NRC Publications Archive Archives des publications du CNRC

Occupant response during a residential highrise fire Proulx, G.

This publication could be one of several versions: author's original, accepted manuscript or the publisher's version. /
La version de cette publication peut être l'une des suivantes : la version prépublication de l'auteur, la version acceptée du manuscrit ou la version de l'éditeur.

Publisher's version / Version de l'éditeur:

Fire and Materials, 23, Nov-Dec. 6, pp. 317-323, 1999-11-01

NRC Publications Record / Notice d'Archives des publications de CNRC:

<https://nrc-publications.canada.ca/eng/view/object/?id=8639281b-1269-4e00-83ab-5ba66e5856b1>
<https://publications-cnrc.canada.ca/fra/voir/objet/?id=8639281b-1269-4e00-83ab-5ba66e5856bb>

Access and use of this website and the material on it are subject to the Terms and Conditions set forth at

<https://nrc-publications.canada.ca/eng/copyright>

READ THESE TERMS AND CONDITIONS CAREFULLY BEFORE USING THIS WEBSITE.

L'accès à ce site Web et l'utilisation de son contenu sont assujettis aux conditions présentées dans le site

<https://publications-cnrc.canada.ca/fra/droits>

LISEZ CES CONDITIONS ATTENTIVEMENT AVANT D'UTILISER CE SITE WEB.

Questions? Contact the NRC Publications Archive team at

PublicationsArchive-ArchivesPublications@nrc-cnrc.gc.ca. If you wish to email the authors directly, please see the first page of the publication for their contact information.

Vous avez des questions? Nous pouvons vous aider. Pour communiquer directement avec un auteur, consultez la première page de la revue dans laquelle son article a été publié afin de trouver ses coordonnées. Si vous n'arrivez pas à les repérer, communiquez avec nous à PublicationsArchive-ArchivesPublications@nrc-cnrc.gc.ca.

National Research
Council Canada

Conseil national
de recherches Canada

NRC - CNRC

Occupant response during a residential highrise fire

Proulx, G.

NRCC-43149

A version of this document is published in / Une version de ce document se trouve dans :
Fire and Materials, v. 23, no. 6, 1999, pp. 317-323

www.nrc.ca/irc/ircpubs

OCCUPANT RESPONSE DURING A RESIDENTIAL HIGHRISE FIRE

Guyène PROULX, Ph.D.

Fire Risk Management Program

Institute for Research in Construction

National Research Council of Canada

ABSTRACT

On 31 January 1997, a fire occurred in a 25-storey highrise apartment building located in Ottawa, Ontario, Canada. The building contains 296 condominium apartments which were occupied mainly by senior citizens. The fire, which started at 4:30 p.m. in an apartment on the 6th Floor, rapidly burned through the apartment corridor door and spread into the corridor. The fire department arrived promptly on location and extinguished the fire within 10 minutes of the notification call.

On the orders of the fire department, a live announcement was issued, from the building voice communication system, advising all residents to evacuate the building immediately. Many occupants (83%) attempted to evacuate while some (17%) decided to stay in their apartments and initiate protect-in-place activities. During their evacuation, all occupants above the fire floor encountered smoke conditions. Only 54% who attempted to evacuate managed to

escape. The others had to return to their apartment (25%) or seek refuge (21%) in a neighbour's apartment.

Four of the evacuees had to be treated for smoke inhalation; two seniors suffered heart attacks and one of them died 10 days after the fire. A second person from the apartment of fire origin died 2 months later. This paper discusses the occupants' response and their actions during this fire.

INTRODUCTION

The study of occupants' behaviour during a fire incident is one of the best ways to learn about the impact of human factors on the circumstances and outcomes of a fire. The victims of a fire are prime witnesses; they can easily describe their perception of the event, their interpretation and their reactions during the fire. The information gathered helps researchers to understand the conditions in the building at the time of the fire and to explain the occupants' behaviour during the event and the rationale behind their actions. A complete report of the fire discussed in this paper is currently available [1].

