The design of the traffic plan of line S1 of Taizhou railway in Zhejiang Province

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Abstract. At present, China is in the period of rapid urbanization construction, and gradually build a set of efficient, new and fast comprehensive urban transportation system. The urban railway construction with the same city commuter and convenient public transport service can effectively extend the urban development space and accelerate the adjustment process of urban planning and layout. According to the current situation of Taizhou's economic and traffic development, as well as Taizhou's unique geographical advantages, combined with the relevant research at home and abroad, this paper comprehensively discusses the necessity of building Taizhou City railway line S1. By sorting out the relevant preliminary, short-term and long-term passenger flow forecast data, this paper calculates the maximum section passenger flow in each period of the day, analyzes the characteristics of passenger flow in each period, compiles the full-time driving plan compilation data, and makes corresponding adjustments according to the actual situation, and finally designs the full-time driving plan to meet the passenger flow demand in each period. The second chapter describes the research background, the third chapter analyzes the characteristics of passenger flow, and the fourth chapter designs the driving plan and draws the train diagram.

1. Introduction

Taizhou city is located in the central coastal area of Zhejiang Province. Its spatial structure is "one heart, six veins and four groups"[1]. Taizhou city is composed of Jiaojiang District, Luqiao District and Huangyan District[2]. Although there is a trend of integrated development, the development is relatively scattered, and the population and urban construction scale of each district is relatively small. Taizhou city planning S1 line city railway, will highlight the central city of Taizhou as the core, gradually form the "12459" network urban agglomeration spatial structure, further enhance the central position of Taizhou city[3]. In a word, from the aspects of realizing the master plan of Taizhou City, planning the city railway system to meet the needs of Taizhou city's urban development and citizens' travel, improving residents' travel conditions and realizing the urban development goals, improving the urban comprehensive transportation system, implementing the priority development strategy of Taizhou Public Transport, and realizing the needs of sustainable development of the city, the planning and construction of Taizhou City railway line S1 phase I project is very urgent and necessary[4].
2. Design background

2.1. Line overview
After field investigation, the first phase of Taizhou City railway line S1 will run in a north-south direction. The line starts from the passenger terminal station, turns south after leaving the station, and then goes southeast along the Central Avenue and Nanguan avenue to the south end of Nanguan Avenue. The line goes from fengjiang to the west of Zeguo town in Wenling, and then goes along Yingbin Avenue and Zhanqian road to Wenling railway station, and then goes along Zhanqian road after leaving the station Yingbin Avenue, Chengxi Avenue, Zhonghua Road, Stadium Road, South Ring Road to Wenling south bus station, the terminal of phase I project. The line will ease the passenger flow distribution of Taizhou Wenling railway station, Wanchang Road station, Wenling south bus station and other important hub stations, as well as establish the urban rapid connection channel between Jiaojiang, Luqiao and Wenling group.

2.2. Distribution of stations along the line
The total length of Taizhou City railway line S1 is 43.381km, with 16 stations, including passenger terminal station, citizen square station, Kaifa Avenue station, Yintai city station, Hongjia station, convention and Exhibition Center Station, Xin'an West Street station, fengjiang station, Zeguo station, Wenling railway station, Hengfeng station, Zhongxin Avenue station, Chengxi station, Wanchang Road station, Wenling Stadium station Wenling south bus station. Among them, there are 5 underground stations and 11 elevated stations. The starting point of the line will also be the transfer station of line S2. The average station spacing is 2.87km, the maximum station spacing is 6.551km from fengjiang station to Zeguo station, the minimum station spacing is 1.52km from Chengxi station to Wenling Stadium station, and a parking lot is set in the east of Wenling south bus station.

3. Passenger flow analysis
According to the existing data, the passenger flow forecast of Taizhou City railway line S1 can be divided into initial, short-term and long-term. The initial forecast results show that the daily passenger flow is 72636 person times up and 73703 person times down; The short-term forecast results show that there are 182602 passengers going up and 184120 passengers going down; The long-term forecast results show that the daily passenger flow is 275618 and 277656 respectively.

