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ScienceDirect

Procedia Engineering 211 (2018) 427–432

Procedia Engineering

www.elsevier.com/locate/procedia

2017 8th International Conference on Fire Science and Fire Protection Engineering (on the Development of Performance-based Fire Code)

The experiment and simulation analysis of bus emergency evacuation

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Abstract

In this study the emergency evacuation experiment of electric buses is carried out for three different scenes. From the observation of the experimental procedure it can be found that the evacuation efficiency and speed of wider backdoor are larger than the front door, but the total evacuation time of the back door is more than the front door. At the same time, the experimental results are compared with the simulation results by software STEPS. It shows that it can fit well when the parameter Patient equals 0.7. Using the STEPS to do further simulation, the estimated action time for the scene that the initial 70 passengers evacuating from only front door, is about 2.5 minutes.

Peer-review under responsibility of the organizing committee of ICFSFPE 2017.

Keywords: bus emergency evacuation, simulation, experiment

Nomenclature

$ASET$	Available Safe Egress Time
E_{front}	Evacuation efficiency of front door
E_{back}	Evacuation efficiency of back door
F_{front}	Average flow rate of front door
F_{back}	Average flow rate of back door
$RSET$	Required Safe Egress Time

1. Introduction

With the development of public transport means, bus fire accidents also happen occasionally. It shows that there are dozens or even hundreds of automobile fires in the cities above medium each year. At the same time, electric buses are gradually promoted in all cities under the support of national policies. While electric buses are unlike traditional buses. They are powered by batteries, which are vulnerable to external environmental incentives, its safety performance at this stage is worrisome. However, at present scholars at home and abroad are less concerned about public bus fire accidents, and the research to combine physical experiment and simulation calculation is very rare. The occasional visible scattered study is mainly focused on the construction of the bus evacuation model [1,2], these models are mainly based on traditional evacuation models and are added to consider the impact of narrow space and obstacles, most of their real validity have not been validated through further experiments. In addition, there are some analysis on risks of passengers in the initial position of the different regions based on the mathematical methods [3,4]. However, there is no in-depth study on the time and the

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1877-7058 © 2018 The Authors. Published by Elsevier Ltd.
Peer-review under responsibility of the organizing committee of ICFSFPE 2017
10.1016/j.proeng.2017.12.032

rules of passenger behaviors in the process of total evacuation.

Based on the above situation, this research carries out the pure electric bus emergency evacuation experiment for three scenes. Through video to observe the behaviors of experiment personnel in evacuation process. Meanwhile the experiment results are compared and verified with the software simulation results to adjust the model parameter. Considering the safety of laboratory personnel, the number of initial persons in the experiment cannot exceed the maximum number of persons allowed in bus. And then software model is used to estimate the evacuation action time of personnel whole evacuation for the adverse scene. The results can be used with battery combustion and smoke spread regular pattern for the further research, which will provide reference for the specific requirements of electric bus fire safety design.

2. Experiment

2.1. Design of experiment

In order to observe the actual process of bus emergency evacuation, and to verify the simulation result, an entity evacuation experiment is carried out in this research. What utilized in experiment is the pure electric bus provided by Shanghai Bus Company, with the load of 63 people, length is about 12 meters, net width of front door is 0.88 meters, and net width of the backdoor is 1.1 meters. The evacuation process of the experiment is recorded by 7 cameras. Cameras NO.1 and NO.7 are set out of the bus on the ground, to shoot the evacuees from the front door and back door. Cameras NO.2 and NO.5 are set in the bus to shoot the evacuation from two doors. Cameras NO.3, NO.4 and NO.6 are set to shoot the scenes in bus. All cameras are adjusted to ensure evacuation process is clearly recorded. The layout of the scene is shown as below.

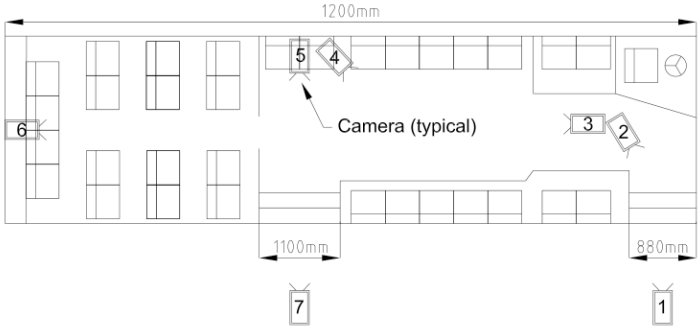

Figure 1. Layout of the experiment scene

To avoid selection of distortion after people are familiar with the fixed evacuation path, three experiments are designed respectively corresponding to different conditions of exits. Meanwhile the volunteers involved in the experiment shall not be informed in advance. In the experiment, the number of people is controlled about the rated number of 63, in the case of ensuring that 32 seats are fully seated, the rest of people are evenly dispersed in the vacant position. Set alarm bell in the experiment, when the alarm sounds, people evacuate immediately, representing the evacuation experiment begins. Evacuees can move from the starting position to the exit, shoving and mutual blocking are not allowed. Specific experimental scenes are set as follows:

(1) Scene 1: initial total number of people is 63, front door opened and back door closed;
(2) Scene 2: initial total number of people is 63, front door opened and back door closed;
(3) Scene 3: initial total number of people is 66, front door and back door all opened.

2.2. Results of experiment

The process of the whole experiment is recorded and some phenomena is observed as below:

(1) As for a bus which its person capacity is 63, when initial number of people is fully loaded, for scene 1 that front door opened and back door closed, the total evacuation time is about 50s. The time is only required to person's movement, excluding alarm time, response time, etc.

(2) When the front door and back door of bus are both opened, the evacuation efficiency and average flow rate of back door are greater than front door, and the effect of back door is more important than front door during the overall evacuation.

(3) In scene 3, the evacuation time of back door is greater than front door. It can be founded that some part of people in the middle compartment choose to evacuate from front door, meanwhile some choose back door. However, as for the people