The general objective of this study was to gather information on the behaviour of the occupants who were in the building at the time of the fire incident. Two data-gathering methods were used. First, face-to-face interviews were carried out with the occupants of the fire floor (the 6th floor) and the floor above, to obtain detailed accounts of the event from the occupants closest to the fire. Secondly, a questionnaire developed by the Office of the Fire Marshal of Ontario, used previously in a dozen highrise residential fires, was distributed to the door of each

apartment. This two-fold research strategy offers the advantage of combining the detailed account of the closest witnesses with an extensive quantity of information from the other occupants thus providing a complete overview of the event. This strategy is also cost-effective in terms of time and staff required for interviews, data analysis and documentation of the results.

The results of this study will be used by the National Research Council of Canada (NRC) and the Office of the Fire Marshal of Ontario, NRC's collaborator on this study, to develop recommendations to improve fire safety in highrise apartment buildings. This research will help better define evacuation procedures, training and education programs and changes in the regulations and codes of practice. These results will also be used to verify the NRC computer model FIRECAM™ [2], which is used to assess occupants' risk to life from fires.

THE FIRE

On January 31, 1997, in the late afternoon, a fire started in Apartment 602 on the 6th floor at 1081 Ambleside Drive in Ottawa, Ontario. At the time of the fire, the two occupants of the apartment, a husband and wife, aged 80 and 82 years old, were in the apartment. The husband was in the living room when he heard the apartment smoke alarm activate. His wife was in the kitchen preparing supper. He went to investigate and discovered smoke pouring out of the closet in the apartment entrance foyer. He slid open the closet door to discover extensive burning. He called to his wife to warn her, but she may not have heard because of her poor hearing. He ran to the master bedroom to use the phone to call 911. There was smoke in the bedroom so he opened the patio door to ventilate the room. After calling 911

(his call was received at 16:34) he attempted to return to the hall to reach his wife but the smoke was too dense and hot, forcing him to retreat to the bedroom balcony. The wife, who was using a walker to assist her movement, moved from the kitchen to the living room, where she collapsed.

The fire spread from the closet to the foyer area of the apartment, burned through the closed tubular-core wood apartment entrance door and spread into the 6th floor public corridor. The fire spread extended approximately 17 m down the corridor before being extinguished by the fire department. Smoke damage to the 6th floor corridor was extensive, with some units close to Apartment 602 also receiving some smoke damage. There was no significant smoke damage to other areas of the building.

The fire alarm system was activated by a couple on the 4th floor who saw smoke pouring out of a patio door from their living room window. This couple went into the corridor then pulled the fire alarm before leaving. The fire alarm sounded in each apartment and throughout the common areas of the building. It is anticipated that the fire alarm was activated within 1 or 2 minutes of the first 911 call and before the fire department arrival.

At the time of the fire, heavy snow was falling and the temperature was -9°C. The Ottawa Fire Department received a 911 notification of the fire at 16:34 and arrived at the scene at 16:39. Firefighters accessed the 6th floor from Stairwell A (see Figure 1). They encountered flames and smoke in the main corridor and noticed flames coming through the doorway of Apartment 602. The fire department attached a hose to the 5th floor hose standpipe and extended it up

Stairwell A to the 6th floor. Fire suppression operations extinguished the fire in the corridor and in Apartment 602 at 16:46. Both occupants of the apartment of fire origin were taken to the Ground Floor and life support procedures were started on the woman. She suffered from smoke inhalation and severe burns. Two months after the fire, she succumbed to her injuries. Four other evacuees had to be treated for smoke inhalation; two seniors suffered heart attacks, one of whom died 10 days after the fire.

THE BUILDING

The building was built in 1973 in compliance with 1992 Retrofit Section 9.6 of the Ontario Building Code. Some refurbishment had taken place in 1996. The building was constructed of reinforced concrete and comprises 296 luxury condominium-apartments on 25 storeys plus 3 basement levels of parking and leisure rooms. Figure 1 shows the "Y" shape floor plan of the building with the four elevators in the central core. Each storey has 12 apartments per floor except for the first floor, which has 8 apartments and the building lobby. Each of the three wings terminates in exit stairwells, designated A, B and C.

