Study of the occupants' behaviour during the 2 Forest Laneway fire in North York, Ontario January 6, 1995

Proulx, G.; Pineau, J.; Latour, J. C.; Stewart, L.

Internal Report (National Research Council of Canada. Institute for Research in Construction); no. IRC-IR-705, 1995-09-01

National Research Council Canada
Conseil national de recherches Canada

NRC·CNRC

Study of the Occupants' Behaviour During the 2 Forest Laneway Fire in North York, Ontario January 6, 1995

Guylène Proulx
Joelle Pineau
John C. Latour
Lisa Stewart

Internal Report No. 705

Date of Issue: September 1995

Published by
Institute for Research in Construction
IRC

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

We are very grateful to the occupants of the 2 Forest Laneway building, who agreed willingly to participate in this study by answering the questionnaire or meeting with us. We understand that it was not easy to describe what had happened during this traumatic fire. A large number of people took the time to fill out this long questionnaire providing us with first hand information without which this study would not have been possible.

We would like to take this opportunity to acknowledge significant contributions from a number of persons from the Office of the Fire Marshal of Ontario (OFM).

Mr. Bernard A. Moyle - The Fire Marshal of Ontario
Mr. Douglas M. Crawford, P.Eng - Deputy Fire Marshal of Ontario
Dr. Joshy Kallungal, P.Eng - Manager of Research & Standards, OFM
Mr. Alex McKenna - Manager Fire Safety, OFM
Mr. Paul Martini - Manager Fire Investigation, OFM
Mr. William Hiscott - Investigator, OFM
Mr. Robert Harpur, P.Eng - Fire Protection Engineer, OFM

We would also like to thank the Coroner, Dr. Donald G. Bunt, M.D. and Ms. Rita F. Fahy of the National Fire Protection Association, as well as Mr. Paul Reid, the property manager, who answered our questions.

Many people of the National Research Council were involved in this project. We would especially like to thank Mrs. Linda Hayes for editing the manuscript, as well as Dr. David Yung and Mr. J. Ken Richardson for their fruitful comments.

This work was jointly funded by the National Research Council of Canada (NRCC) and the Office of the Fire Marshal of Ontario (OFM).

EXECUTIVE SUMMARY

On January 6th 1995, at around 5:00 in the morning, a fire started on the north-east corner of the 5th floor at 2 Forest Laneway in North York, Ontario. It appeared that the fire started in the living room of Unit 509. The sole occupant reports the following: he was working on his computer in the second bedroom when at around 5:00 he noticed smoke coming from the living room couch. He tried to extinguish the fire but rapidly the situation got out of control. He left the area and the apartment door remained open.

The North York Fire Department received the first call at 5:09. Upon arriving on location at 5:14, they discovered Apartment 509 engulfed in fire. This fire took the lives of 6 people who were found in the two staircases on the upper floors. Other occupants suffered from smoke inhalation and had to be treated in hospital.

The National Fire Laboratory of the National Research Council Canada (NRCC) and the Office of the Fire Marshal of Ontario (OFM) agreed to collaborate on a study of the occupants' behaviour during the fire. Both groups agreed on the importance of gathering data on human behaviour during this major highrise apartment building fire.

The study used a questionnaire mailed to occupants of every unit in the building. The questions were aimed at identifying the way and the time at which occupants became aware that something unusual was happening. Once they became aware of the fact that it was a fire, what were their first few actions. There were questions on the time at which occupants left their units, as well as the smoke and lighting conditions they encountered during their evacuation. Some occupants mentioned to the media about not hearing the building fire alarm; therefore, some questions attempted to identify the locations and times that this situation occurred. A number of occupants had to turn back in the staircases and return to their units or had to take refuge in a neighbour's unit; it was necessary to know where and when these situations occurred. The smoke condition on different floors of the building was an essential variable, as well as the actions occupants undertook to ensure their safety. Variables such as gender, age and limitations were identified, since these are parameters that can play an important role during a building evacuation.

A total of 233 questionnaires were returned representing 190 units, 54% of all apartments from which responses could be expected. This return rate is very good, since most research using questionnaires to study human behaviour after a fire has a return rate of about 30%. The questionnaires returned were coded, scored and input into a data sheet. The data were analysed using Excel and SPSS, a powerful statistical software package.

Four major findings were identified during this study. First of all, the characteristics of the occupants of the building proved to be significant. The most significant differences were related to the ages of the respondents, as those aged 65 and over had a tendency to exhibit different behaviours from younger occupants for such

factors as their perception of the alarm, their choice of actions and their knowledge of fire safety. Older occupants were told about the fire more often than they heard the fire alarm. They were less likely to try to evacuate by themselves or to go onto their balconies. They were also more likely to seek information but had a limited knowledge of fire safety.

The second important factor was the location of the respondent in the building. The situation was much more serious on the 5th floor, on which the fire occurred, and was accurately perceived so by its occupants. The floors situated below the fire floor appear to have been only slightly affected by the fire. The location of the occupants had a direct effect on their choice of actions and on their evacuation possibilities. Occupants on the upper floors were more likely to have to turn back and seek refuge during their evacuation. A greater proportion of them also thought that they could go to the roof to take refuge. Above the 16th floor, a higher number of respondents judged that the fire alarm was not loud enough. Occupants of different areas were also different in their behaviour, specifically in the north-east quadrant, which is the quadrant in which the fire occurred.

The third factor, dealing with smoke conditions, cannot be considered separately from the location of the respondents since smoke conditions varied greatly from one area of the building to another. Floors situated above the neutral plane contained significantly more smoke than floors below, with the exception of the 5th and 6th floors. The presence of smoke was the major factor in determining the evacuation potential of occupants. Both staircases appear to have been clogged with smoke only minutes after the fire alarm sounded.

The time to start evacuating is the fourth factor and is also closely linked to the smoke conditions. For people living above the 5th floor, only those leaving their units at a very early time had a chance of reaching ground level safely. As time progressed, the propagation of smoke and heat made it impossible for people to get past the 5th floor and many had to return to their apartments or seek refuge in another unit until the situation was under control. They were evacuated later by rescue personnel.

Analyses showed that many occupants were prepared to travel through smoke, even though it could endanger their lives. This illustrates the need for public education on the danger of smoke. A large number of occupants had not received appropriate fire safety information. Some specific groups of people, particularly, lacked fire safety information: senior citizens, not employed people and those with different cultural backgrounds, especially those speaking a language other than English at home. It appears essential to provide fire safety information through a variety of means such as fire safety signs, posted evacuation procedures, brochures, training classes and publicity campaigns. It seems important to use multiple means to communicate fire safety information to make sure that the message reaches the building users and that everyone has access to the information. Once fire safety information is provided, it would be useful to assess the occupants' understanding of what they are expected to do during a fire by carrying out fire

drills. Holding regular fire drills is a good way to educate occupants and increase public awareness of fire safety.

This fire demonstrated that communication to the occupants on immediate measures to be taken during a fire needs to be improved. A number of people did not hear the alarm, mostly older occupants or people living in corner units. The P.A. system was also inefficient in communicating with the residents. Judicious use of the media during such a fire situation could prove to be an effective way to provide information.

RÉSUMÉ

Le 6 janvier 1995, aux environs de 5 h du matin, un incendie s'est déclaré au 2, Forest Laneway, à North York en Ontario. Le sinistre aurait pris naissance dans le salon de l'appartement 509, situé à l'angle nord-est du 5e étage. L'unique occupant de cet appartement a déclaré par la suite qu'il était en train de travailler à l'ordinateur dans sa salle de travail quand, vers 5 h, il a remarqué de la fumée provenant du divan du salon. Il a tenté d'éteindre le feu mais s'est aperçu rapidement qu'il en avait perdu la maîtrise. Il a pris la fuite en laissant la porte de son appartement ouverte.

Le service d'incendie de North York a reçu un premier appel à 5 h 09. Arrivés sur les lieux à 5 h 14, les pompiers ont constaté que l'appartement 509 était la proie des flammes. Ce sinistre a coûté la vie à 6 personnes, qui ont été retrouvées dans les deux cages d'escalier aux étages supérieurs. D'autres occupants ont dû être traités à l'hôpital suite à l'inhalation de fumée.

Conscients de l'importance de recueillir des données sur le comportement des occupants au cours de cet incendie majeur dans un immeuble d'appartements de grande hauteur, le Laboratoire national de l'incendie du Conseil national de recherches du Canada (CNRC) et le Bureau du commissaire des incendies (BCI) de l'Ontario ont convenu de collaborer à une étude.

L'enquête reposait sur un questionnaire, qui a été posté aux occupants de tous les appartements de l'immeuble. Les questions visaient à déterminer de quelle façon et à quel moment les occupants s'étaient rendu compte que quelque chose d'inhabituel se passait et quelles avaient été leurs premières réactions. Il y avait des questions sur le moment où les occupants avaient quitté leur appartement ainsi que sur les conditions d'enfumage et d'éclairage pendant leur évacuation. Certains occupants ont mentionné aux médias qu'ils n'avaient pas entendu l'alarme; des questions ont donc été prévues pour déterminer les endroits et les moments où cette situation s'est produite. Un certain nombre d'occupants ont dû rebrousser chemin dans les cages d'escalier et revenir à leur appartement ou demander refuge à des voisins; il fallait savoir où et quand ces situations se sont produites. Les conditions d'enfumage sur les différents étages de l'immeuble constituaient une variable essentielle, tout comme les mesures prises par les occupants pour assurer leur sécurité. D'autres variables comme le sexe, l'âge et les handicaps des occupants ont été considérées, car elles peuvent jouer un rôle important au moment de l'évacuation.

Deux cent trente-trois questionnaires ont été retournés par les occupants de 190 appartements, ce qui représente un taux de réponse de 54 %. Cette participation est très élevée, car pour la plupart des recherches utilisant un questionnaire visant à étudier le comportement des gens pendant un incendie, le taux est d'environ 30 %. Les réponses recueillies ont été codées, comptabilisées et consignées sur une feuille de calcul informatisée. Les données ont été analysées à l'aide d'Excel et de SPSS, un puissant logiciel statistique.

L'étude a permis d'identifier quatre facteurs déterminants. Le premier, les caractéristiques des occupants, semble avoir un effet prépondérant. Les différences les plus importantes étaient liées à l'âge des répondants : les personnes âgées de 65 ans et plus ont généralement des comportements différents de ceux des plus jeunes sous divers aspects, par exemple la perception de l'alarme, les réactions et la connaissance de la sécurité incendie. Plus souvent qu'autrement, les occupants âgés ont été avisés du feu de vive voix, car ils n'avaient pas entendu l'alarme. Ils avaient moins tendance à évacuer les lieux par leurs propres moyens ou à se réfugier sur le balcon. Ils cherchaient davantage à s'informer mais avaient une connaissance limitée de la sécurité incendie.

Le deuxième facteur important était l'emplacement de chaque appartement. La situation était beaucoup plus grave au 5e étage, où le feu avait pris naissance, et ses occupants l'ont nettement perçu. Les étages au-dessous du 5e ne semblent avoir été que peu affectés par le feu. L'emplacement des occupants avait un effet direct sur leurs réactions et sur leurs possibilités d'évacuation. Les occupants des étages supérieurs ont souvent dû revenir sur leurs pas et chercher refuge. Nombre d'entre eux pensaient qu'ils pourraient trouver refuge sur le toit. Au-dessus du 16e étage, un nombre plus élevé de répondants jugeaient que le signal d'alarme n'était pas assez fort. Le comportement des gens variait également en fonction du secteur où ils se trouvaient, en particulier ceux du quadrant nord-est, où le feu a pris naissance.

Le troisième facteur, les conditions d'enfumage, ne peut être considéré indépendamment de l'emplacement du répondant, car ces conditions variaient grandement d'un endroit à l'autre. Les étages situés au-dessus du niveau de pression neutre étaient beaucoup plus enfumés que ceux au-dessous, exception faite des 5e et 6e étages. La présence de fumée était le facteur prépondérant qui déterminait les possibilités d'évacuation des occupants. Il appert que la fumée a envahi les deux cages d'escalier quelques minutes seulement après le déclenchement de l'alarme.

Le délai d'évacuation, qui constitue le quatrième facteur, est aussi étroitement lié aux conditions d'enfumage. Dans le cas des étages situés au-dessus du 5e étage, seuls les gens qui ont quitté très rapidement leur appartement ont eu la chance de se rendre au rez-de-chaussée en toute sécurité. Après quelques minutes, la propagation de la fumée et la chaleur ont fait qu'il était absolument impossible de descendre au-delà du 5e étage et bon nombre d'occupants ont dû rebrousser chemin jusqu'à leur appartement ou trouver refuge chez des voisins jusqu'à ce que la situation soit maîtrisée. Ils ont ensuite été évacués par les secouristes.

Les analyses ont montré que de nombreux occupants étaient prêts à affronter la fumée même s'ils mettaient ainsi leur vie en péril. Voilà qui illustre bien la nécessité d'informer les gens des dangers de la fumée. Un grand nombre d'occupants n'étaient pas bien renseignés sur la sécurité incendie. Certains groupes manquaient particulièrement d'information : les personnes âgées, les gens sans emploi et ceux d'origine culturelle différente, surtout ceux qui parlent une autre langue que l'anglais à la maison. Il paraît essentiel de transmettre l'information sur la sécurité incendie par différents moyens comme

la signalisation, l'affichage des consignes d'évacuation, des dépliants, des séances de formation et des campagnes publicitaires. Il semble important d'emprunter différents véhicules pour communiquer l'information sur la sécurité incendie afin de veiller à ce que le message atteigne tous les occupants et que tous aient accès à l'information. Une fois l'information transmise, il serait utile de vérifier, au moyen d'exercices d'évacuation, si les occupants ont bien compris ce qu'ils ont à faire en cas d'incendie. Ces exercices constituent une bonne façon d'éduquer les occupants et de sensibiliser davantage le public à la sécurité incendie.

Ce feu a montré qu'il faut mieux informer les occupants des mesures qu'ils doivent prendre dès les premiers instants d'un incendie. Un certain nombre de personnes, surtout les personnes âgées ou les gens habitant les appartements situés dans les angles de l'immeuble, n'ont pas entendu l'alarme. Le réseau de communication phonique ne permettait pas de joindre efficacement les occupants. Un usage judicieux des médias d'information, dans ce genre de situation, pourrait constituer une façon efficace de transmettre l'information.

1.0 INTRODUCTION

The study of occupant behaviour during a fire incident is one of the best ways for researchers to learn about the impact of human factors on the circumstances and outcome 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 data gathered in a human behaviour study can provide extremely valuable and unique information to researchers, code developers, enforcement officials and public safety officials. Such findings will enhance their understanding of the conditions encountered in the building at the time of the fire, the behaviour of different occupants during the event and the rationale behind their decisions and can result in improved codes, regulations and practices to prevent future occurrences of this type.

The National Fire Laboratory of the Institute for Research in Construction, National Research Council of Canada (NRCC) and the Office of the Fire Marshal (OFM) are extremely interested in increasing their respective knowledge bases in the area of human behaviour to enhance their respective mandates in fire safety. The fire at the 2 Forest Laneway building, although tragic, provided a unique opportunity to study the occupants' behaviour under an actual fire conditions. This fire is believed to be an infrequent, significant event for a highrise residential occupancy.

On the day of the fire, the Office of the Fire Marshal contacted NRCC to explore and establish the basis for a collaborative project to study the occupants' behaviour during this fire. Since both NRCC and the OFM were greatly interested in the potential findings from such a study, a joint venture partnership agreement was established.

Fire statistics for the province of Ontario show that during the five year period between 1989 and 1993, a total of 42 people died in highrise (over 5 storey) residential building fires [1]. This represented an average of eight deaths per year in such buildings. During this period none of the fire resulted in more than two fatalities. In light of these statistics, the 2 Forest Laneway Fire, where six persons died, appears to be an uncommon and significant event that warrants study in considerable detail.

The findings from the study will be used to develop recommendations to improve fire safety in highrise apartment buildings. This work will help to define better evacuation procedures, training and education programs, as well as changes in regulations and codes of practice. Diffusion of the results will be accomplished through scientific publications, conferences, magazines and presentations to specific groups. The results of this study will be presented during the Coroner's Inquest associated with this significant fire. The results will also be used to verify the NRCC computer model FiRECAM [2], which is used to assess the risk to life of occupants from fires. The results will be used by the OFM to further develop their framework model "Comprehensive Fire Safety Effectiveness Model" [3], which can be used either in a macro or micro framework to provide guidance in optimizing fire safety effectiveness.

2.0 STUDY OBJECTIVES

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. It is very important to identify what went wrong during this fire as well as what went right. The occupants are the best individuals to explain the danger they were exposed to, their understanding of the situation and the different actions they took during the fire.

The study is aimed at identifying the way and the time at which occupants became aware that something unusual was happening; and once aware it was a fire, what actions the occupants undertook. The time at which occupants left their units is also important, as well as the smoke and lighting conditions they encountered during their evacuation. Some occupants mentioned to the media about not hearing the building fire alarm; it is therefore important to identify the locations where this situation occurred. A number of occupants had to turn back in the staircase and return to their units or had to take refuge in a neighbour's unit; it is necessary to know where and when these situations occurred. The smoke condition on the different floors of the building is an essential variable, as well as the actions occupants undertook to ensure their safety when they encountered smoke. Variables such as gender, age and limitations are identified since these are parameters that can play a role during a building evacuation.

A human behaviour study is a systematic method to gather essential information about a traumatic situation such as a fire. This kind of study has the great advantage of helping others to draw a clear picture of the fire situation sometime after the event. The results will facilitate the work of investigators and researchers who have to understand the overall fire situation to develop recommendations to prevent such a tragedy from recurring.

3.0 THE FIRE INCIDENT

On January 6th 1995, at around 5:00 in the morning, a fire started on the north-east corner of the 5th floor at 2 Forest Laneway in North York, Ontario. From the preliminary investigation, it appeared that the fire started in the living room of Apartment 509. According to the deposition of the occupant of Unit 509, at that time he was alone in his apartment and was working on his computer in the second bedroom. At around 5:00, he noticed smoke coming from the living room, where he found a smouldering fire on the couch. He attempted to extinguish the fire using a saucepan filled with water. Unexpectedly, the couch burst into flames. Due to the smoke in the room, he opened the living room patio door to vent the room. Meanwhile, the two men living next door were awakened by the smell of smoke. These two men investigated their own apartment in search of the fire and discovered that the smoke was coming from the apartment next door. One of the neighbours knocked on the door of Unit 509 to alert the occupant to the

fire. The occupant of Unit 509 came to the door and the two men attempted unsuccessfully to use a fire extinguisher taken from a nearby fire hose cabinet. During that time, the second neighbour returned to his apartment to call 911. Rapidly the situation got out of control. The neighbour activated the alarm pull-station located next to the staircase door. The three men left the area with two other neighbours using the elevator. The door to the fire apartment was left open.

The North York Fire Department received the first call at 5:09. Upon arriving on location at 5:14, they discovered that Apartment 509 was engulfed in fire and flames were visible outside coming through the patio door.

This fire resulted in the loss of life of six people who were found in the two staircases on the upper floors. Others suffered from smoke inhalation and had to be treated in hospital.

4.0 RESEARCH STRATEGY

To gather information on human behaviour during the 2 Forest Laneway Fire, there are different research methods available such as face-to-face interviews, phone interviews or a questionnaire survey [4]. Each method could be applied to a different extent; for example, the face-to-face interview can be used to interview 15 subjects during 3 hours each or 500 occupants can be asked a few precise questions. It is important to select the best method for the specific research context and decide on the best way to apply this method.

A few criteria were used to decide on which research strategy was most suitable. These criteria were: time, cost, feasibility, staff needed, and results expected. A strategy involving direct interviews, either face-to-face or by telephone, with the occupants was rejected because this method would have taken a lot of time, would have required trained staff to carry out the interviews, was costly and the data gathering would have been tedious to code and analyze. The mailed questionnaire presented the advantages of reaching all occupants at the same time, it required less staff to be involved in gathering the information, it was cost effective, it limited the amount of data to code, it was easier to analyze because the questions were the same for everyone and it still gave excellent information. A questionnaire mailed to occupants of every unit in the building was the strategy selected.

