

СЕКЦИОННЫЕ ЗАСЕДАНИЯ

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RESEARCH ON THE OPTIMIZATION OF INTERCITY RAILWAY TRAIN OPERATION SCHEME BASED ON PASSENGER TRAVEL CHARACTERISTICS: TAKING GUANGQING INTERCITY AND GUANGZHOU EAST RING INTERCITY RAILWAY AS AN EXAMPLE

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1 Introduction

The national "Medium and Long-term Railway Network Planning (2016–2025)" proposes that while giving priority to the use of high-speed railways and general-speed railways to operate intercity trains to meet the needs of intercity passenger flow, it is necessary to plan and build intercity railways that serve commuter functions and drive the development of new urbanization, effectively connecting cities within various regions. In recent years, many ministries and commissions of the state have jointly issued the "Guiding Opinions on Promoting the Development of Urban (Suburban) Railways" and other documents, clearly proposing to promote the development of multi-standard rail transit systems in an orderly manner through top-level design, further build a modern metropolitan circle on the track, and promote the "four-network integration" of trunk railways, intercity railways, urban (suburban) railways and urban rail transit.

Intercity Rail is a dedicated railway passenger line dedicated to serving adjacent cities or urban agglomerations. At present, the "seat rate" of China's intercity railway is not high as a whole, especially the downturn in passenger flow in the early stage of the opening of the line, resulting in losses for most operating enterprises. The reason is that most intercity railways are still in the passenger flow cultivation period and the cultivation time is long; Second, due to the mismatch between the existing operating mode of intercity railway and the current situation of passenger flow, it is mainly reflected in the train operation plan.

2 Research status of intercity railway train operation plan

2.1 Research status of train running plan

According to the commuting characteristics of intercity railways, to meet the short-distance passenger flow and realize the operation of public transport, according to the needs of the allocation of train operation maps, the current domestic

intercity railway train operation map can be subdivided into daily operation charts, weekend operation charts and holiday operation charts, of which holiday operation charts and weekend operation charts are usually line peak hours operation charts.

The technical standards of intercity railways are generally based on the establishment of an independent high-speed railway system, and only high-speed trains on the line generally run, but there are some intercity railways connected with passenger lines with other technical standards, and the operation of cross-line trains occurs. In terms of optimizing the stopping plan, Shao Changhong et al. proposed a high-speed railway train stop scheme design method based on the standardized operation chart by first compiling the full-capacity standardized train operation map of the line, and then using the route selection method to compile the cross-line train operation line. This method is a practical high-speed rail stop scheme design method that satisfies the frequency, balance, accessibility and maximum utilization of the passing capacity of the train, and realizes the coordinated optimization of the Beijing-Shanghai high-speed railway train stop scheme and the train operation map. However, the heuristic solution method cannot guarantee that the solved stop scheme is optimal, and the precise solution algorithm of the mathematical model will be further studied, and the design method of the Beijing-Shanghai high-speed railway train stop scheme based on the standardized train operation chart will be improved, so as to provide a research basis for the design of the stop scheme of the high-speed railway train [1, 2].

In terms of optimizing the transfer continuity, Li Tianqi, Nie Lei, etc. established a multi-objective mixed integer programming model based on the optimization of the high-speed rail periodic train operation map, and made optimization improvements on the basis of the CPF model and research results, and improved the transfer service quality from the three aspects of transfer frequency, dynamic continuity and transfer time. The model introduces the optimization goal of passenger flow OD transfer service frequency constraint and minimizes the lack of transfer service frequency, so that the model not only considers the passenger transfer demand caused by some ODs due to no direct train access, but also takes into account the increase of fast transfer services for passenger flow OD with insufficient direct service frequency of trains. She also proposed that the refinement of the transfer design such as the station connection capacity, the reasonable number of trains and the robustness of the connection needs to be further studied [3].

