Economic Impact Analysis of Newly-Built Toll Station Around Jiaozhou Bay based on TransCAD

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Abstract

In view of the problem of rapid increase of traffic congestion in Huanjiaozhou Bay Expressway, it is proposed to set up toll stations between Yinghai Town and Hongshiya Town, and to alleviate the existing traffic congestion problems by establishing toll stations. And promote the economic development of Qingdao Jiaozhou Economic Development Zone. Combined with the data of social and economic base, the road network is modeled with TransCAD software, and the traffic volume distribution in the future year is predicted according to the four-stage method of traffic planning. The reasonable evaluation results of the economic development of Jiaozhou Economic Development Zone in Qingdao were obtained by the newly built toll collection station in Jiaozhou Bay.

Keywords

Traffic congestion; TransCAD; four-stage method; economic development.

1. Introduction

Jiaozhou Bay is the mother's bay of Qingdao. Qingdao has determined the strategic layout of protection and development of Huan Wan. In the northern part of Jiaozhou Bay, Qingdao Hi-tech Development Zone has been set up, and the Jiaozhou Economic and technological Development Zone has been set up in the west. At present, Jiaozhou Bay ring opened the undersea tunnel, cross-sea bridge, Jiaozhou Bay around the high-speed, double-product road and other channels. In the early stage, Jiaozhou Economic and technological Development Zone was a tidal flat to be developed, with less production and living activities. The Jiaozhou Bay Expressway is about 20 km from Yinghai to Hongshiya, and no toll station has been set up. With the construction of the development zone, Residential, colleges, production, logistics and other economic activities are increasingly prosperous, Jiaozhou Development Zone, the volume of travel surge. In order to promote the economic development of the development zone and facilitate transportation, the Jiaozhou branch of the Jiaozhou Bay Bridge is expected to be opened to traffic in 2019. In order to optimize the structure of the regional road network, it is proposed to establish a toll station in the Jiaozhou Bay High Speed Development Zone from Yinghai to Hongshiya. It is connected with the branch line of the cross-sea bridge to form the traffic trunk network for the development zone to travel abroad. The location of the newly built toll station needs to be analyzed in combination with the overall plan of the Jiaozhou Development Zone, the road network, and other social and economic data. The analysis of the impact of new toll booths on local economic development can establish the traffic allocation model to compare the traffic volume and economic development forecast before and after the proposed project, and provide decision support for the government.

2. Basic Steps of Traffic Volume Prediction Based on Four-Stage Method

To study the impact of toll booths set up at high speed around Jiaozhou Bay on the economy of Qingdao Hi-tech Development Zone and Jiaozhou Economic and technological Development Zone. Through the establishment of transcad model, this paper analyzes the effect of adding high speed entrance and exit on the traffic accessibility of Jiaozhou Bay and the development of Jiaozhou Economic Development Zone in Qingdao. The reasonable evaluation results of the newly built toll station around Jiaozhou Bay to the economic development of Jiaozhou Economic Development Zone in Qingdao are obtained. The four-stage method of highway traffic volume prediction mainly studies the occurrence and attraction of highway traffic volume and the relationship between highway traffic volume and social economy. At the same time, the elastic coefficient method is used to predict the highway traffic volume, which is the supplement of the four-step model. The overall research thinking is shown in figure 1.

