Study on Evaluation Model of Service Level based on Orbital Transfer Passenger Convenience and Comfort

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Abstract

Firstly, based on internal passenger flow characteristics at transfer station, the transfer facility function area is divided. Then adopting questionnaires and barrel principle, a service level evaluation model of transfer facility is established with "comfort" and "convenience" as evaluation index. In the model, the comfort level of the transfer tunnel, stair and platform is defined by the passenger flow density. Similarly, the convenience level of the transfer tunnel and stair is respectively defined by the tunnel length and the stair step numbers. Finally, according to the transfer facility service level classification standards, the model is used to evaluate the service level of Beijing Jianguomen Station. The case analysis results show that the model is practical, feasible and widely adaptable.

Key words: passenger, convenience, comfort, service level, evaluation model

Introduction

Not only orbit transfer station is a key node in the urban transport system, but also is the conversion of various transport modes. Reasonable service level evaluation of transfer facility is important to improve transfer station capacity, transfer security and transfer management. Fruin firstly introduced the concept of service level in the crowd moving, and established the service level standards and calculation methods of service facility in pedestrian passageway and queuing area. Based on survey data and simulation, others presented some methods to determine the transfer facility service level of pedestrian passageway, stair and platform[1-2]. But these methods were focused on single facility, which are difficult to reflect the whole service level of transfer station. Then some researchers used “fuzzy comprehensive evaluation method” or “data envelopment analysis method” to evaluate service level of transfer station[3]. However, most of the methods are considered based on the facility supply, not the passengers using. So, in the paper, the index of passenger’ perception, such as comfort and convenience, are used to divide the service level classification standards. The comfort level is depicted by passenger flow density, walking speed and saturation, and the convenience level is depicted by facility length, cost and walking time. Based on questionnaires and barrel principle, author establishes the service level evaluation model which considers passenger flow features and facility adaptability. Case analysis results show that the model is practical, feasible, widely adaptable, which can be used to evaluate the transfer facility service level adequately.

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1. Service Level Evaluation Model of Transfer Facility

Transfer facility function area is divided into transfer tunnel, stair and platform mainly. The transfer tunnel is usually unidirectional. During the peak, the stair capacity will influence passenger safety greatly. Platform is consists of passenger walking area and waiting area.

1.1 Function Areas Service Level Evaluation Model

1.1.1 Service Level Evaluation Model of Transfer Tunnel

The transfer tunnel service levelis mainly determined by the passenger comfort and convenience, which can be expressed as:

$$Los(PE) = \gamma_1 Los(X_1) + \gamma_2 Los(X_2) \quad (1)$$

Where: $Los(A)$, $Los(X_1)$, $Los(X_2)$ respectively is the tunnel service level, comfort level, convenience level.

γ_1 is tunnel comfort weight, $\gamma_1$is tunnel convenience weight. The ranking method is used to determine weight coefficient. Based on questionnaire investigation, the comfort and convenience weight is 63% and 37% respectively.

1.1.2 Service Level Evaluation Model of Stair

The stair service level is mainly determined by the stair comfort and convenience, which can be expressed as:

$$Los(S) = \gamma_1 Los(Y_1) + \gamma_2 Los(Y_2) \quad (2)$$

Where: $Los(S)$, $Los(Y_1)$, $Los(Y_2)$ respectively is the stair service level, comfort level, convenience level.

γ_1 is stair comfort weight, γ_2 is stair convenience weight. The ranking method is used to determine weight coefficient. Based on questionnaire investigation, the comfort and convenience weightare44% and 56% respectively.

1.1.3 Service Level Evaluation Model of Platform

Platform service level is mainly determined by the waiting are aservice level and walking area service level, Based on barrel principle, it is determined by choosing the worse service level between waiting area and walking area.

$$Los(PM) = Min(Los(Z_1), Los(Z_2)) \quad (3)$$

where： $Los(PM)$ ， $Los(Z_1)$ ， $Los(Z_2)$ respectively is the platform service level, walking area service level, waiting area service level.

