Traffic Forecasting Method for Passenger Flow of Urban Rail Transit

Jianwei CUI
Chongqing Jiaotong University, Chongqing, 400047,CHINA

Abstract: Passenger flow forecast is based on an important project and the project feasibility analysis, traffic forecasting results not only determine the use of light rail or subway line mode, but also affect the size of nets, driving cross road, the trend line, grid spacing, vehicle marshalling, vehicle the main section of the scale factor, the number of the car, the full range of project cost and other factors. Make urban rail transit planning in particular to ensure that the passenger volume forecast for rail transit construction science, rationality and feasibility of great importance. Rail Transit passenger flow forecast not only in urban rail transit planning is extremely important, it is also the main basis for rail transit construction scale decisions, and plays an important role in the project design.

Keywords: Passenger flow forecast; Rail; Traffic flow

1. Introduction

1.1. Occurrence attraction model

a) The growth rate

The method of the present situation occurred in different partitions (attract) and forecast traffic growth multiplied, resulting in the occurrence of each partition (attract) traffic, the following formula:

(1)

The key problem with this issue is to determine Fi. Can usually be expressed as the index growth rate of each cell occurs (attract) growth rates. Such as:

$$F_i = \alpha_i \cdot \beta_i \tag{2}$$

α_i as regional target population than the base of the regional population;

β_i as target area per capita bicycle ownership rate than the bicycle ownership base year

b) Original unit method

Original unit method divided into two types, Individual original unit method and area original unit method. Individual original unit method use resident population or working population the average traffic volume per occurrence to estimate the amount of travel, Area original unit)method use an average of different types of land area (attract) the amount of traffic to predict the amount of travel.

1.2. Traffic distribution model

This method assumes that the distribution in the form of traffic forecasts is the same as the current distributions in the form, to research the OD table of goals year on this basis. Growth rate method is simple, but it have no ability to be considered urban layout, influence of urban construction changing on urban travel OD, and OD survey will question the status quo into the forecast.

1.3. Transport mode split

Transport mode split into two processes, pre-transportation division model is mainly based on setting partitioning model, called the aggregate model, mainly refers to the period before the 1960s. After 70 years, the division of traffic mode is mainly focused on performance selection model, it is basic assumptions random utility theory and personal travel utility maximization theory, also referred to disaggregate model [1].

Aggregate model mainly include the share ratio curve method and linear regression method. The model of share ratio is findings from personal travel survey results, according to the thought to be the main factors influencing the traffic mode selection (regional distance, the ratio of inter-regional travel time and the difference of walking time indicators), for all modes of transportation are divided. Share ratio curve method is simple, less information required, still use value in the country.

With respect to the share ratio curve, linear regression model can consider the various factors affecting the use of the transport mode. Model variables should be the starting point for trips to generate some kind of partition modes of transport, namely

$$P_{im} = \alpha + \beta_1 L_{O1i} + \beta_2 L_{O2i} + L + \beta_z L_{dzj} \tag{3}$$

Or some mode of transportation to reach the end of a partition to attract the amount of travel

$$A_{jm} = \alpha + \beta_1 L_{d1i} + \beta_2 L_{d2i} + L + \beta_z L_{dzj} \tag{4}$$

Linear regression model developed earlier, but the result of the share ratio determined does not meet this condition: $0 \le P_i \le 1$.

Disaggregate model is based on random utility theory, it is assumed to be selected utility travelers largest selection of items. Utility is a selection of their travelers to reflect the degree of satisfaction.

The basic equations of utility:

$$U_{i,n} = V_{i,n} + \varepsilon_{i,n} \tag{5}$$

Among them:

$U_{i,n}$ -Utility value constituted options i to travelers n .

$V_{i,n}$ -Definable effectiveness of the constituted options i to travelers n

$\varepsilon_{i,n}$ -Uncertain effectiveness of the constituted options i to travelers n , this kind of utility can be calculated explicitly, and vary according to different persons. $V_{nj} = A^{'} \cdot X_n + B^{'} \cdot Z_n + C^{'} \cdot W_{nj} \quad j \in C_n$ (6)

Among them:

V_{nj} -The utility of select branches from travelers n to j .