According to the proportion of the predicted passenger flow in each period of the day in the figure, the maximum section passenger flow in each period of the day can be obtained by multiplying the total passenger flow in the whole day. After calculation, the maximum section passenger flow data of line S1 at the beginning, near and long term of the day are shown in Table 1.

| Operation time | Initial maximum section passenger flow | Recent maximum section passenger flow | Long term maximum section passenger flow |
|---------------|--------------------------------------|--------------------------------------|----------------------------------------|
| 5: 00-6:00    | 2780                                 | 5501                                 | 5533                                   |
| 6: 00-7:00    | 10097                                | 27504                                | 43155                                  |
| 7: 00-8:00    | 24146                                | 54275                                | 80778                                  |

4. Driving plan design

4.1. Full day traffic planning information
The number of train personnel is the product of the number of train marshalling vehicles and the number of vehicles[5], and the formula is as follows,

\[ p_t = m \times p_d \]  

(1)
Where, \(Pt\) is the number of train personnel (person); \(M\) - number of train formation (vehicles); \(Pd\) - fixed number of vehicles (person).

According to the data, it is determined that the number of train formation is 6 and the number of train personnel is 1114. Full load ratio of \(\beta\) It refers to the utilization rate of train carrying capacity on a specific section in unit time[5]. The formula is as follows,

\[
\beta = \frac{p_{\text{max}}}{c_{\text{max}}} \times 100\%
\]

(2)

Where, \(\beta\)- Full load rate of train; \(P_{\text{max}}\) - one way maximum section passenger flow (person); \(C_{\text{max}}\) - capacity of line energy transmission in peak hours (person).

According to the data, the transportation capacity of the line in peak hours is determined to be 33420 people, and then the full load rate of the train in unit time is obtained according to the calculated one-way maximum section passenger flow in the whole day. Table 2 shows the full load rate of trains in the initial, near and far phases.

Table 2. Table of full load rate of train in partial period of the whole day at the beginning, near and long term of line S1

| Operation time | Initial full load rate | Recent full load rate | Long term full load rate |
|----------------|------------------------|-----------------------|-------------------------|
| 5:00-6:00      | 4.19%                  | 8.26%                 | 8.31%                   |
| 6:00-7:00      | 15.22%                 | 41.32%                | 64.80%                  |
| 7:00-8:00      | 36.39%                 | 81.54%                | 121.30%                 |

The full load rate of the train reflects the full load degree of the train running in the peak hour of the maximum passenger flow section. Because the line is designed as urban rail transit, the method of overloading properly in the peak hour will be adopted when setting the full load rate. According to the calculation data, the full load rate is set as 110% in the early and recent peak period, 90% in the normal peak period, 130% in the long-term peak period and 90% in the normal peak period.

4.2. Preparation of all day driving plan

The number of trains per hour in the whole day \(n_i\) refers to the number of trains that can be operated on the line in each time period. The formula is as follows,

\[
n_i = \frac{P_{\text{max}}}{pt\beta}
\]

(3)

Where, \(n_i\) is the number of hourly trains in the whole day (pairs); \(p_t\) - the number of train personnel (person); \(P_{\text{max}}\) - passenger flow of discontinuous surface in time sharing maximum area; \(\beta\)- Acceptable full load rate of line section.

According to the determined full load rate of trains in each period, the number of trains in each hour during the operation time can be calculated. Headway refers to the interval between two passenger trains in the same direction. The formula is as follows,

\[
t_j = \frac{3600}{n_i}
\]

(4)

Where, \(t_j\) is the interval time between trains (s); \(n_i\) - the number of trains running in the whole day (pairs).

In order to improve the service level and facilitate the travel of passengers, the design adjusts the driving interval of each period. The adjustment measures will consider the following factors; ① Meet most of the passenger demand. ② Considering the main line traffic organization, and convenient to carry out the yard construction organization. ③ Comply with relevant international or domestic industry standards. For example, the minimum running interval of the train in the initial peak period should not be greater than 5min, the maximum running interval in the peak period should not be
greater than 10min, the minimum running interval in the long-term peak period should not be greater than 2min, and the maximum running interval in the peak period should not be greater than 6min[5].

