Analysis and Research on Current Situation of Flight Bridge Rate of Large Airports in China

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Abstract. Under the background of promoting the high-quality development of civil aviation, the research on airport flight bridge rate is helpful to improve the quality of aviation service and enhance the travel satisfaction of air passengers. There are many factors affecting the flight bridge rate. This paper explored the influence of relevant factors on the flight bridge rate, concourse gate turnover frequency and towing operation from the perspective of the number and layout of airfield gates. First, the bridge rate of 41 ten-million passenger capacity airports in China was systematically analyzed, including starting, overnight and stopover flights, international and domestic flights. Then, the study was carried out from the perspective of the ratio of the number of flights to concourse gates and the layout of gates. Further, the factors affecting flight towing were analyzed. Finally, optimization suggestions were put forward according to the special rectification work of the Civil Aviation Administration of China on flight bridge rate of ten-million passenger capacity airports.

Keywords: Airport, Bridge rate, Flight, Gate, Turnover frequency.

1 Introduction

Under the background of promoting the high-quality development of civil aviation, we will adhere to the concept of "developing people's aviation for the people", and effectively improve the airport flight bridge rate, which is of great significance in improving the quality of air service and enhance the travel satisfaction of air passengers. Both the *Civil Aviation Development Plan in the "14th Five-Year Plan" Period* and the *Air Transportation Passenger Service Special Plan in the "14th Five-Year Plan" Period* make it clear that by 2025, the flight bridge rate of concourse gates in ten-million passenger capacity airports will reach 80%[1-3].

In June 2023, focusing on international hub airports, the Civil Aviation Administration of China (CAAC) launched a special rectification work to improve the flight bridge rate of concourse gates (During the statistical period, the percentage of passenger flights on and off the aircraft using the concourse bridge gates in the total passenger flights.) in 41 ten-million passenger capacity airports in China, and all the relevant units of the industry cooperated and acted actively, and the flight bridge rate of concourse gates in ten-million passenger capacity airports and the number of passengers served by the corridor bridges increased significantly. The author of this paper had the honor to participate in this work, investigated and researched

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the situation of the bridge rate of 41 ten-million passenger capacity airports in China, and made a statistical analysis of the flight operation data. The current researches on the flight bridge rate mainly focuses on gate allocation algorithms[4,5], gate number planning[6] or intelligent gate management models[7], and there is a lack of in-depth analysis of the current situation of bridge rate of domestic airports. Therefore, on the basis of analyzing the current situation of the bridge rate in domestic airports, this paper carried out research from the perspective of the number and layout of concourse gates in the airport, analyzed the factors affecting flight towing, and finally put forward optimization suggestions according to the special rectification work on flight bridge rate.

2 Current Situation of Flight Bridge Rate

In 2023, since the gradual recovery of airport flight capacity in China, the average bridge rate of flights in ten-million passenger capacity airports at the end of May (Week 1, May 29-June 4) was 79.82%, of which the bridge rate of stopover flights was 87.59%, and the bridge rate of starting flights was 62.29%. There were 8 airports with a bridge rate over 90%, 16 airports with a bridge rate of 90%-80%, 8 airports with a bridge rate of 80%-70%, and 9 airports with a bridge rate less than 70%. The average bridge rate of flights at the 13 international hub airports in China was 74.59%, of which the bridge rate of stopover flights was 88.24%, the bridge rate of starting flights was 57.04%, and the average bridge rates of international and domestic flights were 77.83% and 74.61% respectively. Relevant statistics were reported by each airport and summarized by the regional administration of civil aviation.

The bridge rate of starting and overnight flights decreased significantly compared with that of stopover flights, which was especially prominent among the 13 international hub airports. Hub airports have a large volume of overnight flights, and a large number of starting flights are centrally released in the morning peak; the bridge rate of stopover flights had a smaller difference between the hub airports and the ten-million passenger capacity airports.

