Large-Scale Escalator Risk Assessment Technology Coupling Model

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ABSTRACT

Safety assessment is an effective means to improve the safety of escalators. In recent years, there are more than 4,000 escalators that need to be evaluated in Beijing to ensure the city’s public management level. This paper introduces the Functional Hazard Analysis (FaHA), which illustrates the application of large-scale risk assessment of urban scale in Beijing, the safety assessment process and assessment project improvement based on functional hazard analysis in escalator risk assessment, and traditional risk assessment. Highly dependent on the quality of personnel, it is difficult to ensure quality comparison when the quantity is huge. This method has the advantages of fairness and efficiency, and is especially suitable for large-scale evaluation.1

KEYWORDS

Large-scale, Escalator, Risk Assessment, FaHA.

INTRODUCTION

An escalator is a fixed electric drive device with a circulating running step for tilting passengers up or down [1]. Since New York State created the world's first escalator in 1899, the escalator has a history of over 100 years. From 1935, Shanghai Daxin Department Store installed two Otis single escalators, and it can be designed and manufactured independently at the Capital Airport in 1976. China's escalator road has also gone through 80 years. [5] Due to the large number of people

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carrying escalators and the concentrated use period, once an accident occurs, it is easy to cause serious social impact. At the same time, a considerable number of escalators, especially those in the public transportation sector, are already in an extended service due to their high passenger flow and high use intensity. Under the condition that the administrative inspection resources of elevator supervision are very limited, the safety assessment of escalators is beneficial to the rational allocation of administrative resources and the effective classification of escalators is an effective management method to improve the safety of escalators. How to evaluate the overall safety performance of the escalator during use is the basis for the safety management of the escalator.

In China, the manufacture and installation of escalators follows the national standard GB 16899-2011 "Safety regulations for the manufacture and installation of escalators and moving walkways". The safety performance requirements of escalators are mainly for the characteristics of the machine, and more importantly, considering the machine pairs. The risk of injury to personnel is not fully considered in terms of manned equipment, lack of safe environmental space and measures to limit irregular behavior of personnel. Safety education is not in place, and passengers’ safety awareness is poor, which increases the risk of riding an escalator. According to the information obtained by Xinmin Evening News from the Shanghai Metro operator, from January to July 2015, there were 300 passenger injuries in the Shanghai Metro network, of which 1 was caused by equipment failure, accounting for 0.3%. A total of 277 guest injuries were caused by passengers accidentally taking the elevator, accounting for 92.4% of the passenger injuries in the elevator; elderly passengers aged 60 and above accounted for 67.3% of the total number of passenger injuries in the elevator. Most of the passenger injuries caused by passengers sitting on the stairs are caused by not taking the ladder correctly. If you do not hold the handrails, lean on the elevator side fences, carry large luggage (trailer boxes, small carts, etc.) and take the escalator. In the morning and evening peak hours, 59 cases occurred, nearly 20%, and there were 241 cases in the usual time period, exceeding 80%. It can be seen that most elevator passenger injuries are not caused by crowded passengers. On the contrary, when people are few, it is more likely to happen. [5][6]

RISK ASSESSMENT BASED ON FUNCTIONAL HAZARD ANALYSIS

In China, the escalator safety risk assessment mainly refers to GB/T20900-2007 "Elevator, escalator and moving walkway risk assessment and reduction method of this standard". The Zhejiang Provincial Government DB33T 869-2012 "Evaluation Rules for Evaluating Evaluated Elevators" also adopts similar rules. The above method adopts the method of group analysis + expert evaluation, which is particularly affected by the subjective and technical level of the evaluators. The compiler of GB/T20900-2007 also specifically stated in the article: “Because there
are different degrees of subjectivity in the evaluation process, risk assessment is not an accurate science."[7]

Choosing a suitable and operational safety risk assessment method is the core issue that needs to be addressed in elevator risk assessment. There are many methods for safety risk assessment. There are more than a dozen risk assessment methods commonly used at present. Among them, there are many methods for risk assessment of special equipment such as elevators. The more common ones are risk probability assessment and safety checklist, fault tree analysis, etc. However, for the city of Beijing with nearly 20,000 escalators, the traditional assessment method has a large workload, a long evaluation period, and the assessment conclusion is greatly affected by the technical level and subjective knowledge of the assessors. It is necessary to explore a Beijing-style characteristic. Elevator safety risk assessment system, which is using scientific and technological means to reduce human interference, and to achieve elevator safety risk assessment fairly, fairly and efficiently.

