Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 165 (2016) 433 – 447

Procedia Engineering

www.elsevier.com/locate/procedia

15th International scientific conference "Underground Urbanisation as a Prerequisite for Sustainable Development"

The establishment and application of underground space safety evaluation system in Shanghai

Shan Lu [a,*], Nakamura Hitoshi [a], Yu Shu [a]

[a] *Graduate School of Engineering and Science, Shibaura Institute of Technology, Japan*

Abstract

With nearly 10 years of large-scale construction of Shanghai subway network, the drive of expo 2010, and also the pressing needs of space extension for urban regeneration and modernization, the exploitation of underground space in Shanghai has been greatly advanced. By the end of 2015, the total volume of underground space in Shanghai had reached 65 million square meters, and the per capita possession of the area of underground space is nearly 3.0 square meters. In the meanwhile, the safety issues during the use of underground space facilities are also increasingly prominent, not only because of the internal closure features that easily cause and spread disasters, but also the safety management and disaster prevention hardware that hide great danger. These problems have already been the important restriction factor in the comprehensive utilization of underground space resource in Shanghai. The authors and their team began to undertake the government-sponsored research projects of underground space safety issues in 2008, and by combining the literature research and empirical research during the following several years, the team made site surveys of more than 100 underground architectures in use. On the basis of this, the team used experts experience analysis and bowknot analysis methods to identify the causes and risks of the disasters and accidents, therefore refined and summed up the underground space safety evaluation index system. In order to achieve the quantitative evaluation, the team also made the evaluation criteria system according to the current law and technical standards, and used the AHP methods to build the weight system, and finally established the whole underground space safety evaluation system. The system has already been used for trial evaluation practice of several underground projects in Shanghai and provided effective basis for the improvement of the disaster control facilities and safety management of these projects.

Peer-review under responsibility of the scientific committee of the 15th International scientific conference "Underground Urbanisation as a Prerequisite for Sustainable Development

* Corresponding author. Tel.: +81-487206217.
E-mail address: lushanallen@126.com

Peer-review under responsibility of the scientific committee of the 15th International scientific conference "Underground Urbanisation as a Prerequisite for Sustainable Development
doi:10.1016/j.proeng.2016.11.718

Keywords: underground space safety evaluation, risk identification, evaluation index system, evaluation criteria system.

1. Research background

Shanghai has become the largest city in the development of underground space in China. According to the new underground space survey data in 2015, the total space of various types of underground space and construction in Shanghai has been more than 60 million square meters, the mileage of track traffic operation has been more than 400km, the total attendance to various types of underground space facilities has been more than 1000 million and the average usage area of capital urban underground space has reached 320 square meters. The space of Shanghai public is gradually expanded from the ground into the underground.

At the same time, the safety problems during the usage of the underground space are becoming more and more important. Through the analysis and continuous research on the use of underground space in Shanghai research group from 2009 by the author and his group, the following safety hidden troubles and disaster risks are very popular in the underground space facilities in Shanghai in the aspects of the safety management and the hardware configuration of disaster emergency prevention and control and so on:

- the risk of fire, flood, chemical pollution, terrorist attacks, power outages and other accidents are very high and with great harm;
- the risk management and disaster emergency system construction and regulations construction and technical standards for construction are seriously lagging behind, users and managers have low risk awareness, behavior deviation and low safety culture;
- disaster risk identification, pre-control and emergency disposal of hardware equipment investment is less, the lack of practical and reliable emergency plan and supporting technology;
- the lack of practical and effective use of safety assessment standards and methods;
- the lack of long-term use of safety supervision and management mechanism.

The above problems have become a significant constraints on the comprehensive exploitation and utilization of Shanghai underground space resources and are one of the important contents of the city overall safety and disaster prevention. By the continuous research analysis in recent years, our research group has made a systematic survey on five kinds of formats around the existing underground space facilities which have the most intensive users, the most frequent activities usage, the easiest to cause accidents and the most likely to cause serious loss of life and property (such as the underground garage, underground shopping malls, underground catering, cultural entertainment, underground Hotel), the team research to create various types of formats of underground space for the use of facilities and disaster risk identification system, the use of underground space safety evaluation index system, standard system, it can provide technical support and system security be make management regulations of the development of Shanghai underground space and improve the safety level of development and utilization of underground space resources in Shanghai.

2. The characteristics of underground space disasters and accident statistics

2.1. Characteristics of underground space disaster

Strong closure, disaster destructiveness aggravation

Underground spaces have strong closure, people are easy to lose their sense of direction, when a disaster occurs, the level of psychological panic and action confusion is more serious than that in the buildings on the ground; secondly, keeping the air quality in the underground space normal is much more difficult than that in spaces with window, only a small amount of air can come into the air intake and outlet , when the malfunction of mechanical ventilation system happens, it's very difficult to rely on natural ventilation as a remedy. What's worse, materials are not easy to burn fully in the environment of closed underground space, the smoke of combustible is very big when