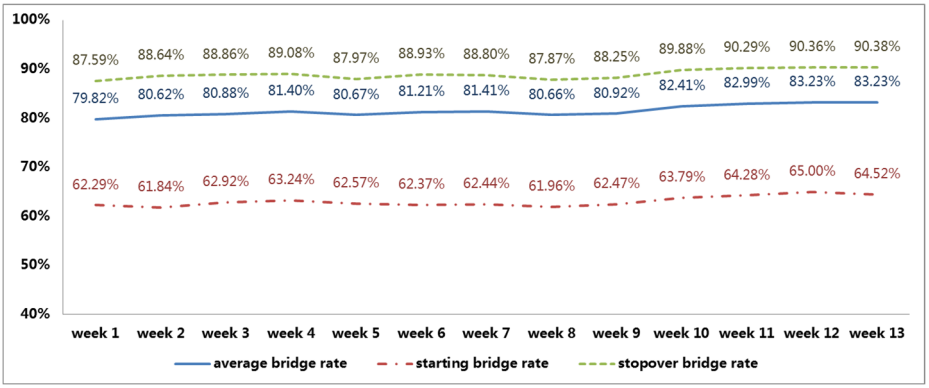

Fig. 1. Change trend of flight bridge rate of 41 ten-million passenger capacity airports.

After the launch of the special rectification work, airports, airlines and air traffic control authorities cooperated with each other and took a series of effective measures to improve the bridge rate according to their own operational characteristics. After 3 months of special

rectification of the bridge rate, the average bridge rate of 41 ten-million passenger capacity airports in China increased by 3.41%, reaching 88.23%, with an increase of 150,000 bridging flights. The bridge rate of starting, overnight and stopover flights increased by 2.23%, 6.98% and 2.79% respectively, as shown in Fig. 1. The number of airports with a bridge rate over 90% increased to 12, the number of airports with a bridge rate of 90%-80% was 14, the number of airports with a bridge rate of 80%-70% was 12, and the number of airports with a bridge rate less than 70% decreased to three.

The average bridge rate of the 13 international hub airports increased by 5.94% to 80.53%. A total of 72,900 additional flights were bridged, and 22,388,000 more passengers used the concourse gates. The bridge rate of starting, overnight and stopover flights increased by 1.77%, 11.63% and 3.38% respectively, as shown in Fig. 2; the average bridge rate of international and domestic flights increased by 7.15% and 5.36% respectively, as shown in Fig. 3.There were many factors affecting the bridge rate, including: the number of airport concourse gates, airfield layout, flight scheduling, aircraft proportion, gate allocation system, ground service guarantee level, etc.

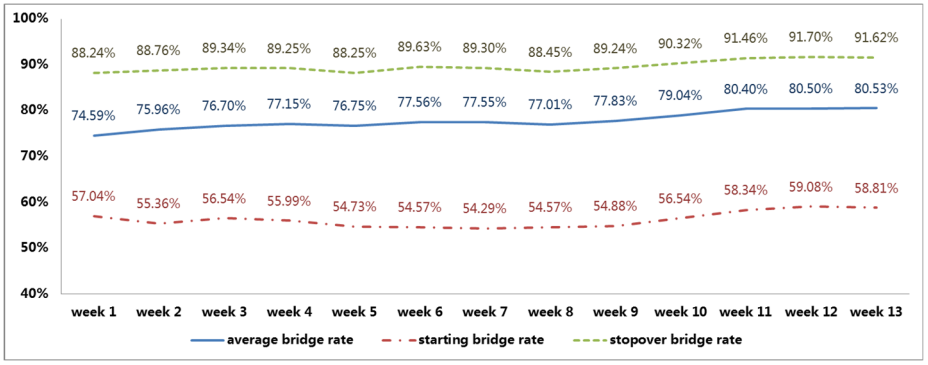

Fig. 2. Change trend of flight bridge rate of 13 international hub airports.

