

**NISTIR 6588**

---

**FIFTEENTH MEETING OF THE UJNR  
PANEL ON FIRE RESEARCH AND SAFETY  
MARCH 1-7, 2000**

**VOLUME 1**

---

Sheilda L. Bryner, Editor



**NIST**

**National Institute of Standards and Technology**  
Technology Administration, U.S. Department of Commerce

**NISTIR 6588**

---

---

**FIFTEENTH MEETING OF THE UJNR  
PANEL ON FIRE RESEARCH AND SAFETY  
MARCH 1-7, 2000**

**VOLUME 1**

---

---

Sheilda L. Bryner, Editor

November 2000



**U. S. Department of Commerce**

Norman Y. Mineta, Secretary

**Technology Administration**

Dr. Cheryl L. Shavers, Under Secretary of Commerce for Technology

**National Institute of Standards and Technology**

Raymond G. Kammer, Director

# **PROGRESS AND OVERVIEW OF STUDY ON EVACUATION SAFETY AND FIRE RISK ASSESSMENT IN JAPAN**

Manabu EBIHARA

Izumi Research Institute, Shimizu Corporation  
2-2-2 Uchisaiwai-cho, Chiyoda-ku, Tokyo 100-0011, JAPAN

Ai SEKIZAWA

National Research Institute of Fire and Disaster  
3-14-1 Nakahara, Mitaka, Tokyo 181-8633, JAPAN

## **INTRODUCTION**

Recent studies in Japan regarding evacuation safety and fire risk assessment are encouraged in developing performance-based design method and performance assessment method, in common with the other fields of the fire safety engineering. Researchers and engineers are now preparing tools and methods that will be applicable to fire safety design based on the performance-based code, because the performance-based code for the building regulation will be enforced in June, 2000 in Japan. In this paper, the studies and papers regarding evacuation safety and fire risk assessment in Japan mainly from 1997 to 1999 are reviewed, and the future issues are discussed.

## **EVACUATION SAFETY**

In the studies for evacuation safety assessment, there was a performance assessment method for egress routes [1, 2]. In this study, they turned their attention to assess legibility that means how evacuees can easily find or understand egress routes. The legibility is considered one of important performance required for egress route design in performance-based code. In this method, they assess the legibility using an expected travel distance to safety zone, for example a fire escape staircase, as an index. And, the studies have been conducted to assess the safety level of egress route in consideration of the reliability of fire protection systems that are required for egress routes [3, 4].

There is another kind of risk assessment method for evacuation [5, 6]. In these studies, an expected number of evacuees remaining in a space at the critical egress time is treated as an index, while the dispersion of evacuation starting time, number of evacuees, and difference of fire conditions are considered as parameters. The new simplified calculation method for evacuation behavior is proposed [7] to aim at practical use as an assessment tool for evacuation safety design based on the performance-based code.

Regarding fire safety design method, there are studies to aim at realizing an effective evacuation planning, especially for egress route design, based on psychological characteristics of evacuees, such as inclination of choosing a wider or lighter passage in evacuation [8~11].

There are some guidelines and provisions for the evacuation safety design that are described in the prescriptive building code in Japan. In the study for the evacuation safety code, alternative concepts of the prescriptive codes are represented from the viewpoint of making the performance-based code [12, 13]. There are other papers that introduced the fire safety engineering tools for evacuation applicable to the design based on the performance-

based code [14, 15].

Studies to investigate the evacuation behavior at real fires were presented [16~19]. And, we also had the studies to understand psychological characteristics of the evacuees by observing a change of heart rate or using a virtual reality simulator [20, 21].

The study on the evacuation behavior of the elderly and handicapped-persons is necessary [22~26]. In this regard, simulating evacuation behavior in a hospital or a facility for the elderly were presented [27~29]. In these simulation models, it is very important how to model the assistance action to disabled occupants by staff.

## **FIRE RISK AND FIRE RISK ASSESSMENT**

Fire safety regulation has been changed several times depending on the social requirement, especially after the occurrence of serious or remarkable fires. The amendment of the fire safety regulation on fire protection measures was investigated to study its effect on fire risk [30].