To allow for people who wanted to participate in the study but who did not want to fill out the questionnaire, a phone number was provided for individual interviews. Occupants could call the principal researcher to set a time for a face-to-face interview at a location of their choice. Four occupants asked for meetings in their apartments. During these meetings, the conversation was recorded and the questionnaires were filled out with them. Their questionnaires were analyzed with the questionnaires returned by mail.

This research strategy was approved by the Human Subjects Research Ethics Committee of the National Research Council Canada. To ensure confidentiality to the respondents, the name of the occupant did not appear on the questionnaire, although the unit number was pre-printed for coding purposes. All questionnaires were mailed on January 31, 1995, 25 days after the fire.

It is important to mention that a separate questionnaire was delivered to every unit in the building by the investigation team of the Office of the Fire Marshal. The results of that questionnaire are not considered in this report.

4.1 The Questionnaire

The questionnaire comprised 64 questions, with a number of sub-questions, for a total of 167 elements that respondents had to answer (see Annex 1). Different styles of questions were used [4]. A majority of questions were closed-ended questions, such as "Did you call 911? Yes ❑ No ❑" or "What time was it?" A number of other questions were open-ended, giving the opportunity to the respondent to describe something in a few words, such as in the question "While staying in your unit, what did you do?" Usually the respondent had only one line to answer open-ended questions. This design offered sufficient flexibility to the respondent while keeping later coding and scoring of the answers simple. At the end of the questionnaire, the respondent was asked to draw his or her evacuation route on the building plans provided and to write on the back of this page any complementary information considered to be important.

The questions were presented under eight headings. Section 1 was the respondent Profile, to provide demographic data on the respondent and the other people who were in the unit at the time of the fire. Section 2 was on the Initial Actions of the respondent, from how he or she became aware of the incident and the first few actions up to the time at which the person left the unit. Section 3 concentrated on the Evacuation of the Building from the time at which the respondent left the unit, the movement in the stairs and the time at which ground level was reached. Section 4 dealt with the Alarm and Public Announcement that the respondent perceived during the whole event. Section 5 was on the Smoke Condition in the unit as well as during the movement to reach safety. Section 6 was about the Rescue Effort and the presence of firefighters and police officers in the building. Section 7 was on the Fire Safety Knowledge and Experience of the respondent in relation to this building. Finally, Section 8 presented a floor plan and an elevation of the building to help the respondent sketch his or her Evacuation Movement.

The formulation of the questions was inspired by the work of Prof. John L. Bryan and the questionnaires he used to study the fires at the MGM Grand Hotel [5], the Westchase Hilton [6], Georgia Towers [7] and Thurston Hall [8]. Previous questionnaires used to study human behaviour during evacuations, such as the New York World Trade Center Study [9, 10] and fire drills [11,12], were also used. A number of reports and papers from researchers in other countries were reviewed. The Ontario report on "The

Public Inquiry into Fire Safety in Highrise Buildings" 1983 [13] was also reviewed. The Office of the Fire Marshal provided a list of points to be covered in the questionnaire and finally different persons from the National Research Council, the Office of the Chief Coroner, the North York Fire Department and the National Fire Protection Association gave input on the formulation of the questions.

Two copies of the questionnaire were sent to every unit in the building. The first page of the questionnaire specified that everyone in the unit who was over 14 years old at the time of the fire should fill out a copy of the questionnaire, extra copies could be obtained by calling the principal researcher. A covering letter asked the occupants to contact the principal researcher if they wanted a face-to-face interview in the language of their choice. A pre-paid return envelope was provided.

Respondents could provide their name and address on the last page of the questionnaire to receive a free copy of the report. This last page was immediately detached from each questionnaire when received and put in a separate box to ensure confidentiality of the respondents.

5.0 QUESTIONNAIRE ANALYSIS

The questionnaires returned were coded, scored and input into a data sheet. A coding manual was developed. The data were analyzed using the software packages SPSS for Windows Version 6.01 and Excel Version 5.0. SPSS is a very powerful statistical software package for social sciences and can perform a multitude of statistical analyses.

Descriptive statistics were calculated to summarize the results and look at frequency distributions, percentages and means. Correlation analyses were also used to identify the degree of relationship between two dependent measures using the Pearson Correlation Coefficient. Cross tabulations were used with Chi-Square tests to determine the relationship between two nominal scale variables such as the Yes/No questions or gender comparisons. All these statistical tests were judged significant at the 0.05 level or when $p \leq 0.05$ [14], which is the accepted convention for testing hypothesis in social sciences.

5.1 Questionnaires Returned

The building at 2 Forest Laneway has a total of 365 apartments. According to the building management, on the day of the fire, 10 units were vacant. Overall, responses from 349 units could be expected, after subtracting the units for the six casualties.

A total of 233 questionnaires were returned, representing 190 units or 54% of all the apartments from which responses could be expected in the building. This is a very good return rate. Most questionnaires used to study human behaviour during fires are

sent essentially to a sample of the whole population and the return rate is about 30% [5, 9]. Considering that the questionnaire for this study was sent to every unit, representing the whole population, the 54% return implies that the results can be generalized to the entire building with confidence.

The questionnaires were mailed out 25 days after the fire. Around this time, most occupants started moving back to their apartments after many days spent away to allow for cleaning and repairs. Figure 1 shows that over 80% of the questionnaires returned arrived within 3 weeks of the mailing. This fast return of the questionnaires implies that most respondents answered the questions in the month following the fire, which improves the consistency of the responses. The last questionnaire used in the analysis arrived on April 28, 1995.

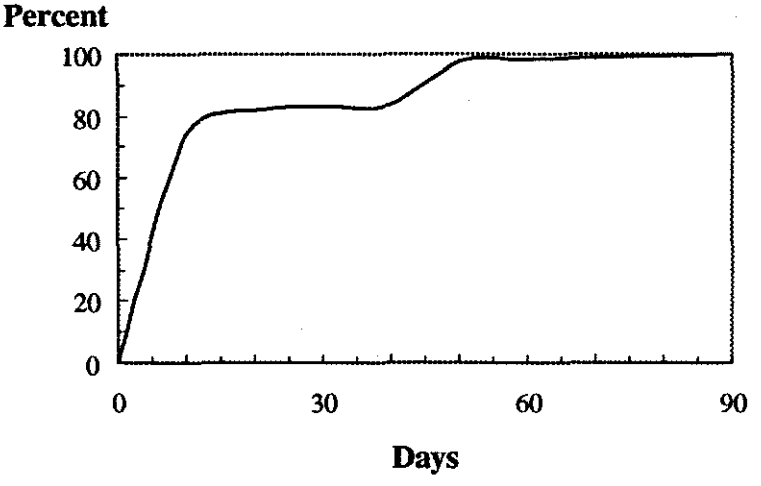


FIGURE 1: Distribution Over Time of Questionnaires Returned

Of the 233 occupants who returned the questionnaire, 14 or 7% mentioned they were not in the building at the time of the fire. The total number of questionnaires used in this analysis corresponds to the 219 respondents from 176 units who were in the building at the time of the fire. Except for the first floor, where there are 4 units and for which no questionnaire was returned, the average return was 7 questionnaires per floor (there are 10 units on the 2nd floor and 13 units on all other floors).

It is impossible to know exactly how many people were in the building on the day of the fire. It is, however, possible to calculate an approximate value from the results of the survey. The results show an average of 1.65 occupants per unit. Out of the 365 units of the building, 10 were vacant at the time of the fire, for a total of 355 occupied units (355 x 1.65 = 586). A percentage of 7% of 586 should be deducted for the people who were out, giving an approximate total of 545 occupants in the building that morning.

5.2 Response Analysis

None of answers given by the respondents was changed for the analysis. In a few cases, it was clear that the answer was not correct or accurate, however, answers were taken as given without modification. One aspect that is likely to be somewhat inaccurate is the specific times provided for different events. In all time-based analyses used in this study, it is difficult to determine the accuracy of the results. All respondents filled in the questionnaire approximately three weeks after the incident and while many remembered numerous details about the situation, specific times may not be absolutely accurate. As well, the occupants were caught in a fire emergency and may not have given much consideration to the time, concentrating their energies on finding safe solutions to the problem at hand. One clear example of that problem is illustrated by the fact that three of the respondents mentioned being alerted by the building fire alarm before 5:00, which appears very unlikely. Nonetheless, they were included in the analysis without changing their answers. Respondents also had a tendency to round off the given times; therefore these time-analyses should be used with caution, especially when considering small time intervals.

It was essential throughout this research to ensure confidentiality of the respondents. The ethics committee at NRCC has very strict requirements protecting the privacy of any person participating in a research project [15]. In order to meet the confidentiality requirements and to simplify the analysis, some of the data were grouped. The data were grouped by the age of the occupants, the floors where occupants resided and the spatial location of their units.

The analyses compare the occupants according to three age groups: 18 to 40 years old, 41 to 64 years old and 65 years old and over. Table 1 gives a distribution of the respondents in terms of their gender and their age. The majority are women (55%), and 53% of respondents are between the ages of 18 and 40. Respondents range in age from 16 to 90 years old. One female respondent did not specify her age.

TABLE 1: Profile of Respondents

Age Group	Male		Female		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
1 to 17	2	0.9	1	0.5	3	1.4
18 to 40	51	23.3	66	30.1	117	53.4
41 to 64	27	12.3	29	13.2	56	25.6
65 and older	18	8.2	24	11.0	42	19.2
No answer	0	0.0	1	0.5	1	0.5
Total	98	44.7	121	55.3	219	100.0

Some respondents did not answer all questions in the questionnaire. The results in some cases are given as a valid percent, which corresponds to a percentage of people who answered this specific question, as opposed to a percentage of all respondents.

The building was divided into groups of floors. Figure 2 presents the six floor groups. The first floor group comprises Floors 1 to 4, which are floors located beneath the fire floor. The 5th floor, or fire floor, forms a group by itself. The third group consists of Floors 6 to 10 just above the fire floor. Another group is made of Floors 11 to 16 (note that there is no 13th floor). The fifth floor group is made of Floors 17 to 21. Finally, the last group represents Floors 22 to 30. The two last groups of floors are located over the theoretical neutral plane of the building. This is an important distinction because the neutral plane is the horizontal level where the air pressure inside equals that outside; smoke rises above the neutral plane to the upper floors of a building [16, 17]. Not every floor group contains the same number of floors; however, this distribution is acceptable to take into account the possible smoke movement in the building.

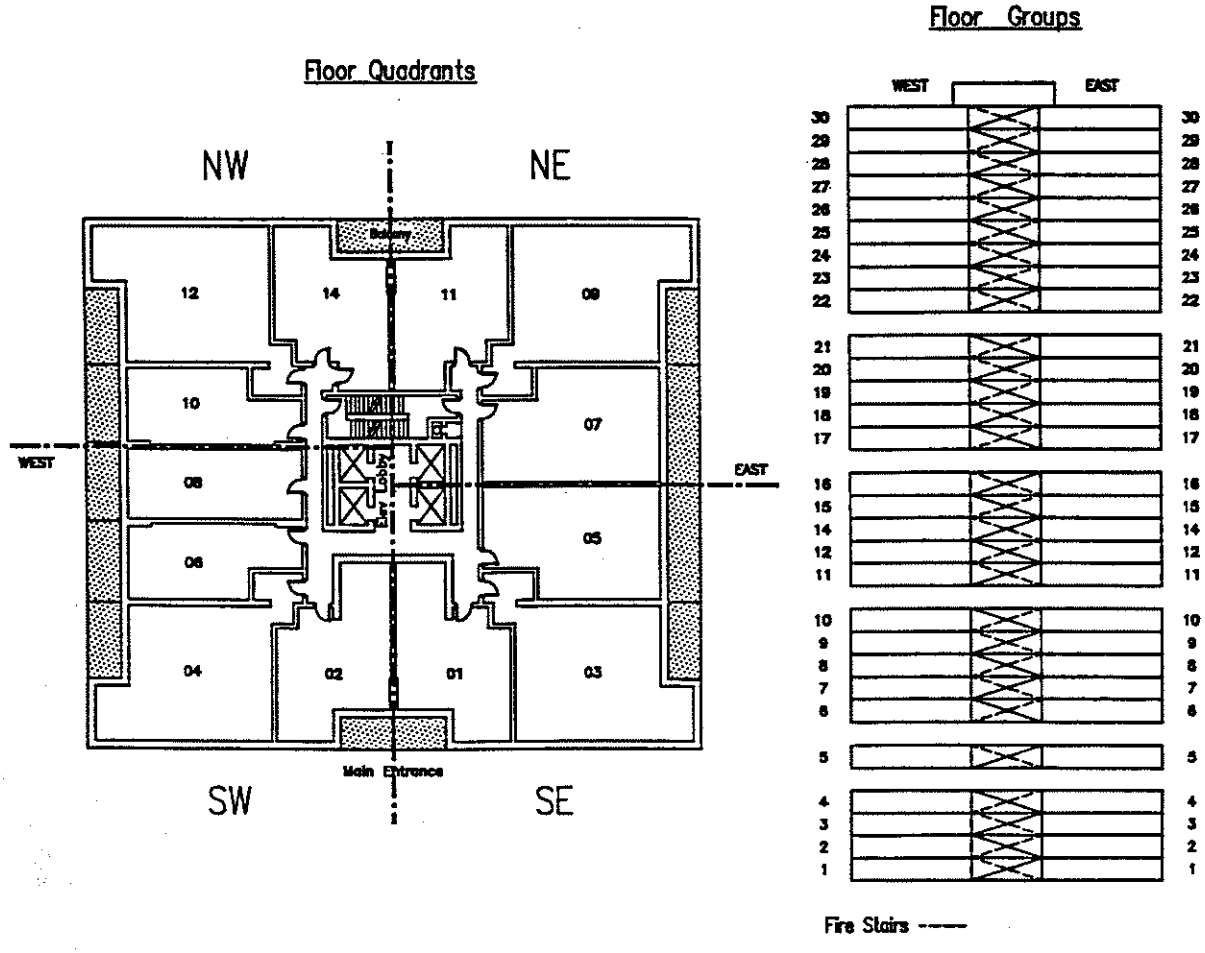


FIGURE 2: Floor Plan and Building Elevation

Each floor of the building was divided in four quadrants according to cardinal points. Figure 2 shows a typical floor plan and the dividing lines of the four quadrants. The units ending with numbers 07, 09 and 11 are in the north-east quadrant, numbers 01, 03, 05 are in the south-east, numbers 02, 04, 06 and 08 are in the south-west and numbers 10, 12 and 14 are in the north-west.

This grouping of the data allows the researcher to meet the confidentiality requirements in reporting the results but also simplifies the analysis and helps to generalize the results. Using groups helps in identifying patterns and enables the researcher to obtain better understanding of the findings.

There are two separate staircases in the building. In this report, they will be referred to as the Fire Staircase and the Other Staircase. The term "Fire Staircase" is used for the staircase which has a door facing the odd-numbered units on the 5th floor. The door to that staircase on the 5th floor is located diagonally across the corridor from Unit 509, where the fire started. Due to this proximity, the smoke density in the Fire Staircase could be different than that in the Other Staircase. Because such scissor-stairs are complex, it is important to refer to Figure 3, which presents a schematic representation of the two staircase organization.

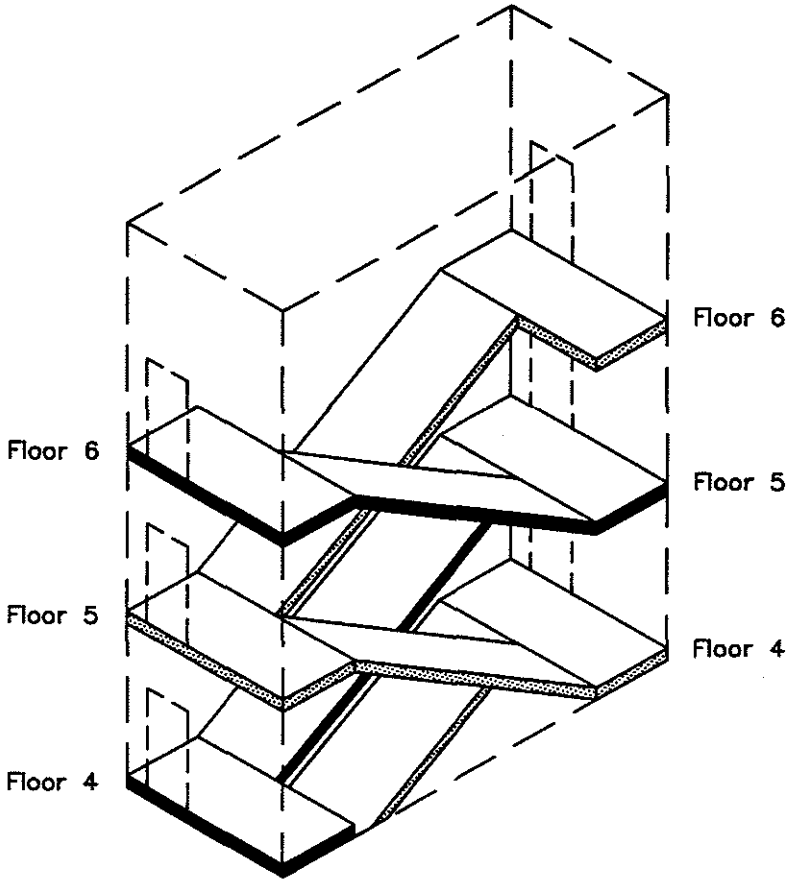


FIGURE 3: Schematic Representation of Scissor-stairs

6.0 OCCUPANT PROFILE

The first section of the questionnaire considered the occupant profile. Of the 219 respondents who were in the building at the time of the fire, 121 (55%) were females and 98 (45%) were males. People of all ages (between 16 and 90 years old) answered the survey, as shown in Table 2. The average age of the respondents was 44 years old and the median was 37 years. Overall, 69% of respondents were less than 50 years old and 19% were over 65 years old. Both males and females are represented in each age category. The average age for women was 45 years and the average for men was 43 years.

TABLE 2: Age Distribution of Respondents

Age Group	Frequency	Percent
11 - 20	6	2.7
21 - 30	57	26.0
31 - 40	57	26.0
41 - 50	37	16.9
51 - 60	10	4.6
61 - 70	19	8.7
71 - 80	19	8.7
81 - 96	13	5.9
No answer	1	0.5
Total	219	100.0

Table 3 shows the distribution among different types of occupations. Under the category "Professional" are included individuals working for example as: accountants, engineers, researchers, managers, programmers, social workers, registered nurses and teachers. The "Support staff" category refers to employment such as: secretary, clerk, librarian, dental assistant or mechanic. Some young children are included under the category "Student," which also refers to adult students. All people without specific employment are declared "Not employed," including housewives and other stay-at-home workers. Finally the term "Retired" is used only for people who specified that they were retired, as opposed to anyone over the age of 65.

Table 4 summarizes the limitations reported by the respondents, such as difficulties that could affect a respondent's ability to evacuate a building in an emergency situation. Limitations due to health include heart and lung problems, as well as asthma, to name only a few. Physical problems include mainly weak or broken limbs and other difficulties possibly resulting in impaired mobility. Perceptual problems refer to poor eyesight or a hearing impairment.

TABLE 3: Occupation of Respondents

Occupation	Frequency	Percent
Professional	95	43.4
Support staff	55	25.1
Student	15	6.8
Not employed	9	4.1
Retired	41	18.7
No answer	4	1.8
Total	219	100.0

A total of 14% of respondents reported having limitations. This is representative of the general Canadian population where, according to Statistics Canada, 14.5% of the people have limitations of one type or another and live in private households [18, 19].

TABLE 4: Limitations of Respondents

Type of limitations	Frequency	Percent	Valid Percent
Health	11	5.0	36.7
Pregnancy	4	1.8	13.3
Physical	9	4.1	30.0
Perceptual	5	2.3	16.7
Sound sleeper	1	0.5	3.3
No limitation	107	48.9	-
No answer	82	37.4	-
Total	219	100.0	100.0

The valid percent represents the percentage of the total number of people who answer a specific question when excluding all missing answers. The percent, however, refers to the overall percentage of people in that category with respect to the total number of respondents to the questionnaire.

Tables 5, 6 and 7 are similar to Tables 2, 3 and 4, respectively, but apply to an additional person present in the apartment, with the respondent, at the time of the fire. At that time, 49% of apartments were occupied by only one person, namely the respondent. When a second individual was present, as in 51% of apartments, in 55% of the cases it was a female and in 45% it was a male. In 50% of cases, the second occupant was an adult who had a "Professional" occupation. Only 10% of the second occupants had limitations.