FIGURE 1: TYPICAL FLOOR PLAN OF THE BUILDING

Floor assemblies are 2 h fire-rated separations. The corridors and stairwell separations are constructed of gypsum wallboard on steel studs. Walls separating apartments are constructed of concrete or gypsum wallboard on steel studs. Stairwell doors are a 1½ h rated hollow metal type in steel frames. Apartment entrance doors are of tubular-core wood construction, approximately 45 mm thick, in steel frames. The apartment and stairwell doors are provided with self-closing devices and latching hardware.

The building has a single-stage fire alarm system equipped with heat detectors in corridors and stairwells and manual pull stations located at all corridor exit doors. Alarm signals are transmitted via speakers that are provided throughout all floor areas and in each apartment. These speakers are also used as part of the normal building voice communication system. The fire alarm signal is silenced during voice communication use. Fire alarm activation shuts down the building's recirculating ventilation system and prevents elevator operation except by the use of over-ride and manual recall switches. Battery-powered smoke alarms are provided in each apartment and are maintained by apartment occupants.

The building had an approved fire safety plan, with a copy of the fire emergency procedures supplied to each tenant as part of their Tenant's Binder. The fire safety plan stated that, upon hearing the fire alarm and after checking that the fire was not in their unit, occupants were expected to await further instructions to be provided through the voice communication system. If an evacuation was judged necessary by the fire department, instructions regarding which floors should evacuate and which stairwells should be used would be given through the voice communication system.

The Resident Manager was responsible for the operation of the voice communication system. On the afternoon of the fire, he recalls giving out 4 or 5 messages (the exact wording of each message was not recorded). The first message was given before the arrival of the fire department; it stated:

- **"There is a fire on the 6th floor. The fire department is on its way".**

After the fire department arrival and initial assessment of the situation, the chief in command gave the order to evacuate and the Resident Manager issued the message:

- **"All occupants should evacuate using Stairwells B and C".**

After firefighters encountered occupants coming down Stairwell A, which was being used for fire fighting, another message was issued:

- **"Occupants should not evacuate through Stairwell A".**

Finally, as many exhausted, anxious occupants exited from all stairwells into the lobby complained of the crowd and smoke conditions encountered, the chief in command decided to change strategy and the following message was issued:

- **"Occupants who have not started to evacuate should remain in their units".**

This was the last message issued regarding the evacuation.

STUDY RESULTS

The building has 296 apartments. At the time of the fire, 6 vacant units were for sale and 24 residents were away on holiday and had registered their departure with the building superintendent. Replies to the questionnaire could then be expected from 265 units, excluding the unit of fire origin.

A total of 213 questionnaires were returned. This represents a return rate of 80% which is excellent for this type of study [3, 4, 5, 6]. This exceptional return rate implies that the results can be generalized to the entire building population with confidence.

As indicated previously, the questionnaires were distributed to every unit during the week following the fire. Most questionnaires were returned within two weeks. Of the 213 questionnaires returned, 76 or 35% mentioned that they were not at home at the time of the fire. Therefore, the remaining 137 questionnaires from occupants who were at home during the fire were used in the final analysis.

OCCUPANT PROFILE

Respondents were asked to "Please indicate the number of individuals in the suite at the time of the fire, by their ages and gender". As presented in Table 1, there were only a few children or teenagers living in the building or visiting the building at the time of the fire. Adults aged 21 to 65 years old represented 29% of the respondents. Over two-thirds of the respondents were over the age of 65. Of the respondents, 85 were alone in their apartment at the time of the fire. Out of this group, 63, or 74%, were occupants over 65 years old, of which 54, or 86%, were women and 9 or 14%, were men.