The Tokyo Fire Department collects the data of fire protection systems based on an annual inspection to buildings. Using this data, the reliability of fire protection systems is discussed [31, 32]. In these papers, it was reported that the reliability of fire protection systems is decreasing along with the secular change. Also, the Tokyo Fire Department intends to develop the fire risk assessment method in consideration of the reliability of both fire prevention actions performed by security staff and fire protection systems. In relation with this project, several studies [33~36] were conducted.

On the other hand, the cost-effectiveness of fire protection systems is discussed from the viewpoint of evacuation safety [37, 38]. Regarding fire risk, the study to describe the relationship between fire risk and cost of fire protection systems [39], and the risk transfer for the external hazards and the internal hazards from the viewpoint of the property/casualty insurance [40] are conducted. And also, the issues of fire safety task from the viewpoint of risk management of buildings are discussed[41]. In Japan, there have not been so many studies regarding analysis on the relationship between fire risk and cost, or the fire risk management, but there is increasing necessity to discuss about this issue in the future. Furthermore, the study to discuss the mitigation of fire and fire deaths based on the recent statistical data of residential fires is reported [42].

## **CONCLUSIONS AND FUTURE ISSUES**

In the background of movement toward the performance-based building codes in Japan, there are a number of studies on fire risk assessment and performance-based design methods in recent years. However, it has been recognized that there is not enough data available to estimate fire risk and fire safety performance of fire protection measures. In relation to this situation, it is important to discuss about the treatment of the evacuation starting time in the evacuation safety assessment method. And, in fire risk assessment method, it is also recognized that the discussion of treatment of both fire incident rate and performance of public fire departments is important.

On the other hand, as a new movement to be worth attention from the viewpoint of performance-based design and regulation, the Fire and Disaster Management Agency (FDMA) started the 3-year project for developing synthetic fire safety design method in 1999.

Along with the recent current of deregulation of technological standards in the Fire Codes in Japan (Fire Service Law etc.) such as standards for installation of fire protection equipment and the possible movement toward performance-based fire codes in the future. This project aims to develop evaluation methods of performance of fire protection systems such as sprinklers, fire alarm systems, and smoke exhaust systems together with a guideline for performance-based design method and the database of engineering tools and knowledge.

In the current studies regarding fire risk assessment method, most of them aim at proposing a kind of framework of fire risk assessment, because of lack of available data. Therefore, it is necessary to collect more data that is useful to fire risk assessment, and also to grope for the method to put the current data to practical use.

## REFERENCES

### *Evacuation Safety Assessment Method*

1. Hiroaki. NOTAKE and Manabu EBIHARA, Yoshiro YASHIRO: Assessment of Legibility of Egress Route in a Building from the Viewpoint of Evacuation Behaviour, Proceeding of the First International Symposium on Human Behaviour in Fire, 1998.
2. Hiroaki NOTAKE, Manabu EBIHARA and Yoshiro YASHIRO: Quantitative Evaluation of Legibility of Egress Route by Using Expected Travel Distance □ Study Based on Calculation Result of Egress Route in Shopping Stores□, JAFSE and AIJ Annual Meeting, 1997.
3. Shuji KAKEGAWA: Reliability Analysis of Egress Routes in Fire, JAFSE Annual Meeting, 1997.
4. Mamiko KUJIME, Hiroyuki KANEKO, Katsuaki KUBOTA, Yuka IKEHATA, Manabu EBIHARA and Yoshifumi OMIYA: Study on Method of Evaluating Safety of Evacuation Route, JAFSE Annual Meeting, 1997.
5. Yuka IKEHATA, Manabu EBIHARA, Hiroaki NOTAKE and Yoshifumi OMIYA: Assessment Method for Evacuation Safety Under Consideration of Uncertainty of Human Behaviour and Fire, Proceeding of the First International Symposium on Human Behaviour in Fire, 1998.
6. Toshiyuki YOSHIDA, Yoshiteru MUROSAKI and Akihiko HOKUGO: Evaluation Model for Safety in Evacuation □ In Case of Delay to Escape□□ AIJ Annual Meeting, 1999.
7. Masayuki MIZUNO, Yoko HOSHINO, Daisuke MURAKAMI, Ichiro HAGIWARA and Takeyoshi TANAKA, Takao WAKAMATSU: Development of Practical Calculation Method for Evacuation in Fire, JAFSE and AIJ Annual Meeting, 1998.

