

Study on the Safety and Disaster-Prevention Signing System of the Subway Based on Site Investigation at Home and Abroad

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Abstract—The subway has become an important form of transportation in our daily life. And the sign system is a part of the subway engineering, which plays an important role in improving the convenience and the efficiency of emergency dispersion. In the present paper, by site investigation of the subway sign system at home and abroad, such as Busan & Seoul (Korea), Tokyo (Japan), Beijing & Nanjing (China), analysis were made on the subway sign system of the cities mentioned above. On the basis of cognitive psychology and human body engineering, suggestions on the subway sign planning and design were made, which contain subway sign location, the impact of billboards on the signs, the relevance between the sign and the device and so on. The optimization suggestions on subway sign design are proposed to make it functional, systematic, international, concise and humanistic.

Keywords—subway; disaster-prevention; emergency dispersion; sign;

I. INTRODUCTION

City subways are public places with high density of people, especially during the rush hour. Take the Beijing subway as an example, now there are more than 4 million passengers every day. People who are in high density crowd are vulnerable to the impact of unexpected events and that will easily result into a confusion and even accident. And as the subway is constructed beneath the ground, with complex structure, it has the inherent characteristics as being strongly closed, passengers taking the ride themselves, limited entrances and exits, long evacuation route, limited safe evacuation time, difficult emission of heat and smoke in fire risk, bad lighting and ventilation condition, too many kinds of electrical equipment, and being susceptible to external factors, so when a disaster occurs, it is very difficult to evacuate and carry out emergency relief, which will easily result into heavy casualties.

Disasters happen frequently in the subway in recent years, such as the Japan subway gas attack, English Channel tunnel fire, South Korea Daegu subway fire which all have resulted into heavy casualties. And those are driving the cities with subway to start to take consideration of the safety of subway. Under such circumstances, how to ensure the station runs

efficiently, keep passengers safe and ensure them reach the destination on time, evacuate passengers in time and effectively, and reduce the property loss when disasters happen, are currently a series of problems need to be solved urgently.

As an important component of subway project, subway safety and disaster-prevention sign system plays a crucial role in guaranteeing the efficiency of the use of subway by passengers in normal use and the emergency evacuation in disaster. In the confrontation of natural disasters or emergencies, reasonable and effective signs can enable passengers in disaster to assess the conditions they are in, shorten the evacuation time, supply passengers with a proper emergency evacuation route, ensure the smooth proceeding of emergency rescue work, guarantee the safety of passengers as well as the normal operation of the scheduling command system and emergency rescue system of the emergency preplan for disaster prevention system. Therefore, the optimization study on subway safety and disaster prevention system is particularly important.

Foreign scholars have started the study on the subway sign system a long time ago. As the first "city railway" in the world was put into operation in 1863, London subway system not only started an entirely new mode of communication, but also brought an enormous influence to the guiding design of subway space in the whole world. The United States Federal Ministry of Transportation and Communications[1] "National Public Sign Design and Graphics Principles of the Complete Works" defined public sign design principles in U.S., collated and analyzed graphics which were used in various places to make it systematic. With the rapid development of the railway communication system, the sign system of Japan railway communication station has been improved for many times and is becoming more and more perfect, and has set up a corresponding installing and design theory. Japan subway sign system has a very sound guiding system, and can provide instruction help to users of various kinds.

China has also done a lot of work on the subway disaster prevention and emergency evacuation, and has made the relevant codes and rules. For example, the "Code for Design

of Subway” published in 2003 has made strict technical requirements and technical measures requirements on the emergency rescue and evacuation; Beijing provided "Beijing Subway Emergency Safety Guide" for the public in 2006. As we try to do the formulation and publicity of the codes well, domestic scholars have carried out in-depth research on subway sign system. L.M. Zhu[2] finds that there are some problems in Beijing subway line sign design by comparing with the Paris subway environment. X. Wang[3] compares the setting, the system, and the color of the system in Japan, Taiwan, Hong Kong and Shanghai's mass transit. L. Wang[4] take analysis and study in space induction system, improves and refines existing principles of sign design of underground space.

The site investigation and study shows problems in the planning and design of the subway sign system currently, such as the improper locations of evacuation signs, large impact from billboards in the station to the subway sign system, fire signs are not well related to the fire equipment and so on. It is necessary to improve the sign system to face the various possible disasters.