X_n -The feature vector of select branches from travelers n to j .

Z_j -The property vector of select branch j .

W_{nj} -The Cross vector of travelers character and select branches character.

C_n -The select group option of travelers n .

$A^{'}$, $B^{'}$, $C^{'}$ -Vector of model parameter.

Assumed ε_1, ε_2, $\mathbb{L}, \varepsilon_j$ are independent and subject to the same extreme value distribution, can be deduced:

$$P_{n1} = \frac{\exp(bV_{n1})}{\sum_{j \in C_n} \exp(bV_{nj})} = \frac{V_{ni} - V_{nm}}{\left[1 + \sum_{j \neq m} \exp(b(V_{nj} - V_{nm}))\right]}, \ \forall i, j \in C_n \tag{7}$$

The MNL model is a relatively mature disaggregate model, one of the used models.

1.4. Traffic assignment model

The road distribution network is with the principle of proportionality, of which there are two balances between the principles.

The first principle of War drop: The user of the road network know the status of the network and attempt to select the shortest route, the network will reach equilibrium. In considering the impact of congestion on the network running time, when the network reaches equilibrium, each group's individual OD used paths have equal and minimum travel time, has not been using the path of the travel time is greater or less than the minimum travel time, namely "user equilibrium".

The second principle of War drop: In the equilibrium state, the shortest total travel time of the system, namely that "the system equilibrium."

These principles ignore that the traveler's own and external factors cause the path selection of randomness, there is a big discrepancy with actual situation. Therefore, stochastic equilibrium model (SUE) established for actual traffic plan has theory and actual application value [2].

In the stochastic user equilibrium assignment for r point to s point travelers who choose a valid path k $P_k^{rs}(t)$ satisfy:

$$P_k^{rs} = \frac{\exp(-bc_k^{rs})}{\sum_i \exp(-bc_i^{rs})} = \frac{\exp\left[-\theta c_k^{rs} \Big/ c^{rs}\right]}{\sum_{i=1}^{m} \exp\left[-\theta c_i^{rs} \Big/ c^{rs}\right]} \tag{8}$$

Among them:

c_k^{rs} -The actual traffic impedance for path K

θ -error in the judgment.

For OD points in rs assigned to effective traffic path car traffic volume f_k^{rs} satisfy:

$$f_k^{rs}(t) = q_{rs} \frac{\exp(-bc_k^{rs})}{\sum_i \exp(-bc_i^{rs})} = q_{rs} \frac{\exp\left[-\theta c_k^{rs} \Big/ c^{rs}\right]}{\sum_{i=1}^{m} \exp\left[-\theta c_i^{rs} \Big/ c^{rs}\right]} \tag{9}$$

Wherein q_{rs} is the amount of OD in rs . θ is a dimensionless parameters, regardless of the traffic impedance and variation range is relatively stable, at between 3.00 to 4.00 .For the average urban road network, θ is between 3.00 to 3.50.

2. Improvement of the Four Stage Passenger Flow Forecasting Method

2.1. Traffic generation model

District traffic volume is divided into two steps. First, the number of resident population and the number of jobs in each planning year were calculated, the original unit method was used to calculate the traffic generation and attraction traffic. In which the residential area is used as the main index of the population calculation, the main indicators of the post calculation of the area of land use, industrial land, storage land, urban public facilities, and special land for the population.

Calculation of the occurrence of traffic area and the amount of attraction:

$$\begin{cases} G^m = P\omega^m \\ G_i^m = G^m \cdot u_t^m N_t^m \Big/ \sum_{i=1}^{n} (u_i^m N_i^m) \\ A^m = G^m \\ A_i^m = A^m v_i^m T_i^m \Big/ \sum_s (v_i^m T_i^m) \end{cases} \tag{10}$$

Among:

n -Traffic cell number

P -Total population planning.

ω^m -Per capita trip rate.

G^m -Total travel volume.

N_i^m -i cell travel destination m the occurrence of the original unit volume.

u_i^m -i cell travel destination m the original unit travel rate.

A^m -Total attraction of m for travel purposes.

T_i^m -i cell travel destination m to attract the original unit volume.

v_i^m -i cell travel destination m primary unit travel attraction rate.