When there were two respondents from a single unit, the second respondent was considered as a second (or third, or fourth) person in the first respondent's questionnaire and vice versa. This implies a doubling of some of the data for Tables 5 to 12. The information is not doubled in any of the other analyses; each questionnaire is analyzed as

describing the behaviour of the first respondent and since no one returned more than one completed questionnaire, there is no doubling of the results.

TABLE 5: Age of Second Person

Age Group	Frequency	Percent	Valid Percent
11 - 20	5	2.3	4.5
21 - 30	32	14.6	39.1
31 - 40	30	13.7	27.3
41 - 50	17	7.8	15.5
51 - 60	11	5.0	10.0
61 - 70	8	3.6	7.2
71 - 80	5	2.3	4.6
81 - 96	2	0.9	1.8
No other person	107	48.9	-
No answer	2	0.9	-
Total	219	100.0	100.0

TABLE 6: Occupation of Second Person

Occupation	Frequency	Percent	Valid Percent
Professional	53	24.2	50.0
Support staff	23	10.5	21.7
Student	9	4.1	8.5
Not employed	9	4.1	8.5
Retired	12	5.5	11.3
No other person	107	48.9	-
No answer	6	2.7	-
Total	219	100.0	100.0

TABLE 7: Limitations of Second Person

Type of limitations	Frequency	Percent	Valid Percent
Health	5	2.3	45.5
Pregnancy	2	0.9	18.2
Physical	2	0.9	18.2
Perceptual	2	0.9	18.2
No limitation	52	23.7	-
No other person	107	48.9	-
No answer	49	22.4	-
Total	219	100.0	100.0

Tables 8, 9 and 10 reflect the characteristics of a third person present in the apartment at the time of the fire. Only 9% of respondents (20 out of 219) reported that their apartment was occupied by more than two people. In the cases where a third person was present, 65% of the time it was a male and 35% of the time it was a female. Fifteen of the 20 'third persons' were children or teenagers who were 'Students.'

TABLE 8: Age of Third Person

Age Group	Frequency	Percent	Valid Percent
0 - 10	10	4.5	50.0
11 - 20	5	2.3	25.0
21 - 30	1	0.5	5.0
41 - 50	2	0.9	10.0
51 - 60	1	0.5	5.0
71 - 80	1	0.5	5.0
No other person	199	90.9	-
Total	219	100.0	100.0

TABLE 9: Occupation of Third Person

Occupation	Frequency	Percent	Valid Percent
Professional	1	0.5	7.7
Support staff	1	0.5	7.7
Student	10	4.6	76.9
Retired	1	0.5	7.7
No other person	199	90.9	-
No answer	7	3.2	-
Total	219	100.0	100.0

TABLE 10: Limitations of Third Person

Type of limitations	Frequency	Percent	Valid Percent
Health	1	0.5	100.0
No limitation	6	2.7	-
No other person	199	90.9	-
No answer	13	5.9	-
Total	219	100.0	100.0

Tables 11 and 12 reflect the characteristics of a fourth person present in the apartment at the time of the fire. Only 5% of respondents (10 out of 219) reported that their apartment was occupied by more than three people. In half of the cases, the fourth person present was a male and in the other half, it was a female. This fourth person was a

child or teenager in eight of the 10 cases. No limitation was reported for any of the 'fourth' persons present in the apartment.

TABLE 11: Age of Fourth Person

Age Group	Frequency	Percent	Valid Percent
0 - 10	6	2.7	60.0
11 - 20	2	.9	20.0
31 - 40	1	0.5	10.0
41 - 50	1	0.5	10.0
No other person	209	95.4	-
Total	219	100.0	100.0

TABLE 12: Occupation of Fourth Person

Occupation	Frequency	Percent	Valid Percent
Support staff	2	0.5	16.7
Student	3	2.3	83.3
No other person	209	95.4	-
No answer	4	1.8	-
Total	219	100.0	100.0

Only one respondent declared that there were five people in the apartment at the time of the fire. The fifth individual was a 40 year old female, not employed and with no limitations.

Overall, 55% of the respondents were females and 45% were males. Their average age was 44 years. Forty-three percent of the respondents were "Professionals" and 25% were "Support Staff." Another 19% of the respondents who were retired and 7% were students. Close to half of the respondents (49%) were alone in their units at the time of the fire, while 37% of the units had two occupants, 9% had three and 5% had four or more. The average number of occupants in each unit at the time of the fire was 1.65. Of the 42 people with limitations, which includes respondents and all other persons present in the unit, 40% had a health problem, 26% had physical limitations, 6 women (14%) were pregnant, 17% had a perceptual problem and one (2%) was a sound sleeper.

The great majority of respondents (83%) reported using mostly English for verbal communication at home. Ten percent of people reported speaking Chinese: ten people spoke Cantonese and five people did not specify Cantonese or Mandarin. They were combined in Table 13 as speaking Chinese at home. The Indian language refers to people speaking either Farsi (two people) or Punjabi (one person).

TABLE 13: Language Used at Home

Language	Frequency	Percent	Valid Percent
English	125	57.1	83.3
Chinese	15	6.8	10.0
French	4	1.8	2.7
Indian	3	1.4	2.0
Korean	2	0.9	1.3
Spanish	1	0.5	0.7
No answer	69	31.5	-
Total	219	100.0	100.0

7.0 FIRE SAFETY KNOWLEDGE AND EXPERIENCE

Fire safety knowledge varied a great deal from one individual to the other. Table 14 sums up the various sources of information to which the respondents could have had access. These sources could have provided them with information on which actions to take in a fire situation. Of the respondents speaking a language other than English at home, 42% mentioned not having any previous information on actions to take in a fire situation, compared to only 15% for the English speaking group. Analysis showed no significant difference between genders ($\chi^2 = 49.74$, DF = 1, $p = 0.48$) in terms of whether or not they obtained any information on fire safety. Women, however, were more likely to obtain the information at work, while men obtained more information in publications or from the radio and television.

TABLE 14: Previous Sources of Information on Procedures in a Fire Situation

Source	Frequency	Percent
Multiple	60	27.4
Work	35	16.0
School	24	11.0
Publication	24	11.0
Radio, TV	11	5.0
Others	18	8.2
No information	35	16.0
No answer	12	5.5
Total	219	100.0

People in the 18-40 age group were more likely than older people to have received general fire safety information at school (15%), at work (13%) or to have been exposed to multiple sources of information (43%). People between the ages of 41 and 64 were more likely to have received information at work (27%), in publications (15%), from multiple sources (20%) or to have no information at all (16%). Seniors (65+ years old) generally

obtained their information in publications (35%) or by other non-specified sources (24%); they were also more likely to have had no information at all (24%).

Analysis showed a significant difference between people with different occupations ($\chi^2 = 14.97$, DF = 4, p = 0.00). Working adults, such as professionals and support staff, were more likely to have had previous information than not employed people. Only 40% of the not employed people had access to previous information, compared to 83% of all respondents. Working adults generally obtained their information at school, at work or through multiple sources. Retired people were informed mostly through publications.

7.1 Length of Stay

On average, the respondents had been living in the 2 Forest Laneway Building for close to 4 years at the time they answered the questionnaire; but the mean length of stay was only of 1 year and 9 months, with answers ranging from one week to 20 years, as shown in Table 15. A statistical analysis showed a relationship between the length of time a person had lived in the building and that person's knowledge of the evacuation procedure ($\chi^2 = 31.18$, DF = 5, p = 0.00). People who had lived in the building for more than four years were much more likely to be familiar with the evacuation procedure than people who had moved in during the last year. People who had lived in the building for one to two years, however, were generally slightly more familiar with the evacuation procedure than those with two to four years of residence.

TABLE 15: Length of Stay in the 2 Forest Laneway Building

Length	Frequency	Percent
1 year or less	77	35.2
1 to 2 years	47	21.5
2 to 3 years	22	10.0
3 to 4 years	13	5.9
4 to 10 years	36	16.4
10 to 20 years	24	11.0
Total	219	100.0

Sixty-one, or 30% of the respondents, were aware of the evacuation procedure for the 2 Forest Laneway building, having read about it on written notices and signs (2 or 4%), in the hall (38 or 73%) or in the "Building Information Packet" (12 or 23%). Based on that information, 6 people believed they were supposed to evacuate, 5 thought they ought to stay in their apartments and 35 knew not to use the elevator. Men were significantly more likely to be familiar with the evacuation procedure than women ($\chi^2 = 6.86$, DF = 1, p = 0.01).

Among the 25 respondents who mentioned using another language than English at home, two or 8% said they knew about the evacuation procedure by reading the information posted in the hall, which informed them that they should not use the elevator. Twenty-one of them (84%) were not familiar with the procedure and two (8%) did not answer the question. For the 117 English speaking respondents who answered this question, 31% were familiar with the building evacuation procedure. From that group, 72% had read the posted instructions and 28% had read the "Building Information Packet"; the majority of them (80%) recalled that they should not use the elevator during a fire.

Statistical analysis showed a significant difference between age groups ($\chi^2 = 8.68$, DF = 2, p = 0.01). Respondents over 64 years old were more likely to be aware of the evacuation procedure for the building than respondents aged 18 to 40. No significant difference was found between respondents having different types of occupation ($\chi^2 = 8.35$, DF = 4, p = 0.08). Forty-seven percent of retired people were aware of the procedures compared to 13% of not employed respondents, 23% of professionals, 29% of support staff and 33% of students.

Thirty-nine or 19% of the respondents had experienced a fire before, ranging in time from two years ago to 45 years ago. This experience had no impact on their first action that morning or on their feelings during the event. They had no tendency to judge the situation as more serious or less serious than the occupants who had not had a previous fire experience ($\chi^2 = 6.16$, DF = 3, p = 0.10).

7.2 Fire Drills and False Alarms

It is interesting to note that three people thought they had previously participated in a fire drill in this building, even though management confirmed that such an exercise with all the occupants had not been held. Two of them thought it had been done in the summer of 1994. False alarms have been occurring regularly and 144 people, or 68%, were aware of such alarms. Table 16 shows the frequency of false alarms, according to the respondents, over a period of one year preceding the survey.

TABLE 16: Occupants' Assessment of Number of False Alarms in the Past Year

Number of Alarms	Frequency	Percent	Valid Percent
0	2	0.9	2.2
1 to 3	73	33.3	78.5
4 to 6	14	6.4	15.1
7 to 10	4	1.8	4.4
No answer	126	57.5	-
Total	219	100.0	100.0

According to the North York Emergency Call Reporting System, a total of 11 false alarms had been recorded in 1994 in the 2 Forest Laneway building. Three false alarms had been recorded in 1993. Table 17 shows the frequency and type of false alarms recorded during 1993 and 1994.

TABLE 17: Number of Actual False Alarms in the Past Two Years

Type of False Alarm		1993	1994
Malicious False Alarms	Manual Pull Station Activated	2	1
Accidental False Alarms	Sprinkler Pressure Change	1	3
	Detector Activated		1
	Equipment Malfunction		4
	Smoke, steam, etc. (mistaken for fire)		2
Total		3	11

7.3 Use of Stairs

Prior to the day of the fire, 62% of the respondents had used the stairs. Analysis showed a significant difference between age groups. People in the 18-40 age group were more likely than the 65+ age group to have used the stairs prior to the fire ($\chi^2 = 6.11$, DF = 1, $p = 0.01$). This difference was not significant between the 18 to 40 and 41 to 64 age groups ($\chi^2 = 2.40$, DF = 1, $p = 0.12$) and between the 41 to 64 and 65 and over age groups ($\chi^2 = 0.90$, DF = 1, $p = 0.34$). When comparing blocks of floors, a significant difference appears, showing that people living below the 17th floor were also more likely to have used the stairs in the past than the people living on the 17th floor and above ($\chi^2 = 16.50$, DF = 5, $p = 0.01$). There was no significant difference found between the previous use of the stairs by men and by women ($\chi^2 = 1.15$, DF = 1, $p = 0.28$).

Surprisingly, 10 or 5% of the respondents believed there was only one staircase in the building, 182 or 83% knew there were two staircases, two people or 1% thought there were more than two and 25 or 11% did not answer the question. Of the 10 people who thought there was only one staircase in the building, 3 had used the stairs before, five were men and five were women, all were younger than 65, except one who was 87 years old and none of them had limitations, with the exception of one lady who was pregnant at the time. The two people who thought there were more than two staircases were both men, aged 22 and 43 and one of them had used the stairs before. All these twelve people lived between the 5th and the 27th floors.

7.4 Exit to the Roof

In general, 47 people or 22% think that it is a good idea in a fire to try to exit to the roof of a building while 164 or 78% do not agree. There is no statistical significant difference to show that people on higher floors were more likely than people on lower

floors to think that, in general, it would be a good idea to go onto the roof of a building ($\chi^2 = 8.74$, DF = 5, p = 0.12).

Prior to this fire, 39 of the residents (19%) thought they could go to the roof of the 2 Forest Laneway building while 163 (81%) did not think they could exit onto the roof of this building. The people who thought the roof would be a good exit to get away from the fire believed it would be a safer place and/or a good place to eventually be rescued (14 people or 36% of those in favour of the roof exit). A number of them thought that going to the roof might be a good idea depending on the situation and whether the door to the roof was locked. People living between the 17th and the 30th floors inclusive were more likely to think that they should exit onto the roof of the 2 Forest Laneway building in the event of a fire ($\chi^2 = 14.44$, DF = 5, p = 0.01).

7.5 Injuries

Injuries to people in the building, related to this fire were reported by 11 or 5% of the respondents. Seven of them suffered from smoke inhalation, two from exhaustion, one from exposure to the cold and one did not specify the nature of the injury.

8.0 ACTIONS PRIOR TO EVACUATION

This section contains a detailed analysis of the initial actions of the respondents prior to their evacuation. First of all, it examines the circumstances of the initial awareness stage. Secondly, it discusses the actions taken by the respondents from the time they were made aware of the emergency situation to the time they left their apartments to evacuate the building.

8.1 Initial Awareness

The majority of the occupants of the building (57%) were first made aware that something unusual was happening by the sound of the alarm. Table 18 describes the various ways in which people were alerted. The second way by which occupants were alerted was by being told by another person (17%). A number of occupants were alerted by the smoke (14%) or by the sound of movement (7%).

There is no statistical evidence to show that men and women were alerted in different ways ($\chi^2 = 2.96$, DF = 4, p = 0.56). Analysis showed, however, a significant difference in the way older people became aware that something was happening, compared to younger people ($\chi^2 = 35.62$, DF = 8, p = 0.00). Compared to the 18 to 40 and 41 to 64 year olds, the occupants over 64 years old were significantly more likely to be told about the situation rather than to perceive the alarm or the smoke. The younger groups were generally warned by the alarm and the presence of smoke.

TABLE 18: Initial Awareness of Occupants

Cause	Frequency	Percent
Alarm	125	57.1
Being told	37	16.9
Smoke	31	14.2
Hearing movement	15	6.8
Smoke and alarm	10	4.6
No answer	1	0.5
Total	219	100.0

The location of the unit in the building in terms of floor level and quadrant was not shown to have a significant effect on the way people became aware that something unusual was occurring (floor level: $\chi^2 = 29.93$, DF = 20, p = 0.07; quadrant: $\chi^2 = 15.90$, DF = 12, p = 0.20). This can be explained by the fact that most people were alerted by the sound of the alarm (see section on Alarm and Public Announcements) which probably sounded throughout the building at the same time. A higher percentage (28%) of respondents from the 22nd to the 30th floors, however, said that they initially noticed the smoke compared to respondents living on lower floors: 15% for residents living between the 17th and 21st floor, 15% between the 11th and 16th floor, 9% between the 6th and the 10th floor and 8% between the 2nd and the 4th floor. On the 5th floor, two-thirds of respondents noticed the smoke before anything else.

8.2 Time of Initial Awareness

Respondents had a marked tendency to round off the various reported times, therefore, the time analyses should be used with caution, especially when considering small time intervals. Very few people gave time measures that were not multiples of five. The time reported by the respondents should not be used to determine within one minute the time at which the fire started, the alarm rang, the smoke appeared or any other significant event. For events of less significance or that were less noticeable, respondents could easily round off the time measure by more than five minutes, giving answers with respect to the closest half hour in many cases.

Figure 4 shows the different times at which people became conscious of the emergency situation. It illustrates in 5 minutes intervals the time frequencies for the period between 5:00 and 6:00. This is the period of time during which 93% of the respondents became aware that something was happening. With the exception of the 2nd floor, where respondents noticed something unusual was happening on average around 6:10, the average time to notice something was happening for all the other floors was 5:11. When considering all blocks of floors but the 5th floor, between 5:00 and 6:00, there is no significant difference for the time of initial awareness of the respondents at different levels ($\chi^2 = 10.11$, DF = 8, p = 0.26).

There is a significant difference in the way residents were alerted as a function of the time of initial awareness ($\chi^2 = 48.97$, DF = 6, p = 0.00). Occupants aware of the presence of the fire before 5:15 were more likely to have been alerted by the alarm bell, while occupants alerted at 5:15 and later were more likely to have been told about the fire or to have seen or smelled the smoke.

Statistical analysis showed a correlation between the age and the time of awareness ($r = 0.14$, $p = 0.04$). People in the 65 and over age group were alerted significantly later than younger residents. The difference is not significant between the 18 to 40 age group and the 41 to 64 age group. On average, people aged 65 and over became aware of the problem at 5:21, compared to 5:12 and 5:11 for the other two age groups.

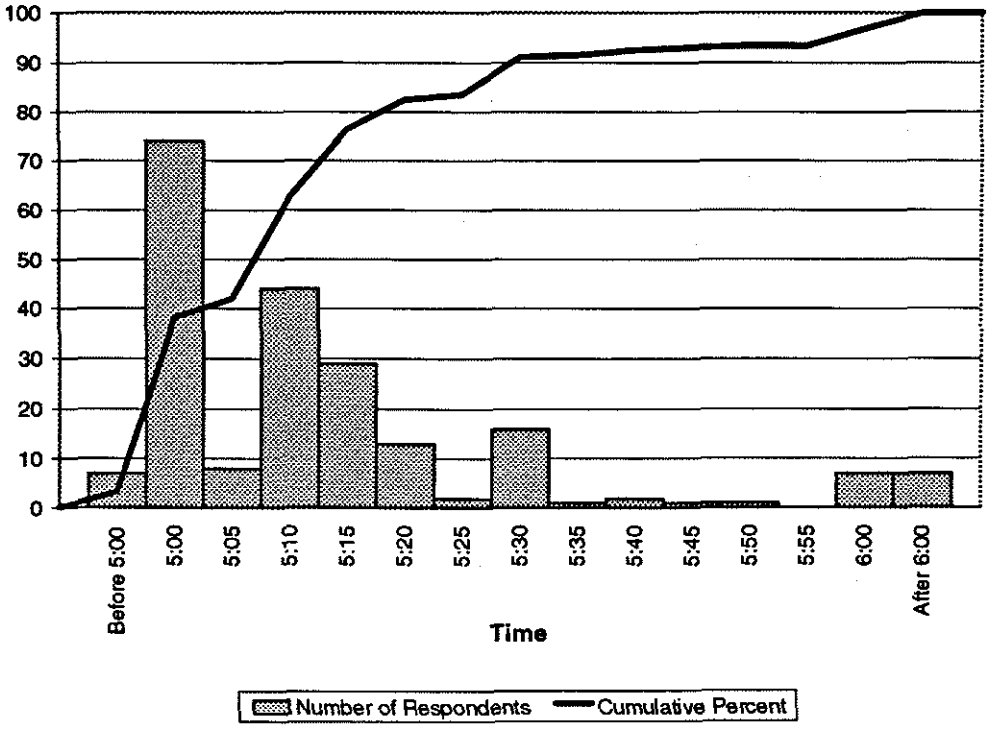


FIGURE 4: Frequency of Initial Awareness between 5:00 and 6:00

8.3 Activity at Time of Initial Awareness

Table 19 shows that 92% of people were in bed and 84% were asleep until some initial sign awoke them and they first acknowledged that something unusual was happening. No difference was found between the people who were asleep and those who were awake at the time of initial awareness ($\chi^2 = 3.20$, DF = 3, p = 0.10). People who

were awake at the time of initial awareness did not realize that there was a problem significantly earlier than the people who were asleep.