TABLE 1: Age Distribution of Respondents

Age Group	Female	Male	Total	Percent
0-10	2	3	5	2.6%
11-20	0	1	1	0.5%
21-45	6	9	15	7.9%
46-65	26	14	40	21.1%
Over 65	91	38	129	67.9%

Total	125	65	190	100%
-------	-----	----	-----	------

To the question, "Indicate the number of individuals over age 10 who have physical limitations or special needs and require assistance to evacuate the building", a total of 43 respondents, or 23%, reported having perceptual, physical or intellectual limitations. This is higher than the general Canadian population where, according to Statistics Canada, 15% of the population having limitations live in private households [7, 8]. This high proportion of occupants with limitations is probably due to the fact that 68% of the respondents were over 65 years old. A total of 37 females and 6 males reported limitations.

When asked, "How long have you lived in this building?", a majority answered that they lived in the building for more than 10 years at the time of the fire. Respondents were asked: "Were you familiar with the fire emergency procedures for this building prior to this fire?"; a total of 88% indicated being aware of the procedure. They described this procedure as *"upon hearing the fire alarm, wait for instructions coming through the voice communication system and follow instructions"*.

The fire alarm was activated regularly in the building due to false alarms or fire alarm testing. Only two respondents were not aware of such alarms. During the last year, 37% mentioned that they were aware of over 12 incidents of false or test alarms, while 21% said the alarm had been activated frequently. A new alarm system had been installed 5 months prior to the fire. This new system was tested monthly with first a message provided through the voice communication system by the Resident Manager, followed by the test of the fire alarm.

INITIAL AWARENESS

Respondents were asked "How did you first become aware of the fire emergency?". Many building occupants (39%) were first made aware of the fire by the sound of the fire alarm and 70% included the fire alarm as one of many sources notifying them of the emergency. The second means by which occupants indicated they were most often alerted was by the voice communication system; 13% identified the voice communication system only while 42% indicated the voice communication system along with at least another source.

Interestingly, all 10 respondents who mentioned having hearing limitations, were notified of the emergency by hearing the fire alarm. Among them, 8 said the voice communication was clear and it was the cue to start the evacuation for 6 of them.

At the time of the fire, most respondents were awake preparing supper, watching television or doing some leisure activities such as reading, knitting or listening to music. When occupants first became aware of the emergency, 30% indicated attempting to obtain more information by contacting neighbours or dialling 911. A majority of respondents (70%) did not attempt to obtain additional information, as they were waiting to receive instructions from the voice communication system. Messages provided through the voice communication system were clear for 95% of the respondents. The large majority (89%) followed the instructions provided which were judged useful for 64% of the respondents.

ATTEMPTED EVACUATION

It is clear that 83% of those respondents in the building at the time of the fire attempted to evacuate their apartments that afternoon. When asked "How long after you were alerted to the fire did you attempt to evacuate?", the largest group (34%), indicated a delay of about 5 minutes before starting to evacuate. Many specified starting their evacuation when instructed by the voice communication system, which was probably between 6 to 10 minutes after the fire alarm sounded. Among the respondents who identified the cue that prompted their evacuation movement, 83% identified voice communication messages in addition to some other cue. Only 5 respondents (4%) indicated starting evacuation after hearing only the fire alarm.

Respondents were asked "What activity did you do between the time you were alerted to the fire and the time you attempted evacuation?". Answers show that 82% took time to get dressed, putting on a coat, mitts and boots, 23% picked up belongings such as purse, wallet or keys.

Among the 43 respondents who mentioned having a limitation, 72% attempted to evacuate the building while only 12 or 28% did not make such an attempt. Six of the respondents with limitations were located under the fire floor; all six attempted to evacuate and 4 of them managed to escape the building. Above the fire floor, 25 people with limitations attempted to evacuate and only 5 were successful. The successful evacuees from this group were all located between the 6th and 15th floors. The group included 2 females with mobility

limitations, 1 female with a hearing limitation and 1 man and 1 woman with other types of limitations.

Of the 48 cases of people who indicated that they were with others when they were made aware of the fire, all but one evacuated in groups. During evacuation, 7 respondents mentioned being separated from their companion. In 5 cases, it was in stairwells where groups were separated due to others entering the stairwell. In 2 cases, adults lost children who went ahead of them. Some older residents indicated that staying in a group became difficult when they were overtaken by faster evacuees in the stairwells. One female specified she became separated from her group "*because of the crowd in the stairwell and the heavy black smoke encountered around the 8th floor*". She also lost consciousness in the stairwell and was rescued by the Resident Manager and other residents.

