Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 135 (2016) 33 – 39

Procedia Engineering

www.elsevier.com/locate/procedia

A comparative analysis on the evacuation time of atrium-style metro station

Gang Zhao[a], Yan-feng Li[a], Yan-qiang Cui[a], Wei-han Zhao[a]

[a]*College of Architecture and Civil Engineering, Beijing University of Technology, Beijing 100124, China*

Abstract

This article is to study the similarities and differences in terms of computational methodologies in different nations, as well as to analyze the accuracy and reliability of them, and consequently to raise proposals to improve this methodology in China. The author chose an atrium-style metro station as a study case. Computations and comparisons were carried out on the evacuation time, according to the terms in Chinese "CFDOM" (GB50157-2013), the U.S. "NPFA130" (2014) and Japanese "JIS Railway Standards". The results indicate that, the computational methodology in China is readily to be comprehended, while it ignores some important features. A certain extent of irrationality can be found in this methodology. While the American and Japanese codes specify the evacuation path in details, which leads to a more reasonable evacuation time. Therefore, in practical use, a synthetic methodology that considers multinational codes is commonly suggested, for the most precise evacuation time.

Peer-review under responsibility of the organizing committee of ICPFFPE 2015

Keywords: latest metro code; evacuation time; atrium-type metro station; NPFA130 (2014)

Nomenclature

A	throughput capacity (person/s)
B	the total width of the staircases (m)
N	the number of escalators
Q	occupants (persons)
T	walking travel time(s)
W	waiting time(s)

1. Introduction

For the past few years, a number of atrium-style metro stations have been progressively built up in Beijing, Shanghai, Xi'an, Hangzhou, Shenzhen, Zhengzhou, etc. The fire safety of this type of station, therefore, attracted more attention by scientists and the public [1]. In terms of the atrium-style metro station, due to its intrinsic absence of fire compartmentation and natural ventilation at the atrium that connects the public zone, may impede the evacuation and magnify the hazard. This risk of sort can be deteriorated by the chimney effect, which occurs under the condition where multi-storey communal spaces and large storey height exist.

Numerous scientists have worked on the subject of fire safety of the atrium-style metro station in recent years. He [2] conducted a numerical simulation based on Legion and FDS, to analyze the evacuation capability of the atrium-style metro station in 2010; In accordance with the CFDOM and with reference to the numerical simulation. 2013, Shen [3] made a

* Corresponding author.
E-mail address: tom_zhg@126.com

Peer-review under responsibility of the organizing committee of ICPFFPE 2015
doi:10.1016/j.proeng.2016.01.076

comparative analysis on various scenarios about the smoke control system of the atrium-style metro station; In 2014, Hao [4] designed the smock control system against fire conditions in different locations, and verified its effect by imposing the FDS simulation.

Nevertheless, there is an obvious shortage of research on the evacuation time of the atrium-style metro station. Following the renewal of "Code for Design of Metro" in China (GB50157-2013) [5] and the United States NPFA130 (2014) [6], the computational methodologies regarding to the evacuation time in metro has been updated and developed. Meanwhile, it is worth mentioning that, the Japanese "JIS Railway Standards" [7] is highly acknowledged internationally. Based on these settings, the author deems it of necessity to select a typical atrium-style metro station, compare the results of different evacuation time that are derived from calculations regarding to different codes. Comparative pros and cons are required to be discussed by taking the American and Japanese standards into consideration, meanwhile constructive proposals and suggestions are to be raised in order to optimize the methodology of calculating the evacuation time in an atrium-style metro station.

2. The computational methodology of evacuation time

2.1. Chinese "Code for Design of Metro" (GB50157-2013)

According to Sub-clause 28.2.11 of CFDOM (GB50157-2013), the width of the exit staircase and the evacuation passage should enable all the occupants, including those on aboard, to be safely evacuated from the platform within 6 min in case of fire during peak hours in the far-future. Differ from the CFDOM (GB50517-2003), the latest code stipulates that station staffs on the platform are not part of the evacuation occupants, as the staffs should command, assist and guide those occupants to the safe zone. The following is the formula of the emergency evacuation time from the platform level to the safe zone:

$$T = 1 + \frac{Q_1 + Q_2}{0.9\left[A_1\left(N-1\right) + A_2 B\right]} \le 6\,\text{min} \tag{1}$$

Where Q_1 is the train occupant; Q_2 is the platform occupant; A_1 is the throughput capacity of automatic escalator; A_2 is the capacity of the staircases. 1 is the response time of the personnel, which is fixed by CFDOM according to the response time of alarming system, broadcasting system design inside the subway [8].

2.2. The United States "NPFA130" (2014)

Sub-clause 5.3.3.1 of NFPA130 (2014): There shall be sufficient egress capacity to evacuate the platform occupant load from the station platform in 4 minutes or less.

Sub-clause 5.3.3.2: Evacuation time to a point of safety: The station shall be designed to permit evacuation from the most remote point on the platform to a point of safety in 6 minutes or less.

To calculate the evacuation time, NPFA130 stipulates that the total evacuation time is the sum of the walking time during the longest exit route and the waiting times at various circulation elements, using the following formula:

$$T_{total} = T + W_P + \sum_{i=1}^{N} W_N \tag{2}$$

2.3. Japanese "JIS Railway Standards"

As is prescribed in the "JIS Railway Standard", in the situation of a train fire on the platform, the station is required to permit the evacuation from the platform to the ground in 10 minutes or less.

Apart from this, JIS defines the evacuation time as "the time from the evacuation starts, till the last occupant arrives at the ground". Evacuation time is generally divided into two categories, walking time and dwell time. Especially, the considerations of the emergency evacuation route and the configuration of the station are highly emphasized in case of a complex metro station [9].

$$T_{total} = \sum t_i + T_{i-\max} \tag{3}$$