TABLE 19: Activity at Time of Initial Awareness

Occupation	Frequency	Percent
In bed - Asleep	185	84.5
In bed - Awake	16	7.3
Awake and active	7	3.2
In washroom	5	2.3
Eating	2	0.9
No answer	4	1.8
Total	219	100.0

8.4 Seriousness of Situation

Table 20 shows the respondents' initial interpretation of the situation in terms of the seriousness of the event. No relation has been found between the initial perception of the situation and the respondent's floor, if the fifth floor is excluded from the calculations ($\chi^2 = 11.36$, DF = 12, p = 0.50). The people on floors situated closer to the fire were not more likely to think that the situation was very serious than the people located much farther from the 5th floor. There appears to be a significant difference where the fifth floor is concerned: 4 out of 5 fifth floor respondents believed the situation was *Extremely Serious*.

TABLE 20: Initial Interpretation of the Situation

Interpretation	Frequency	Percent
Not at all serious	79	36.1
Only slightly serious	38	17.4
Moderately serious	56	25.6
Extremely serious	39	17.8
No answer	7	3.2
Total	219	100.0

Females generally thought at first that the situation was more serious than men. This gender difference was statistically significant ($\chi^2 = 7.50$, DF = 3, p = 0.05). The correlation analysis also showed that age groups were statistically different. The occupants over 65 years old judged the situation as significantly more serious than the younger groups ($r = 0.20$, p = 0.00). Analysis did not show a significant difference between people having different occupations ($\chi^2 = 17.13$, DF = 12, p = 0.14). The presence of another person was not shown to cause a significant difference in the initial interpretation of the situation ($\chi^2 = 1.04$, DF = 3, p = 0.79).

8.5 First Action Taken

Occupants described a variety of first actions taken. In order to facilitate the analysis of these first actions, it was important to define categories. Previous research on human behaviour in fire situations has categorized the actions of occupants into nine categories from *Investigation* to *Protective Action* (see Table 21) [5, 9, 20]. In relation to these categories, the first actions following initial awareness reported by the occupants of the 2 Forest Laneway building are listed in Table 21. The *Investigation* category refers to actions such as: getting out of bed, checking the corridors, checking the apartment, looking out the window or feeling the door. *Seeking Information* can be described as talking to neighbours or others, calling the building management or calling 911. A number of people reported stopping the smoke from entering, which is a *Protective Action*. *Alerting* is often done by warning others and *Waiting* describes best the people who reported doing nothing. No one reported actions falling in other categories such as *Preparation to Evacuate*, *Evacuation*, *Assisting* or *Seeking Refuge* as their initial action.

Analysis on the actions reported by the occupants did not show a difference between genders ($\chi^2 = 2.01$, DF = 4, p = 0.73). It appears males and females were equally likely to take the various actions described in Table 21. Statistical analysis showed that there was a difference between people alone in their units and people who were not alone ($\chi^2 = 13.37$, DF = 4, p = 0.01). The difference resided mainly in the fact that people who were alone in their apartments were unlikely to list *Alerting* as their first action but were more likely to *Investigate* or *Seek Information*. In fact none of the 104 people who were alone in their units said their first action had been to *Alert*. When a second person was present in the apartment, 12% of respondents' first action was to *Alert*.

TABLE 21: First Action Following Initial Awareness

Action	Frequency	Percent
1. Investigation	135	61.6
2. Seeking Information	20	9.1
3. Preparation to Evacuate	0	0.0
4. Evacuation	0	0.0
5. Alerting	13	5.9
6. Assisting	0	0.0
7. Seeking Refuge	0	0.0
8. Waiting	34	15.5
9. Protective Action	11	5.0
No answer	6	2.7
Total	219	100.0

Statistical analysis showed a difference between people with different occupations ($\chi^2 = 22.71$, DF = 8, p = 0.00) when comparing professionals, support staff and retired occupants. Professionals were more likely to *Wait* than the others, respondents working as support staff had a tendency to *Investigate* and retired people were more likely to take *Protective actions*. No evidence has been found to suggest that limitations had an effect on a person's first action, however, the sample of people with limitations was very small ($\chi^2 = 19.05$, DF = 16, p = 0.27).

Statistical analysis showed a significant difference between age groups ($\chi^2 = 25.69$, DF = 8, p = 0.00). Respondents aged 65 and older were more likely to *Protect* or *Seek Information*, people aged between 41 and 64 were more likely to *Investigate* and people between 18 and 40 years old were more likely to *Alert* or to *Wait*. The difference is not significant between the respondents 18 to 40 years old and those 41 to 64 years old ($\chi^2 = 6.26$, DF = 4, p = 0.18).

The time of first awareness was not shown to have a significant effect on the choice of first action ($\chi^2 = 16.96$, DF = 12, p = 0.15). However, as shown in Table 22, a higher proportion of people with an early initial awareness time decided to *Wait* or to *Alert*. People with a later initial awareness time were more likely to *Investigate* or to *Protect*. The expected values are shown in parentheses in Table 22 beside the actual numbers. The expected values correspond to the values that would have been obtained if there was absolutely no difference among the various categories, corresponding to a perfect fit of the normal curve. The expected value for any given cell can be obtained by multiplying the sum of the row by the sum of the column and dividing by the sum of all cells in the table.

TABLE 22: First Action as a Function of the Time of Initial Awareness

Action	TIME								Row Total	
	Before 5:05		5:05 to 5:14		5:15 to 5:24		After 5:24			
Investigate	50	*(51.3)*	30	*(32.3)*	33	*(28.5)*	22	*(22.8)*	135	63%
Wait	15	*(12.9)*	10	*(8.1)*	8	*(7.2)*	1	*(5.7)*	11	5%
Seek Info	7	*(7.6)*	5	*(4.8)*	3	*(4.2)*	5	*(3.4)*	20	9%
Alert	6	*(4.9)*	4	*(3.1)*	0	*(2.7)*	3	*(2.2)*	13	6%
Protect	3	*(4.2)*	2	*(2.6)*	1	*(2.3)*	5	*(1.9)*	34	16%
Column Total	81	- 38%	51	- 24%	45	- 21%	36	- 17%	213	100% 100%

The resident's initial interpretation of the seriousness of the situation was likely to affect his or her first action. Statistical analysis showed a significant difference between people who had different initial perceptions of the gravity of the situation ($\chi^2 = 43.45$, DF = 12, p = 0.00). People who thought the situation was *Not at all Serious* were much more likely to *Wait*, people who thought the situation was *Only Slightly Serious* or *Moderately Serious* decided in a greater proportion to *Investigate* and people who believed the situation to be *Extremely Serious* were more likely to *Alert*.

Table 23 shows how previous information about fire safety or information on the building evacuation procedure affected residents' first actions. Analysis showed there was a significant difference between people who had had some form of previous information on actions to take in a fire situation and those who had not had any information (χ^2 = 11.79, DF = 4, p = 0.01). People exposed to previous information were more likely to *Investigate*, while people without any previous information were more likely to *Seek Information* or to *Wait*. Analysis did not show a significant difference between people who were aware or not aware of the evacuation procedure and their first action (χ^2 = 9.01, DF = 4, p = 0.06).

TABLE 23: First Action as a Function of Fire Safety Knowledge

Knowledge	TYPE OF FIRST ACTION					Row Total
	Investigate	Protect	Seek Info	Alert	Wait	
Obtained Previous Information on Fire Safety						
Yes	113 *(105)*	8 *(8.3)*	12 *(16.6)*	10 *(9.9)*	25 *(28.1)*	168 83%
No	14 *(21.9)*	2 *(1.7)*	8 *(3.4)*	2 *(2.1)*	9 *(5.9)*	35 17%
Column Total	127 - 63%	10 - 5%	20 - 10%	12 - 6%	34 - 17%	203 100% 100%
Aware of Building Evacuation Procedures						
Yes	43 *(38.1)*	6 *(3.3)*	3 *(5.6)*	3 *(3.5)*	5 *(9.5)*	60 30%
No	86 *(90.9)*	5 *(7.7)*	16 *(13.4)*	9 *(8.5)*	27 *(22.5)*	143 70%
Column Total	129 - 64%	11 - 5%	19 - 9%	12 - 6%	32 - 16%	203 100% 100%

Statistical analysis showed no significant difference between people who had experienced a fire before and those who had not (χ^2 = 1.08, DF = 4, p = 0.90).

8.6 Awareness of the Fire

Following an initial awareness, some action is likely to be performed by an individual, as described by the categories in Table 21. The completion of that action will generally give the person a better understanding of the situation. As a result of the information obtained in one way or another, eventually all occupants were made aware that there was a real fire. Table 24 describes the different cues leading to that understanding.

Analysis showed no significant difference between genders (χ^2 = 3.35, DF = 8, p = 0.91). People of different age groups, however, became aware that there was a fire in ways that are significantly different (χ^2 = 26.36, DF = 16, p = 0.05). People in the 18-40 and 41-64 year age groups were more likely to notice signs of smoke (smell and sight), while people in the 65 year and older age group were more likely to be told. The

difference between the ways of becoming aware that it was a real fire is not significant between the 18-40 and 41-64 year age group ($\chi^2 = 5.58$, DF = 8, p = 0.69). No relation has been established between the fire cues described in Table 24 and the quadrant block in which the respondent's unit is located ($\chi^2 = 31.64$, DF = 24, p = 0.14).

TABLE 24: First Cues of a Fire Emergency Situation

Cue	Frequency	Percent
Saw smoke	81	37.0
Smelled smoke	60	27.4
Told by others	32	14.6
Saw fire trucks outside	20	9.1
Told by firefighters	8	3.7
Opened door	6	2.7
Heard fire crackling	4	1.8
Heard alarm	3	1.4
Alarm and smoke	1	0.5
No answer	4	1.8
Total	219	100.0

8.7 Attempt to Give or Obtain Information

Table 25 shows the respondents' attempts to contact others to give or obtain information on the situation prior to their evacuation. Overall, 129 people (59%) successfully used one form of communication or another to obtain and/or give information concerning the situation. A number of people used more than one form of communication; this explains why the frequencies in Table 25 add up to more than 129.

In summary, the 911 emergency service was contacted by 16% of all respondents. They were informed that they should remain in their units, stay calm, put towels to seal the door and go on the balcony. Unfortunately, the times of these calls were not reported in the questionnaires and it is not possible to determine when a particular response was provided by 911.

None of the respondents said they pulled the fire alarm. Obviously, if the alarm was already ringing, this was not of any use but, since many of them reported not hearing the alarm, it is interesting to note that no one tried to activate it. It could be explained by the fact that the people who were not woken up by the alarm, in many cases, were woken up by the smoke and chose not to go into the corridor to pull the alarm.

A large number of people (35% of respondents) called friends or relatives, in most cases to let them know that they were safe and sound. Ninety-six people (46%) listened to the radio or watched television while staying in their units. Some of them reported that

this was frustrating since the news would report that there was a fire, which they obviously knew at that time and that people had died, which was frightening them, without giving any information on what to do if one was still inside the building.

Statistical analyses have shown no significant difference between genders or between age groups in terms of the respondents' communication efforts. This applies to all the items listed in Table 25.

In Table 25, the number starting each line in the "Information Received" column corresponds to the number of respondents who received that information.

TABLE 25: Communication Effort

Action	Frequency	Information Received
Call 911	36	12 Towels at door 9 Stay calm and in unit 5 Towels and balcony 4 Go on balcony 1 Evacuate
Call fire department	4	1 Evacuate 1 Towels at door 1 Firefighters coming
Operate fire alarm pull station	0	
Alert other occupants	35	How: 14 Tell others 13 Knock on door 4 Balcony
Telephone friends or relatives	75	
Watch television or listen to radio	96	37 Fire in building 21 Follow instructions 18 People have died
Call security	2	

8.8 Stay in their Units

As many as 29% of the occupants did not mention any activity, which may imply that they left their apartments immediately. A number of individuals, however, stayed in their units rather than trying to evacuate immediately. Table 26 shows their motivation in staying in their apartments and Table 27 lists their activities during the wait. A majority of occupants (50%) reported there was too much smoke to attempt an evacuation and 13% thought it was safer to stay inside their units. Another group, representing 20% of the respondents to this question, said they had been told to stay in their units, generally by the rescue personnel. Seven people (5%) stayed in their apartments because they were not worried. The latter were generally situated on the west side of the building, where less

smoke was reported. They often did not think the situation was serious and thought the fire would not spread to their floor. The four people who were unsure of what to do saw smoke in the corridors and were not sure whether they should evacuate immediately or stay in their units, therefore, they decided to wait for instructions or further development of the situation. The reasons motivating people to stay in their units were not significantly different between males and females ($\chi^2 = 0.09$, DF = 3, p = 0.99) or between age groups ($\chi^2 = 9.53$, DF = 6, p = 0.15).

TABLE 26: Reasons People Stayed in their Units

Reason	Frequency	Percent	Valid Percent
Too much smoke/heat	85	38.8	54.8
Told to stay	31	14.2	20.0
Safer inside	20	9.1	12.9
Unsure it was a real fire	19	8.7	12.3
No answer	64	29.2	-
Total	219	100.0	100.0

TABLE 27: Activity While Staying in Unit

Occupation	Frequency	Percent	Valid Percent
Go on balcony	51	23.3	34.9
Seal door	28	12.8	19.2
Seal door and go on balcony	19	8.7	13.0
Wait	14	6.4	9.6
Watch TV	14	6.4	9.6
Get dressed	7	3.2	4.8
Breakfast	6	2.7	4.1
Call others	4	1.8	2.7
Look out window	2	0.9	1.4
Look for water	1	0.5	0.7
No answer	73	33.3	-
Total	219	100.0	100.0

While staying in their apartment, 35% of occupants simply went onto their balconies. Some 19% sealed their door and another 13% specified that they sealed the door and then went onto their balconies. A number of people (10%) watched television, 10% waited, 5% got dressed, 4% had their breakfast and 3% made phone calls.

Following the different categories of actions described in Section 8.5, no significant difference was observed between genders ($\chi^2 = 5.17$, DF = 4, p = 0.27). Statistical analysis, however, showed a significant difference between age groups ($\chi^2 = 16.82$, DF = 8, p = 0.03). People between the ages of 18 and 64 were more likely to complete *Protective actions* while a higher percentage of people 65 years old and older

decided to *Seek information*. The difference was not significant between the 18 to 40 and 41 to 64 year age groups.

8.9 Go Onto Balcony

All units in the 2 Forest Laneway Building have access to a private balcony. Many residents (72%) chose to stay on their balconies rather than inside the apartment during the fire, in many cases because smoke had entered the apartments. Table 28 describes the occupants' use of their balconies. Of the 142 occupants who went on their balconies, 48% left the door open. Smoke on the balcony was reported by 66 people, representing 67% of people who answered this question. Smoke and heat were present on 6% of the balconies.

TABLE 28: Use of the Balcony

		Frequency	Percent	Valid Percent
1) Did you go on the balcony?	Yes	142	64.8	71.7
	No	56	25.6	28.3
	No answer	21	9.6	-
IF YES (to question 1)				
2) Did you leave the door open?	Yes	69	31.5	47.9
	No	75	34.2	52.1
	No answer	75	34.2	-
IF YES (to question 1)				
3) Was there smoke on the balcony?	Smoke	66	30.1	66.7
	Smoke and Heat	6	2.7	6.1
	No	27	12.3	27.3
	No answer	120	54.8	-

Statistical analysis showed no significant difference between genders ($\chi^2 = 0.69$, DF = 1, p = 0.41), however, there was a significant difference between age groups ($\chi^2 = 5.71$, DF = 2, p = 0.05). People 65 and over were significantly less likely to go on their balconies. Many of them explained their decision by stating that it was very cold outside on that January morning. The temperature was recorded as -8°C that morning.

8.10 Time to Leave Unit

The time at which people left their units varies greatly, as shown in Figure 5. Three respondents declared that they had left their apartments before 5:00 after perceiving fire cues. One is a 4th floor resident who left at 4:55, a second one left the 19th floor at 4:31 and both are sure of the accuracy of their reported time. Finally, a third occupant said he left his 7th floor apartment at 4:00 but is not sure of that time. All this is rather

surprising since it is unlikely that the fire started before 5:00. On the other hand, one respondent did not leave her apartment until 13:00; on the day following the fire, that is, more than 24h after the fire. She said she did not know that the entire building had been evacuated until a rescue officer found her at that time.

In general, people who successfully evacuated the building without help immediately after becoming aware of the fire, did so between 5:00 and 6:00. The majority of people who waited in their units left the building with the help of firefighters or police officers between 10:00 and 12:00. The time at which people left their units is significantly related to the time at which they realized there was a problem ($\chi^2 = 56.65$, DF = 9, p = 0.00). People who were alerted before 5:15 were significantly more likely to leave their units before 5:30 than people who were alerted at 5:15 and after.

It has not been shown that people living on lower floors were significantly more likely to leave their units earlier or later than others ($\chi^2 = 10.54$, DF = 10, p = 0.39). Statistical analysis showed, however, that there was a significant difference between age groups ($\chi^2 = 15.69$, DF = 6, p = 0.02). Occupants aged 18 to 40 had a net tendency to leave their units before 5:30, while occupants 41 years old and older were more likely to leave their units much later in the day, often between 10:00 and 12:00.

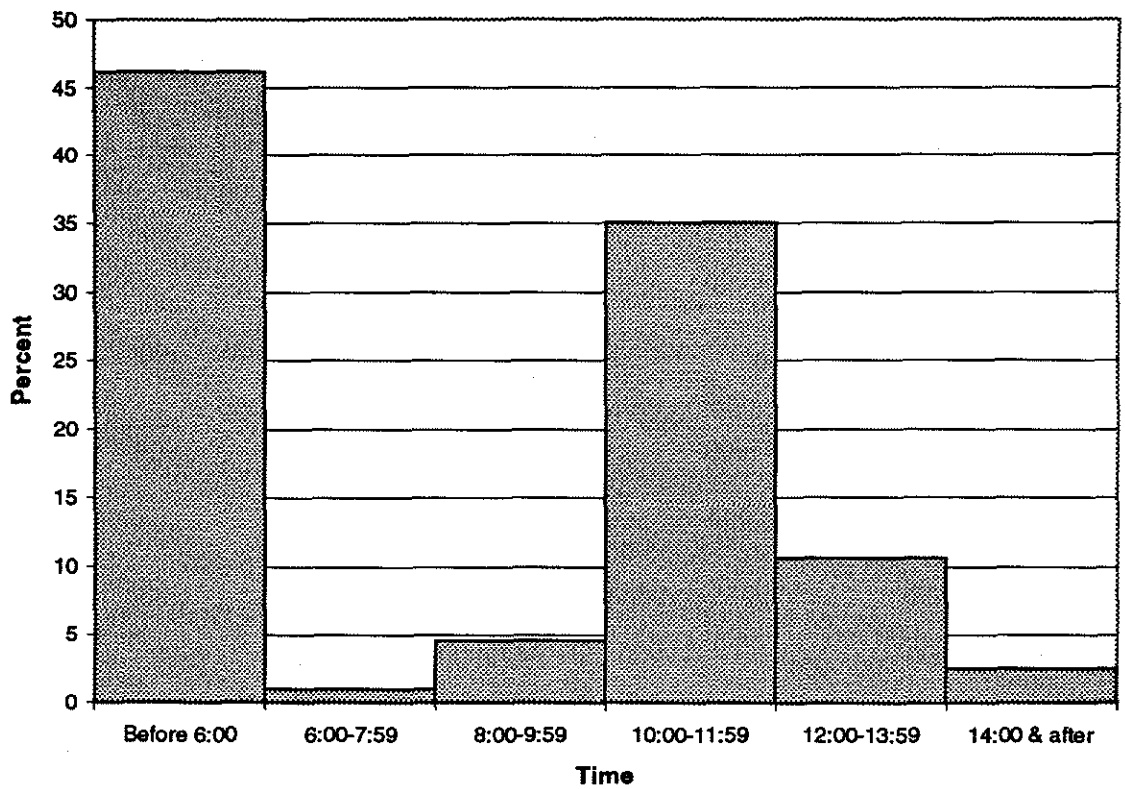


FIGURE 5: Time at Which People Left their Units

People who had been given previous information on fire safety were not significantly different from the others and that information did not seem to have an effect on their departure time ($\chi^2 = 0.76$, DF = 3, p = 0.86). Occupants who were aware of the evacuation procedure were not significantly different either and that awareness did not affect the time at which they left their units ($\chi^2 = 0.93$, DF = 3, p = 0.82).