### *Evacuation Safety Design Method*

8. Yoshiteru. MUROSAKI, Hiroaki HAYASHI and Taro NISHIGAKI: Effect of Passage Width on Choice of Egress Route at a T-Junction in a Building, Proceeding of the First International Symposium on Human Behaviour in Fire, 1998.
9. Hiroaki HAYASHI, Yoshiteru MUROSAKI and Taro NISHIGAKI: Effects of Passage Illuminance and Passage Width on Choice of Egress Route at a T-Junction in a Building, Journal of Architecture, Planning and Environmental Engineering (Transactions of AIJ), No.498. 1-6, Aug., 1997.
10. Katsuaki KUBOTA, Yoshiteru MUROSAKI and Ichiro TAKAHASHI: Effect of Wall-Surface Luminance and Light Source Colors on Selecting an Escape Route in a Model

Space, Proceeding of the First International Symposium on Human Behaviour in Fire, 1998.

11. Katsuaki KUBOTA, Yoshiteru MUROSAKI and Ichiro TAKAHASHI: The Effect of Wall Surface Luminance in a Model Space to Select Escape Route □ A Study on Toward Light Character when Select Escape Route in Building Fire□, Journal of Architecture, Planning and Environmental Engineering (Transactions of AIJ), No.500. 1-7, Oct., 1997.

#### ***Evacuation Safety Code***

12. Takeyoshi TANAKA, Ichiro HAGIWARA and Toshio MIMURA: Requirements of Two or More Exits in Room □ A Consideration on the Safety Performance of Two Way Exits Provisions Part 1□, Journal of Architecture, Planning and Environmental Engineering (Transactions of AIJ), No.491. 17-22, Jan., 1997.
13. Ichiro HAGIWARA, Takeyoshi TANAKA and Yoshio MIMURA: Allowable Condition for a Single Means of Escape □ A Consideration on the Safety Performance of Two Way Exits Provisions Part 2□, Journal of Architecture, Planning and Environmental Engineering (Transactions of AIJ), No.498. 7-14, Aug., 1997.
14. Ichiro HAGIWARA, Kazunori HARADA, Masayuki MIZUNO, Takeyoshi TANAKA and Takao WAKAMATSU: Fire Safety Engineering Tools for Room Evacuation, AIJ Annual Meeting, 1998.
15. Ichiro HAGIWARA: Fire Safety Engineering Tools for Evacuation, AIJ Annual Meeting, 1999.

#### ***Evacuation Behavior***

16. Ai SEKIZAWA, Manabu EBIHARA, Hiroaki NOTAKE, Mina NAKANO, Yoshifumi OMIYA and Hiroyuki KANEKO: Occupants' Behavior in Response to the High-Rise Apartment Fire in Hiroshima City, Proceeding of the First International Symposium on Human Behaviour in Fire, 1998.
17. Mina NAKANO, Katsuaki KUBOTA, Manabu EBIHARA, Hiroaki NOTAKE, Hiroyuki KANEKO and Yoshifumi OMIYA: Egress Behavior in the Case of Fire at Hiroshima Motomachi High-Rise, JAFSE and AIJ Annual Meeting, 1997.
18. Shinji NAKAHAMA, Yuka IKEHATA and Hiroaki HAYASHI: Study on Availability of Evacuation by an Elevator in Consideration on the Aged People, □Example of the Hiroshima Motomachi High-Rise Apartment Fire□, Journal of JAFSE, (No. 234), 1998.
19. Yoshifumi OMIYA, Masayuki MIZUNO and Mina NAKANO: Human Behavior in the Hotel Fire at Shirahama, JAFSE and AIJ Annual Meeting, 1999.
20. Katsuaki KUBOTA and Yoshiteru MUROSAKI: Study of Psychological Changes for Escape Persons at Escape Drill by R-R Interval Measurement, JAFSE Annual Meeting, 1999.
21. Hidekazu KAKEI, Hiromi SATO, Toshihoko SAKO: The Experimental Study of the Evacuation Using VR Simulator, Proceeding of the First International Symposium on Human Behaviour in Fire, 1998.

#### ***Evacuation Safety for a Handicapped-person***

22. Satoshi KOSE: Emergence of Aged Populace: Who is at Higher Risk in Fire?, Proceeding of the First International Symposium on Human Behaviour in Fire, 1998.
23. Satoshi KOSE: Fire Safety of People with Disabilities and Elderly, AIJ Annual Meeting, 1997.