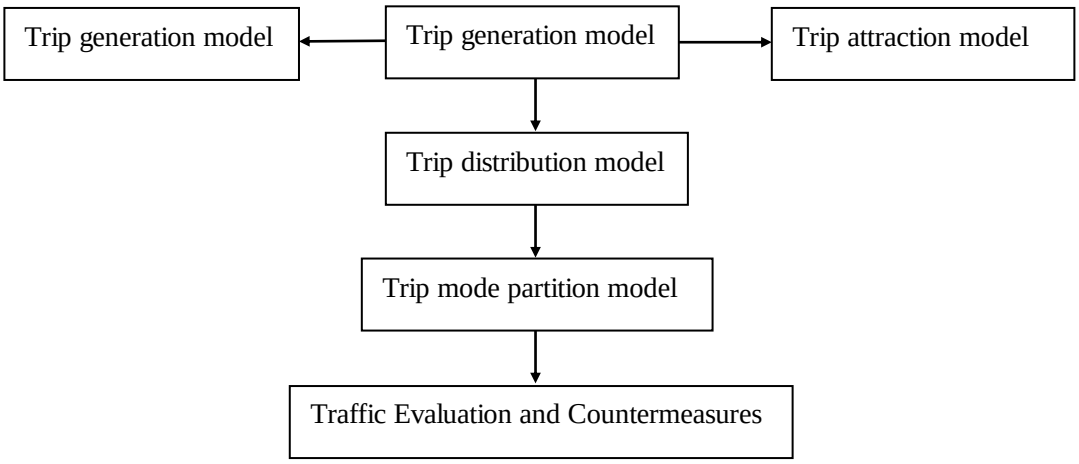

Fig 1. Traffic forecast frame

3. Traffic Forecasting Process Based on TransCAD

3.1 Location of the Proposed Toll Station

According to the construction plan of Jiaozhou branch of cross-sea bridge and the planning of regional road network, the location of new toll station should be located in Jiaozhou Economic Development Zone and form a fast passage with Jiaozhou spur line through S397 road.

The proposed project area is shown in figure 2.

Fig 2. Proposed project location

3.1.1 Compartmentalization of Traffic Zones

According to the geographical location, social and economic development, land use nature, road network structure and traffic distribution of the proposed project, the project is divided into 20 traffic districts on the basis of the areas affected by the proposed project. This includes 14 internal traffic cells and 6 external traffic cells, as shown in figure 3.

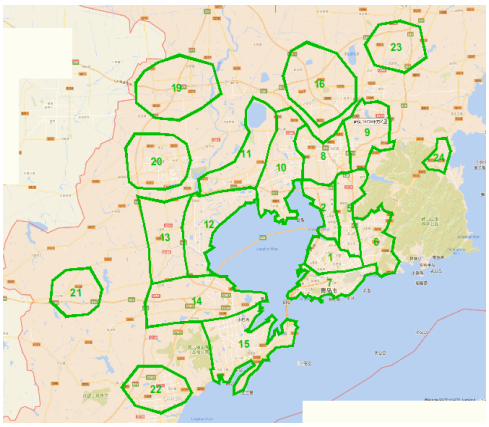

Fig 3. Traffic plot partition diagram

3.1.2 Establishment of Road Networks

Based on the traffic volume of the proposed project area and the road network structure of the surrounding area, a new road network model is established. The distribution of the road network is shown in figure 4. According to the function of TransCAD, two directions (AB direction and BA direction) are created for each road section. According to the different road grades, the road network is constructed by using TransCAD line layer editing tool. The attribute fields of road mainly include road name (name), road design speed (speed), road start and end mark (Node), road traffic volume (count), road design capacity (capacity), road traffic flow time (time) and so on [2].

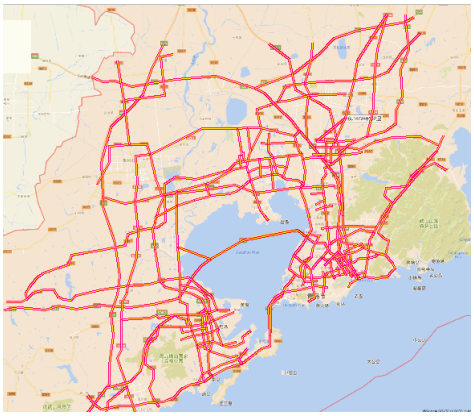

Fig 4. Road network distribution map

3.2 Traffic Generation and Attraction Prediction

The forecasting of occurrence and attraction of traffic volume is the first stage of the four-stage forecasting of traffic demand, and it is one of the most basic parts of traffic demand analysis. Traffic trip generation is forecasted by cross-classification forecasting method, that is, taking family as the basic forecasting unit, the average travel rate of the family is counted, and then the corresponding travel rate is multiplied by the number of basic units of the family. And then through summing up the amount of traffic travel generated by residents. Traffic attraction refers to all home-based travel and non-home-based terminal travel, the use of traffic attraction ratio prediction method, that is, according to the travel rate of each type of land area and unit area to predict traffic attraction traffic generation prediction.