When leaving their apartments, 95% of occupants locked their door and 97% remembered to take their key. These numbers do not take into account the 8 respondents who did not answer this question. Statistical analysis showed no significant difference between genders or between age groups, possibly because such a small number of people forgot to lock their doors and/or take their apartment keys.

9.0 EVACUATION OF THE BUILDING

The term "Evacuation of the Building" was interpreted by some of the respondents as referring to any initial attempt, successful or not, to leave the building. It was interpreted by others as the final move leading to their departure from the building. Many people attempted a first evacuation early in the morning but were forced back into an apartment by the smoke and/or the heat. Later in the day, they proceeded to evacuate the building under the guidance of rescue officials. In much of this analysis, it was necessary to establish a distinction between the occupants who evacuated on their own, generally in the early stages of the fire, and those who evacuated later with the help of rescue personnel.

9.1 Groups Who Separated

Of the 112 respondents who were not alone in their units, only two declared that they did not stay in the apartment together but did not give any reason for their separation. This implies that at least one of the occupants left the unit before the other(s).

Fourteen of the respondents (6% of all respondents but 13% of respondents to this question) reported that they had been separated from the people with whom they left their units to evacuate. One couple was separated when the firefighters and police officers proceeded to evacuate everyone left in the units, and the elevator could only contain a certain number of people. Two of the respondents had provided a refuge for other people and the refugees stopped by their own apartments before evacuating. The thick smoke in the stairs on the 12th floor separated one couple when it caused one of them to faint. They were rescued and pulled out of the staircase by another resident. One couple was separated for a minute when one of them chased after a cat which had run away. While in the stairs, one couple was separated when one of them went back to their apartment for a forgotten wallet. Finally one group was separated when one of them stayed to help a pregnant woman, while the other people in the unit went looking around the floor to the different staircases to find the best escape route for their group. Ninety-six respondents

(87% of respondents to this question) declared that they had not been separated from their group. Fifty percent of respondents did not answer the question. The location of the respondent's apartment in terms of the floor block ($\chi^2 = 3.85$, DF = 5, p = 0.57) or the quadrant ($\chi^2 = 1.61$, DF = 3, p = 0.66) was not shown to have a significant effect on the likelihood that someone would be separated from his or her group.

9.2 Try to Meet Someone

Before leaving the building, 30 or 16% of respondents said they tried to meet someone from another unit. Two-thirds of them however, declared that they had met that person in the hall, in the stairs or in the lobby. This could indicate that they did not really *intentionally try to meet* that person before leaving the building but rather that they simply *met* that person during their evacuation. Four more respondents indicated that they actually went to someone's apartment to find that person. The others did not provide an explanation. No evidence has been found to suggest that the gender ($\chi^2 = 0.10$, DF = 1, p = 0.75) or the age of the respondent affected his or her likelihood of trying to meet someone before leaving the building ($\chi^2 = 3.20$, DF = 2, p = 0.20).

9.3 Use of the Elevator

When evacuating, 83 people or 40% of respondents said they used the elevator, successfully or not and with or without the rescue personnel. Only 4 of the 219 respondents, however, reported having tried to use the elevator without specific instructions from the rescue personnel. In the first case, a small group of five people from the 5th floor successfully took the elevator to the main floor at apparently 5:20, after trying unsuccessfully, because of the smoke, to reach the east side staircase door. Shortly after 5:00, someone on the 7th floor tried to use the elevator, but since that did not work, went back to a neighbour's apartment, after trying unsuccessfully to exit via one of the staircases. At 5:30 on the 10th floor, someone tried to get on an elevator but was forced back into an apartment by the smoke in the hallway. At 8:30 on the 12th floor, a person tried to leave by the elevator, which was not in operation and the person had to use the stairs. Finally, the rescue personnel evacuated everyone left in the building, floor by floor, using the elevator to evacuate 37% of the respondents, mostly those living above the 7th floor. Six people were evacuated by the rescue personnel before 8:00, 9 were evacuated between 8:00 and 9:59 and 109 were evacuated at 10:00 or after. These numbers reflect all the people evacuated by the rescue personnel, not only those who used the elevator to reach the ground level.

In total, after a careful look at each of the questionnaires, it was determined that 162 people or 74% of the respondents used the elevator to reach ground level, all (but one group of five people) under the guidance of rescue personnel. A total of 57 or 26% used the stairs to reach ground level. These statistics reflect how people finally reached ground level to exit the building, without any consideration given to possible earlier unsuccessful

attempts to evacuate by either the stairs or the elevators. Of the 162 people who took the elevator to reach ground level, 16 were in a somewhat special situation in that they started by using the stairs, went down a number of flights of stairs before having to take refuge in an apartment on another floor and were later evacuated by elevator from that floor.

9.4 Use of the Staircases

Six people (6% of the 105 stairs users) indicated that they took the stairs to go up, while 97 or 92% of stairs users indicated that they had tried to go down. Two stairs users did not specify their direction. Of the six going up, four had to do so because of the smoke: three on the 19th floor and one on the 21st floor. A fifth one was trying to reach a family member living on an upper floor and the 6th person did not provide an explanation.

Of the 105 people or 48% of respondents who attempted to use the stairs to evacuate, 69% (or 71 people) used the stairs before 6:00. Table 29 gives a detailed account of these 71 people. All these occupants have the following conditions in common:

- They personally made the decision to evacuate.
- They made that decision within 5-10 min of becoming aware that there was a real fire.
- They started evacuating before 6:00.
- They tried using the stairs to evacuate.
- They did all of this without instructions or help from the rescue personnel.

The 'Starting Time' given for each person in Table 29 corresponds to the time at which the person mentioned leaving his or her unit. The time given in brackets in the 'Reached Ground' column corresponds to the time at which the person finally reached the ground level. People are divided into two categories: those who 'Reached Ground,' making it to the first floor in their first attempt to evacuate; and those who 'Turned Back,' which refers to the people who went back to their units or took refuge in another unit for some time. These people, very often because of the smoke density in the staircase, had to abandon their evacuation until they received instructions and were helped to evacuate by the rescue personnel later in the day.

Twenty-nine people, 41% of the 71 people listed in Table 29 as having used the stairs without assistance before 6:00, tried to use the Fire Staircase. Their average starting time was 5:14. The nine persons who started from floors under the fire floor all reached the ground level by the Fire Staircase within 5 minutes. A total of four people who started above the fire floor, also reached the ground level using the Fire Staircase. Three of them reached the first floor within five minutes. The fourth person reported reaching ground level 30 minutes after leaving the 19th floor unit without providing explanations for what he or she did during that period of time, except that this person started by going upwards.

A lady on the 20th floor deserves a special note for being the one to make it from the highest floor while taking the Fire Staircase. She explains her success and rapid response by "I had a dream on the night of the fire that I and my neighbours had to evacuate the building by the stairwell because of an earthquake, not a fire. When the alarm sounded, I was mentally prepared." Of the people starting above the 9th floor, 16 or 80% had to turn back, returning to their apartments or finding refuge in another unit.

Of the 42 people (59% of the 71 people listed in Table 29) trying to evacuate by the Other Staircase before 6:00, 12 or 29% made it to ground level. The average starting time for the people trying to use the Other Staircase was 5:16. For the 35 people starting above the 5th floor, 5 or 14% succeeded in reaching ground level and 30 people had to turn back. Only one person coming from above the 7th floor was able to reach ground level between 5:00 and 6:00: an occupant who left the 21st floor at 5:15. All the people reaching ground level completed their descent within 5 minutes, with the exception of someone on the 7th floor who required 7 minutes to reach the first floor. Unfortunately not all respondents were able to report specific times with great accuracy and therefore only a very limited number of time-based comparisons can be made with acceptable levels of accuracy.

There are a few cases, included in Table 29 under the Other Staircase column, that deserve further explanation. On the 19th floor, a woman reported leaving her unit at 4:35, after being woken up by the fire alarm at 4:31 and says that she is sure of that time. It is strongly believed, however, that the fire alarm did not sound until after 5:00. The same can also be said of a man who left his 4th floor unit in the south-east quadrant at 4:55 after hearing the alarm at 4:50 and is positive this time is accurate.

Analysis shows a statistical difference between the floor of origin of the occupants and the likelihood of using the stairs to evacuate. People living below the 6th floor or between the 17th and the 21st floor were significantly more likely to use the stairs to evacuate than the occupants of other floors ($\chi^2 = 31.20$, = 5, $p = 0.00$). Respondents living in one quadrant do not appear to have been more likely to use the stairs to evacuate than people living in any of the other quadrants ($\chi^2 = 1.40$, DF = 3, $p = 0.70$). For these comparative analyses, all of the people using the stairs at one moment or another were considered, whether they used the stairs for an early evacuation or whether rescue personnel took them down the stairs much later in the day. People usually used the staircase door closest to their apartment; ten of the respondents, however (10% of stairs users), used the staircase on the other side of the floor.

A total of 52 men (60% of male respondents) used the stairs to evacuate while 53 females (48% of female respondents) did the same. Analysis, however, did not show a significant difference between genders for use of the stairs during the fire ($\chi^2 = 2.83$, DF = 1, $p = 0.09$). Statistical analysis showed a significant difference between age groups ($\chi^2 = 13.10$, DF = 2, $p = 0.00$). Respondents between the ages of 18 and 40 were more likely than older respondents to use the stairs to evacuate. The difference is not significant

between the 41-64 year age group and the 65 year old and over ($\chi^2 = 2.72$, DF = 1, p = 0.10).

TABLE 29: Use of Stairs Before 6:00

Floor	Fire Staircase			Other Staircase		
	Starting Time	Reached Ground	Turned Back	Starting Time	Reached Ground	Turned Back
2				5:15	2 (5:15)	
3	5:10 5:16 5:30	1 (5:10) 1 (5:17) 1 (5:30)		5:10 5:15	1 (5:10) 2 (5:16, 5:20)	
4	5:05 5:08 5:15 5:20 5:30	2 (5:05, 5:10) 1 (5:10) 1 (5:18) 1 (5:22) 1 (5:35)		4:55 5:50	1 (4:57) 1 (5:55)	
6				5:10 5:20	1 (5:12) 1 (5:20)	
7				5:00 5:20	 1 (5:27)	1
9				5:25		2
10	5:10	1 (5:15)	1			
14				5:15		1
15	5:10		1			
16	5:10 5:20	1 (5:15)	 1	5:20 5:45		1 1
17	5:15		2	5:10 5:20		1 1
18	5:20		1	5:15 5:20		1 1
19	5:15	1 (5:45)		4:35 5:15 5:25	1 (?)	 2 1
20	5:00	1 (after 5:00)				
21	5:15		1	5:10 5:15 5:20	 1 (5:18)	1 2
22	5:15		1			
23	5:05		1			
24	5:00		1	5:15		1
25				5:10 5:15 5:20		3 3 2
26	5:10		2			
27	5:10		2			
28	5:15		1	5:40		1
29				5:10		3
30	5:15		1	5:20		1

9.5 Changing Staircase and Turning Back

While in the stairs, 14 people or 13% of stair users had to change staircases, because of the smoke in 12 of the 14 cases. Another 47 people or 45% of stair users, while on their way down the stairs, had to turn back. The 46 people who gave reasons for turning back are shown in Table 30. A majority of the evacuating occupants (85%) turned back because of the smoke. Forty-one of them (39% of stairs users or 87% of people who turned back) went back to their apartments. Five men and one woman did not go back to their apartments after turning back, which implies that they took refuge in another unit.

Statistical analysis showed a significant difference between occupants of different age groups ($\chi^2 = 8.52$, DF = 2, p = 0.01). People 65 years old and over were less likely to turn back. The statistical difference is not significant between the 18 to 40 and 41 to 64 year age groups or between genders ($\chi^2 = 0.80$, DF = 1, p = 0.37)

TABLE 30: Reasons for Turning Back in the Stairs

Reason	Frequency	Percent	Valid Percent
Smoke	39	17.8	84.8
Crowded / Smoke	2	0.9	4.3
Dark	2	0.9	4.3
Instructions	2	0.9	4.3
Pregnant	1	0.5	2.2
Did not turn back	64	29.2	-
No answer	109	49.8	-
Total	219	100.0	100.0

The analysis also showed a significant difference in the likelihood of turning back according to the floor the occupant left when considering all blocks of floors ($\chi^2 = 48.52$, DF = 5, p = 0.00), or when considering only blocks of floors above the 5th floor ($\chi^2 = 21.27$, DF = 3, p = 0.00). People living above the 16th floor were much more likely to have to turn back. It was not shown that the apartment quadrant had an effect on the rate of turning back ($\chi^2 = 5.04$, DF = 3, p = 0.17).

Five respondents (5% of stairs users) said they had difficulty opening the staircase door for a number of different reasons. One claims that the 1st floor door was locked. This is true from the outside but should not have caused a problem for someone trying to exit. Turning the door handle in the wrong direction, however, can give the impression that the door is locked when it actually is not. On the 29th floor, the smoke made it difficult to see the door and the handle for another one of the respondents. On the 24th floor, someone reported having difficulty opening the staircase door without providing any further information. On the 6th floor, two people reported that the west staircase door was locked, which is very unlikely since this door was not equipped with a lock. This was the Fire Staircase only one floor above the fire. It is likely that the door was blocked or

jammed, possibly because of the air movement in the staircase or due to the effect of the fire that might have twisted the door. A few hours later someone reported using that door to evacuate without any problem.

9.6 People in Corridors and Staircases

Table 31 is an indication of the density of people in the corridors and in the staircases.

TABLE 31: People Encountered in Corridors and Staircases

Number of people encountered	Corridors			Stairs		
	Frequency	Percent	Valid Percent	Frequency	Percent	Valid Percent
0	72	32.9	52.2	34	15.5	34.0
1 - 10	51	23.3	37.0	50	22.8	50.0
11 - 20	13	5.9	9.4	12	5.5	12.0
+20	2	0.9	1.4	4	1.8	4.0
No answer	81	37.0	-	119	54.3	-
Total	219	100.0	100.0	219	100.0	100.0

From these results it does not appear that the crowd in the corridors or in the staircases was a major factor during this fire. A majority of respondents to that question (84%) saw 10 or fewer occupants during their use of the stairs. In general, respondents saw 3 or 4 people in the corridor and 5 to 6 people in the stairs.

9.7 Refuge Activities

Table 32 describes the movement from their original location to their refuge location, of the 44 respondents who moved from one unit to another during the fire. Twenty-six of 44 people (60%) changed floors before having to take refuge in another unit. Of those individuals, 16 or 62% reportedly had to find refuge because of the smoke. It was not specified whether they encountered excessive smoke, forcing them to seek refuge, while in their own units or while in one of the staircases. It is likely that, in many cases, they encountered smoke in the stairs; this would explain why people travelled on average 9 floors before seeking refuge. Among the 18 people (40% of the 44 respondents) who changed units while remaining on the same floor, only three moved to another unit because of the smoke, while many others were motivated to relocate mainly to join family, friends or neighbours for help and support.

TABLE 32: Voluntary Relocation of Individuals between Units

Location of refuge	# of people in unit (total, or tenant + other)	Original location of refugee	Knew tenants of refuge unit	Length of stay (hours)	Reason for refuge
7 SE	2 + 1	7 NE			
7 NW	4	10 NW (1 person) 14 SW (1 person) 17 SE (1 person)	no no no	5:30 6:00 7:00	proximity smoke smoke
7 NW	4	7 SW (1 person)	no	3:00	
7 ??	1 + 1	7 NW	yes	1:00	confused
8 SW	approx. 10	17 SW (2 people) 24 NE (1 person) 27 SW (2 person)	no no no	6:00 6:00 8:00	smoke
9 SW	1 + 15	9 SW (1 person) 28 NE (1 person)	yes no	6:00 5:00	invited smoke
9 NE	2 + 1	24 NW	no	5:00	smoke
10 SE	3 + 4	10 SW (3 people) 27 ?? (1 person)	no		smoke
10 SE	5	15 SW (1 person)	no	6:10	smoke
10 NE	8	25 SE (2 people) 25 NE (1 person)	no yes	4:00 5:00	smoke
11 SE	3 + 1	11 NE			
11 SW	1 + 1	11 NW	no	6:00	locked out
12 NE	1 + 6	12 NE (3 people) 12 NW (1 person) 16 SW (2 people)	no	5:00	fainted
12 SW	1 + 1	12 NW			
15 SE	2 + 1	22 SE			
16 SE	2 + 1	16 SE	no	0:30	confused
18 SW	2 + 6	21 SE (2 people)	no	2:00-2:30	smoke
18 NW	1 + 1	18 NE	no	5:00	smoke
20 SW	1 + 2	29 SW	yes	0:10	family
22 NE	4 + 1	22 ??			
23 SE	4	28 NE (1 person)	no	2:00	needed air
23 SE	1 + 2	23 NW	yes	6:00	friends
23 NE	3	17 NE (1 person) 21 NE (1 person)	no	1:00 3:00	smoke
24 SE	2 + 2	24 SE	yes	5:00	smoke
24 NW	2 + 2	24 NW 25 SW	yes no	6:00 2:00	invited smoke
28 SW	1 + 5	21 NE 21 NW			
29 SE	2 + 3	25 NE (2 people) 30 ?? (1 person)	no	5:00-6:00	smoke
29 NE	2 + 2	19 NE	no	2:30	smoke
29 NW	1 + 1	29 NW			
30 SW	1 + 2	30 SW 19 SE			

The majority of people (17 out of 29 or 59%) who gave information on their relationship to the tenant of the rescue unit did not know the tenant who offered them refuge and had to do so because of the smoke. Another four (14%) had to ask strangers for refuge for reasons other than smoke, such as injuries and one did not give a reason for seeking refuge. Of the remaining seven (25%) who moved to be with people they knew, only two did so because of the smoke; the rest were looking for comfort and support from friends and family.

Most people stayed in the unit in which they took refuge until rescue personnel instructed them to safely exit the building. Some of them were permitted to go back to their units to pick up necessities before leaving the building. On average, they spent over 4 hours in the refuge apartment before being allowed to exit the building.

9.8 Occupants with Limitations

The respondents' profiles included in this report provide information on different limitations that the respondents had which could possibly have impeded their evacuation. In some cases, the evacuation scenario of a respondent was affected by that limitation; while in other cases, limitations did not result in any problem during evacuation.

Ten people who had asthma or heart problems remained in their units until they were evacuated using the elevator by rescue personnel between 10:00 and 12:00, depending on the floor. Four pregnant women also waited and were taken down by elevator; one of them, however, indicated that she had tried to use the stairs earlier but had to abandon this attempt because of her condition.

Five people reported having hearing problems, although none of them is completely deaf. Three of them were awoken by the presence of smoke, one by his wife, and one by a phone call from a sister. None of them were impeded in their evacuation by the fact that they were hearing impaired. One man on the 5th floor, south-west quadrant, said he was a very sound sleeper but the smoke woke him up at 5:15. Once awake, he had no difficulty evacuating the building through the staircase at around 7:00, after waiting on his balcony for the smoke to dissipate.

Some other people had specific mobility problems. One lady on the 2nd floor, who used a walker, evacuated using the stairs with the help of rescue personnel around 14:00. A person on the 3rd floor, who was unsteady walking, was able to evacuate alone at 5:10 using the stairs. A woman, who has multiple sclerosis, on the 6th floor also used the stairs at 11:30, with help from friends and rescuers. On the 6th floor, a man, recovering from a lung operation, evacuated using the stairs with his adult daughter at 5:10. A person, who uses a cane, was helped down the stairs by firefighters later in the morning. Finally five people, located on the 17th floor and above, were taken down by police officers using the elevator between 10:00 and 13:00: one with weak legs, one in a wheel chair, one with a broken foot, one using a cane and one using a walker.

9.9 Exit Used

Table 33 lists the doors used by the respondents to exit the building. The majority of respondents to this question (63%) reported using the lobby door and another 29% used the exit leading to the 4 Forest Laneway building. An important number of respondents (48 or 22%) did not specify which exit door they used.