2.2. Traffic distribution method for modeling the area and the interval

Taking into account the main factors of traffic volume in the area are traffic volume, traffic volume, area, and the calculation formula of travel distribution:

$$T_{ii} = KG_i^{\alpha} A_i^{\beta} S_i^{\gamma} \quad (11)$$

T_{ii} - i area traffic (travel times).

G_i - i Neighborhood happen traffic number (travel).

A_i - i District to attract traffic number.

S_i - i Plot area.

K, α, β, γ -Multiple linear regression calibration parameters.

2.3. The second phase of the rail transportation division method

The original city without rail transportation, rail transit passenger flow forecast in the planning for the future, considering the existing residents trip survey data is without rail transit data and existing transportation into the future the possibility of rail transit transfer, using two phase partitioning model of rail transit mode.

For the first stage: the original hypothesis predicted years without orbit transportation, by existing travel survey data to build a model, the share rate of calculate the original share rate of each mode of transport.

The second stage: by rail transit intention survey data and the study of time value in the future, set up the transportation to the original transfer rate model of rail transportation, computational prediction in rail transit OD.

3. Case Analysis

Taking Chongqing Rail Transit Line 1 as an example, the passenger flow of line 1 is forecasted. The following steps are as follows:

a) Traffic volume production comes from the attract forecasting

The production of traffic volume prediction is to generate traffic to each traffic area, then getting the number of trips from the different areas. Which Chongqing City, the different purposes of the production forecast of the main city, which is from the number of days per capita travel times multiply by the planning year population of Chongqing urban.

b) The choice of indicators

As far as work is concerned, the amount of the occurrence can be described by the resident population, and the amount of the trip attraction can be described by the employment. On school, the amount of the occurrence and the amount of the trip attraction can be explained by the resident population.

Living shopping is a place of residence, from the characteristics of the facilities which is focus on the malls. The occurrence can explain by the resident population, the attraction can explain by the resident population and jobs.

Other purposes contain official duties, due to the number of people in the future employment will be increased, so the occurrence and attraction all can use the resident population and employment posts as the indicator.

c) The original unit is set to attract occurrence

Since the work to attracting the original units is poor regularity, therefore, according to using about a variety of land to distinguish the original units and settings, while the researching on the basis of 2002 survey and the results of recent. The occurrence of the original unit is set to attract as follows Table1.

Table 1. Distinguish between the each object of the occur and attract about the original units

		The original unit (frequency/person)
Working	Occur	1.37
	Attract	1.03
Going school	Occur	0.35
	Attract	0.25
Shopping	Occur	0.52
	Attract	0.26
Other	Occur	0.21
	Attract	0.22

d) Forecast result and its analysis

According to the sub purpose, taking into account the location of the traffic generation method, the use of planning years of different land use land area and population, can be predicted by the number of daily travel and attract people. 2013、2023, the number of main Chongqing population, they are705.25 million, 1008.79 million, we can forecast the quantum of city are 14034,500 passengers/day,19.974million passengers/ day[3].

e) Traffic distribution model

In addition to the travel to work in the area, going to school in district is also very important part of the area of transportation trip. The all-way trip OD is made up by the walking and motor vehicles produced in the individual, the Railway and Bus not will produce.

According to the calculation method of traffic distribution model as described above, the area with the interval area can be obtained traffic distribution model parameters,

and distribution of results. Their distribution results in the following Table2.

Table 2. Distribution model parameters in cell

	k	α	β	γ
Going school	0.1402	0.5112	0.3635	0.3382
Working	0.1002	0.5657	0.4521	0.5216
Shopping	0.0725	0.4198	0.3965	0.3058
Other	0.3045	0.6245	0.3527	0.4158

f) Traffic mode division model

The calculation results of the model for: 2013, 2023 the number of total travel, Chongqing urban district residents who use the conventional bus and rail transit (hereinafter referred to as the bus line), is about 671.64 million passengers/day, 955.88 million passengers day. Bus line way in 2013, 2023 residents of the main city of Chongqing Rail Transit day trips a total of about 1,180,700 passengers/day, 1.7216 million passengers / day.

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