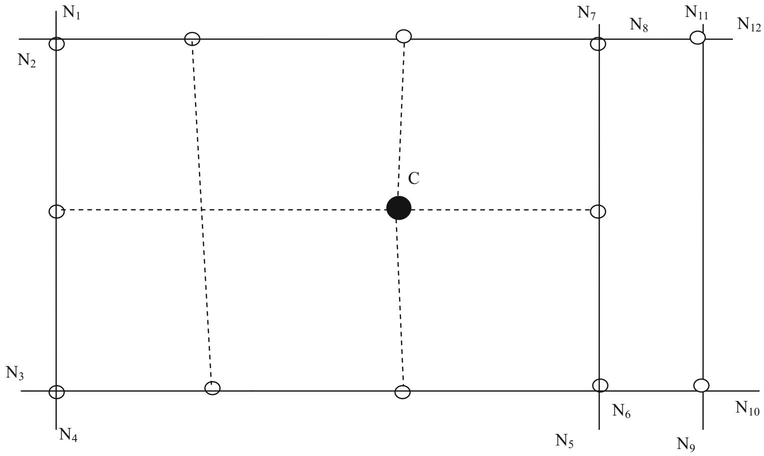


**Fig. 2** Road network model (2)

In Beijing, for example, the agreed standard value of $r$ agreed is as follows: Located in downtown area, $r = 1.0$; Located in the built-up area of the suburbs, $r = 0.9$; Located in the non-built-up area of the suburbs, $r = 0.8$.

(g) If the results of a certain road $R > 5\%$, the scope of the study was extrapolated to the parallel urban trunk road outside the road (or Urban Expressway). Thus, the expanding road network model is established, as shown in Fig. 2.

(h) In the expanding road network model, we need to repeat steps d–f, until there is no longer any peripheral road to reach the standard in step g, or the expansion of the road network has reached the maximum limit of traffic impact assessment. The cycle will be stopped.

At this point, the scope of the presumption can be used as the scope of the traffic impact analysis of development project. Field traffic survey, traffic demand forecasting, and other work will be carried out within the defined area.

# 5 Parking Demand Forecasting

## *5.1 Prediction Model*

Parking demand forecasting has some applications in many big cities in the world. However, the urban development patterns are different in different countries, the social and economic development patterns are different, the parking prediction model is not the same, and there will be a large difference in the calculation. To sum up, there are several kinds of prediction methods:

(1) **Car growth model**. As there is a close relationship between the city's parking demand and the national income and the development of economy and the car ownership rate, so in this model, it is assumed that there is a linear relationship between parking demand and the number of vehicles owned by urban residents. Based on the growth data of cars over the years, a linear regression model is established to calculate the number of cars in the target year. Then, the parking demand of each district is calculated by using the relationship between parking and vehicle ownership. This model can also be used to obtain the nonlinear function relationship between vehicle ownership and parking demand through a large number of statistical data.

$$D_{pi} = D_{bi} \times \frac{C_p}{C_b} \tag{2}$$

$D_{pi}$ Parking demand in zone $i$, in year $p$ (forecast);
$D_{bi}$ Number of parking in base area $I$;
$C_p$ Regional forecast, in year $p$ (forecast);
$C_b$ Number of vehicles in the region.

(2) **Trip attraction model**. The model assumes that the generation of parking demand is related to the social and economic activities in different regions. If the region is able to attract a variety of travel activities, the demand for parking in the region will increase. First, we can get all kinds of travel data for the target year in the region, and then we assign the data to the travel through by the car. Then, the use of the car carrying rate will be converted to the number of vehicles arrived, and finally multiplied by the number of parking peak hours, we can get the peak hours of parking demand. Mathematical models are as follows:

$$D_{pi} = \frac{\left(\sum_{j=1}^{N} \mathrm{TD}_{pij}\right) \times \left(\mathrm{MS}_p\right)}{F_p} \times K \tag{3}$$

$D_{pi}$ Peak hour parking demand in $i$ area, in $p$ year;
$\mathrm{TD}_{pij}$ $i$ area $j$ trip destination number, in $p$ year (There are $n$ kinds of travel purpose);
$\mathrm{MS}_p$ Car traffic distribution coefficient, in $p$ year;
$F_p$ Vehicle carrying capacity, in $p$ year;
$K$ Parking peak value.

(3) **Production rate model**. The production rate model assumes that there is a functional relationship between the parking demand and the land use type and the intensity of each region. The model needs to investigate all kinds of land use and parking rate of the building, and convert them into various types of land unit parking rate. The model is more intuitive and easy to operate, but it needs to be calibrated strictly. Mathematical models are as follows:

$$D_{pi} = \sum_{j=1}^{N} \left(R_{pij}\right)\left(\mathrm{LU}_{pij}\right) \tag{4}$$

$D_{ij}$ Peak hour parking demand in $i$ area, in $p$ year;
$R_{pij}$ Parking demand generation of $j$ land use unit area in $i$ area, in $p$ year;
$\mathrm{LU}_{pij}$ Use area of $j$ land in $i$ area.