TABLE 33: Exit Used During Evacuation

Exit Location	Frequency	Percent	Valid Percent
Lobby	107	48.9	62.6
To 4 Forest Laneway	49	22.4	28.7
Parking garage	11	5.0	6.4
Back exit	4	1.8	2.3
No answer	48	21.9	-
Total	219	100.0	100.0

9.10 Time to Reach Safety

Figure 6 is a representation of the time at which people finally reached ground level, considered as the area of safety in this study. The majority of them (56%) exited the building between 10:00 and 12:00. One person was not evacuated until 18:00 and another lady from the second floor stayed in her apartment until 13:00 the next day.

Figure 7 shows the cumulative percent of respondents for the time at which they became aware of the situation, the time at which they left their units and the time at which they reached ground level. Not all respondents answered the three questions. Figure 7 represents strictly the cumulative percent of people answering each question. It should be noted that their time approximations are not always accurate.

As shown in Figure 7, between 6:00 and 10:00 approximately half of the respondents had left their units, but do not seem to have left the building right away. It is unlikely that they just lingered in the corridors. There are two scenarios that can explain what most of them did during that time interval. Some of them indicated that they left their units between 5:00 and 6:00 and that time is represented in Figure 7; however, they had to go back to their units as they were unable to exit at that time, generally because of the smoke in the staircases. They evacuated later in the morning, usually between 10:00 and 12:00, with the help of rescue personnel. The other scenario applies to people who left their units but took refuge in another unit, as discussed previously. They were also later evacuated by the officials.

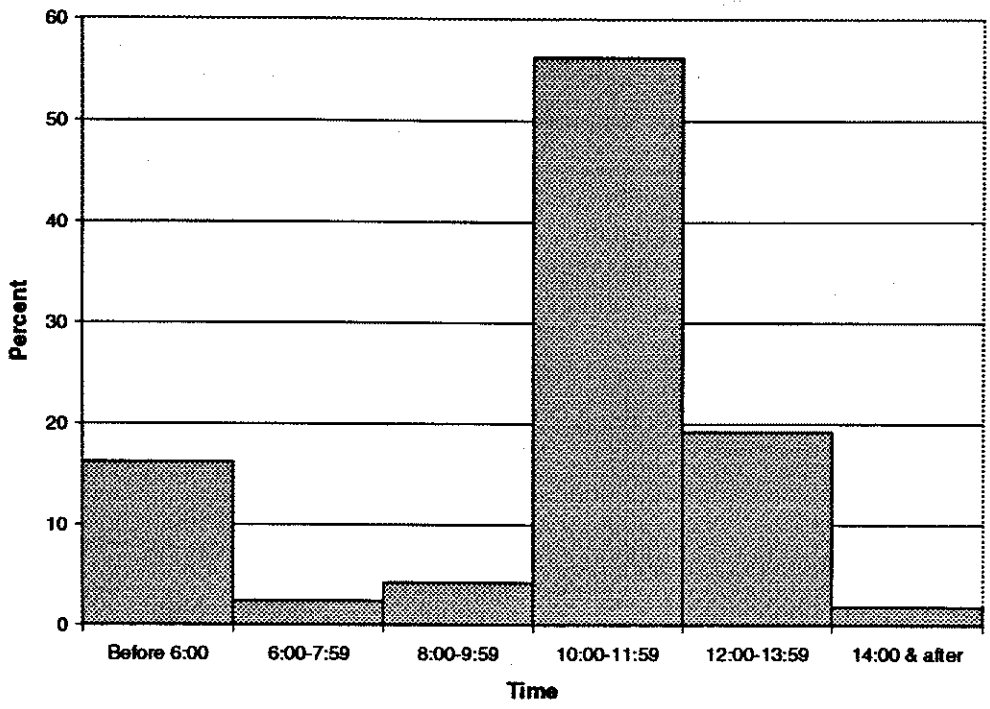


FIGURE 6: Time at Which Occupants Reached Ground Level

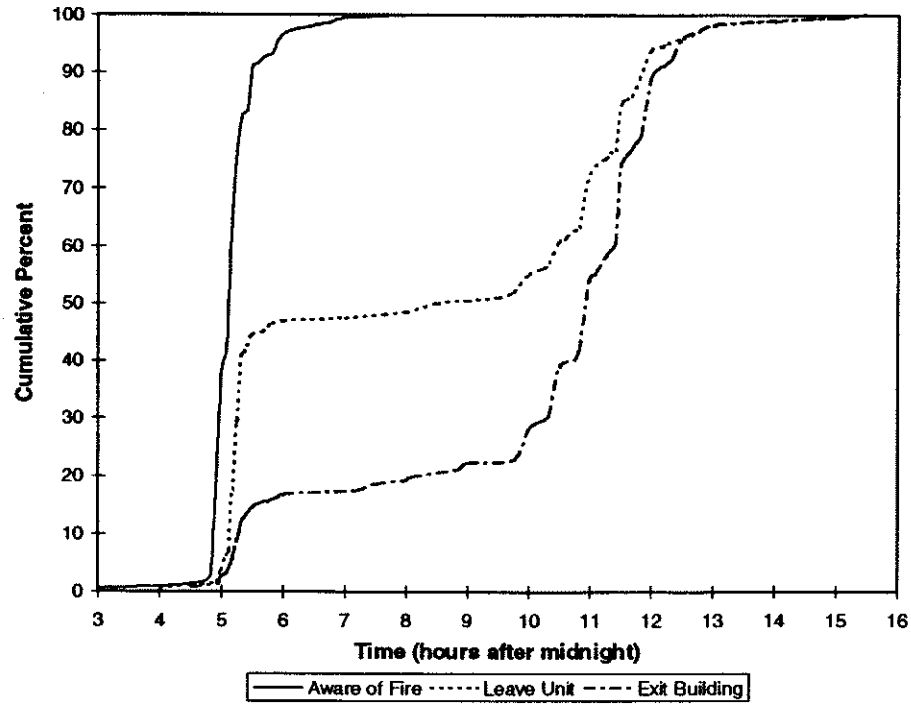


FIGURE 7: Summary Statistics of Evacuation Over Time

9.11 Re-entering the Building

After evacuating, 17 people or 8% of the respondents, consisting of 6 men and 11 women, re-entered the building for a number of reasons. Most of them did that much later in the afternoon, with the knowledge and permission of the police officers or firefighters. They were allowed to get hand bags (7 people), keys (1), medication (4), glasses (1) or pets (1). Three of them went back inside because of the cold. The gender, the age of the respondents or the location of their apartment was not shown to have an effect on whether or not the person would re-enter the building. Statistical analysis did not show that the time at which a person left the apartment had an effect on the likelihood of that person having to re-enter the building ($\chi^2 = 2.63$, DF = 3, p = 0.45). None of the people re-entering the building seem to have done so when there was still a risk and when the situation was not under control.

10.0 ALARM AND PUBLIC ANNOUNCEMENTS

The building fire alarm was heard by 164 of the 219 respondents or 75%; 52 or 24% of them did not hear it and three or 1% did not answer the question. All people who heard the alarm were in their apartments at the time. Statistical analysis showed a significant difference between age groups ($\chi^2 = 31.61$, DF = 2, p = 0.00). People 65 years old and older were significantly less likely to hear the alarm than younger people. This difference is not significant when comparing respondents 18 to 40 and 41 to 64 years old ($\chi^2 = 1.29$, DF = 1, p = 0.26). Statistical analysis showed no significant difference between genders ($\chi^2 = 0.20$, DF = 1, p = 0.65). When considering blocks of floors for statistical analysis, a significant difference was found between floors, showing that people on the 6th to the 10th floor were more likely to have heard the alarm ($\chi^2 = 15.86$, DF = 5, p = 0.01). Table 34 shows the location of the people who heard the alarm.

TABLE 34: Location of Individuals and Perception of the Building Alarm

Floor	Heard the Alarm	Did Not Hear the Alarm
1 to 4	18	8
5	2	3
6 to 10	30	2
11 to 16	20	14
17 to 21	31	9
22 to 30	63	16
Total	164	52

No statistical evidence was found that would suggest that the quadrant in which people were located could affect their ability to hear the alarm ($\chi^2 = 1.56$, DF = 3, p = 0.67). Figure 8 shows the proportion of occupants who did not hear the alarm for each unit. Analysis showed a significant difference between units located in the corners of the

building and other units ($\chi^2 = 17.73$, DF = 1, p = 0.00). Occupants of units 03, 04, 09 and 12 were significantly less likely to hear the building alarm; their apartments were situated in the corners of the building.

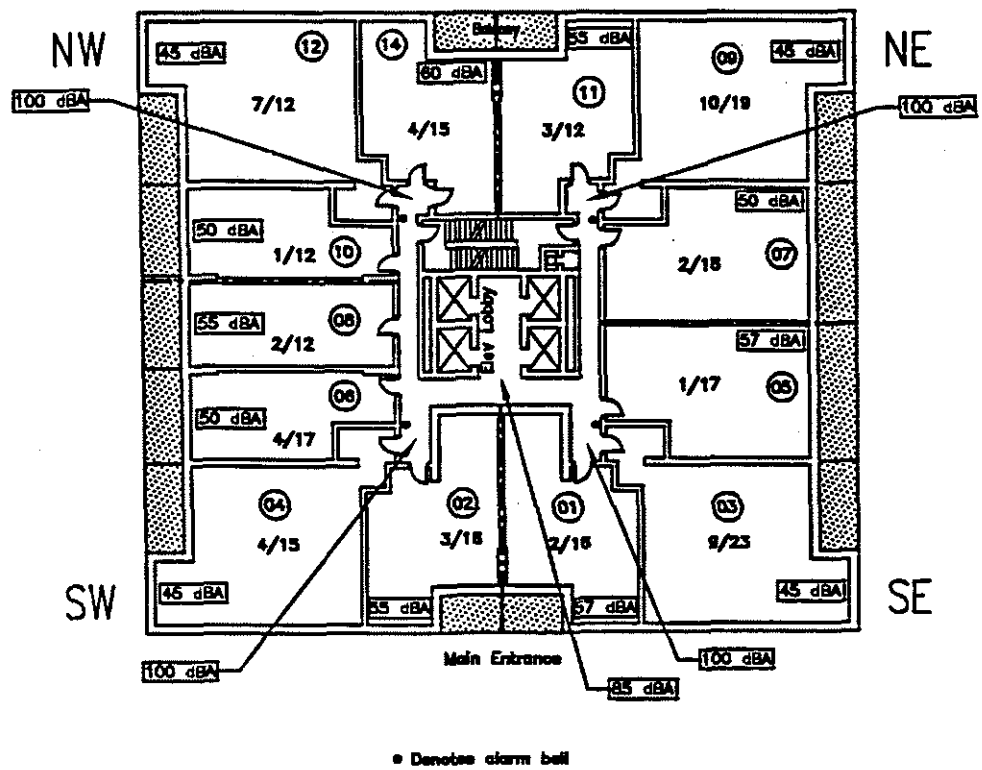


FIGURE 8: Proportion of Occupants Who Did Not Hear the Building Alarm

In the week following the fire, before occupants returned to the building, the OFM did a series of measurements on the sound level of the building fire alarm. Figure 8 shows the sound levels of the alarm in different locations on the 17th floor. In the corridors and elevator lobby, the sound level reached more than 85 dBA. In the bedrooms of some units, however, even with the bedroom door open, the sound level was less than 50 dBA.

The questionnaire asked people to evaluate the volume of the building fire alarm in their apartments, in the corridor and in the staircases. Table 35 shows the results. For the statistical analysis, the *Too Loud* option was not considered since too few people chose that option. Statistical analysis showed no significant difference between the respondents' opinion of the volume of the alarm for different age groups (in apartment: $\chi^2 = 3.89$, DF = 2, p = 0.14; in corridor: $\chi^2 = 2.84$, DF = 2, p = 0.24; in staircase: $\chi^2 = 1.71$, DF = 2, p = 0.42) or between genders (in apartment: $\chi^2 = 2.52$, DF = 2, p = 0.28; in corridor: $\chi^2 = 3.23$, DF = 2, p = 0.20; in staircase: $\chi^2 = 1.31$, DF = 2, p = 0.52). Only five people, four men and one woman between the ages of 26 and 49, suggested that the alarm

was too loud in their apartments. All of them lived on the east side of the building: units 03 (3 of them), 07 and 11.

TABLE 35: Sound of the Building Alarm

Volume	In Apartment		In Corridor		In Staircase	
	Frequency	Valid %	Frequency	Valid %	Frequency	Valid %
Not loud enough	77	43	34	23	30	34
Loud enough	97	54	98	65	55	62
Too loud	5	3	18	12	4	4
No answer	40	-	69	-	130	-
Total	219	100	219	100	219	100

Statistical analysis showed that there was a significant difference between different floor blocks ($\chi^2 = 17.06$, DF = 5, p = 0.00). People above the 16th floor were more likely to think that the alarm was not loud enough in their apartments. After statistical analysis, no significant difference of opinion on the volume of the alarm in the corridor was found between people from different floors ($\chi^2 = 8.95$, DF = 5, p = 0.11). Statistical analysis did not show that the location of the apartment in terms of quadrants had an effect on the respondent's opinion of the volume of the alarm, either in the apartment ($\chi^2 = 7.59$, DF = 6, p = 0.27) or in the corridor ($\chi^2 = 9.13$, DF = 6, p = 0.17).

10.1 Alarm Stopped

Only 76 people, 41% of respondents to this question, heard the alarm stop and at that time 63 of them, or 83%, were in their apartments. Four others (5%) were in the staircase, two (3%) were in the corridor, one was in the lobby, one was in a neighbour's unit and the rest do not know when it stopped or did not answer the question. None of the respondents on their balconies heard the alarm stop.

No statistical evidence was found that would suggest a significant difference between people of different floors ($\chi^2 = 9.22$, DF = 5, p = 0.10), between genders ($\chi^2 = 0.12$, DF = 1, p = 0.73) or between age groups ($\chi^2 = 2.74$, DF = 2, p = 0.25). Forty-four percent of people 18 to 40 years old heard the alarm stop, however, compared to only 27% of residents 65 years old and over.

Respondents do not agree on the time at which the alarm stopped. Table 36 illustrates this divergence. The three people who said they thought the alarm stopped after 8:00 also said that they were not sure of the time. Overall, only 32% of people who gave an approximate time at which the alarm stopped were sure of the accuracy of that time.

TABLE 36: Time at Which the Building Alarm Stopped on Each Floor

Floor	Time						Total
	5:00-5:29	5:30-5:59	6:00-6:59	7:00-7:59	8:00+	Not Sure	
2						3	3
3						1	1
4	1						1
5						3	3
6			1			3	4
7			1			1	2
8		2				2	4
9			1			2	3
10	1	3					4
11	1				1	2	4
12					1	1	2
14			1			2	3
15							0
16	1						1
17		1				1	2
18					1		1
19			1			1	2
20			1		1	1	3
21		3				1	4
22	1	3					4
23							0
24		2				2	4
25	2		1	1		1	5
26							0
27				1		1	2
28		1			1		2
29	1			1	2		4
30				1		2	3
Total	8	15	7	4	7	30	71
Valid %	20	37	17	10	17	-	100

In addition to giving the time at which they heard the building alarm stop, the questionnaire asked people how sure they were of that time's accuracy. Figure 9 shows by each bar the total number of people who believe the alarm stopped during that time period, but also indicates the degree of precision of the time given. The height of the bar represents the total number of respondents who gave that time and each sub-section is illustrated in full (e.g., between 5:00 and 5:29, 8 people heard the alarm stop: 3 are sure of that time, 3 remember vaguely and 2 are not sure).

Twelve people said they were sure of the time at which the alarm stopped, but the times they gave varied between 5:00 and 8:00. It is possible that the alarm did not stop at the same time in different sections of the building. In summary, for the respondents who are sure of their reported time, one person heard the alarm stop at 5:00 on the 11th floor; one heard it stop at 5:20 on the 16th floor; according to one respondent it stopped at 5:25 on the 29th floor; according to three people from the 17th, 21st and 24th floor it stopped at 5:30; two people, from the 21st and 22nd floor heard it stop at 5:40; one reported 5:45 on the 21st floor; two said it was at 6:00 on the 14th and the 19th; and finally a resident of the 20th floor said the alarm stopped at 6:30 and an 11th floor resident believes it stopped at 8:00.

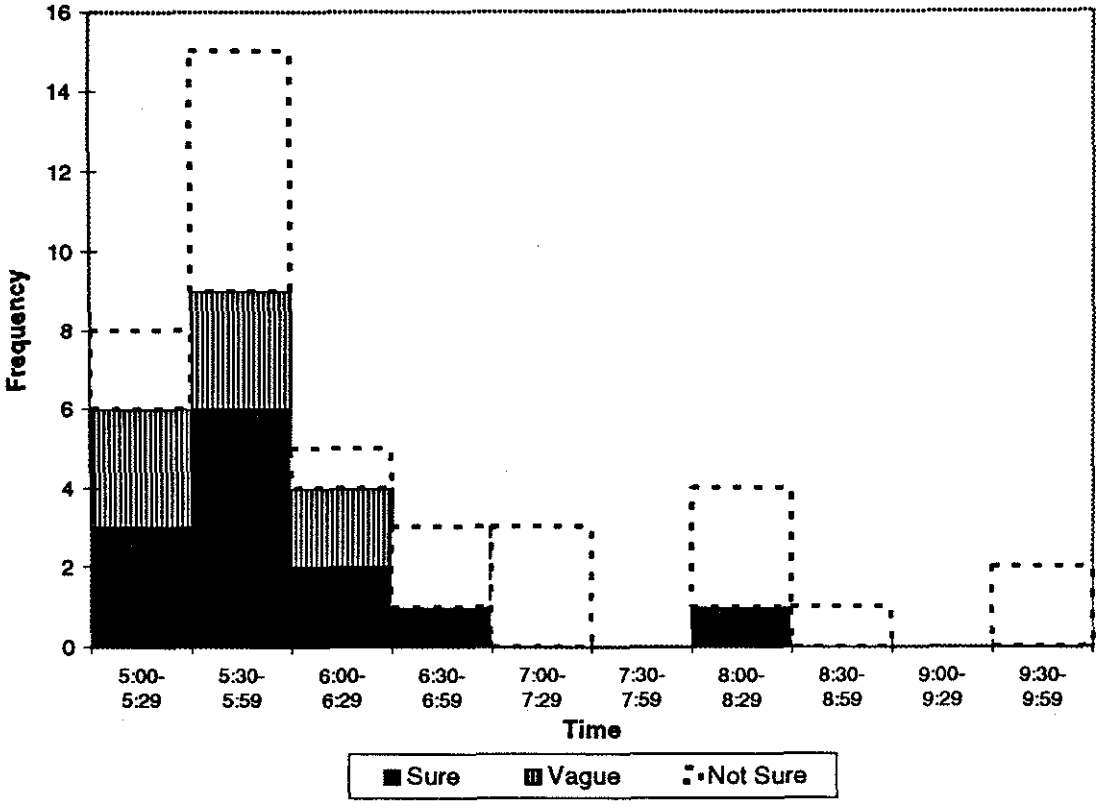


FIGURE 9: Time at Which the Building Alarm Stopped

10.2 Smoke Alarms

A battery operated smoke alarm was present in the apartments of 201 of the respondents or 93% of people who answered this question. Only 28 or 15% of the battery operated smoke alarms were activated. Four of these 28 respondents (14%) decided to remove the battery from their alarm. Table 37 shows the state of the battery operated smoke alarms for residents in each quadrant. Provided the smoke alarms were operational, this is a good indicator of the smoke density in these areas. It appears that

more smoke detectors were set off on the upper floors: 20% for the 22nd to the 30th floor compared to 12% for the 2nd to the 21st floor. Statistical analysis showed a significant difference between quadrants ($\chi^2 = 9.29$, DF = 3, p = 0.03). A greater number of smoke alarms were activated in the north-east quadrant which corresponds to the fire area quadrant. Analysis showed no significant difference between age groups for the likelihood that their battery operated smoke alarm would be activated ($\chi^2 = 0.27$, DF = 2, p = 0.87).