3.3 Traffic Distribution Forecasting

Traffic distribution prediction is to allocate the predicted total traffic generation and attraction to different traffic districts to reflect the spatial flow distribution in the small area. The travel distribution model uses gravity model method, gravity model introduces the impedance between traffic areas, can reflect the impact of land use changes on travel distribution, but also reflect the impact of changes in transport facilities on travel distribution. Qingdao is a rapidly developing city, and the land use will change greatly in the future. Gravity model method can fully reflect the change of the city[3]. Gravity model method is more comprehensive in traffic distribution prediction, especially this method emphasizes the interaction between the local and the whole[4], combined with the travel characteristics of residents in various districts of Qingdao, gravity model method can objectively reflect the reality. Formula of gravity model method:

$$T_{ij} = K_i K'_j P_i A_j f\left(R_{ij}\right)$$

$$K_i = \left(\sum_j K'_j A_j f\left(R_{ij}\right) \right)^{-1} \ (i = 1,.....,n)$$

$$K'_j = \left(\sum_i K_i P_i f\left(R_{ij}\right) \right)^{-1} \ (j = 1,.....,n)$$

T_{ij} is the Traffic volume between i and j, P_i is the travel yield of i in traffic district, A_j is the travel attraction of traffic district j, K_i , K'_j is the constraint coefficient of trip yield and trip attraction, $f\left(R_{ij}\right)$ is the friction factor.

According to the travel characteristics of Qingdao residents and the complexity of the road network, the impedance function is used to predict the friction factor. The PA matrix of prediction results is shown in Table 1.

Table 1. PA matrix

ID	Area	Base_P	Base_A	BALANCE.Base_P	BALANCE.Base_P
1	53.91	2160	2560	2160	2502.44
2	46.81	2170	2200	2170	2150.54
3	68.07	2020	2220	2020	2170.09
4	71.92	2702	2582	2702	2523.95
5	65.97	2087	2337	2087	2284.46
6	87.83	2103	2130	2103	2082.11
7	86.29	2803	2873	2803	2808.41
8	126.08	3403	3530	3403	3450.63
9	118.81	2209	2309	2209	2257.09
10	119.4	2708	2708	2708	2647.12
11	118.71	2206	2277	2206	2225.81
12	162.45	2506	2450	2506	2394.92
13	152.81	1777	1797	1777	1756.6
14	159.01	1648	1864	1648	1822.09
15	152.83	1842	1429	1842	1396.87
16	117.25	1707	1878	1707	1827.96
17	73.11	1673	1683	1673	1645.16
18	86.44	1586	1516	1586	1481.92
19	87.89	1971	1999	1971	1954.06
20	20.9	898	809	898	790.81

3.4 Traffic Mode Classification

The traffic mode division is the third stage of the four-stage traffic demand forecasting method. Its main purpose is to divide the traffic volume between different districts into the distribution of various traffic modes. According to the "Bay Bridge Traffic Forecast and Analysis report" and the proposed project around the traffic volume of investigation and determination.

3.5 Traffic Allocation

The assignment of traffic volume is the last stage of the four-step traffic demand model. The purpose of traffic assignment is to assign the O-D traffic volume matrix of various traffic modes to the roads of the traffic road network according to a certain method. Find out the travel volume of various travel modes newly generated by the proposed project, and then convert the new motor vehicle traffic volume. Finally, the new traffic volume is distributed and distributed in the study area. The traffic assignment models in TransCAD software include all-in-nothing model, stochastic model, incremental load model, capacity limitation model, user equilibrium model, stochastic user equilibrium model and system optimal model. According to the characteristics of Qingdao road network and the establishment of the model, the user balance model is adopted [5]. The user equilibrium model is based on Wardrop's first principle. The core of the model is that the road users will not shorten the travel time by changing the path.

4. Comparison and Analysis of The Forecast of the Proposed Project

4.1 Impact of the Proposed Toll Station on the Jiaozhou Bay Ring Road

A toll station will be built between Yinghai Town and Hongshiya. The toll station will be upgraded from east to west. It will be connected with the Jiaozhou spur Line in the east and the Jiulong Interchange Toll Station at the Shenhai Expressway in the west, forming an east-west expressway in the Jiaozhou Development Zone. In order to form a convenient distribution channel for the cross-sea bridge, the traffic flow in the service area can be effectively attracted to the bridge. At the same time, the distance between the bridge and G22 13km (Fig. 5), the density of the road network becomes reasonable, the capacity of the road network and the level of road service are also improved correspondingly, which further exerts the traffic guidance and radiation driving role of the sea-crossing bridge to the development of the integration of the two sides of the Taiwan Straits.