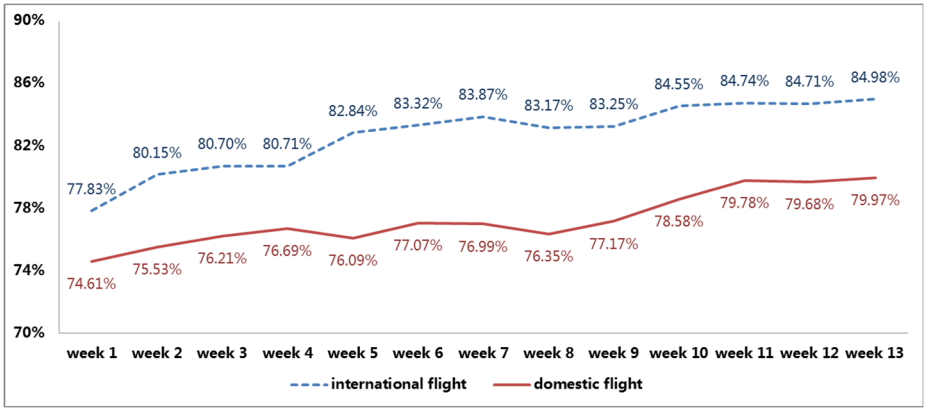

Fig. 3. International and domestic flight bridge rate of 13 international hub airports.

The daily turnover frequency of concourse gates in ten-million passenger capacity airports increased from 9.6 to 11.2 flights/day, of which the daily turnover frequency of domestic narrow-body gate increased from 11.4 to 12.5 flights/day (see Fig. 4).

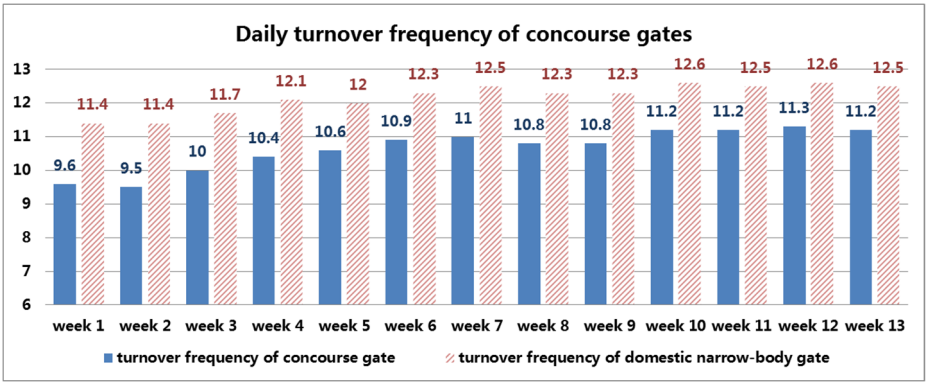

Fig. 4. Daily turnover frequency of concourse gates in 41 airports.

3 Number and Layout of Concourse Gates

The airport flight bridge rate is closely related to the number of concourse gates and the number of flights they serve. For the 41 ten-million passenger capacity airports, the flight operation data for one week in mid-June was selected to analyze the ratio of the number of daily flights to the number of concourse gates (RDFCG). There were obvious differences in the ratios between airports with different bridge rates: for airports with a bridge rate over 90%, the ratio of the number of daily flights to the number of concourse gates ranged from 6-12, with a mean value of 8.7; for airports with a bridge rate of 90%-80%, the ratio ranged from 9-18, with a mean value of 12.2; for airports with a bridge rate of 80-70%, the ratio ranged from 10-19, with a mean value of 13.4; and for airports with a bridge rate less than 70%, the average ratio was 20.2, among which Beijing Capital International Airport had the lowest value of 9.0, Sanya Airport had the highest value of 34.7 (some gates were out of service due to airport expansion), and the remaining airports had a ratio of 16-22, as shown in Fig. 5.

