Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 11 (2011) 179–184

Engineering Procedia

The 5th Conference on Performance-based Fire and Fire Protection Engineering

Global Sensitivity Analysis of Occupant Egress Safety Model

KONG De-peng[a, b,c], LU Shou-xiang[a,c,*], LO SM[b,c]

.[a]State Key Laborotory of Fire Science, USTC, Hefei, China,230027;
[b]Department of Building and Construction, City University of Hong Kong, Hong Kong, China, 999077;
[c]USTC-CityU Joint Advanced Research Centre, Suzhou,China, 215000

Abstract

Identification of the important factors for the occupant egress safety under building fire is important. In order to achieve this goal, a global sensitivity analysis method, Fourier Amplitude Sensitivity Test (FAST), was instead of the local sensitivity analysis to indentify the important factors for the safe evacuation level under building fire. The equation for safe egress level under building fire was determined by a series of empirical formulas. The result indicates that uncertainty of CFAST model has the dominating influence on the safety egress level while uncertainties associated with exit flow rate and population density have little influence. The relative differences between the first order sensitivity indies and the total sensitivity indies indicate that the interaction between fire growth rate and other factors has the largest influence on the safety egress level.

© 2011 Published by Elsevier Ltd.

Keywords: life safety; occupant egress;global sensitivity analysis;building fire

1. Introduction

In performance-based fire protection design (PFPD) and fire risk assessment, how to deal with uncertainty is an essential issue[1]. As one of the important aims for PFPD, determination of safety level of occupant egress under fire also should consider the uncertainties. Two questions should be answered for this issue[2]: (1). How we should represent uncertainty? (2). How many uncertainties we should consider? The former can be answered by the uncertainty analysis (UA) while the latter can be answered by the sensitivity analysis (SA). Due to many uncertainties involved in the occupant egress, SA seems to be more necessary for the fire engineering.

SA can be categorized into local SA and global SA[3]. Local SA examines the response of the output when varying input parameters one at a time and holding other input parameters as fixed values. Local SA is flexible and easy to implement. However, it can only inspect one point at a time. Furthermore, it is practicable only when the relation between input and output is linear. Global SA can examine the response of the output by exploring a finite region. The influence of the interaction between input parameters is also can be inspected by global SA. Unfortunately, the majority of SA in fire engineering is local SA. Fu and Fan[4] studied the influence of input

* Corresponding author. Tel.: +86-551-3603141; fax: +86-551-3603449.
E-mail address: sxlu@ustc.edu.cn.

1877–7058 © 2011 Published by Elsevier Ltd.
doi:10.1016/j.proeng.2011.04.644

parameters for a two zone model by giving the input a small change. Using the similar SA method, Wang[5] identified the important factors for RSET. Based on Wang's study, Wang[6] utilized single-factor sensitivity analysis to investigate the important factors for occupant evacuation under building fire. Due to the complexness of fire dynamic and evacuation, available safety egress time (ASET) and required safety egress time (RSET) are non-linear with input parameters. In this situation, global SA is more appropriate for analyzing ASET and RSET.

In this paper, we make an attempt to employ one kind of global SA, Fourier Amplitude Sensitivity Test (FAST), to analyze important factors for occupant egress under building fire. Section 2 gives a brief description of the occupant egress safety model. In Section 3, the global sensitivity analysis, FAST, is presented in details. Then we present an application of FAST to indentify the important factors for the safety level of occupant egress in a one-storey commercial building. Finally, a brief conclusion is given in Section 5.

2. The model of occupant egress safety under fire

In PFPD, ASET and RSET are compared to determine the safety level of occupant egress[1]. If ASET is larger than RSET, it is considered that occupant can evacuate safely and no casualties occur. Therefore, the equation of safety level for occupant evacuation can be written as following:

$$G = ASET - RSET \tag{1}$$

Where, G is the time margin of occupant evacuation, s; ASET is available safety egress time, s; RSET is required safety egress time, s.

If G>0, it indicates that occupants can evacuate successfully. If G<0, occupant cannot evacuate successfully. If G=0, Eqn.1 can be considered as the limited state equation for occupant evacuation.

ASET can be determined by the zone models or filed models. RSET usually has three components, i.e. fire detection time, occupant pre-movement time and movement time. Fire detection time can be obtained by are influenced by detection actuation time models, such as DETECT-T2 model. Occupant movement time can be determined by evacuation models. Since ASET and RSET are influenced by many factors, most of which are uncertain. Therefore, Eqn. 1 can be written as following:

$$G = g(X) \tag{2}$$

Where, $X=(X_1, X_2,\ldots, X_n)$ is the uncertain factors influencing occupant egress safety level.

3. The Fourier Amplitude Sensitivity Test (FAST)

The Fourier Amplitude Sensitivity Test (FAST) was originally developed by Shuler et al[7-8]. It is an effective global SA when the input-output is nonlinear and non-monotonic. Considering the nonlinear relationship between inputs and G, it is appropriate to conduct sensitivity analysis using FAST. The main idea of FAST is to assign each input parameter with an integer frequency according to the Fourier transformation. The influence of a specific input parameter on the output, the sensitivity index, can be assessed by the variance contribution, which can be obtained by the characteristic integer frequency [9-10].

For the model G=g(X_1, $X_2 \ldots X_n$), every uncertain factor Xi can be transformed into a function of character frequency:

$$X_i = F_i^{-1}\left(\frac{1}{2} + \arcsin(\sin(\omega_i s))\right), \quad -\pi \le s \le \pi \tag{3}$$

Where, F_i^{-1} is the inverse cumulative distribution function for X_i. ω_i is the character frequency for X_i and s is the common variable for all variables. If s varies, all X_is vary simultaneously in their own regions of variance at the rate according to ω_i.

Substituting Eqn.3 into G, we can present the model as a Fourier series:

دریافت فوری ← متن کامل مقاله

ISIArticles
مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات