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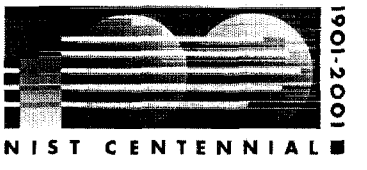
VOLUME 1

Sheilda L. Bryner, Editor



National Institute of Standards and Technology
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U. S. Department of Commerce
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Technology Administration
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Evaluation Method of Egress Safety

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ABSTRACT

The Building Standard Law and Enforcement Order are revised, and performance criteria are introduced in Japan. Functional requirements of fire safety are clarified, and evaluation methods of fire safety are defined. In this paper, the outline of evaluation method of egress safety is presented. However, because we are still working on, the details of the method are not fixed and subject to change.

KEYWORDS: means of escape, performance-based code, egress safety

1. INTRODUCTION

In the present law and order, the egress safety is written in some groups of specifications. These are number of escape stairs, travel distance to stairs, stairs width, smoke exhaust equipment, limitation of lining materials and so forth, as shown in FIGURE 1. The framework developed in the MOC's SOPRO (comprehensive project for technical development) resulted that the functional requirements need some sets of performance criteria and evaluation methods for them. So, the evaluation method of egress safety is necessary as a part of the revised law and order. This will be one of the approved methods used for a verification of required performance. It means to allow a building plan, which does not meet the specifications for the egress safety.

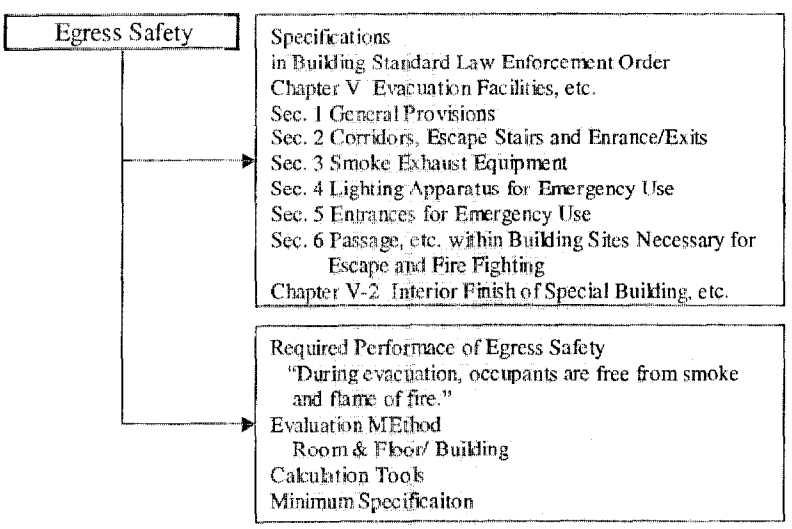

FIGURE 1 Framework of performance based egress safety

2. REQUIRED PERFORMANCE OF EGRESS SAFETY

In the performance-based evaluation, the design fire is introduced. The functional requirements of egress safety are "all occupants of a building are able to escape without difficulties and dangers from the design fire." So, required performance of egress safety are as shown below.

- During evacuation, occupants are free from smoke and flame of fire.
- There are some escape routes from any point to final safety place.
- It is easy to find out a safe escape route for unfamiliar occupants.
- There is no over queuing at any doors and junctions.
- ...etc.

Among these, the required performance of "free from smoke" is the most ready to be evaluated by using engineering tools. This is the required performance of egress safety, and the others are not subject to.

In Japan, it is recommended to calculate the egress time of a floor or a building larger than certain size. In a sense, it is valid for evaluating the performance of egress safety. However, it is lacking in taking account of important factors such as expected fire size, smoke management system, exit arrangement, occupant's character and so on.

This evaluation method consist of estimating smoke condition and escape condition. Smoke condition is estimated by taking account of the performance of smoke control equipment and the performance of smoke compartment such as walls and openings. Escape condition is estimated including the escape start time and the movement time. The evaluation is done by comparing the life threat time by smoke and the escape time in each escape route for each design fire.

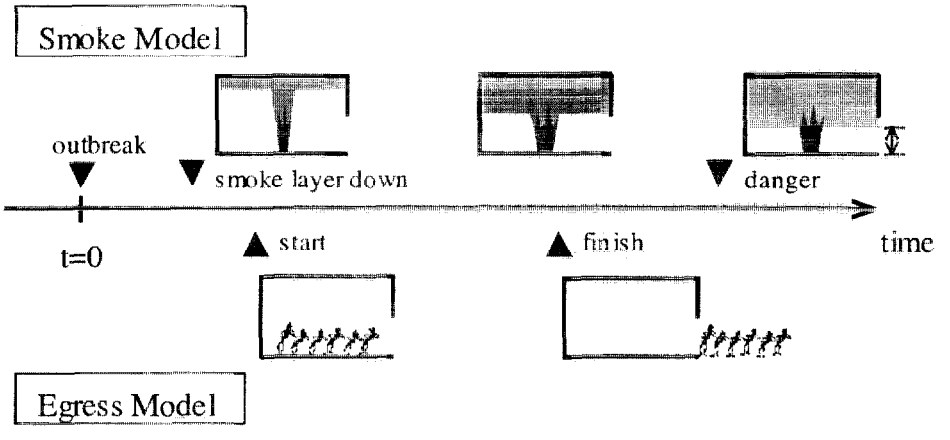

FIGURE 2 Concept of required performance of egress safety

3. EVALUATION METHOD

The evaluation of egress safety consists of two parts, escape from a fire floor and escape from a building. The escape from a fire floor includes the escape from a fire room. In each part, the life threat time by smoke is compared to the escape time. If the performance of egress safety is verified, some specifications such as travel distance, width of escape routes, and so forth will not be required.

3.1. Escape from a fire room

"The time needed for escaping out all occupants from a fire room" should be less than "the time of smoke layer descending down to the critical height in a room."

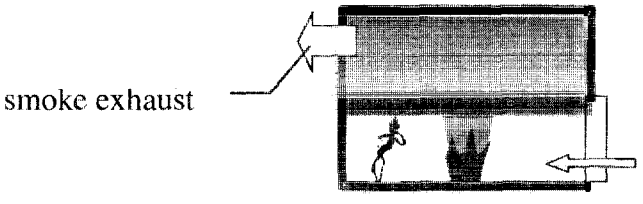

FIGURE 3 Escape from a fire room

3.2. Escape from a fire floor

"The time needed for escaping all occupants from the floor to the stairs" should be less than "the time of smoke layer descending down to the critical height in escape routes."

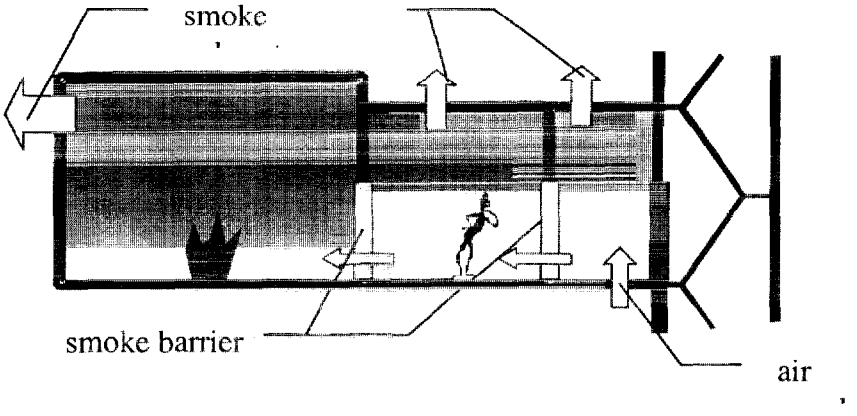

FIGURE 4 Escape from a fire floor

3.3. Escape from a fire building

"The time needed for escaping all occupants from the building to the outside" should be less than "the time of smoke spreading into stairs or other floors."