After integrating the calculation results and considering the actual factors, the full day driving plan of the initial stage, short term and long term is obtained. The full day driving plan is shown in the Table 3.

Table 3. Full day operation schedule of line S1

| Operation time | Initial train (pairs) | Initial headway (s) | Recent train (pairs) | Recent headway (s) | Long term train (pairs) | Long term headway (s) |
|----------------|-----------------------|--------------------|----------------------|--------------------|------------------------|----------------------|
| 5:00-6:00      | 6                     | 600                | 6                    | 600                | 6                      | 600                  |
| 6:00-7:00      | 6                     | 600                | 14                   | 257                | 22                     | 164                  |
| 7:00-8:00      | 10                    | 360                | 22                   | 157                | 28                     | 129                  |
| 8:00-9:00      | 7                     | 514                | 17                   | 212                | 26                     | 138                  |
| 9:00-10:00     | 6                     | 600                | 14                   | 257                | 22                     | 164                  |
| 10:00-11:00    | 6                     | 600                | 6                    | 514                | 9                      | 360                  |
| 11:00-12:00    | 6                     | 600                | 9                    | 360                | 14                     | 257                  |
| 12:00-13:00    | 6                     | 600                | 6                    | 600                | 6                      | 600                  |
| 13:00-14:00    | 6                     | 600                | 7                    | 450                | 11                     | 327                  |
| 14:00-15:00    | 6                     | 600                | 8                    | 450                | 12                     | 300                  |
| 15:00-16:00    | 6                     | 600                | 11                   | 327                | 16                     | 212                  |
| 16:00-17:00    | 6                     | 600                | 13                   | 257                | 20                     | 171                  |
| 17:00-18:00    | 7                     | 514                | 16                   | 212                | 20                     | 171                  |
| 18:00-19:00    | 7                     | 514                | 15                   | 240                | 25                     | 144                  |
| 19:00-20:00    | 6                     | 600                | 8                    | 450                | 11                     | 327                  |
| 20:00-21:00    | 6                     | 600                | 6                    | 600                | 6                      | 514                  |
| 21:00-22:00    | 6                     | 600                | 6                    | 600                | 6                      | 600                  |
| 22:00-23:00    | 6                     | 600                | 6                    | 600                | 6                      | 600                  |

4.3. Drawing of train diagram

This line is designed for Taizhou City railway, which is divided into initial operation diagram, short-term operation diagram and long-term operation diagram. The bipartite diagram which is widely used in urban rail transit system with larger running interval is selected. The abscissa of the diagram is time and the ordinate is distance. The horizontal axis takes two minutes as a unit, and is divided by vertical lines. The painting time is from 4 a.m. to 24 p.m.

According to the calculated whole day driving plan, the early, near and far operation diagrams can be drawn. During the peak period of operation, in order to meet the demand of passenger flow, an appropriate number of additional trains will be opened before the peak period. After the peak period, some additional trains will return to the parking lot of Wenling south bus station. Some trains will pass through the middle section without stopping when there are no passengers. The initial, short-term and long-term train operation diagrams are shown in Figure 1, Figure 2 and Figure 3.
5. Conclusion
In order to adapt to the rapid development of Taizhou's urban economy and transportation in recent years, Taizhou's urban railway line S1 will be used as an important urban transportation framework to connect the city, and the planned line S2 will be used as the backbone transportation line of the city together to coordinate the spatial structure of Taizhou's urban development. As the daily transportation planning task of urban rail transit lines, the whole day operation plan will become the basic data for compiling train diagram, which determines the number of trains per hour on urban rail transit lines during operation time. The design is based on the passenger flow forecast plan. In the preparation of the whole day driving plan, the passenger flow forecast results and the actual situation of the line are fully considered, which can ensure that the design conclusion meets the passenger flow demand and operation economy and other conditions. Future research can consider the traffic organization in abnormal or emergency situations, and further plan the appropriate traffic organization plan in turn.

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