2.2 The current situation of domestic intercity train operation plan

The railway passenger train operation plan determines the operation section of the passenger train, the type of train, the path, the number of driving pairs and the plan of the undercarriage bureau. Intercity railway is a regional rail transit system, which mainly serves the passenger flow between central cities, sub-central cities and towns under the jurisdiction of cities in the urban economic circle [4]. As the basis for the daily operation organization of intercity railways, the train operation

plan determines the logarithm of train operation, stop plan, and marshalling type. Through the survey, it is found that the current domestic intercity railway operation plan mainly has the following characteristics:

(1) The departure interval is large. Taking the Guangqing Intercity Railway as an example, the departure interval reaches 30 minutes, which causes the waiting time of passengers to be too long and has not achieved "public transportation", which is not conducive to attracting and stabilizing passenger flow during the passenger flow cultivation period.

(2) The train stops in a single mode. At present, intercity railways mostly adopt the stop-stop mode of station stopping, and a single stop-stop mode cannot adapt to the existing time-space distribution of passenger flow, resulting in a mismatch between the service frequency and demand of stations along the line, thereby increasing passenger transfer time, travel time in transit, and resulting in waste of transportation capacity and increasing train stopping costs.

(3) The train marshalling mode is single. Due to the uneven distribution of intercity railway passenger flow in time and space, under the single marshalling mode, the train capacity cannot be fully utilized, resulting in waste of transportation capacity and enterprise losses. In order to stop losses, the operating company will reduce the number of trains running logarithm or reduce stops, resulting in an increase in train departure intervals and a decrease in the frequency of service at some stations, forming a vicious circle [5–8].

At present, most scholars use a two-tier planning model to optimize the operation plan by considering the total operating cost of the train, the total travel time of passengers, the number of passengers lost and the number of trains [9–10]. Through the investigation of the daily passenger flow of intercity railways, it is learned that the passenger flow demand of intercity railways has obvious time-varying characteristics, and the passenger flow demand between the same OD pair will change with time. Therefore, studying the optimization of train operation schemes based on passenger travel characteristics and improving the service level of intercity railways is conducive to the passenger flow attractiveness of intercity railways.

3 Passenger travel characteristics of Guangqing Intercity and Guangzhou East Ring Intercity Railway

3.1 Passengers live far from the station and travel less frequently

Through the investigation of Guangqing Intercity and Guangzhou East Ring Intercity Passenger Flow OD, it is found that most of the passengers' residences are far away from the Guangqing Intercity and Guangzhou East Ring Road lines, and the frequency of passengers taking intercity railways is not frequent, and most people have not yet taken Guangqing Intercity and Guangzhou East Ring Intercity. Most of the passengers who choose to take the Guangqing Intercity and Guangzhou East Ring Intercity are for commuting or school needs. At the same time, due to the short opening time of the Guangqing Intercity and Guangzhou East Ring Intercity Lines, the service equipment and facilities of the relevant stations are not perfect, and the nearby

supporting services and transportation facilities are not perfect, resulting in inconvenience for passengers; In addition, there are alternative transportation schemes, passengers can choose to take the subway from Baiyun Airport North Railway Station to Guangzhou North Railway Station, and high-speed rail and Pusu also have routes from Guangzhou to Qingyuan. There are more options for passengers, and the attraction of intercity railways is not enough. The data on the distance from the passenger's place of residence to the station and the number of rides per week obtained from the specific questionnaire survey are shown in Table 1 and Table 2 below, respectively.

Table 1 – Survey of the distance distribution from the passenger's place of residence to the station

Station	Less than 5 km	5–10 km	10–20 km	More than 20 km	Total
Huadu station	15 (30,61 %)	17 (34,69 %)	7 (14,29 %)	10 (20,41 %)	49
Qingcheng station	12 (30 %)	10 (25 %)	9 (22,5 %)	9 (22,5 %)	40
Baiyun Airport North Station	13 (20,63 %)	20 (31,75 %)	14 (22,22 %)	16 (25,40 %)	63
Other intermediate stations along the line	9 (12 %)	25 (33,33 %)	14 (18,67 %)	27 (36 %)	75
Other	18 (11,76 %)	7 (4,58 %)	24 (15,69 %)	104 (67,97 %)	153

Table 2 – Survey of passenger travel frequency by Guangqing Intercity Railway

Number of rides per week	Person	Rate, %
Less than one time	284	74,74
One time	48	11,84
Two times	30	7,89
More than three times	21	5,53