1.2 Service Level Evaluation Model of Transfer Facility

In the paper, transfer direction is considered to research service level of transfer facility[4], because passenger, coming from different transfer direction, has different feeling to importance of the facility. Therefore, the service level evaluation model can be expressed as:

$$Los(A) = \frac{Q_{\mathrm{I}\to\mathrm{II}}}{Q} Los(A_{\mathrm{I}\to\mathrm{II}}) + \frac{Q_{\mathrm{II}\to\mathrm{I}}}{Q} Los(A_{\mathrm{II}\to\mathrm{I}}) \quad (4)$$

Where: $Los(A)$ is the service level of transfer facility at transfer station.

$Q_{\mathrm{I}\to\mathrm{II}}$, $Q_{\mathrm{II}\to\mathrm{I}}$ is respectively the passenger flow volume of platform Ⅰ → Ⅱ and platform Ⅱ → Ⅰ. (p/hour) $Los(A_{\mathrm{I}\to\mathrm{II}})$, $Los(A_{\mathrm{II}\to\mathrm{I}})$ is respectively the service level of the transfer facility of platform Ⅰ → Ⅱ and platform Ⅱ→ Ⅰ.

$$Los\left(A_{\text{I}\to\text{II}}\right)=\omega_1 Los\left(PM_{\text{I}}\right)+\omega_2 Los\left(S_{\text{I}\to\text{II}}\right)$$
$$+\omega_3 Los\left(PE_{\text{I}\to\text{II}}\right)+\omega_4 Los(PM_{\text{II}}) \quad (5)$$

$$Los\left(A_{\text{II}\to\text{I}}\right)=\omega_1 Los\left(PM_{\text{II}}\right)+\omega_2 Los\left(S_{\text{II}\to\text{I}}\right)$$
$$+\omega_3 Los\left(PE_{\text{II}\to\text{I}}\right)+\omega_4 Los(PM_{\text{I}}) \quad (6)$$

Where:

$Los(PM_{\text{I}})$、$Los\left(S_{\text{I}\to\text{II}}\right)$、$Los\left(PE_{\text{I}\to\text{II}}\right)$、$Los(PM_{\text{II}})$ respectively is the service level of platform Ⅰ, stair, tunnel and platform Ⅱ; $\omega_1,\omega_2,\omega_3,\omega_4$ is corresponding weight coefficient respectively, and $\omega_1+\omega_2+\omega_3+\omega_4=1$.Based on questionnaire investigation, the weight coefficients can be obtained, which is respectively $\omega_1=0.03$, $\omega_2=0.48$, $\omega_3=0.43$, $\omega_4=0.05$

2. Service Level of Transfer Facility Classification Standards

Based on the camera method, the passenger flow volume, speed and density are obtained. Then using SPSS statistical software, the speed--density relation is obtained. According to the relationship of passenger flow rate-speed-density, the ultimate value of density and flow rate is obtained respectively. By comparing the existing standards with survey results, the comfort and convenience classification standards are formulated as following:

Tab.1 Service Level Standard of Tunnel Comfort

Comfort	Density (p/m^2)	Flowrate (p/m•s)	V/C	Speed (m/s)
A	0-0.29	0-0.56	0-0.4	≥1.92
B	0.29-0.55	0.56-0.83	0.4-0.6	1.92-1.51
C	0.55-1.0	0.83-1.11	0.6-0.8	1.51-1.13
D	1.0-2.03	1.11-1.39	0.8-1.0	1.13-0.66
E	>2.03	variable	variable	<0.66

Tab.2 Service Level Standard of Tunnel Convenience

Convenience	Tunnel length (m)
A	≤40
B	40-60
C	60-100
D	100-150
E	≥150

Tab.3 Service Level Standard of Stair Comfort

Comfort	Passenger flow density (p/ m^2) /Pedestrian space (m^2 / p)
A	≤0.61/≥1.63
B	0.61-0.89/1.12-1.63
C	0.89-1.12/0.89-1.12
D	1.12-1.61/0.62-0.89
E	1.61-2.86/0.35-0.62

Tab.4 Service Level Standard of Stair Convenience

Convenience	Ascending stair step number
A	≤20
B	20-28
C	28-38
D	38-47
E	47-53

Tab.5 Service Level Standard of Platform Walking Area

Service level	Density (p/ m^2)	Speed (m/s)	Flow rate (p/m•s)
A	0-0.29	≥1.30	0-0.38
B	0.29-0.55	1.04-1.30	0.38-0.57
C	0.55-1.0	0.80-1.04	0.57-0.80
D	1.0-2.03	0.51-0.80	0.80-1.04
E	>2.03	<0.51	variable

Tab.6 Service Level Standard of Platform Waiting Area

Service level	Pedestrian space (m^2 / p) / density (p / m^2)
A	≥1.17/≤0.85
B	0.71-1.17/0.85-1.41
C	0.45-0.71/1.41-2.21
D	0.26-0.45/2.21-3.80
E	0.17-0.26/3.80-5.82

3. Case Analysis

Beijing Jianguomen Station is used as a case to study. The investigation time is 7:00am-9:30am and 17:00pm-19:30pm. The investigated results are showed in Fig.1 and Fig.2.From the Fig.1 and Fig2, during morning peak, the maximum passenger flow volume is 25362 appearing during7:45am - 8:45am, in which 11636 from the platform Ⅰ to the platform Ⅱ and 13726 from the platform Ⅱ to the platform Ⅰ. During evening peak, the maximum passenger flow volume is 22859 appearing during 7:45pm -8:45pm, in which 12320 from the platform Ⅰ to the platform Ⅱ and 10539 from the platform Ⅱ to the platform Ⅰ.

Passenger volume size at orbital transfer station will influence passengers comfort and convenience. Furthermore, it will affect the service quality evaluation of transfer facility. Because the transfer passenger volume during morning peak is more than the volume during evening peak, the paper uses the volume during morning peak to analysis the passenger average density, velocity and V/C which are showed in Tab.7

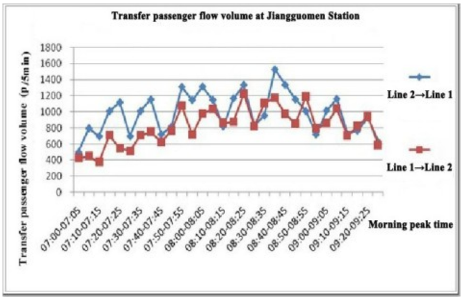

Fig.1 Transfer Passenger Flow during Morn ing Peak

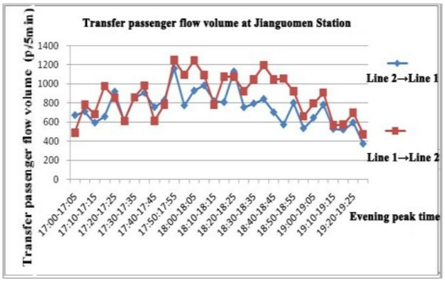

Fig.2 Transfer Passenger Flow during Evening Peak

Tab.7 Proportion of Facility Average Density, Speed and V/C

	acility	Density (p/ m^2)	Speed (m/s)	V/C
Platform I	Waiting area	1.450	--	--
	Walking area	1.133	0.78	--
Stair I → II	--	1.278	0.67	0.77
Tunnel I → II	--	0.773	1.12	0.62
Platform II	Waiting area	1.668	--	--
Stair II → I	Walking area	1.342	0.69	--
	--	1.451	0.52	0.65

Based on the Tab.1-Tab.6and Tab.7, the service levels of the transfer tunnel, stair and platform at Jianguomen Station are calculated which are showed in Tab.8