All respondents above the fire floor who reported attempting to evacuate encountered smoke during their evacuation movement. The 18 respondents who did not encounter smoke during their evacuation were located below the fire floor. According to 5% of respondents, the lights were off in their corridor. Lack of lighting in the corridor may have been due to fire damage to wiring or more likely, to smoke obscuration in the corridor.

As presented in Table 2, the colour of the smoke encountered in the corridors varied from "total blackout" to "thin haze", with 33% describing the smoke as "black", 40% "grey" and 4% "white". The respondents' description of the smoke colour and their movement under these conditions, indicates that most were prepared to move through a certain amount of smoke.

There were significantly more occupants in Wings A and B reporting "total blackout" or "black" smoke than in Wing C.

TABLE 2: Smoke Colour

Smoke	Frequency	Valid Percent
Total blackout	14	15%
Black	30	33%
Grey	37	40%
White	4	4%
Thin haze	7	8%
Total	92	100%

A relationship can be established between the smoke colour described and the visibility distance. Some 45% who indicated they could see "nothing at all" or "little" in their corridors were in units located on all floors from the 4th floor through the 25th. Another 30% said that, even though there was smoke, they could see between 12 to 15 m down to the exit stairwell door from their apartment entrance door when they started to evacuate.

To the question, "Did you encounter smoke in the stair?", most respondents, 82%, said there was smoke in the stairwells. Smoke was encountered at different levels from the 4th floor to the 25th floor. Many respondents (84%) mentioned they used more than one stairwell to

attempt to evacuate. It is not known which of the three stairwells they used. Some occupants may have tried to call the elevator but all 4 elevators were recalled to the ground floor of the building upon fire alarm activation.

The response when encountering smoke in the stairwells was "Kept going down" for 34%, another 31% "Reversed direction, and went up stairs", 11% indicated "Sought refuge" and 10% "Changed stairs, and reached outside by alternate exit stair".

REMAIN IN BUILDING, RETURN TO APARTMENT OR SEEK REFUGE

A number of respondents decided to stay in the building during the fire as presented in Table 3. A total of 23 respondents (17%) indicated that they made the early decision to stay in their own apartment during the fire, disregarding the instructions from the voice communication system. These occupants never attempted to evacuate the building, some had a look in the corridor but they never dressed to leave or went to a stairwell. These respondents were located on Floors 5, 6, 8, 9 to 11, 13 to 15, 17 to 19 and 23 to 25. It appears that all respondents understood that there was an actual fire in the building. Respondents indicated that they tried to leave but could not because of the smoke; some added that they could not manage the stairs due to a limitation; others indicated that staying in their apartment was the best thing to do.

TABLE 3: Occupant Response to Fire

Response	Frequency	Valid Percent
----------	-----------	---------------

Remain in building	23	17%
Attempt to evacuate	114	83%
Manage to escape	61	54%
Return to apartment	29	25%
Seek refuge in someone else's apartment	24	21%

Of the 83% who attempted to evacuate the building during the fire, only 61, or 54%, managed to escape. The remaining 53, or 46%, who were unsuccessful in their attempt to evacuate, had to return to their own apartment or seek refuge in someone else's apartment.

The 29 respondents (25%) who decided to return to their apartment after an initial attempt to evacuate, said they went back because of the smoke conditions either in the corridor or in the stairwell. The respondents who returned home had their apartments on Floors 3, 5, 7 to 10, 12 to 21, and 23 to 25. Respondents went down a number of floors, from 1 floor to 14 floors, before turning back up to return home. All the respondents who decided to return home had dressed in winter clothing for the evacuation.

Another 24 respondents, or 21%, had to seek refuge in someone else's apartment after starting their evacuation. The reasons given for seeking refuge were the smoke conditions and the fact that they thought they could not make it back to their own apartment. These apartments of refuge were found on Floors 5, 7, 8, 9, 10, 12, 14, 15, 16 and 17. Six of the respondents took refuge in a neighbour's apartment on the same floor as their own apartment.