3.2 Most of them are commuter passenger flow, and the passenger flow increases significantly during the morning and evening peak periods

Through the investigation and analysis of the passenger flow between Guangqing Intercity and Guangzhou East Ring Intercity, it is learned that the current weekday passenger flow is concentrated in the morning and evening peak hours, and the full load rate is still at a low level; From the passenger flow weekly distribution data, it can be seen that the weekend passenger flow has increased significantly compared with the weekday passenger flow, and the reason is mainly due to the attraction of tourist resources along the route; Judging from the OD

distribution data of passenger flow, the passengers from the beginning to the end account for the vast majority, and the passenger flow at the intermediate station accounts for a very small number. Therefore, accurately grasping the travel characteristics and needs of intercity passengers, and adjusting the train operation plan on this basis, and maximizing the passenger flow is an issue that intercity railway operators need to focus on.

3.3 The line is relatively independent and has not yet formed a good connection with other lines

Guangzhou East Ring Intercity Railway consists of the first phase of the northern section (Huadu Station to Baiyun Airport North Station), the second phase of the northern section (Baiyun Airport North Station to Zhuzi Station) and the southern section (Zhuzi Station to Panyu Station), the northern section originally belonged to the new Baibai section of the Suizhou-Shenzhen Intercity Railway, and the southern section originally belonged to the Guangzhou-Foshan Ring Line Intercity Railway. At present, only the first phase of the northern section of Huadu Station to Baiyun Airport North Station has been opened, and the second and southern sections of the northern section of the Guangzhou East Ring Intercity Railway are still under construction, and will be interconnected with the Guangzhou-Foshan South Ring Intercity Railway after completion. Therefore, at present, it has not been connected with other intercity railway lines such as Xinbaiguang Intercity, the road network structure is relatively simple, and it is in the early stage of opening, and the passenger flow attraction is very limited.

3.4 The land development of the stations along the line is insufficient, and the growth of passenger traffic is relatively slow

Intercity rail transit is positioned as a metropolitan circle, economic zone between cities, the service object for short- and medium-distance passengers, intercity railway after completion, can improve the comprehensive level of competition in urban agglomerations, economic zones and other areas, give play to the central city's radiation drive, functions and complementary coordination functions between surrounding cities, is conducive to the integration of economic and social implementation, promote the diversified development of economy and society, and further plan the reasonable division of labor between cities [11].

Guangqing intercity rail transit is a fast channel between Guangzhou and Qingyuan intercity, mainly responsible for the passenger flow between Guangzhou and Qingyuan city and northern Guangdong and the Pearl River Delta region and the passenger flow between cities and towns along the line, which can strengthen the core role of Guangzhou as a national central city and the 1-hour city circle from Guangzhou to Qingyuan, and is a green transportation mode to improve regional land development, meet the high quality and convenient travel of residents along the line, and effectively support the development of cities and surrounding villages and towns along the route. However, the development of land at stations along the

intercity railway will also directly affect the attraction of intercity railway passenger flow. Up to now, the Guangqing intercity has been open for nearly 1 year, but due to the insufficient land development of the stations along the line, the current passenger flow along the line is still at a low level.

4 Optimization suggestions for intercity railway transportation organization in Guangqing

4.1 Implement the intercity railway public transport operation model

Compared with the traditional railway operation mode, the intercity railway public transport operation mode needs to be improved in terms of ticket service, station service, train service, etc., to improve the service level of intercity railway and attract more passenger flow.

In terms of ticketing services, advocate the implementation of a diversified ticketing system and improve the convenience of ticket purchase and refund; At the same time, Guangqing Intercity and Guangzhou East Ring Intercity, as the representatives of the intercity railway lines operated by the subway company for the first time in China, should adapt to the needs of public transportation operations in terms of ticket services, strive to achieve interconnection with subway tickets, realize "one ticket", reduce passenger travel chain obstacles, and improve the travel efficiency of passengers.