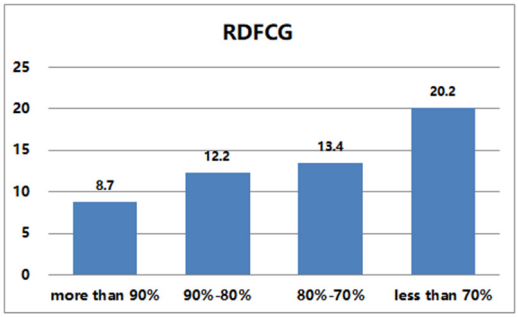

Fig. 5. Ratio of the number of flights to the number of concourse gates.

A further analysis is made to the ratio of the number of domestic flights to the number of domestic concourse gates (RDFDCG). For airports with a flight bridge rate over 90%, the ratio ranged from 7-14, with a mean value of 11.0; for airports with a flight bridge rate of 90%-80%, the ratio ranged from 10-21, with a mean value of 14.0; for airports with a flight bridge rate of 80%-70%, the ratio ranged from 11-23, with a mean value of 16.0; the average ratio of airports with a flight bridge rate less than 70% was 23.3, except for Beijing Capital International Airport and Sanya Airport, the ratio of the remaining airports was in the range of 21-25, as shown in Fig. 6. With the advancement of the special rectification work, some airports have put newly built satellite halls into service, or the terminal building renovation and expansion projects have been completed and put into operation, which effectively supplement the resources of concourse gates and play a key supporting role in enhancing the bridge rate. For example, Beijing Capital International Airport started to use the T1 waiting function, Kunming Airport put the S1 satellite hall into service, and Harbin Airport completed the transfer of T1 terminal; the bridge rate of the above airports increased by more than 6%.

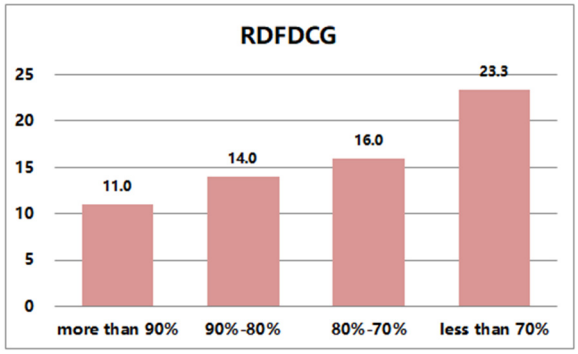

Fig. 6. Ratio of the number of domestic flights to the number of domestic concourse gates.

In general, the airports with a bridge rate over 90% have a significantly lower ratio of flights to gates, which means that there are relatively abundant concourse gate resources; for airports with a bridge rate less than 70%, the number of flights increases significantly compared with the number of concourse gates, and the lack of concourse gate resources is one of the main factors affecting the bridge rate. For some airports with a bridge rate of about 80%, there is a weak correlation between the bridge rate and the flight-gate ratio, such as Guangzhou, Chengdu Tianfu, and Chengdu Shuangliu airports. It is recommended that the turnover frequency of the corridor bridge gates be increased by improving operation management and optimizing flight structure, so as to further increase the bridge rate.

Where the flight capacity is full, the gate turnover frequency was usually higher for the front-type/near front-type terminal gates layout, as shown in Fig. 7. The daily turnover frequency of domestic C/D concourse gates was 16~18 times/day in Changsha, 16~18 times/day in Xiamen, and 14~15 times/day in Shenyang.

The gate turnover frequency of bay or multi-finger corridor terminal gates layout was slightly lower than that of the front-type layout. The daily turnover frequency of domestic C/D concourse gates was 11~12 times/day in Beijing Daxing and 11~12 times/day in Hangzhou.