The other 18 respondents travelled a number of floors from 4 floors to 13 floors down before seeking refuge.

A majority of the respondents (64%) who stayed in the building, including the respondents who returned home or sought refuge, were in groups which varied in size from 2 to 15 persons. The majority who stayed home alone during the fire were female over 65 years old.

All apartments had balconies which 54% mentioned using. In most cases, respondents did not stay on the balcony for a long time; they stepped out to watch the fire department, to escape the smoke for a few minutes or to obtain information. Smoke migrated into apartments through the entrance door of 56% of the respondents and 63% indicated sealing the main apartment door with a towel or tape.

INFORMATION ON FIRE SAFETY

Responses to the question, "Was your knowledge of fire safety adequate in preparing you for this fire emergency?", show that 80% felt that they had adequate knowledge. Still, 81% said they would like to obtain more information on fire safety. To the question, "Having been through this fire emergency, will you do anything differently in the future when you hear the fire alarm?", opinions are split. Some 52% would react the same way; the other 48% would do things differently, which in most cases would be to stay in their apartment. Many mentioned they would not follow voice communication instructions in the future.

CONCLUSIONS

This fire incident resulted in many interesting findings regarding the occupants' behaviour. The impact of the evacuation procedure for this building based on following voice communication instructions, the age and characteristics of the occupants as well as the impact of this fire experience on occupants' attitudes toward evacuation and fire safety are noteworthy.

The evacuation procedure for this building was that, upon hearing the fire alarm, occupants had to investigate to ensure that the fire was not in their own apartment, then to wait for instructions coming through the voice communication system. Consequently, it is not surprising that most occupants waited to receive instructions before initiating their evacuation. In fact, only 4% initiated evacuation based solely on hearing the building fire alarm. This confirms the observation made in a number of evacuations that most occupants treat the sounding of a fire alarm as a warning and wait for further information over the voice communication system, or from other sources, before starting to evacuate.

The building occupants prefer this practice of waiting for voice communication instructions before starting to evacuate because it can prevent them from evacuating unnecessarily if the alarm activation is due to a false alarm or a test of the system. This procedure implies, however, that, in the event of a fire, there will be a delay between the time that the alarm is activated and the time at which occupants receive instructions to evacuate, if judged necessary. This time delay is a result of the building management or the fire department investigating and assessing the situation before the evacuation order is given through the

voice communication system. This investigation and assessment time can be from a few to many minutes.

In this fire, it is assumed that the fire alarm was activated at approximately the time of the first 911 call, which was at 16:34; the message to evacuate was, at best, issued at around 16:41, 2 minutes after the arrival of the fire department at 16:39. These times indicate a 7 - minute delay between the fire alarm sounding and the evacuation order. From the time the message was issued, occupants probably spent another 2-3 minutes getting dressed and finding their belongings before leaving their apartments. In the best case, it can be assumed that occupants started their evacuation 10 minutes after the initial alarm activation. It could be risky for occupants to start their evacuation 10 minutes into the fire unless the exit routes are very well protected from smoke entry and no one opens doors on the fire floor that could allow smoke into other locations such as the stairwells. The procedure to wait for instructions from the voice communication system, which is becoming very popular in highrise buildings, implies that the time at which occupants start their evacuation will be late in the fire event. Most fire growth scenarios would indicate that a fire that has burned free for 10 minutes, emits quantities of smoke, heat and toxic gases that could impede egress. By that time, it may be hazardous for occupants above the fire floor to attempt to evacuate using some of the exit stairwells. Occupants of highrise buildings are vulnerable during an evacuation since they have a long distance to travel to reach ground level and, during their evacuation, the situation could change unexpectedly. Generally, the greater the delay in initiating evacuation, the greater the vulnerability of the occupants during evacuation. At some stage of fire

development, it is probably safer to instruct occupants to stay in their apartments and protect in place unless they are in immediate danger.