(4) **Multiple regression model**. The model assumes that there is a certain relationship between the parking demand in the city and the city's socioeconomic activities and land use, therefore, multiple linear regression analysis is used to build parking demand model. The advantage of this model is that it can reflect most of the factors that affect the parking demand, but the cross relationship between factors is not easy to distinguish. Mathematical models are as follows:

$$D_{pi} = f\left(\mathrm{ER}_{pi}, \mathrm{PO}_{pi}, \mathrm{FA}_{pi}, \mathrm{DU}_{pi}, \mathrm{RS}_{pi}, \mathrm{AO}_{pi}, \ldots\right) \tag{5}$$

$D_{pi}$ Peak hour parking demand in $i$ area, in $p$ year;
$\mathrm{EP}_{pi}$ Number of employed persons in $i$ area, in $p$ year;
$\mathrm{PO}_{pi}$ Population in $i$ area, in $p$ year;
$\mathrm{FA}_{pi}$ Floor area of $i$ area, in $p$ year;
$\mathrm{DU}_{pi}$ Number of households in $i$ area, in $p$ year;
$\mathrm{RS}_{pi}$ Retail floor area in $i$ area, in $p$ year;
$\mathrm{AO}_{pi}$ Car ownership in $i$ area, in $p$ year.

(5) **Traffic volume—parking demand model**. Assuming that there is a functional relationship between the parking demand in each region and the traffic flow through the area, the number of parking demands is assumed to be a function of the number of vehicles passing through the area. Mathematical models are as follows:

$$D_{pi} = f(V_i) \tag{6}$$

$D_{pi}$ Peak hour parking demand in $i$ area, in $p$ year;
$V_i$ Traffic flow in $i$ area, in $p$ year.

(6) **Land use—Parking demand model**. The model assumes that the long-term parking demand is related to the job opportunities, and the short-term parking demand is related to the commercial and retail floor area, while the total parking demand is the sum of long-term demand and short-term demand. Mathematical models are as follows:

$$D_i = A_l\left(e_i \Big/ \sum^{j} e\right) + A_s\left(F_i \Big/ \sum^{j} F\right) \tag{7}$$

$D_i$ Peak hour parking demand in $i$ area, in $p$ year;
$A_l$ Cumulative value of long-term parking demand;
$A_s$ Cumulative value of short-time parking demand;
$e_i$ Employment opportunities in $i$ area;
$e$ Total number of jobs in the central business district;
$F_i$ Floor area of commercial and retail buildings in $i$ area;
$F$ Total floor area of commercial and retail buildings in $i$ area;
$j$ Region number.

(7) **Multivariate geometric mean growth model**. The model assumes that there are geometric mean relation in the growth of parking demand, the growth of population, the number of vehicles, the growth of national income, the floor area of buildings, and other variables. Mathematical models are as follows:

$$D_{pi} = D_{bi}(1 + R_{bi})^{p-b} \tag{8}$$

$$R_{bi} = \sum W_{bij} \sqrt{\prod_{i=1}^{N} r_{bij}^{W_{bij}}} \tag{9}$$

$D_{pi}$ Parking demand in $i$ area, in $p$ year;
$D_{bi}$ Parking demand in $i$ area, in $b$ year;
$r_{bij}$ Population growth in $i$ area, in $b$ year ($j = 1$); Vehicle growth ($j = 2$); National income growth rate ($j = 3$); Floor area ($j = 4$), etc.;
$W_{bij}$ Weighted values of $i$ area in the year;
$R_{bi}$ Annual growth rate of $i$ area, in $b$ year.

## *5.2 Suggestions of Parking Demand Forecast*

To sum up, it is suggested that parking demand forecasting is an important part of traffic impact analysis: In the investigation of the current situation, it is necessary to investigate the situation and operation of the parking system. In the analysis of the new generation of traffic demand, traffic system should be analyzed according to the nature of the use of parking demand, use object, location characteristics, and the supply and demand situation, including the analysis of similar project travel analysis, traffic generation, traffic distribution, mode split and traffic assignment and parking demand forecasting, etc.; In the traffic impact analysis of development project, we should analyze the matching degree between land use and construction scale and the planning of traffic facilities, and analyze the rationality of the arrangement of entrance, internal and external traffic organization and parking facilities.

## 6 Conclusion

As a tool to coordinate land development and urban traffic, traffic impact analysis has been widely used in our country, but there is no national standard to regulate traffic impact analysis. In this chapter, the key technologies of traffic impact analysis, such as traffic impact analysis type, start threshold, research scope, and parking demand prediction. They provide the basis and technical support for "Specification for traffic impact analysis" (Guobiao standards) and the subsequent traffic impact analysis.

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