II. INVESTIGATION ON SIGN SYSTEM AT HOME AND ABROAD

The study of subway safety and disaster-prevention sign system is based on the site investigation of subway stations home and abroad, in the purpose of studying on the subway sign planning and design in normal time and in disaster and perfecting the subway sign system, so as to effectively direct passengers to use subway safely, make the most use of sign system set in normal time and to minimize the casualties as far as possible in disaster. Through the site investigation and study upon some large and medium subway stations of Seoul, Busan, Tokyo, Beijing and Nanjing, a comparison and analyzed of the existing problems of domestic subway disaster-prevention sign system were made in the present paper, mainly on the placement of signs, large influences from too much billboards on the sign system, the correlation between the fire equipments and the signs, the relevant auxiliary apparatus, and provided with some optimization suggestions.

A. The Direction of Evacuation Sign

Evacuation sign plays an important role in the subway. Emergency evacuation time can be shorten and the most scientific emergency evacuation line can be provided by reasonable effective sign, then the subway emergency rescue work can proceed smoothly, and passengers security, scheduling command system and emergency rescue system can be confirmed[5].

The sign direction is a very important factor in sign design. Normally, the sign direction should be vertical with the direction of people's line of evacuation, but the sign of emergency exit in Beijing subway is paralleled with people's line of evacuation, as shown in Fig. 1. When the accident occurred at a lower visibility subway space, it will be difficult to discover sign and distinguish emergency evacuation routes in the down-channel direction of escape. Moreover, there is no obvious sign in some subway stations platform, as shown in

Fig. 2. In the case of disasters or conflict event, it will result in confusion in the evacuation because of the uncertainty of the evacuation sign.



Figure 1. Evacuation sign in Beijing subway station.



Figure 2. No obvious evacuation sign in Beijing subway station.

In comparison, the Seoul Subway Station set up contingency evacuation sign more obviously, as shown in Fig. 3. New subways in our country have made the corresponding set of the evacuation sign. Fig. 4 shows the exit signs in Nanjing subway station.



Figure 3. Evacuation sign in Korea subway station.



Figure 4. Evacuation sign in Nanjing subway station

B. The Impact of Billboard in the Subway

Because billboards are always more colorful than signs, it is much easier for them to arouse the attention of passengers. Many commercial networks are set in the Beijing subway station hall and platform, as shown in Fig. 5. Advertising lights and plates set in the subway station tunnel and carriages by the subway companies might confuse people's view, delay the fleeing time, disturb the safety evacuation, and even obstruct the whole succoring program. The code on China subway sign design definitely prescribes that the advertising lights and plates should not disturb the evacuation signs, so the billboards should be properly removed.



Figure 5. Too much billboards in Beijing subway station.



Figure 6. Less billboards in Tokyo subway station.

Billboards in Subway Station in Tokyo and Seoul are relatively harmless. Fig. 6 shows that there are nearly no advertising plates in the subway station of Tokyo. In the main concentrated sites, a small number of billboards will not affect the sign function in public environment.

C. Relevance Between the Sign and the Fire Device

At present, there are two sets of automatic fire facilities in Beijing subway: a set of two automatic monitoring system, one located in the station, another located in a central control room, to monitor the subway stations situation; Another set for automatic fire extinguishing spray system, it has water spray and gas spray, suiting to different causes of fire control. There are dedicated smoke extraction devices in subway tunnel, in case of fire, the tunnel fan system will start to work and exhaust the toxic smoke outside in the shortest possible time to prevent passengers suffocation. Subway trains are equipped with clear instruction, alarm switch, fire extinguisher and other safety facilities as shown in Fig. 7.

Subway disaster-prevention should not only do fully in equipment and sign, but also place the sign and related equipment to the correct location, and coordinate with each other. Take fire-fighting equipment as an example, the disaster prevention equipments mainly include fire hydrants, fire extinguishers and fire alarms, etc. Some of the Beijing subway fire-fighting equipments are lack of relevance to a certain degree. As shown in Fig. 8, the fire extinguisher is placed in the car under the seat. Under crowded circumstance, it is difficult to get it into application timely. Moreover, the corresponding sign of this fire extinguisher placed on the window, leading to a certain gap in coordination. In addition, fire sign in Beijing subway is different in different regions, affecting passengers' understanding the sign in certain extent. Therefore, the unification of fire sign is needed to be improved.



Figure 7. Emergency button in Beijing subway train



Figure 8. Fire extinguishers in Beijing subway train

Since the man-made arson subway incident happened in Daegu Korea Subway station, Seoul Subway signs are replaced by those made by burn-resisting, low smoke and halogen free material to prevent similar incidents from happening again. Moreover, the sign design and planning have been improved. As shown in Fig. 9, fire-fighting equipment is placed next to the seat, and the sign is in the appropriate position. In addition, relative subway department in Seoul had increased the inputs in the aspect of emergency rescue equipments, such as emergency masks, emergency stretchers, and reserved power flashlights and so on. For passengers to use relative equipment effectively by themselves in disaster time, the instruction and attention issues should be marked on the equipment repository.