After experiencing this fire, many of the residents said they would not follow evacuation instructions over the voice communication system in future fire situations. They indicated that they would instead stay in their apartments and protect in place. This change in attitude results from two factors. The first factor is the confusion felt during the event when receiving what appeared to be contradictory instructions through the voice communication system stating "you should evacuate" then, later on, "do not evacuate". The second factor is the frustration felt after the fire when realizing that occupants who stayed in their apartment were safe and did not have to cope with the trying experience of going down many flights of stairs, encountering smoke and anxious neighbours.

A complete attitude change by the occupants to protect in place rather than evacuate may not be the best action for all fire situations. It is important that occupants understand that instructions provided over the voice communication system are made in their best life safety interest but they should also understand that they have to use their own judgement of the situation to make the best decision.

There were several factors during this fire that either seriously impacted life safety or had the potential to do so. The use of tubular-core wood apartment entrance doors, the open balcony door to the apartment of fire origin providing oxygen for the fire, the number of senior

occupants, the delay time in starting the evacuation and the smoke movement in the building all had the potential to contribute negatively to life safety during this fire.

It was fortunate, however, that several factors positively impacted on the fire situation to counter the negative factors. These positive factors included a very early "911" call to the fire department and a rapid response and fire extinguishment by the fire department. In addition, most respondents were awake and alert at the time of the initial fire alarm. The survey indicates that all the respondents were made aware of the fire by the fire alarm or the voice communication system. The audibility of these two systems appears excellent. It should be remembered that all 10 respondents with a hearing limitation were made aware of the situation by the sound of the fire alarm. The survey also illustrated that 95% of respondents could clearly hear instructions provided over the voice communication system.

The reactions of most occupants were appropriate in the circumstances since an attempt to evacuate was justified by the order through the voice communication system as established in the fire safety procedure. The inappropriate action was the attempt to pursue evacuation when encountering smoke. At that point, occupants should have judged that the situation was dangerous and should have returned home or sought refuge at once. Some occupants continued down stairwells filled with smoke. That was a dangerous decision that could have led to more injuries and casualties.

The occupants placed considerable trust in the information received over the voice communication system. This is evident from the 83% of respondents who attempted

evacuation as a result of evacuation instructions given over the voice communication system. It confirms that, in most instances, the public is prepared to follow voice communication instructions especially if this means of providing information has been accurate in the past and if the message comes from a person in which they have confidence or from figures of authority such as the fire department.

REFERENCES

1. Proulx G., Ouellette M.J., Leroux P., Bailey K.R., "Study of the Occupant Behaviour during the Ambleside Fire in Ottawa on 31 January 1997", Internal Report No. 771, Institute for Research in Construction, National Research Council of Canada, Ottawa, Canada (1998).
2. Dutcher C.R., Yung D., Hadjosophocleous G.V., "FiRECAM™ System Model Documentation", Internal Report No. 732, Institute for Research in Construction, National Research Council of Canada, Ottawa, Canada (1996).
3. Proulx, G. Pineau J., Latour J.C., Stewart L., "Study of the Occupants' Behaviour during the 2 Forest Laneway Fire in North York, Ontario, January 6, 1995", Internal Report No. 705, Institute for Research in Construction, National Research Council of Canada, Ottawa, Canada (1995).
4. Shaughnessy J.J., Sechmeister E.B., Research Methods in Psychology, Third Edition, McGraw-Hill, New York (1994).
5. Bryan J.L., "An Examination and Analysis of the Dynamics of the Human Behavior in the MGM Grand Hotel Fire", National Fire Protection Association, Quincy, MA., (1983).
6. Proulx G., Fahy R.F., "A Study of the New York World Trade Center Evacuation", Asiaflam '95, Hong Kong, Interscience Communications Limited, London, pp. 199-209 (1995).

7. Statistics Canada, 1991 Census Handbook Reference, Catalogue 92-305E, Statistics Canada, Ottawa, Ontario (1992).
8. Statistics Canada, Dwellings and Households, Catalogue 93-311, Statistics Canada, Ottawa, Ontario (1992).