Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 137 (2016) 806 – 810

Procedia Engineering

www.elsevier.com/locate/procedia

GITSS2015

A Method of Grading Subway Stations

Yun Wei[a,]*,Shan Lin[b],Rui Chu[b],Qing Tian[b], Weiwei Fei[c]

[a]*Beijing Urban Construction Design & Development Group Co.,Ltd, Beijing, China*
[b]*North China University of Technology/ College of Information Engineering, Beijing, China*
[c] *Systems Engineering Research Institute, CSSC, Beijing, China*

Abstract

This paper summarizes the classification method of domestic subway station, and points out the existing defects. In order to design of a relatively reasonable grading system, this paper reference to the existing classification method and passenger flow data. First, obtain a dynamic correction of parameters according to the static factors. Then, combine with the data of dynamic flow to determine the level of the station.

Peer-review under responsibility of the Department of Transportation Engineering, Beijing Institute of Technology

Keywords: subway station, grading method, Dynamic traffic;

1. Introduction The classification method of the existing domestic

According to the statistics in March 8, 2014, the average daily passenger volume has over ten million in Beijing subway, ranked first in the world [6].

The subway station is usually passenger density, relatively closed space, so there are some potential dangers. Especially some environment in station is complex, strongly destructive and sudden and the ability of controlling and evacuation is poor. How to prevent city rail traffic paralysis caused by the incidents? How to ensure the safety of passengers and the subway line smooth in an emergency? This is a difficult problem in front of the Beijing subway operation company.

* Corresponding author. Tel.: +86-010-88336446;
E-mail address: weiyun@bjucd.com

Peer-review under responsibility of the Department of Transportation Engineering, Beijing Institute of Technology
doi:10.1016/j.proeng.2016.01.319

2. The classification method of the existing domestic Urban rail transit station classification method research

Among the existing method of station classification, the related research for subway station is almost a blank. In the documentations "Guide for Design of City Rail Traffic Engineering "[2] and "Organization of City Rail Transit "[3], stations were divided just according to passenger flow volume. And the standard of classification is not match the actual traffic conditions in Beijing subway. It is not suitable for practical application in Beijing metro lines.

In the documentations “Specification for design of Urban Rail Transit Project” [5] and “Metro design code” the construction chapter, the station according to the leading passenger flow and the service function of regional environment are classified into three categories of travel, leisure gatherings and daily commuting. According to the size and importance of the site the stations in each category, then graded into different level.

Although according static properties of the station is a reasonable method, but it did not involve the actual passenger flow volume. The actual traffic of some stations may not conform to the original planning and construction of the situation. Grading subway stations needs to consider many factors, but its fundamental purpose is to ease the pressure, enhance the control ability of operating personnel and provide a safe and convenient travel environment for passengers. Therefore the passenger flow volume is still an indispensable indicator of the classification of subway station.

The method mentioned in the article "Explore the urban rail transit station classification based on quantitative analysis"[1] is a relatively reasonable hierarchy method of subway station. It selects four indexes: The passenger flow volume, Location, Traffic organization and passenger service. Then for each item index distribution proportion, in four categories can be subdivided into several items classification index and scoring according to each index items. Classification of the station with the scoring method, the indexes can be combined by weight. But its weight quantitative is difficult to rationalize. So the various factors affecting the classification of the reasonable combination is a problem in the station classification.

3. Urban rail transit station classification method research

3.1. Selection index and selection principle of the station classification

The influence of the subway station hierarchy index mainly divided into two categories: Station static index and dynamic passenger flow index. The dynamic index treated as the primary basis for dividing the station level. The static attribute station including its geographical location, the station scale and surrounding facilities etc. These properties are hard to change. So the static attribute as a factor will affect the dynamic traffic.

We refer to the grading method from references “Specification for design of Urban Rail Transit Project” and “Metro design code”. First, according to dominate the passenger and metro station service regional environmental function orientation, divided it into travel, leisure, meetings, daily commuter three categories. And then, in each categories, classified by the size and importance.

Station dynamic factor is dynamic traffic. According to the statistics of a month of passenger data from Beijing subway operating company, we conclude the average of total passenger traffic on the subway station in Beijing. Each station of the average daily total traffic is the sum of the in and out volume and the exchange volume of the station.

3.2. Establish system of station classification

Static classification: firstly, according to the Table 1, the subway station will be divided into three categories. Then the stations will be divided into four levels according to the environmental characteristics station such as location, importance and scale. Based on the index from following table stations is divided into four levels. Four grades respectively take N1, N2, N3 and N4 being adjustment factor of dynamic passenger flow.