24. Keiko SUZUKI: Actions of Elderly Persons During Evacuation from a Fire in a Nursing Home, AIJ Annual Meeting, 1997.
25. Akihiro TSUMURA, Kenji KOSHIYAMA, Akihiko HOKUGO and Yoshiteru MUROSAKI: A Research on Measures for Safe Evacuation of Buildings: Considering the Weak, AIJ Annual Meeting, 1999.
26. Hidemasa YOSHIMURA: Sounding Out the Disabled in the Lower-Extremities on Their Escape Behaviour in Building Fire for Safer Fire Escape Design, Proceeding of the First International Symposium on Human Behaviour in Fire, 1998.
27. Kouji SHIDA: Fire Risk Analysis on Hospitals and Welfare Facilities, AIJ Annual Meeting, 1998.
28. Keita ITO and Kouji SHIDA: Evacuation Simulation Model According to Behavior of Aged Disabled, AIJ Annual Meeting, 1997.
29. Manabu EBIHARA and Shuji KAKEGAWA: A Study on Evacuation Safety for Facilities for the Elderly Based on Evacuation Simulation, Journal of Architecture, Planning and Environmental Engineering (Transactions of AIJ), No.521. 1-8, Jul., 1999.

*Fire Risk and Fire Risk Assessment*

30. Masayuki HIROTA: Case Study on Performance of Building Fire Safety of Existing Building Based on Amendment of Building Regulations on Fire Protection Measures, AIJ Annual Meeting, 1997.
31. Shuji KAKEGAWA, Yoshiro INOUE and Katsuyuki KURAI: Reliability Analysis of the Sprinkler System Based on Annual Inspection Data, AIJ Annual Meeting, 1997.
32. Shuji KAKEGAWA and Yoshiro INOUE: Reliability Analysis of Standpipe and Foam Extinguishing System Based on Annual Inspection Data, AIJ Annual Meeting, 1998.
33. Manabu EBIHARA, Hiroaki NOTAKE and Yoshiro YASHIRO: Fire Risk Assessment Method for Building Under Consideration of Actions of Security Staff by Using an Idea of Fire Phase, Proceeding of the First International Symposium on Human Behaviour in Fire, 1998.
34. Yoshiro YASHIRO, Manabu EBIHARA and Hiroaki NOTAKE: Risk Assessment for Action of Security Staffs and Fire Protection Measures Based on the Idea of Fire Phase, JAFSE and AIJ Annual Meeting, 1997.
35. Yoshiro YASHIRO, Manabu EBIHARA and Hiroaki NOTAKE: Risk Assessment Method of Building Fire Based on an Idea of Fire Phase, JAFSE and AIJ Annual Meeting, 1998.
36. Yoshiro YASHIRO, Manabu EBIHARA and Hiroaki NOTAKE, Katsumasa TAKAHASHI, Yasunaga TEZUKA: A Study on Fire Spread Risk Assessment Based on an Idea of Fire Phase, JAFSE and AIJ Annual Meeting, 1999.
37. Mina NAKANO, Kenji ABURANO, Takao YUTANI and Yoshiteru MUROSAKI: The Effect of Prevention Device Set or Not and Reliability Fireproof Cost and Safety in Evacuation, Journal of Architecture, Planning and Environmental Engineering (Transaction of AIJ), No. 516. 1-7. Feb., 1999.
38. Mina NAKANO, Kenji ABURANO and Takao YUTANI: A Study on the Reliability of Fire-Prevention Devices with Statistical Research, Journal of Architecture, Planning and Environmental Engineering (Transaction of AIJ), No. 525. 1-7. Nov., 1999.
39. Kouji SHIDA: Classification of Cost for Risk Analysis, Journal of JAFSE, (No. 243), 1999.
40. Taichiro IZUMI: Common Issues concerning Buildings Property/Casualty Insurance – Risk Transfer for External Hazards and Internal Hazards-, Journal of JAFSE, (No. 243),

- 1999.
41. Shoubu TAKAMI: A Fire Safety Task on Risk Management, Journal of JAFSE, (No. 233), 1998.
  42. Ai SEKIZAWA: Toward Mitigation of Fires and Fire Death from Residential Structures, Journal of JAFSE, (No. 244), 2000.