Figure 9. Fire extinguishers in Busan subway train

D. "Location Map" Sign

To understand the present location in subway troubles the passengers when the disasters happen due to the construction characteristic of subway. "Location map" sign can offer all emergency refuge information to make passengers identify their positions. Furthermore, it can easily show the direction and position of emergency exit, refuge space and refuge tunnel clearly, which can help emergency and refuge evacuation.

Fig. 10 shows the "three-dimensional configuration map" sign of the subway station in Busan which includes the direction of the emergency exit, ordinary exit and the place of the fire extinguishers and the emergency telephone number. "Location map" signs in Subway station of Beijing only tell users the subway station's location without any directional route for evacuation and emergency telephone, etc. that will make it difficult to evacuate.

Moreover, intelligent position touch-pad is in use in Tokyo subway station, as shown in Fig. 11. Through the touch-pad the passengers can be informed of their location and their destination location. Such devices are able to query information of all-round emergency shelters in the subway station, so that passengers get a clear understanding of their location. And through the touch-panel they can easily make an intuitive understanding of the contingency export, shelter space and the direction of evacuation routes and locations in order to reduce the confusion in the case of disaster and ensure the smooth conduct of emergency evacuation.



Figure 10. The three-dimensional configuration map in Busan subway station



Figure 11. Intelligent position touch-pad

E. Ancillary Equipment

Since the space of subway is dark, the artificial lighting is used as the main light source in the subway. However, the artificial lighting is insecure, especially when the disaster occurs, the light can be inadequate because of the broken circuit system, and as a result, the visual signs can not play a

normal role. So apart from the visual signs, the other sensory-type signs should also be set up in the subway. For example, the sign shown in Fig. 12 is just a general evacuation sign when the light is enough. While the light is poor, the both sides of it can shine and then it can be used as an inducement sign, it also can issue the warning voices. Emergency flashlights are shown in Fig. 13, which can supply a help to passengers when the power is off or the light is dim.



Figure 12. Multiplicate functions evacuation sign



Figure 13. Emergency flashlights

In addition, the Busan subway station has the detail descriptions of the use of related equipments so that the passengers can be familiar with them during their waiting. For example, gas masks and oxygen tanks as shown in Fig. 14. In this view, the Beijing subway station could publicize the escape methods when the disaster occurs, and the expression must be easy to read.



Figure 14. Detail descriptions of the use of related equipments

III. OPTIMIZATION SUGGESTION ON NATIONAL SIGN SYSTEM

Through the investigation on subway sign system in some representative cities, it is found that domestic subway sign system still needs to be further improved. And through comparison and analysis, the subway sign system shall be improved in the following aspects:

1) On functional aspect, sign function should be highlighted in sign design. In order to meet that requirement, sign meaning must be express carefully and quickly. Subway sign system shall be clearly "identifiable" and "readable", and be ensured that it is clearly visible in the circumstances.

2) On systematic aspect, subway sign system should be consistent, no matter in the forms, fonts, colors, materials, contents and placements. On contents design, correlation between them should be systematically set up to show the locations and surrounding areas. Some signs which need to be set continuously shall be consistent in height and maintain a

certain internal. Systematization is embodied in the sign comprehensive and integrated, as well as scientific.

3) On international aspect, images of international standards with explanation in both Chinese and English as well as Arabic numerals should be adopted.

4) On concise aspect, the contents of signs should be expressed in the way of images to the greatest extent. If there is no international reference available for the design of sign image, the signs should be as brief as possible on the basis of expressing the meaning clearly. In one word, subway sign system should adhere to the principle of being appropriate, adequate, correct and clear.

5) On humanistic aspect, subway sign system should embody human care, consider the needs of the users on all respects of psychological and physiological, and supply effective guiding information whenever the users may need to make a choice.

IV. CONCLUSIONS

The investigations on subway sign system at home and abroad reflect the problems in the subway sign design of our country. Compared to some foreign subway stations, there are many problems in the domestic subway sign system and a big gap on the rationality and effectiveness.

In order to improve the functionality and efficiency of signs, we must make a overall consideration about the relevant factors when doing the preliminary planning based on a lot of researches and studies on the psychological and physiological point of view and should be people-oriented, so as to make the sign system fully reasonable and effective. The present paper gives some suggestions on the domestic sign system design through comparison and analysis, which can give some direction instructions for the future optimization design of sign system.

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