Fault Hazard Analysis (FaHA) is an analytical method for identifying hazards/accidents caused by component failure modes. The method was developed by Boeing in 1965 for the "Military" missile project. The analysis steps include: defining the system; making the plan; obtaining the data; system partitioning; implementation (including failure mode analysis, fault direct impact analysis, fault system impact analysis and potential hazard and related risk analysis; proposing improvement measures; monitoring improvement measures. The advantages of this method are: 1) the method is easy and fast to implement; 2) the theory is simpler and easier to get started; 3) the cost is less; 4) the focus of the analysis is on the elements and dangers of the system. The difference from the traditional failure mode and impact analysis method is that the method allows the analyst to stop the analysis when it is clear that a certain failure mode does not cause danger, and the conventional method generally needs to improve the overall safety of the product. The failure mode is fully evaluated. In layman's terms, the failure hazard analysis method is designed to reduce the risk of failure. Its advantage is that it can be implemented “it is enough to do it”, while other methods are “poor pursuit” and require long working costs.

EVALUATION PROCESS

The ultimate goal of escalator risk assessment is to reduce the risk. The size of the risk is generally identified by the product of the probability of occurrence of the risk event and the consequences. As long as there is a zero in the probability and consequence of the occurrence, that is, the parameter does not occur, or has no adverse effects, the risk of the risk event is zero, that is, there is no risk. According to the accident causal chain theory, by controlling the failure factors of the elevator, reducing the probability of failure factors and reducing the accident hazard, so that the elevator maintains a high safety state, it can reduce the probability of accidents.
Guided by this, the risk assessment process for escalators includes the following steps:

1) Using the fault tree method to identify the risk points of the escalator, and obtain the probability of occurrence; using the second-order judgment matrix of the analytic hierarchy process, the weights of each risk point are obtained, and the severity is obtained. Severity is divided into four levels from 1 to 4 according to size, and the probability of occurrence is divided into six levels from A to F according to frequent and impossible;

2) Using the failure hazard analysis method to evaluate each risk point, and obtain the risk level, that is, 1 high risk - need to take protective measures to reduce the risk, corresponding to the analysis index 1A, 1B, 1C, 1D, 2A, 2B, 2C, 3A, 3B; 2 Moderate risk - need to carry out a review, after considering the practicality and solution of social value, determine whether further safety protection measures are needed to reduce the risk, corresponding to the analysis index 1E, 2D, 2E, 3C, 3D, 4A, 4B; 3 low risk - no action required, corresponding analysis index 1F, 2F, 3E, 3F, 4C, 4D, 4E, 4F;

3) Using the second Delphi expert method to correct the risk level obtained by the assessment, determine the risk category, and judge whether it is necessary to take corresponding safety measures to reduce the risk according to the obtained risk category;

4) Take appropriate safety measures to reduce or even eliminate the danger;

5) Conduct a general measurement and assessment of the results of each risk assessment and draw conclusions from the safety assessment.

Take the escalator handrail with an anti-trap device as an example to perform a functional hazard analysis. GB 16899-2011 "Safety regulations for the manufacture and installation of escalators and moving walkways" 5.6.4.3 stipulates: "The finger and hand protection devices shall be provided at the handrail belt at the steering end of the handrail, and an i corresponding to Table 6 shall be provided) The specified safety device." Generally referred to as the escalator handrail with an inlet anti-pinch device. Through the functional hazard analysis method, the risk analysis table of the escalator handrail anti-trap device is obtained, and the results are as follows.