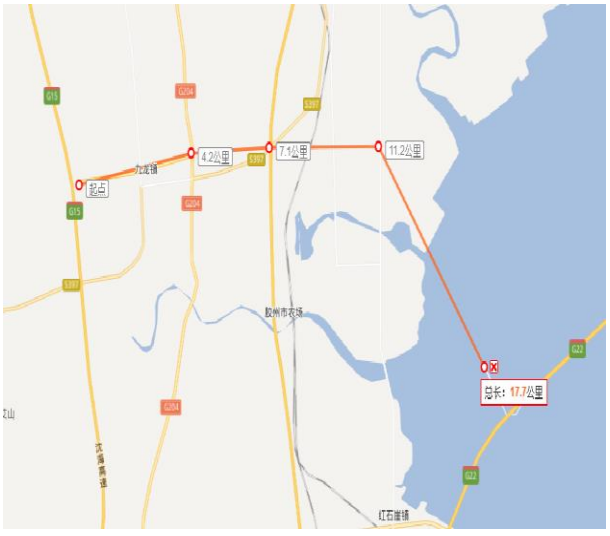

Fig 5. Circumjacent Jiaozhou Bay High Speed Link

4.2 Analysis of the Travel Costs of the Proposed Toll Booths

The final purpose of toll station construction is the most effective use of the bridge, in order to guide and promote the integrated development of Jiaozhou Bay Expressway. The starting price of toll

collection station should be considered in combination with the southern tunnel and Jiaozhou Bay Expressway. The starting price should be moderate and the adjustment of toll price should follow a gradual and orderly way to avoid big ups and downs. This can attract traffic flow to the greatest extent in the early stage, promote the development of the two sides of the strait, thus further increase cross-strait exchanges, forming a virtuous circle, the benefits of the cross-sea bridge will be correspondingly improved.

4.3 Impact of Proposed Toll Booths on Connectivity of Qingdao Jiaozhou Economic Development Zone

The direct economic benefit of the Jiaozhou Economic Development Zone means that after the completion of the proposed project, the traffic situation of the Jiaozhou Economic Development Zone has been improved, the transportation cost has been reduced, and the development of the road transport industry has been promoted. Stimulate the increase in interregional passenger and freight traffic generated by the road user benefits for the Jiaozhou Industrial Park travel convenience. As far as Qingdao port development is concerned, the completion of the proposed project and the reduction of travel costs can not only strengthen the cooperation among Qingdao Old Port, Qianwan Port and Oil Port, but also give full play to the overall lessons of the port. Therefore, it is necessary to make full use of the unique geographical location of the development zone, as well as transportation, to ensure smooth transportation of ferries, roads around the Jiaozhou Bay and cross-sea bridges, as well as tunnels in Haiti. This will play a more positive role in the economic development of Qingdao and the development zone.

5. Prospect

After the completion of the proposed toll station project, improve the traffic situation of Jiaozhou Economic Development Zone, reduce transport costs, promote the development of the road transport industry, stimulate the increase in interregional passenger and freight traffic generated by the road user benefits. On this basis, it is suggested to further optimize the expressway network around Jiaozhou Bay and upgrade S395 into a four-lane expressway, so as to improve the road capacity of S395, at the same time, transform the Yinghai overpass and improve the traffic conditions and investment environment in the service area. Strengthening the role of economic and cultural radiation of the central city has made important contributions to the macroeconomic growth, industrial structure adjustment and optimization of the layout, urbanization development of the areas along the line, and has produced enormous economic benefits and positive social impact.

6. Conclusion

Taking the proposed toll station in Huanjiaozhou Bay as an example, this paper studies the positive impact on Qingdao's economic development, regional traffic convenience and road connectivity after the completion of the toll station. On the one hand, in order to expand the economic hinterland of Qingdao, especially strengthen the economic ties with Rizhao, the proposed Jiaozhou Bay high-speed toll station provides a transport carrier for promoting the integration of Qinghai-Weizhao and Japan. On the other hand, promoting the economic development of Jiaozhou Economic Development Zone plays a vital role in ensuring the employment of people along the route and facilitating the travel of employees.

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