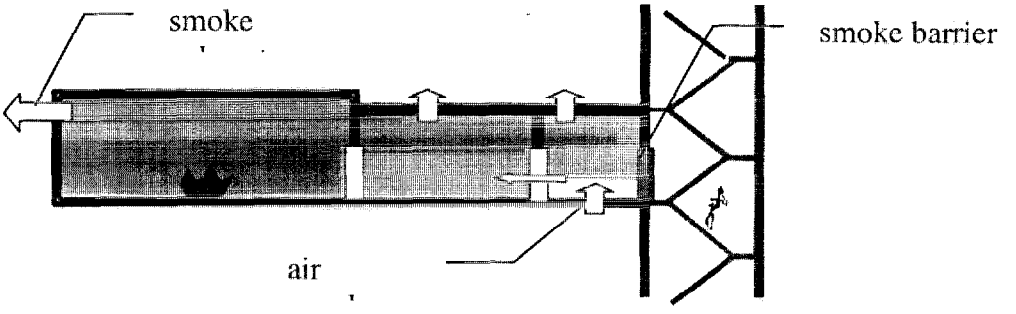

FIGURE 5 Escape from a fire building

4. CALCULATION TOOLS

As a verification method of the law and order, it is very important for practical use that calculation tools are simple rather than precise scientifically. From this point of view the following equations are developed.

4.1. Smoke time

The time of smoke layer descending down in a room is calculated by using the equation below. The smoke generation rate from a design fire M is determined by fire load density and room height, etc. The effective smoke exhaust rate E is determined by smoke exhaust capacity and efficiency. In the present Enforcement Order, the capacity of mechanical fan for smoke exhaust is required based on the area of smoke compartment as the specifications. In this method, the capacity of mechanical fan installed for the room is evaluated. The efficiency of smoke exhaust is calculated by taking account of smoke compartment size and smoke barriers depth, which are also limited by the present Enforcement Order.

$$t_{smoke} = \frac{A_{room} \times (H_{room} - H_{crit})}{M - E} \qquad (1)$$

Where

t_{smoke}	life threat time by smoke (sec)
A_{room}	room area (m^2)
H_{room}	room height (m)
H_{crit}	critical height of smoke (m)
M	smoke generation rate (m^3/sec)
E	effective smoke exhaust rate (m^3/sec)

Excluding a fire room in a floor, the life threat time by smoke is the sum of time calculated in each room and space between the room and a fire room. In these cases, the smoke generation rate M is given as smoke inflow rate through openings and gaps of the compartment. For example, it is assumed that openings fixed by airtight fire doors with self-closing device activated by smoke detector have almost no leakage of smoke.

4.2. Escape time

The escape time is simply the sum of starting time, travel time and clearing queue time. It is calculated by using the equation below. Concerning the travel time and clearing queue time, many experimental data and calculation models are available. In this method, this simple equation is used. The travel speeds on level, upward and downward on stairs are given. The effective flow rate is also given, but adjusted mainly by escape routes area from the room if the area is not large enough to accommodate all evacuees.

$$t_{escape} = t_{start} + \sum \frac{l_l}{v} + \frac{\sum pA_{area}}{\sum N_{eff} B_{avail}} \qquad (2)$$

Where

t_{escape}	escape time (sec)
t_{start}	escape starting time (sec)
l_l	travel length from any point to an exit in each room / space (m)
v	travel speed (m/sec)
p	occupant density (person/m^2•
A_{area}	area of each room (m^2□
N_{eff}	effective flow rate (person/m/sec)
B_{avail}	available door width (m)

The escape starting time is not understood clearly. In this method, the escape start time is given as the sum of two parts. Firstly, it is the time of transferring fire information. It is assumed that it depend on space size mainly. Secondary, it is the time of initial response to fire cues. It is assumed to depend on occupant type such as sleeping facilities and others.

$$t_{start} = [time\ of\ information\ transfer] + [time\ of\ initial\ response] \qquad (3)$$

5. CONCLUSIONS

The evaluation method of egress safety is developed for revising the Building Standard Law and Enforcement Order in Japan. It is a first step of performance-based evaluation of egress safety. However, it is insufficient that egress safety performance is defined only as escaping free from smoke. It should consist of various required performances, such as redundancy of escape routes, easy way-finding and so forth. For developing more reasonable performance based evaluation, more studies on egress safety are necessary.