In terms of station services, mutual recognition of security inspection is implemented with the subway, high-speed rail and Pudong Railway, and the passenger waiting mode can also refer to the urban rail transit waiting mode, and passengers can directly enter the platform to wait for the train after brushing the ticket into the station, without waiting in the waiting hall; At the same time, platform doors are installed on the platform to improve the safety and comfort of passengers waiting; The design of the station entrance and exit should be integrated with the development of the city to facilitate the travel of passengers.

In terms of train services, the implementation of unlimited trains, unlimited seats, on-the-go transport organization mode, passengers can choose to ride without seats or wait for the next train according to their own situation, improve the flexibility of passengers boarding.

4.2 Multiple stop modes are adopted

The train operation scheme of the fixed stop mode is difficult to adapt to the imbalance of the temporal and spatial distribution of passenger flow in the intercity railway. Explore the train operation scheme based on the characteristics of passenger travel needs and adopt a variety of stopping modes, which can achieve a large degree of matching between train capacity and passenger flow time and space distribution, meet passenger travel at the same time, and reduce the operating costs of enterprises. There are fewer stations along the Guangqing Intercity and Guangzhou East Ring Intercity Railway, and the passenger flow in and out of the intermediate station is also less, therefore, the comprehensive operating costs of enterprises and

the travel needs of passengers, the use of a station direct, station stop and large station stop combination of the stop program, peak period can open one more station direct and large station stop train, peak period can take a station direct and station stop combination of the stop program. The specific stopping scenario is shown in Figure 1 below.

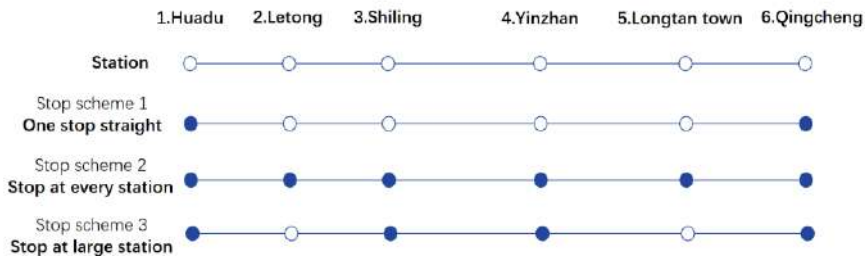


Figure 1 – Guangqing intercity railway stop plan map

4.3 Adopt the mixed running mode of large small group trains and large and small interchange set running mode

Whether in urban rail transit or intercity railway, compared with a single group, the large small group can make the transportation capacity and the time and space distribution of passenger flow more matched, alleviate the waste of transportation capacity, the low frequency of service at some stations, passenger waiting, transfer and long travel time in transit, etc., and reasonably adopt the large small group mode, which will improve the “attendance rate” of intercity railway and reduce train operating costs.

The operation mode of large and small interchange (set running) is widely used in urban rail transit, and this form of operation organization is suitable for the situation where the passenger flow density of the section is large. Therefore, the use of large and small interchange modes in the operation of intercity railways can adapt to the current temporal and spatial distribution characteristics of passenger flow of intercity railways on the one hand, and reduce the number of trains on the line on the other hand, while meeting the travel needs of passengers, rationally allocate transportation capacity and save train operating costs.

5 Conclusion

As a newly opened intercity railway line, the Guangzhou-Qingdao Intercity and Guangzhou East Ring Intercity Railway has not yet been connected with other intercity railway lines such as the new Baiguang-Guangzhou Intercity, and the road network structure is relatively simple; And in the early stage of opening, there is less passenger traffic. Therefore, operating enterprises need to optimize the train opening scheme based on the characteristics of passenger travel, flexibly use a variety of stop schemes, mixed running of large small group trains and large and small interchange running modes, and improve the attractiveness of intercity railways in terms of ticket services, station services, train services, etc., to attract more passenger flow.

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DIGITALIZATION OF PROCESSES IN OPERATIONAL MANAGEMENT TECHNOLOGY OF RAILWAY LOCAL WORK

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To achieve a new level of digitalization for transportation processes and to ensure an implementation of intelligent transportation management system, it is necessary to develop special information models of the railway local work that will