Method to calculate evacuation safety performance in a building fire

HAYASHI Yoshihiko (Ph.D. in Engineering), Head
SUZUKI Junichi (Ph.D. in Engineering), Senior Researcher
Fire Standards Division, Building Department

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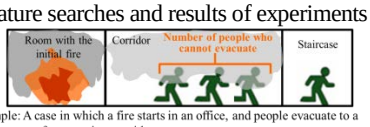
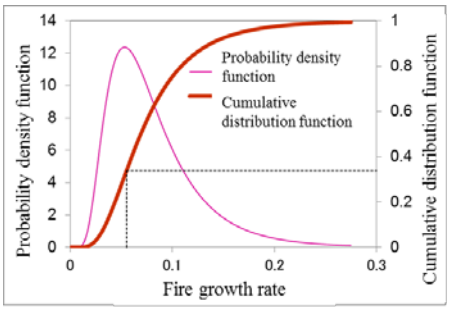
1. Introduction

The number of casualties is used as an index of building evacuation safety performance. The number of casualties can be obtained based on smoke spread predictions (unsteady two-layer zone model BRI2002) and evacuation predictions[1] (Fig. 1). Yet, the result varies greatly depending on fire scenarios, such as many casualties when the fire spreads rapidly and sprinklers and smoke exhaust systems are not activated. The result also varies depending on the time required for people in a building to start evacuating and how fast they walk. Thus, the research team developed a method to calculate the expected value (evacuation risk) from the number of casualties and the probability of onset with the expectation of all types of fire scenarios rather than setting a specific scenario. The calculation requires the probability density distribution of the fire growth rate and the probability of facilities to function. The study found these data through literature searches and results of experiments (Fig. 2).



Example: A case in which a fire starts in an office, and people evacuate to a staircase, a safe zone, via a corridor
In this example, the number of people who cannot evacuate (number of people exposed to smoke) is three.

Fig. 1 Number of casualties



*The fire growth rate is the parameter to determine the size of a fire.
The probability density function is required to compute the probability of the onset of any fire.

Fig. 2 Probability density distribution of fire growth rate

2. Examples of using calculation method of evacuation risk [2)]

When a fire occurs from Office 1 on a floor that is smaller than 3,000 m^2 (Fig. 3), people in the room evacuate to the corridor from the door that is farthest from the fire. People in rooms without a fire will start evacuating later but have access to all the doors (Fig.-3). Smoke from the room where the fire occurred spreads to the adjacent rooms via the corridor. Some people cannot evacuate if sprinklers do not work, depending on the fire scenarios, and the evacuation risk in this case becomes 0.013 (See the table.). The table shows the evacuation risks when the fire occurs from Offices 2 to 4. The total risk on the floor is 0.019 based on the risk in each room and the fire occurrence rate. (In proportion to floor area, the total fire occurrence rate is 1 because the occurrence of fire is the presumption of the risk calculation.) For example, the evacuation risk at a given floor decreases from 0.019 to 0.011 when the reliability for facilities to function improves (sprinkler: from 0.96 to 0.98, smoke exhaust system: from 0.9 to 0.95). The overall risk can be reduced by improving the reliability of facilities to function even when the ratio of people who are slow to evacuate increases, and the evacuation risk increases because of a slower walking speed or other conditions.

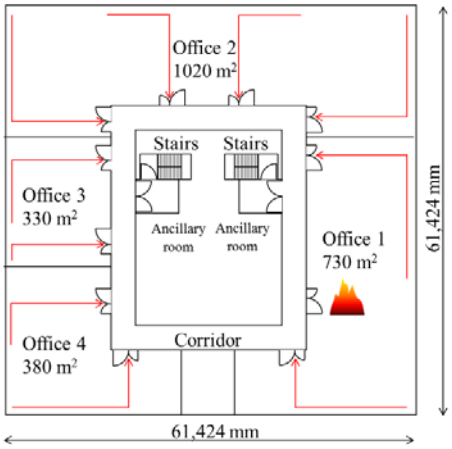


Fig.-3 Floor plan of offices used for calculation of risks

Table. Calculated Evacuation Risk

		Room of fire origin			
		Office 1	Office 2	Office 3	Office 4
SP	×	0.0114	0.0314	0.0020	0.0029
Ex	○				
SP	×	0.0016	0.0038	0.0004	0.0005
Ex	×				
Total		0.013	0.0352	0.0024	0.0034

SP: Sprinkler, Ex: Smoke exhaust system,
○: Proper activation (probability of function SP: 0.96, Ex: 0.9)
×: Failure to function; the risk 0 when the sprinkler works properly.

3. Future efforts

Fire prevention and evacuation regulations will be streamlined in the 2016-2020 General Technology Development Project. Proper standards will be set for target performances to establish regulations without producing a sense of burden. Quantitative examinations are required, and the calculation methods for the evacuation risk are expected to be useful.

1) New Building Fire Control Planning Policy by the Building Center of Japan (supervised by Japan Conference of Building Administration, Construction Supervision Division, Housing Bureau, Ministry of Construction). 1995
2) Hayashi Yoshihiko et al., Development of Risk of a fire Computation Tools for Buildings (in Japanese). Compilation of Academic Lectures, Conference of Architectural Institute of Japan. pp. 347-350, 2016