Tab.8 Service Level of Transfer Facility

	Facility	Comfort	Convenience	Wholeservicelevel
Platform I	Waiting area	C	--	D
	Walking area	D	--	
Stair I → II	-	D	D	D
Tunnel I → II	--	C	C	C
Platform II	Waiting area	C	-	D
	Walking area	D	--	
Stair II → I	-	D	A	C

The volume during morning peak and the service level of the transfer facility are substituted into the formula (4), formula (5) and formula (6).

$$
\begin{aligned}
Los\left(A_{\mathrm{I}\to\mathrm{II}}\right) &= \omega_1 Los\left(PM_{\mathrm{I}}\right)+\omega_2 Los\left(S_{\mathrm{I}\to\mathrm{II}}\right)\\
&+\omega_3 Los\left(PE_{\mathrm{I}\to\mathrm{II}}\right)+\omega_4 Los(PM_{\mathrm{II}})\\
&=0.03\times4+0.48\times4+0.43\times3+0.05\times4=3.53
\end{aligned}
$$

The service level from the platform Ⅰ to the platform Ⅱ is D.

$$
\begin{aligned}
Los\left(A_{\mathrm{II}\to\mathrm{I}}\right) &= \omega_1 Los\left(PM_{\mathrm{II}}\right)+\omega_2 Los\left(S_{\mathrm{II}\to\mathrm{I}}\right)\\
&+\omega_3 Los\left(PE_{\mathrm{II}\to\mathrm{I}}\right)+\omega_4 Los(PM_{\mathrm{I}})\\
&=0.03\times4+0.48\times3+0.05\times4=1.76
\end{aligned}
$$

The service level from the platform Ⅱ to the platform Ⅰ is B.

$$
\begin{aligned}
Los\left(A\right) &= \frac{Q_{\mathrm{I}\to\mathrm{II}}}{Q}Los\left(A_{\mathrm{I}\to\mathrm{II}}\right)+\frac{Q_{\mathrm{II}\to\mathrm{I}}}{Q}Los(A_{\mathrm{II}\to\mathrm{I}})\\
&=\frac{11636}{25362}\times3.53+\frac{13726}{25362}\times1.76=2.57
\end{aligned}
$$

Therefore, the whole service level of the internal transfer facility is C. Because the transfer passenger flow volume is unbalanced, the I→II volume is more than the II→I volume, and the service level of the platform I→II is D. In the paper, in order to improve the whole service level, the transfer tunnel and stair from the platform I to the platform II should firstly be improved.

4. Conclusion

(1) Based on the comfort and convenience, using the questionnaire investigation method, the service level model and standards of the transfer tunnel, stair and platform are established. Considering disequilibrium of the transfer passenger flow volume from different direction, the service level evaluation model of transfer facility is established.

(2) The analyzed results of Beijing Jianguomen Station show that the service level of transfer facility is C and the transfer tunnel and stair of the platform I →II should firstly be improved. Therefore, the model can be feasibly and practically used to evaluate the service level of orbital transfer facility.

5. References

[1] MasamitsuMori, Hiroshi Tsukaguchi. A new Method for Evaluation of Level of Service in Pedestrian Facilities[J]. Transportation Research Part A,pp.223-226,1987,21(3).

[2] Zhang Qingchi. Study on service level of passenger pedestrian in MTR hub [D],Beijing, Beijing Jiaotong university,2008.

[3] Sun Lishan, Rong Jian, Ren Futian. DEA Method for Evaluating the Transfer Efficiency of Urban Public Transportation Terminal[J]. Journal of Beijing university of technology, pp.1289-1293,2007,33(12).

[4] Li Dongping, Xia Kefei, XuMingming. Evaluation Analysis of Arriving Level of Service for Urban Rail Station Facilities[J].Journal of Tongji University.pp.1458-1462,2010.38(10)