About environmental characteristics of the station, the station as the center, the maximum distance of passenger walking as the radius of circle. It is the area of a circle is the coverage of the site. According to the former Korloff’s research results shows that a reasonable walking area is around the station within the scope of the radius 600 meters. Therefore the circle according to the station as the center and the radius is 600 meters [4]. Statistical data in accordance with the circular area formed. Subway stations a densely distributed within the urban area of Beijing. The scope of the radius of 600 meters is enough to cover passenger source. However, the source of the passengers is extensive, which bus station located in the suburb areas. Therefore it is located in the outskirts of the site should be appropriate to increase the radius of 1000 meters. Eventually the determination of static level should be used for the station on the basis of the most significant passenger flow.

Table 1. Static classification.

Category	A (Transport, Travel)	B (Leisure, Assembly)	C (Daily commuting)
Level	Transfer to a inter-city passenger flow	Tourism and commercial shopping passenger flow, the transient impact of passenger flow	Commuter traffic, daily business flow (including the suburban passenger transportation center and business hub, etc.)
a（N_1）	International transportation hub	The world cultural heritage, tourism area, the activities of the international party place (sports venues, activity center, large social activity center, etc.)	International commercial center and the suburban passenger transportation center
b（N_2）	Start from more than 400 km of inter-city bus	The national scenic area and the famous business district, the national party place	City public transport hub city, suburban railway station at the end of the first, national commercial center, international commercial residential area
c（N_3）	Start from 200 to 400 km of inter-city bus	City leisure, commercial center, municipal party activities	The municipal office center, district administration center indoor public transport hub line terminal
d（N_4）	Start distance less than 200 km of inter-city bus	District, leisure, business center, under municipal party activities	General station

Dynamic classification: the station dynamic traffic is evaluated by the statistics of total daily traffic from Beijing subway station. Total daily traffic is the sum of enter and exit passengers and transferring passengers. Selection the data of the passenger flow in May 2014 and it is concluded that the daily average before ordering. It is concluded that traffic trend curve as shown Fig 1.

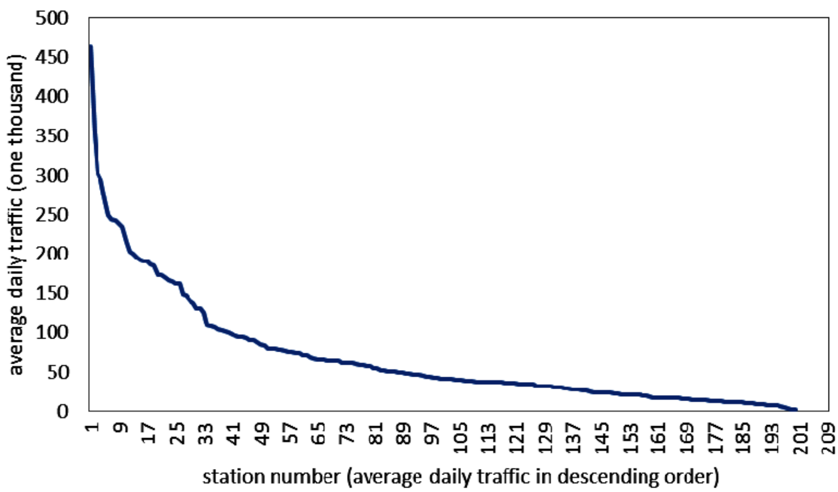

Fig. 1. Average daily traffic of Beijing subway station.

According to the flow curve in Fig 1 can be obtained a nonlinear distribution from each station in Beijing. About half of the station's average daily traffic in Beijing is less than 50000.

Among average daily passenger more than 50000, nearly 60% of the station is between 50000 ~ 100000. Only a small part (about 15%) station the average daily traffic is between 100000~250000.

Some stations such as Xizhimen station, Guomao station can reach 460000, 360000 relatively high values. According to passenger flow volume at the top station traffic (Xizhimen station, F_{max} = 465821 people/day) set out

S_{max} = 100. At the bottom of the station (Qucinan station, F_{min} = 1523 people/day) set to S_{min} = 0. In order to avoid individual station with high value influence the weight of most of the relatively low station in the traffic network. The station is divided into two parts. Traffic below 100000 of the station's curve is roughly present linear distribution and more than 100000 of the station's curve is present nonlinear. Therefore set the passenger flow threshold F_x = 100000. According to the F_x = 100000 passenger station accounts for about 80% of the total station. Set S_x = 80 points, the score of threshold (F_x) .