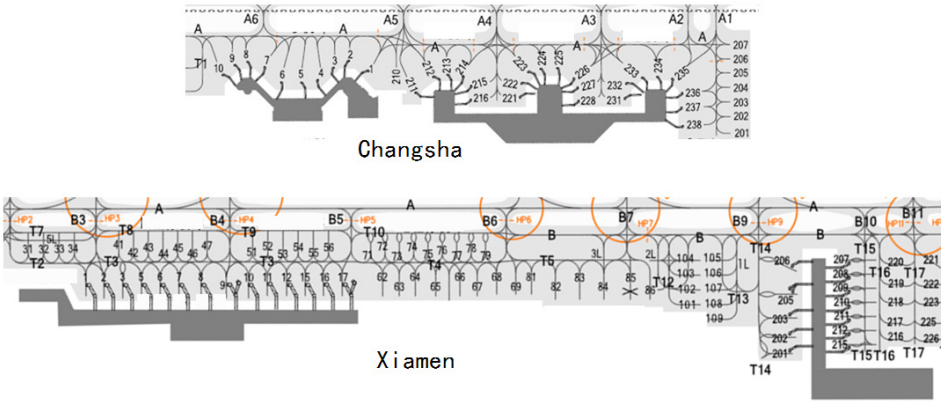

Fig. 7. Front-type/near front-type terminal gates layout.

4 Flight Towing Operations

In case the gate resources cannot be effectively increased, the flight towing operation between concourse gates and remote gates is an important means to improve the bridge rate of airport. Analysis of statistical data showed that among the 41 ten-million passenger capacity airports, the airports with larger number of daily towed flights were Beijing Daxing, Urumqi, Beijing Capital, Shanghai Pudong and Xiamen airports. The numbers of towed flights of each airport are shown in Table 1.

Table 1. Average daily number of towed flights at typical airports.

Rank	Airport	Average daily number of towed flights (flights)	Number of remote gates near corridor gates
1	Beijing Daxing	80-120	30
2	Urumqi	65-75	23
3	Beijing Capital	70-100	41 (T3 Terminal)
4	Shanghai Pudong	40-50	69
5	Xiamen	25-30	41

The number of towed flights is not only related to the towing capacity and management process of airports and airlines, but also affected by the layout of airport gates. For the airports with larger number of towed flights as mentioned above, the gate layout is mainly characterized by:

(1) In the neighboring area around the terminal building corridor bridge gates, there are more remote gates. For example, Beijing Daxing has 30, Urumqi has 23, Beijing Capital T3 Terminal has 41, Shanghai Pudong has 69, and Xiamen has 41 remote gates, respectively.

(2) The corridor bridge gates and neighboring remote gates are all within the airport apron control area, the towing application process is relatively simplified, and there will be less

interference with the operation of the main taxiway, thus facilitating the unified and coordinated management of apron control.

5 Conclusions

Increasing the bridge rate of airport concourse gates can help to improve the travel satisfaction of air passengers and effectively promote the improvement of air service quality. The improvement of bridge rate is a system engineering, which requires the cooperation of airports, airlines and air traffic control authorities. The main suggestions are as follows:

(1) Establish a complete statistical mechanism for flight operation data, corridor bridge use information, and airport security procedures, and strengthen the interactive sharing of related operation data[8].

(2) Reasonably allocate airport gate resources, optimize the setup of combination gates and international/domestic convertible gates, improve the applicability of corridor bridge gates, explore the sharing mechanism of corridor bridge gates and ground service guarantee resources among airlines, and optimize the corridor bridge maintenance strategy.

(3) Optimize the work plan, work procedures and operation standards for the pre-allocation of gates, and build an intelligent gate allocation system by virtue of big data, artificial intelligence, Internet of Things and other information technologies, so as to maximize the utilization efficiency of gate resources by human-computer interaction.

(4) Optimize the flight structure and improve the flight schedule, and focus on high concentration of overnight flights, long transit time and early arrival of flights, etc.

(5) On the premise of ensuring operational safety and not affecting the normal operation of flights, moderately increase the number of aircrafts towed/bridged by self-taxiing, including outbound flights bridged by secondary towing/self-taxiing and inbound flights towed after bridging/leaving bridge by self-taxiing.

(6) Optimize the layout of the airfield and the design of the terminal building configuration in the new airport construction and expansion projects to improve the concourse gate configuration efficiency and resource proportion; optimize the design of remote gates (pressure relieving gates) close to the corridor bridge, strengthen the dynamic interaction between the remote and concourse gates, and improve the towing efficiency.

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