Comparison of safety equipment between London underground and Beijing subway

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Abstract. The purpose of this paper was to improve the safety equipment’s effectiveness through the comparison. Firstly, the history and safety accident of London Underground and Beijing Subway were shown. Secondly, fire equipment between these two cities was compared including station’s hardware installations and carriage’s hardware installations. Thirdly, the relative software installations were also compared such as emergency drills. The results showed that Beijing Subway’s hardware installations were better than London. However, London Underground’s some installations were more effective than Beijing. Both cities would pay more attention on anti-terrorist in tunnel.

1 Introduction
The London Underground was a public rapid transit system serving Greater London and adjacent counties. This was the world’s first underground railway which was opened in 1863 [1]. The City & South London Railway was the first line to operate underground electric traction trains in 1890. The Beijing Subway or Beijing Underground was a rapid transit rail network that served the urban and suburban districts of Beijing municipality. Beijing Subway was the oldest metro system in mainland China, which was opened in 1969. The subway had a rapid development since 2002. [2]

There were 17 main safety accidents in London Underground after World War II. Three fire accidents including electric fire and solid fire were as shown in Table 1. Other accidents due to train operation such as crush or derailment also happened.

| Date          | Location                        | Result          |
|---------------|---------------------------------|-----------------|
| 1958.07.28    | Holland Park                    | 1 death.        |
| 1984.11.23    | Oxford Circus Station           | 14 injures.     |
| 1987.11.08    | King's Cross St. Pancras Station | 32 deaths.      |

There were also some safety accidents in Beijing Subway. The serious fire caused by electrical short circuit happened on November 11, 1969. This fire smoke led to 6 deaths including 1 fireman and more than 200 injures, which happened between Wanshoulu station and Wukesong station. The other two fire accidents happened near the subway line in 2014 and 2016 causing no injuries or deaths in Beijing. The different situation between London Underground and Beijing Subway was mainly caused by the different safety equipment. Therefore, the comparison of these two cities should be carried out to improve the safety equipment’s effectiveness in the future.
2 Hardware installations

2.1 Station’s hardware installation

When there was an accident, the passengers in subway should follow the guide system’s direction and escape through the tunnel routes. The stuff could perform first aid and control small fire in the help point. Therefore, three aspects of hardware installations would be compared including guide system, tunnel route and help point during this process.

Firstly, the guide systems in London Underground and Beijing Subway were both obvious [4]. The information was mainly shown on LED display with audio broadcasting in London’s platform in Figure 1 (left). The information was mainly shown on colour display with audio broadcasting in Beijing’s platform in Figure 1 (right). In addition, the Beijing’s display layout in bigger space was neater than London in smaller space.

Secondly, the tunnel routes in London were more classical. The wooden escalators were replaced by metal escalators after the fire in 1987 as shown in Figure 2. The escalator’s load and lasting time were shown in Figure 3 according to Specification for Heavy Duty Metro Escalators. In addition, the red stop buttons in London were located on the sides of escalator in Figure 2 (right). But the escalator’s stop buttons in Beijing were generally located at the bottom of the escalator in Figure 4 (right) [6].

Figure 1: London Underground (left) and Beijing (right) Subway’s guide systems.

Figure 2: The old wooden escalators (left) and metal escalators (right).
Thirdly, the help point could provide three functions in London Underground as shown in Figure 5 (left) including fire alarm, emergency and information. Everybody could use this point. There were also some special fire alarm points in Figure 5 (right) with emergency microphone [7]. The fire alarm could be seen in Beijing Subway. The first aid stretcher was managed by tunnel stuff in China.

In London Underground, some fire extinguishers were located on the wall in open space in Figure 6 (left). Other fire equipment was located in the closed fire extinguisher box in Figure 6 (right). The other fire hose reels were generally located in another separate place in Figure 7 (left). In Beijing Subway, most of fire equipment was located in closed space. Many integrated extinguishers with fire hose reels were placed together in Figure 7 (right).
Figure 6: The fire equipment on the wall (left) and in the extinguisher box (right) in London Bridge station.

Table 2: Parameters of extinguishers in London and Beijing.

| City    | Extinguisher type      | Fire type          |
|---------|------------------------|--------------------|
| London  | Foam extinguisher      | Class A and B.     |
| London  | CO₂ extinguisher       | Class B and E.     |
| Beijing | Dry powder extinguisher| Class A, B and E.  |

Figure 7: The separate fire hose reel in London (left) and integrated equipment in China (right).

2.2 Carriage’s hardware installation

When an accident happened in a running train, the passengers in carriage should follow the guide system’s direction. Some emergency operations might also be carried out immediately. Therefore, two aspects of carriage’s hardware installation would be compared including guide system and emergency installation.

To guide system, the guide displays were generally located on both side of the carriage in London in Figure 8 (left), in which each carriage was independent. However, the guide displays in Beijing were generally located on both side and central inter-carriage joint in Figure 8 (right), through which different carriages were communicated. The carriage in London was narrower and older than Beijing [8]. The rail gauge in London was only 1432 mm, while the rail gauge in Beijing was standardized 1435 mm.
To emergency installation in carriage, London’s operation was more complex than Beijing. The passenger should lift the emergency alarm flap and pull lever manually in London as shown in Figure 9 (left). In Beijing, the passenger should just press the automatical emergency alarm button in Figure 9 (right). In addition, the voice communication in China was more advanced using indicator lamps with different colours and shapes.