TABLE 37: Percentage of Activated Smoke Alarms

Floor	Apartment Quadrant				Total
	NE	NW	SE	SW	
1 to 4	1				1
5				2	2
6 to 10			1	1	2
11 to 16	2	1	2		5
17 to 21	1		3		4
22 to 30	7	1	2	4	14
Total	11	2	8	7	28

10.3 P.A. Messages

Only 10 of the respondents or 5% heard messages from the P.A. system. Five of them (50%) understood they had to stay in their units, one of them understood that he or she should put a towel under the door but the four others (40%) said that the messages were unclear and that they could not understand them. At the time of hearing the P.A. messages, seven of the ten people were in their apartments, one was on the balcony, one was in the hall and one was outside. Since so few people heard the messages, however, it is not possible to obtain a valid comparison between groups. Table 38 provides details on the situation of each person who heard the P.A. system messages. Statistical analysis did not show that people who had heard the building fire alarm were more likely to hear the P.A. system messages ($\chi^2 = 3.03$, DF = 1, p = 0.08)

Twenty-seven of the respondents (12%) heard the firefighters' bullhorn messages, however, the messages were unclear for 21 of them (78%). Four people (15%) understood that they should wait to be rescued, one understood that he or she was to use the staircase and one heard 'Wake up! Fire in the building!' Seven people (26%) were in their units when they heard the message and 19 (70%) were on their balconies. The other person did not indicate where he or she was. Statistical analysis found no significant difference between floors or quadrants (floor blocks: $\chi^2 = 3.94$, DF = 5, p = 0.56; quadrants: $\chi^2 = 1.97$, DF = 3, p = 0.58). This indicates that the location of the apartment in terms of floor level and quadrant had no significant effect on whether or not the resident could hear the bullhorn messages. Surprisingly enough, 44% of people who heard the message were situated between the 22nd and 30th floors and 24% were between the 6th

and 10th floors. This is quite far from the source considering messages were coming from firefighters at ground level. Furthermore, no significant difference was found between genders ($\chi^2 = 1.04$, DF = 1, p = 0.31) or age groups ($\chi^2 = 2.22$, DF = 2, p = 0.33).

TABLE 38: Situation of Persons Who Heard P.A. System Messages

Floor of Unit	Quadrant	Location in Unit at Time of Message	Content of Message
2	NE	Apartment	No answer
6	SW	Apartment	Stay in
6	SW	Apartment	Stay in
7	NW	No answer	Message unclear
7	NW	Apartment	Put towel
11	NW	Apartment	Message unclear
15	NW	Apartment	Say in
17	SE	No answer	No answer
24	NW	Hall	Stay in
25	SW	Balcony	Stay in

11.0 SMOKE CONDITION

A series of questions was asked about the smoke conditions in the occupant's unit as well as while the person was evacuating the building. It should be noted that all occupants of the 5th floor reported smoke in the staircase, in the corridor and in their unit.

11.1 Smoke and Heat in Units

Smoke entered the units of 157 of the occupants or 76% of respondents to this question. In 102 of the cases (65% of units with smoke), it entered around the door; 21 persons or 13% observed smoke entering through the ventilation system openings and one person said it was coming in through the window. The remaining 21% of the people were not sure how it entered their units. Figure 10 shows that, in the apartments where smoke was present, it entered before 5:20 in more than 60% of cases. The cumulative percent represents the number of people who saw smoke in their units before a given time, as a fraction of the people who saw smoke in their units over the complete duration of the fire.

Figure 11 is a good indication of the smoke condition on each floor. For each floor it illustrates the percentage of people who declared that smoke entered their apartments. It is clear from Figure 11 that there was smoke present in a larger percentage of the apartments on the higher floors than on the lower floors, with the exception of the 5th floor (where the fire originated) and the 6th floor (situated directly above). Statistical analysis also showed a significant difference among floors. The higher the respondents were, the more likely these people were to see smoke in their apartments ($\chi^2 = 61.24$, DF = 5, p = 0.00).

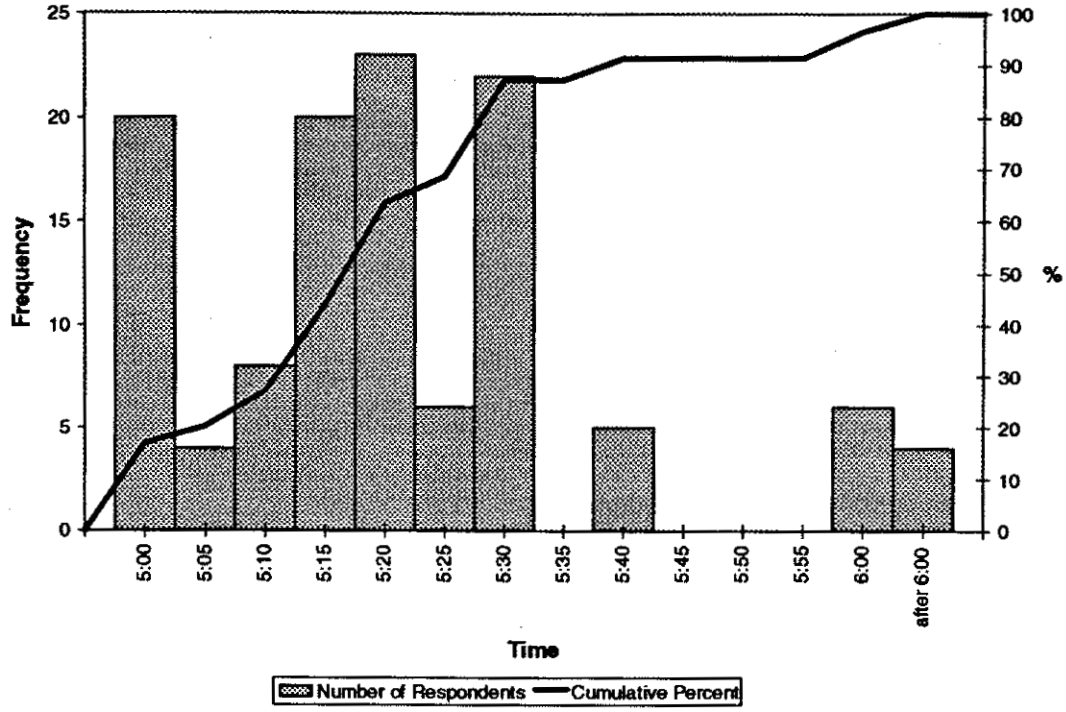


FIGURE 10: Presence of Smoke in Apartments Over Time

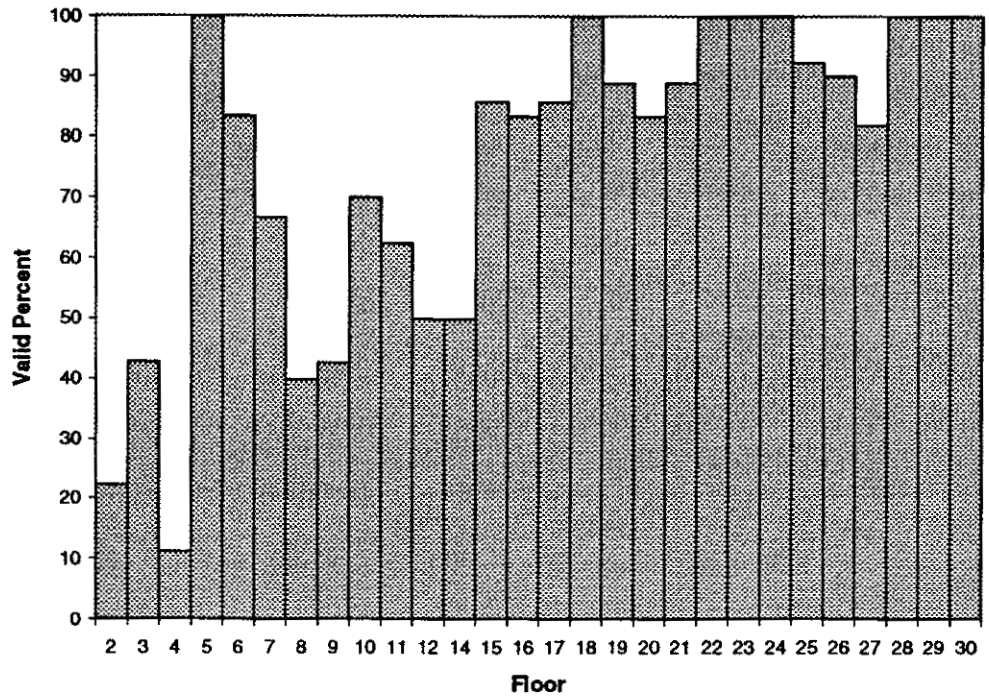


FIGURE 11: Presence of Smoke in Apartments on Each Floor

Statistical analysis showed a significant difference in the appearance of smoke in the units from one quadrant to the other ($\chi^2 = 8.86$, DF = 3, p = 0.03). People in the north-east quadrant (quadrant where the fire occurred) were more likely to see smoke in their units. People in the north-west and south-east quadrants were also more likely to see smoke in their units than people in the south-west quadrant. Statistical analysis did not show that people living on lower floors or closer to where the fire occurred were significantly more likely to see smoke at an earlier time in their apartments than people living on upper floors ($\chi^2 = 8.16$, DF = 9, p = 0.52). Occupants took the measures described in Table 39 to limit the infiltration of smoke.

TABLE 39: Actions Taken to Limit the Entry of Smoke in Unit

Action	Frequency	Percent	Valid Percent
Put wet towel	70	32.0	54.7
Block passage	14	6.4	10.9
Go on balcony	10	4.6	7.8
Leave apartment	7	3.2	5.5
Open window	5	2.3	3.9
Close door	2	0.9	1.6
Nothing	20	9.1	15.6
No smoke entered	51	23.3	-
No answer	40	18.3	-
Total	219	100.0	100.0

Only eight respondents said that they encountered heat in their units. Three of them were situated on the 5th floor (west side), two were on the 6th floor (east side) and one was on the 7th floor (east side). Two more reported heat on the 28th floor.

11.2 Smoke in Corridors

In the corridor, 165 people (81% of respondents to this question) observed smoke. The colour of the smoke was reported by 149 respondent, 57% of them observed grey smoke, according to 26% it was black and 17% saw a mixture of grey and black. Figure 12 shows the frequency of people observing smoke in the corridor over time. More than 50% of the people who saw smoke in the corridor did so before 5:20 and the latest smoke sighting reported was at 7:15. Respondents did not specify if smoke was still present at the time of evacuation of those who did not leave the building until later in the morning with the rescue personnel.

Of the 126 people (58% of respondents) who reported the time at which they saw smoke in the corridor, 113 or 90% said they saw it between 5:00 and 5:44 and 13 or 10% said they saw it at 5:45 or later. Statistical analysis showed a significant difference

between blocks of floors regarding the time at which respondents saw smoke in the corridor ($\chi^2 = 18.33$, DF = 6, p = 0.01). People living between the 6th and the 10th floors inclusive were more likely to see smoke between 5:00 and 5:14 in the corridor, which is earlier than people living on upper floors. People living between the 22nd and the 30th floors were more likely to see the smoke between 5:15 and 5:30 and people on the 11th to the 16th floors were more likely to see smoke between 5:30 and 5:44. People on the 17th to the 21st floor were almost equally distributed among the three time intervals, although 85% of them saw smoke before 5:30.

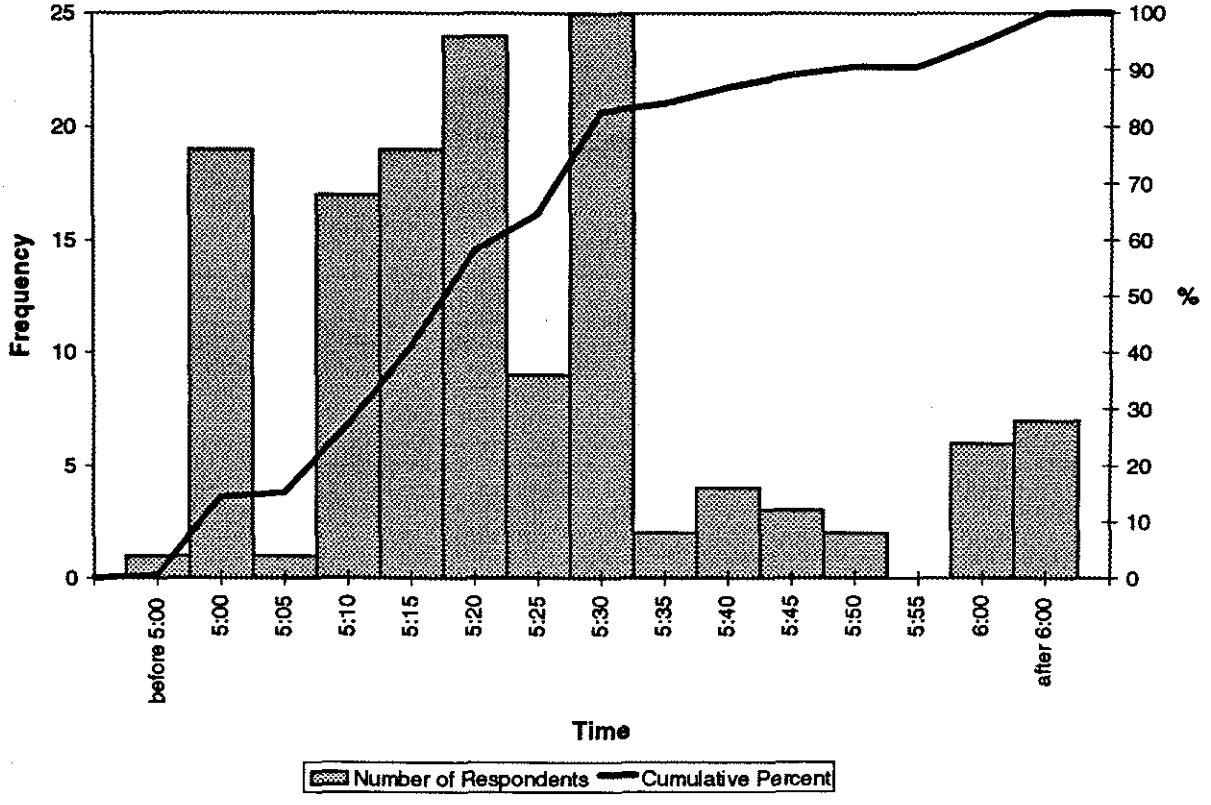


FIGURE 12: Presence of Smoke in Corridors Over Time

Statistical analysis showed a significant difference between floor blocks. The higher the respondent was, the more likely this person was to see smoke in the corridor ($\chi^2 = 55.41$, DF = 5, p = 0.00) with the exception of the 5th floor, where all respondents saw smoke. Figure 13 shows the frequency of respondents noticing smoke in the corridors as a function of the floor on which they were located. The floors, listed in Figure 13, refer to the floor on which each respondent saw the smoke, as opposed to the floor on which the respondent lives. In most cases, these are the same but, in some instances, respondents found refuge on another floor and saw smoke there. Statistical analysis showed no significant difference between the quadrants for the likelihood of seeing smoke in the corridors ($\chi^2 = 2.24$, DF = 3, p = 0.52). Of the 131 people who saw

smoke in the corridors and gave an approximation of how many feet they could see in the smoke, 69% reported being able to see less than 10 feet.

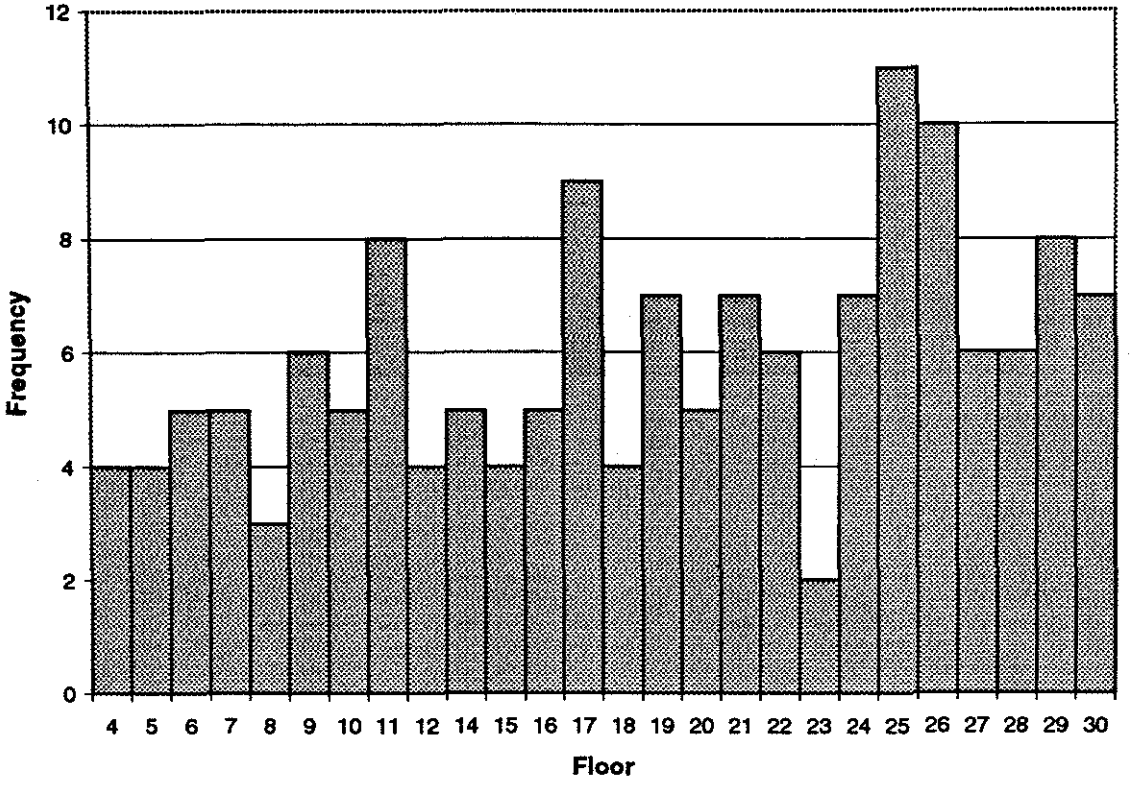


FIGURE 13: Presence of Smoke in Corridors of Each Floor

11.3 Smoke and Heat in Staircases

In the staircases, 99 people, or 75% of 132 respondents who answered this question, said that they saw smoke. The smoke was grey for 37% of them, black for 39%, or a combination of grey and black for 24%. As shown in Figure 14, it was between 5:10 and 5:30 that smoke was encountered by 80% of the 87 people who reported seeing smoke in the staircases and gave the time at which they observed it. This period corresponds to the time at which most people trying to evacuate left their units looking for a way out of the building. Because of the presence of smoke in the staircases, many of them were forced back into their apartments or into someone else's unit. Of the 82 respondents who provided information on how far they could see through the smoke, 74% reported being able to see less than 10 feet.

Statistical analysis showed a significant difference between floor blocks. Respondents living above the 16th floor were more likely to see smoke in the staircases ($\chi^2 = 55.27$, DF = 5, p = 0.00). Only 3 out of 64, or 5% of respondents, using the stairs

on the 17th floor and above did not see any smoke, compared to 25% for the 6th to the 16th floor and 83% for the 4th floor and below. It should be noted that the statistical analysis uses the floor on which the respondent lives for comparison, rather than the specific floor on which smoke was seen.