It can be seen that the risk level of the handrail belt entrance jam is 3C, indicating that the failure mode will make the escalator in an unsafe state, the risk level is moderate, and need to be reviewed, considering the practical value and solution of social value. After that, determine if further security measures are needed to reduce the risk. It is recommended to adjust the opening gap through rectification and eliminate the hidden troubles, so as to reduce the risk. Through evaluation, it also urges the use of units and maintenance units to improve the level of elevator management and promote the improvement of technical level.
TABLE I. RISK ANALYSIS FOR HANDRAIL BELT ENTRANCE ANTI-PINCH DEVICE.

| No. | Item                  | Description                                    |
|-----|-----------------------|------------------------------------------------|
| 1   | part                  | handrail                                       |
| 2   | Risk                  | Handrails with entrance clips                 |
| 3   | probability           | at least once                                  |
| 4   | Impact on subsystems  | Stopping, personnel injury                     |
| 5   | induced causes        | finger in operation during operation          |
| 6   | Risk Index            | 3C                                             |

TABLE II. ITEM NEED TO BE STRENGTHENED.

| No. | Item                                | Content                                | Probability |
|-----|-------------------------------------|----------------------------------------|-------------|
| 2   | Support structure and coamings Risk | 2.3 The gap between the wall panels    | 3B          |
| 4   | drive unit                          | 2.5 anti-pinch device                  | 3B          |
| 6   | armrest device                      | 4.1 host fixed                         | 1C          |
| 7   | step pedal tape chain comb plate     | 6.1 Wear and Defect                    | 3B          |
|     |                                     | 7.1 steps, pedals, tape                | 2B          |

TABLE III. ITEM CAN TO BE OBTAINED.

| No. | Item                     | Content                                | Probability |
|-----|--------------------------|----------------------------------------|-------------|
| 3   | drive and steering station | 3.2 dedicated equipment and stop switch | 4D          |

Due to different use environments, the technical conditions for using the maintenance unit funds are different. The same risk assessment project should be different for different ranges of escalators. For example, the escalator work intensity is high, and the technical and capital requirements for the use units and maintenance units are high. The results of elevator safety assessments with other occasions are quite different on many projects and need to be focused on the general elevator risk assessment project.

In the escalator risk assessment, according to the analysis and risk rating table, the following items are higher in severity due to the increase in severity or the probability of occurrence is higher than that of the general elevator. In the current technical conditions and elevator conditions, the overall assessment of the escalator is required to be strengthened.

Due to the small number, it is not considered as a main factor. In the same way, the main problems of civil installation, maintenance and management factors are obtained. Using the fault tree approach, a three-level fault tree for the passenger elevator safety assessment problem is obtained.

It can be seen that using the functional hazard analysis method, it is possible to establish a project set for different use occasions and different types of escalators, and to develop different inspection plans; instead of checking the risk points of the
escalators as in the conventional method. This has achieved a prominent focus, and on the basis of ensuring the effect, the rational use of resources has been realized.

CONCLUSIONS

The escalation safety risk assessment mainly refers to GB/T20900-2007 "Elevator, escalator and moving walkway risk assessment and reduction method of this standard". The purpose of this standard is to develop uniform and systematic principles and procedures for elevator risk assessment methods. Used as a tool to identify the risk of injury caused by various hazards, dangerous conditions, and injury events, and to evaluate events that may result in the level of damage defined in this standard. Risk assessment is not accurate due to the varying degrees of subjectivity in the evaluation process. The functional hazard analysis method is used to carry out the escalator safety assessment. Through the standardized process, the human disturbance can be effectively reduced, and the elevator safety risk assessment can be completed fairly, fairly and efficiently.

Since 2014, Beijing Special Equipment Testing Center has cooperated with Fengtai Special Inspection Institute in cooperation with Fengtai Special Inspection Institute in Mitsubishi, Hitachi, Otis, Schindler, KONE, etc., for stations, subways, airports and shopping malls within the city. Over five thousand escalators in public gathering places were evaluated for safety. Through safety assessment, the elevator safety situation in Beijing can be analyzed, effectively reduce regional and systemic risks, eliminate hidden dangers, improve the safety and reliability of escalator operation, and achieve better safety and social influence.

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