3 Relative software installation

3.1 Terrorism attract

The safety equipment had been installed in London Underground and Beijing Subway. The fire accident and other emergency safety accident such as crush or derailment became less and less in recent 10 years, which was caused by the technical progress. However, the other accidents such as terrorist attack brought more and more loss. Generally speaking, the conflict between race and religion led to the terrorism attract.

For example, four Islamist extremists separately detonated three bombs in quick succession aboard London Underground trains on July 7, 2005. The forth bomb was fixed on a double-decker bus in Tavistock Square. Then big explosions were caused by homemade organic peroxide-based devices. This terrorist attack targeted civilians during the rush hour and resulted in 52 deaths and over 700 injures. Then all the international community paid more attention on terrorism attract.
3.2 Passenger flow
The high passenger flow also set a higher request. The network of London Underground had expanded to 11 lines, which collectively handled approximately 4.8 million passengers a day. The network of Beijing Subway had 19 lines, 345 stations and 574 km of track in operation. This network collectively handled approximately 9.3 million passengers a day. Compared with London Underground, there were more circular lines in Beijing Subway including Line 10 and Line 4 [3]. The transit capability of Beijing Subway was stronger.

Table 3: The Passenger flow in Beijing Subway without Line 4, Line 14, Line 16 and Daxing Line in January, 2017.

| Date   | Passenger flow | Date   | Passenger flow | Date   | Passenger flow |
|--------|----------------|--------|----------------|--------|----------------|
| 01.01  | 5373100        | 01.11  | 9413600        | 01.21  | 5422300        |
| 01.02  | 5576000        | 01.12  | 9532900        | 01.22  | 7135600        |
| 01.03  | 9085000        | 01.13  | 9858000        | 01.23  | 7220000        |
| 01.04  | 9165200        | 01.14  | 6548100        | 01.24  | 6314300        |
| 01.05  | 9105000        | 01.15  | 5784200        | 01.25  | 4988500        |
| 01.06  | 9446000        | 01.16  | 9431300        | 01.26  | 3371500        |
| 01.07  | 5696000        | 01.17  | 9372100        | 01.27  | 1515800        |
| 01.08  | 5535700        | 01.18  | 9344700        | 01.28  | 2066700        |
| 01.09  | 9366200        | 01.19  | 9107900        | 01.29  | 2471000        |
| 01.10  | 9466000        | 01.20  | 9088700        | 01.30  | 3303700        |

The passenger flow’s data in Beijing Subway was shown in Table 3. The max passenger flow was 9858000 and the mix passenger flow was 1515800. The significant change was caused by the transport during the Spring Festival. In formula (1), n was the samples’ number, s was the standard deviation, \( x_i \) was the sample value and \( \bar{x} \) was the average value. Then the kurtosis value was -1.0072 according to this formula. This negative kurtosis indicated a relatively flat distribution.

\[
\frac{n(n+1)}{(n-1)(n-2)(n-3)} \sum \left( \frac{x_i - \bar{x}}{s} \right)^4 \cdot \frac{3(n-1)^2}{(n-2)(n-3)} \quad (1)
\]

3.3 Safety drill
To improve the software installation’s level, British government and China government ran many safety drills [9, 10]. It could be seen that Beijing’s drill frequency was relatively higher than London [11] as shown in Table 4 and Table 5.
Table 4: The safety drills in London Underground.

| Date       | Detail                                                                 |
|------------|------------------------------------------------------------------------|
| 2003.09.07 | Anti-terrorist drill on chemical and biological weapon attract by firemen in underground system. |
| 2012.03.06 | Anti-terrorist drill by traffic policemen in Oxenhope.                 |
| 2015.04.30 | Anti-terrorist drill by emergency services in Aldwych station.         |
| 2016.02.29 | Emergency drill for underground station landslide in London.           |

Table 5: The safety drills in Beijing Subway.

| Date       | Detail                                                                 |
|------------|------------------------------------------------------------------------|
| 2004.06.28 | Emergency drill for suicide in Line 2 by Beijing police station.       |
| 2005.02.08 | Anti-terrorist drill on poison gas by chemical defense troops.         |
| 2008.09.29 | Anti-terrorist drill in Line 10 by Beijing Subway and municipal fire bureau. |
| 2013.12.19 | Evacuation drill in Line 8 by Beijing Subway.                         |
| 2014.12.05 | Emergency drill for derailment in Line 7 by Beijing Subway.           |
| 2015.04.29 | Anti-terrorist drill in Line 8 by Snow Leopard Commando Unit.         |
| 2016.03.26 | Anti-terrorist drill in Line 5 by Beijing Subway.                     |
| 2016.12.23 | Fire drill in Line 6 by Beijing municipal fire bureau.                |

4 Conclusion
In summary, Beijing Subway’s station and carriage hardware installations were better than London. Some hardware installations in London might be more effective such as the escalator’s red stop buttons. To software installations, both Beijing Subway and London Underground had paid more attention on tunnel safety drill. More and more anti-terrorism cooperation on traffic would be international. The further study should focus on the new type technique’s introduction to improve the tunnel safety equipment effectiveness.

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