If the test station passenger traffic $F_i=F_{min}$, the score:

$$S_i = S_{min} \tag{1}$$

If the test station passenger traffic $F_i<F_x$ and $F_i>F_{min}$, the score:

$$S_i = \frac{F_i - F_{min}}{F_x - F_{min}} S_x \tag{2}$$

If the test station passenger traffic $F_i>F_x$ and $F_i<F_{max}$, the score:

$$S_i = \frac{F_i - F_x}{F_{max} - F_x}\left(S_{max} - S_x\right) + S_x \tag{3}$$

If the test station passenger traffic $F_i=F_{max}$, the score:

$$S_i = S_{max} \tag{4}$$

Final classification: according to the above mentioned method,the test station classified before they are graded. A dynamic passenger flow adjustment factor of Ni was finally determined. Then according to the calculation method in section Dynamic classification, combined with the average daily traffic, calculate a dynamic passenger flow scores -S_i. Combined with dynamic passenger flow adjustment factor(N_i) and dynamic passenger flow scores(S_i). Eventually the station classification results: $R_i = N_i*S_i$.

The results (R_i) were graded according to the following Table 2.

Table 2. Hierarchy form.

	Grade 1	Grade 2	Grade 3	Grade 4
R_i	(z,100]	(y,z]	(x,y]	(0,x]

3.3. The station classification system test

The results of following selection for Beijing subway line 13 tried to classify. The statistics in 2014 May the station daily traffic data from the actual investigation. N_1, N_2, N_3, N_4 temporarily set to 1.2, 1.1, 1.0, 0.9. x,y,z temporarily set to 30,60,80.

Table 3 shows the results of the classification of the station of Beijing Metro Line 13. According to the above classification results can be seen that the grading system is reasonable. The method combine with dynamic factors and static factors is also more effective. For example, line 13 HUI LONG GUAN station average daily traffic is 84158.5. The traffic in many station is not very high, compared with some transport hub station only one-third or even a quarter of the traffic. But the station is located in the large community in the north of Beijing. The station static indexes can be divided into category C level b, the final classification result is B.

Table 3. Classification result of line 13 station in Beijing.

Line 13 Station	Static factors			Dynamic factors		Score	Normalization	Result
	category	level	coefficient	traffic	score			
XI ZHI MEN	A	b	1.1	464508	100	110	100	A
DA ZHENG SI	C	d	0.9	36234.5	28.24373	25.41936	23.10851	D
ZHI CHUN LU	C	c	1	186518	84.74711	84.74711	77.04283	B
WU DAO KOU	C	c	1	95851.75	76.63301	76.63301	69.66637	B
SHANG DI	C	c	1	71248.5	56.66339	56.66339	51.51218	C
XI ER QI	C	b	1.1	249942	88.22709	97.0498	88.22709	A
LONG ZE	C	c	1	79242	63.15144	63.15144	57.4104	C
HUI LONG GUAN	C	c	1	84158.5	67.142	67.142	61.03818	B
HUO YING	C	c	1	107439.3	80.40818	80.40818	73.09835	B
LI SHUI QIAO	C	c	1	149345.3	82.7075	82.7075	75.18864	B
BEI YUAN	C	d	0.9	31253.75	24.20103	21.78093	19.80084	D
WANG JING XI	C	c	1	167116	83.68255	83.68255	76.07505	B
SHAO YAO JU	C	c	1	172826	83.99585	83.99585	76.35987	B
GUANG XI MEN	C	d	0.9	20063.75	15.11849	13.60664	12.36967	D
LIU FANG	C	d	0.9	34566.25	26.88967	24.2007	22.00064	D
DONG ZHI MEN	A	b	1.1	294470.5	90.6703	99.73733	90.6703	A

4. Conclusion

In this paper, through summarizing the previous research results and the comprehensive processing a large number of passenger flow data, designed a relatively perfect urban rail transit station classification system. This designed classification method is different from previous expert scoring method. Instead, the static attributes treated as the correction parameters of dynamic traffic. We combined with stations planning location and the actual traffic. According to the test results of three subway lines, classification system is quite reasonable. And the method provided the reference of the resources allocation and urban rail transit network system weights for metro operation management.

Acknowledgements

This work is supported by Project of Beijing Nova (XX2015A006) and Beijing Science and Technology Council under grant (Z151100001315004).

References

Beijing Municipal Bureau of quality and technical supervision, 2014. DB11/ 995-2013 Metro design code.
[1] F.K. Chen, H.J. Wu, Explore the urban rail transit station classification based on quantitative analysis, 2010.
[2] Z.H. He, Guide for Design of City Rail Traffic Engineering, Beijing: Chinese Building Industry Press, 1993.
[3] L. Ji, G.B. Zhang, Organization of City Rail Transit, Beijing: Chinese Railway Press, 1998.
[4] K. K.I-O, The development of urban transport hub, Beijing: Chinese Building Industry Press, 1982.
[5]Ministry of Housing and Urban-Rural Construction of the People's Republic of China, GB50157-Specification for design of Urban Rail Transit Project, Beijing: Chinese Building Industry Press, 2013.
[6] L. Zou, etc., Beijing Morning News, 2013.