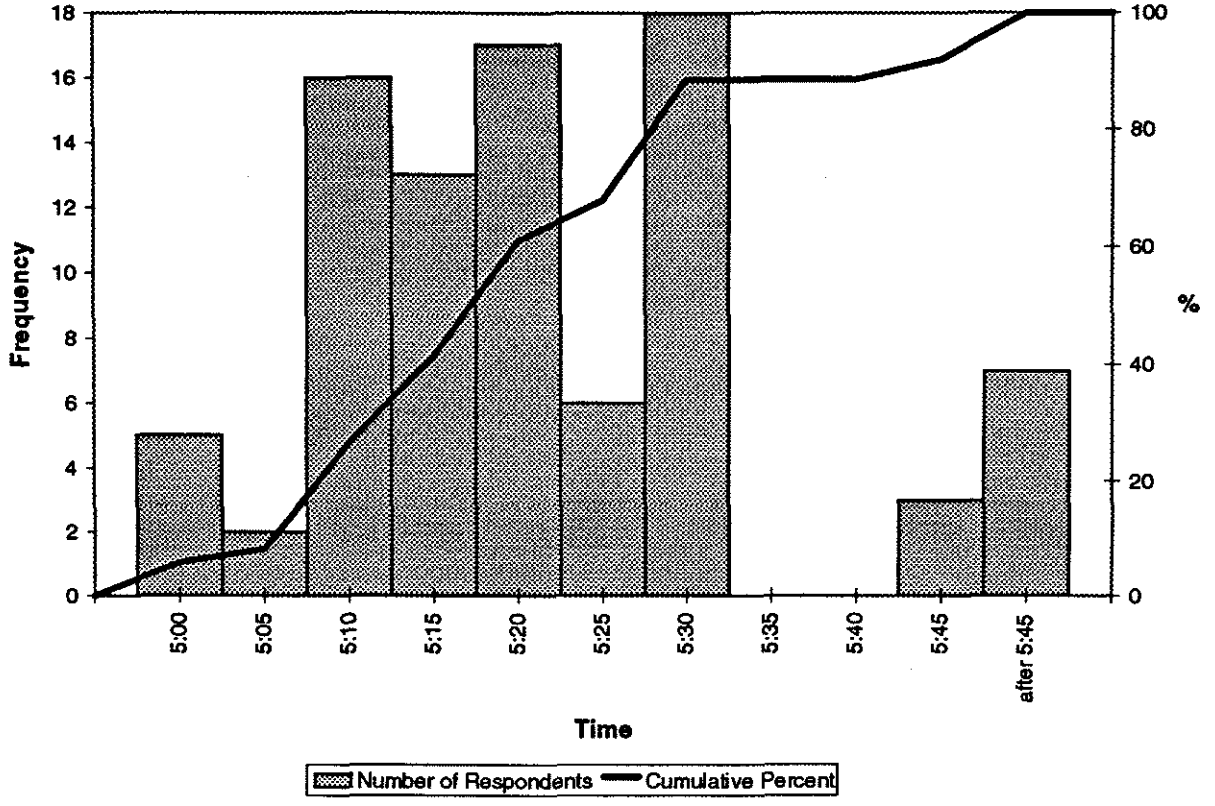


FIGURE 14: Presence of Smoke in Staircases

All the 30 people living on the 5th floor or above who tried to use the Fire Staircase encountered smoke in that staircase. Of the other 46 people (61%) who used the Other Staircase, 42 or 91% saw smoke. Four people did not see any smoke in the stairs. One was coming from the 18th floor at 5:30 and another left the 28th floor at 5:15. Both of them smelled smoke on their way down, at the 11th and 22nd floor levels, respectively, and decided to return to their units. A 7th floor resident left his unit 5 minutes after hearing the alarm and made his way to the ground level without encountering any smoke. Finally an occupant from the 6th floor went down the stairs at 5:20, could smell smoke, but was able to reach ground level and exit the building with no problem. All four of them were using the Other Staircase. Table 40 shows the number of people in each staircase who saw smoke while using the stairs, starting on the 5th floor and above. Expected values are shown in brackets. The analysis did not show that the staircases were significantly different ($\chi^2 = 2.82$, DF = 1, $p = 0.09$) in terms of the likelihood of people seeing smoke. The number of people who did not see smoke in the staircase, however, is insufficient to produce a valid statistical analysis.

TABLE 40: Frequency of People Seeing Smoke in the Stairs Above 4th Floor

Staircase	Saw Smoke		Did Not See Smoke	
Fire Staircase	30	*(28.4)*	0	*(1.6)*
Other Staircase	42	*(43.6)*	4	*(2.4)*
Total	72	-	4	-

During the evacuation, 12 people encountered heat. It forced three of them to turn back. One of them was a 7th floor resident who tried using the Fire Staircase around 5:30 but had to turn back because of the smoke and heat. The other two were on the 19th floor. One tried to use the Fire Staircase also around 5:30 but after going down a few flights of stairs had to turn back up because of the smoke and heat. The other one reported that the door leading to the Fire Staircase was too hot and the group had to return to their unit.

11.4 Lights and Exit Signs

The state of the lights in the stairs and corridors is described in Table 41. Respondents have diverging ideas on where the lights were on or off. Analysis shows a significant difference between floors. In general, people living between the 5th and the 16th floor were more likely to notice that the lights were off in the corridors while people on the 17th to the 30th floors were more likely to say that the lights were on ($\chi^2 = 52.67$, DF = 5, p = 0.00). A few people on the east and west sides commented on the absence of light in the corridors between the 15th and the 19th floors. Someone mentioned the absence of lights on the 17th floor. Statistical analysis showed a significant difference between quadrants. People living on the west side of the building were more likely to notice the absence of lights ($\chi^2 = 13.63$, DF = 3, p = 0.00). The difference was principally between the south-west and the south-east quadrants of the building.

TABLE 41: State of the Lights in Stairs and Corridors

Location of the Lights	State of the Lights	Frequency	Percent	Valid Percent
CORRIDORS	On	146	66.7	81.5
	Off	33	15.1	18.5
	No answer	40	18.3	-
STAIRS	On	77	35.2	65.3
	Off	41	18.7	34.7
	No answer	101	46.1	-

Some of residents agree on a few things concerning the state of lights in the staircases. After using the stairs, 2 people reported that the lights were off between the

16th and the 19th floors and 2 other people reported the absence of lights, one above the 15th floor and one specifically on the 16th floor. Analysis showed a significant difference between floors. People living between the 5th and the 16th floors reported, in a much greater proportion than on other floors, that the lights were off in the staircase (χ^2 = 35.56, DF = 5, p = 0.00). All occupants of the 5th floor reported an absence of lights.

Thirty-nine or 23% of the 168 respondents to this question noticed the exit signs located in the staircases and corridors. Analysis showed no difference between genders (χ^2 = 0.37, DF = 1, p = 0.54) or between age groups for the likelihood of noticing the exit signs (χ^2 = 0.19, DF = 2, p = 0.91).

12.0 RESCUE EFFORT

Both firefighters and police officers were present at the scene of the fire. Firefighters arrived on the scene at 5:14 to discover Apartment 509 engulfed in fire.

Respondents were not always specific when referring to rescue personnel. The statistics comparing the actions of firefighters and police officers could be somewhat affected by this lack of precision.

12.1 Help from Rescue Personnel and Others

During the evacuation, police officers and firefighters provided help to numerous residents of the building. Table 42 shows a distribution of the groups of rescuers providing help to the respondents during the evacuation.

TABLE 42: Help to Evacuate

Source of help	Frequency	Percent
Police Officers	112	51.1
Firefighters	36	16.4
Police Officers and Firefighters	19	8.7
Other occupants	2	0.9
Someone from your unit	1	0.5
Don't know	6	2.7
No one	26	11.9
No answer	17	7.8
Total	219	100.0

Analysis showed no significant difference between genders (χ^2 = 2.27, DF = 1, p = 0.13) or between age groups (χ^2 = 3.87, DF = 2, p = 0.14); analysis, however, showed that people above the 21st floor were significantly more likely to receive help from rescue

personnel during their evacuation than people on lower floors ($\chi^2 = 47.66$, DF = 5, p = 0.00), when comparing blocks of floors for help from officials versus no help. There appears to be a parallel between the use of the stairs and a reduced need for help from rescue personnel: floors below the 6th and between the 17th and the 21st have a higher likelihood of using the stairs and a lower likelihood of receiving help, while above the 21st floor, there is a lower percentage of people using the stairs but a higher percentage of them receiving help from the rescuers. People who were not alone in their units were not significantly different from those who were ($\chi^2 = 1.16$, DF = 1, p = 0.20) and all were equally likely to receive help from the rescue personnel to evacuate.

12.2 Evacuation of the Building by Rescue Personnel

Once the fire was mastered and the danger removed, rescue personnel proceeded to the orderly evacuation of all residents who were still in their units. The manner in which some of these people were evacuated is discussed in Section 9. It appears from occupants' responses that the evacuation started around 10:00. At 6:00, 17% of respondents had evacuated the building, generally on their own. Only 6% evacuated between 6:00 and 10:00. All the others were evacuated by rescue personnel starting around 10:00. The time at which people were asked to evacuate by rescue personnel varies a great deal, as shown in Table 43.

Statistical analysis showed a significant difference between floors ($\chi^2 = 39.72$, DF = 5, p = 0.00). People living on the 22nd floor and above were significantly more likely to wait in their units until they were asked to evacuate by rescue personnel. The firefighters asked 85 respondents (39%) to evacuate, the police officers asked another 76 people (35%) and 53 (24%) of the respondents left on their own initiative. Analysis showed no difference among the residents of the four quadrants ($\chi^2 = 2.56$, DF = 3, p = 0.46).

TABLE 43: Time at Which People Were Asked to Evacuate by Rescue Personnel

Time	Frequency	Percent	Valid Percent
Before 5:00	1	0.5	0.8
5:00 - 7:59	5	2.3	4.0
8:00 - 9:59	9	4.1	7.3
10:00 - 10:59	27	12.3	21.8
11:00 - 11:59	56	25.6	45.2
12:00 - 12:59	23	10.5	18.5
13:00 and after	3	1.4	2.4
Not sure	5	2.3	-
No answer	90	41.1	-
Total	219	100.0	100.0

The rescue personnel instructed 13 people (6%) to evacuate by the stairs; 27 (12%) were told to evacuate by the elevator, 27 (12%) were told to wait and 16 (7%)

agreed to close their door and follow them. The remaining 62% either did not evacuate with the rescue personnel or did not report receiving any instructions. Analysis showed that there was a significant difference between people who had seen smoke in the corridors and those who had not ($\chi^2 = 17.70$, DF = 1, p = 0.00). People who saw smoke in the corridors were more likely to wait for the rescue personnel to evacuate the building.

When evacuating, 66 people or 37% of respondents to this question said that they encountered at least one firefighter in the corridors and 29 or 13% said they encountered at least one firefighter in the staircase. Analysis did not show that the number of people encountering firefighters in the corridors varied significantly from one floor to the other ($\chi^2 = 9.89$, DF = 5, p = 0.08). Statistical analysis showed, however, a significant difference among quadrants. It appears that people living on the west side were more likely to encounter firefighters in the corridors ($\chi^2 = 10.71$, DF = 3, p = 0.01). As for the staircases, analysis showed that people between the 5th and the 10th floors were significantly more likely to encounter firefighters in the stairs ($\chi^2 = 31.67$, DF = 5, p = 0.00) and analysis also showed a significant difference among quadrants ($\chi^2 = 12.42$, DF = 3, p = 0.01). People living on the west side of the building, especially in the north-west quadrant, were more likely to encounter firefighters in the stairs.

The firefighting equipment impeded the evacuation movement of six respondents (3%), five of them in the stairs and one in the corridors, all between the 3rd and 5th floors.

12.3 Feelings During the Event

Table 44 shows the feelings experienced by the respondents during the fire emergency situation. A majority of the respondents (73%) mentioned feeling *Anxious but in control* during the whole event. Ten percent felt *Panicky and unable to think clearly*, 8% felt *Not very concerned* and another 8% felt *Unable to decide what to do*. Only four of the respondents did not answer this question.

TABLE 44: Feelings During Fire Emergency Situation

Feeling	Males		Females		Total	
	Freq.	%	Freq.	%	Freq.	%
Anxious, but in control	71	32.4	88	40.2	159	72.6
Panicky and unable to think clearly	8	3.6	13	5.9	21	9.6
Not very concerned	13	5.9	5	2.3	18	8.2
Unable to decide what to do	5	2.3	12	5.5	17	7.8
No answer	1	0.5	3	1.4	4	1.8
Total	98	44.7	121	55.3	219	100.0

The majority of males and females (74% in both cases) reported feeling *Anxious but in control.* Statistical analysis showed there was a significant gender-based difference

with respect to the feelings experienced during this fire ($\chi^2 = 7..47$, DF = 3, p = 0.058). Women were more likely to report being *Unable to decide what to do* or *Panicky and unable to think clearly*, while men were more likely to say they were *Not very concerned.*

Analysis did not show any significant difference between age groups ($\chi^2 = 7.15$, DF = 6, p = 0.31), however, in the 18-40 age group, 14% of respondents felt *Panicky and unable to think clearly* while 4% of the 41-64 age group and 5% of the 65+ age group experienced similar feelings. Statistical analysis did not show that the occupation of the respondent ($\chi^2 = 12.15$, DF = 12, p = 0.43) or the presence of another person in the apartment at the time of the fire ($\chi^2 = 4.70$, DF = 3, p = 0.20) had an effect on occupant's feelings during the event.

There is no correlation between the floor on which residents lived and the way they felt during the fire ($r = 0.05$, $p = 0.40$), however, a higher proportion of respondents below the 5th floor felt *Not very concerned* (23%) compared to the other floors; the number was always 10% or less for floors above the 5th floor. Regardless of the floor, a majority of people felt *Anxious but in control.* No significant difference was found among the different quadrants ($\chi^2 = 3.18$, DF = 9, p = 0.96) but more information would be needed to obtain a valid conclusion. The results, however, seem to indicate that all quadrants were almost identical when it comes to the way people felt.

Statistical analysis showed no significant difference between people who had previous information on actions to take in a fire situation and people who did not ($\chi^2 = 4.89$, DF = 3, p = 0.18). People with no information were slightly more likely to feel *Panicky and unable to think clearly* (17% versus 9% for those with information) or *Unable to decide what to do* (14% versus 7%). The majority of people, however, felt *Anxious but in control* (76% of people with information and 60% of people without previous information).

Statistical analysis showed a significant difference between people who were aware of the building evacuation procedure and people who were not ($\chi^2 = 12.58$, DF = 3, p = 0.01). People who were not aware of the procedure were significantly more likely to feel *Panicky and unable to think clearly* (14%) or *Unable to decide what to do* (10%) even though the majority of them felt *Anxious but in control* (68%). People familiar with the procedure generally felt *Anxious but in control* (87%). Statistical analysis did not show a difference between people who had experienced a fire in the past and people who had not ($\chi^2 = 4.28$, DF = 3, p = 0.23).

After this experience, 41 or 19% of respondents mentioned seeking assistance to deal with the emotional stress of the event and turned to different sources. Eleven of them consulted a psychologist or psychiatrist, 14 saw a medical doctor and one of them talked to a priest or spiritual counsellor. Finally, 15 of the respondents obtained help from other people, mostly friends or family.

Statistical analysis did not show that people of different genders ($\chi^2 = 2.26$, DF = 1, p = 0.13), age groups ($\chi^2 = 3.75$, DF = 2, p = 0.15) or with different occupations ($\chi^2 = 3.80$, DF = 4, p = 0.43) were significantly different concerning the likelihood of seeking assistance. Residents of different floors or quadrants were not more likely to seek assistance (floor blocks: $\chi^2 = 4.63$, DF = 5, p = 0.46; quadrants: $\chi^2 = 5.26$, DF = 3, p = 0.15). The way the respondent felt during the situation did not correspond either to a significant difference in the likelihood of seeking assistance ($\chi^2 = 6.11$, DF = 3, p = 0.11); however, 29% of people feeling *Panicky and unable to think clearly* decided to seek assistance after the fire, compared to 18% of people feeling *Unable to decide what to do* and 15% of people feeling *Anxious but in control.* None of the respondents feeling *Not very concerned* had to seek help after the event.

13.0 DISCUSSION

The data analyses produced a number of interesting findings. This section of the report summarizes the results that emerged as most important in explaining human behaviour during this fire.

Four major findings have been identified. First, the characteristics of occupants who were in the building at the time of the fire proved to be significant. The gender, occupation, limitations, language spoken and age of the occupants in terms or how they perceived and reacted to this event were all included in these characteristics. Secondly, the location of the occupant in the building at the time of the fire appeared as an important factor. The floor and the quadrant in which the occupant was located can explain some of the occupant's reactions. Thirdly, the smoke condition in the building was responsible for the behaviour of a number of the occupants. Many decisions were made in relation to the presence or absence of smoke in the apartment, corridor or stairs. Finally, the time to start determined the success or failure of an attempt to evacuate. The occupants who started their evacuation very quickly, regardless of the floor, managed to reach safety without problem while the occupants who delayed their evacuation were faced with serious smoke conditions and often had to turn back or take refuge in a neighbour's apartment. These major findings are discussed in detail.

13.1 Characteristics of Occupants

The total number of questionnaires returned represents 54% of all the units in the building from which answers could be expected. In this sample, all floors, except the first floor, are represented. Both men and women and people from each age group were present in each floor block.

When comparing men and women's responses to the questionnaire, the results show that there are few differences in their choice of actions and in their perception of the situation. One important aspect where they differ is in terms of whether or not they were familiar with the building evacuation procedure. It appears that a lower percentage of women were aware of the evacuation procedure. Since a relation has been found between the awareness of evacuation procedures and the feeling respondents experienced during the event, it is not surprising that a higher percentage of women felt *Unable to decide what to do* or *Panicky and unable to think;* whereas men were more likely to feel *Not very concerned.* Initially, women were also more likely to take the situation seriously, although it had no significant influence on the choice of first action for occupants of either gender.

The occupation of the respondents was related to a number of differences. It appears that people with different occupations had significantly different access to general information on fire safety. A much higher percentage (60%) of not employed people had not received any previous information on fire safety, while only 17% of working adults

were in the same position. People with different types of occupation also had a tendency to take different first actions. *Professionals* were more likely to *Wait*, the majority of *Support Staff* decided to *Investigate* and *Retired* people were more likely to *Protect*. For all types of occupation, however, there was always a majority of people who started by *Investigating*.

The presence of another person in the apartment at the time of initial awareness was not shown to be an influential factor on the behaviour of the respondent. The only noticeable difference was found in the first action. None of the people, who were alone in a unit, initially decided to *Alert*, while 12% of people with another person in the unit said their first action was to *Alert*.

People having limitations were not found to be different in any significant way from people with no limitation; that is, it was not shown that their limitations directly affected their actions or perceptions of the situation. This must be carefully examined since many of the people with limitations were people in the 65+ age group and, as discussed later, people from that age group were shown to behave in significantly different ways. Furthermore, when comparing individuals with limitations and those without, only the individuals reporting specific limitations could be considered. Since only 30 of the 219 respondents reported having limitations and the limitations were diverse, some of the analyses could not be completed because of the small number of subjects.

A significant number of aspects were shown to be linked to the age of the occupant. People aged 65 and over, who represented 20% of the respondents, were especially different from younger respondents. Right from the beginning of the situation, they were different in that they were more likely than others to be told about the problem rather than to notice the building fire alarm or the presence of smoke. Since it has been shown that people who were told about the situation were more likely to realize there was a problem at a later time than those hearing the alarm or noticing the smoke, it is not surprising that people in this age group also took longer to understand that there was a problem. This tendency towards late awareness could also explain why they were significantly different from younger residents in a number of other ways.

Analysis showed that people who were aware of the problem earlier also left their units earlier. Since residents aged 65 and over tended to become aware of the problem later than others, they also had a tendency to leave their apartments later in the day.

When people in the 65 and over age group decided to stay in their units, they were more likely to take that decision because they thought it was safer inside the unit rather than mentioning the presence of smoke in the corridors and staircases as a reason. Since 19% of the older occupants were living below the 5th floor and there was substantially less smoke on these floors, it explains, in part, why some of them were not prevented from leaving because of the smoke.

While staying in their apartments, people aged 65 and over were significantly less likely to go out on their balconies, many of them mentioning that it was very cold outside on that January morning (-8°C). They were also more likely than younger occupants to *Seek Information* in one way or another.

Of the occupants aged 65 and over who decided to exit the building using the stairs, none had to turn back, while half the people aged 18 to 64 had to turn back. Once again, this could be explained by the fact that those who were living below the 5th floor and who took the stairs, did not have any reason to turn back since there was little smoke. For those living above the 5th floor, they simply waited in their units for the most part because it was safer inside, and they evacuated later with rescue personnel when it was safe. Older occupants appear to have been quite realistic about their physical limits and did not attempt an evacuation by themselves.

The use of the stairs during the evacuation was different among the age groups, but in this case, both those 41 to 64 and those 65 years old and over were significantly less likely to use the stairs than those 18 to 40 years old. When examining the occupants' use of the stairs prior to the fire, analysis showed that 65 year old and over residents were less likely to have used the stairs in the past than those 18 to 40 years old.

One problem with people in the 65 and over age group was the fact that they were significantly less likely than others to hear the building fire alarm; this explains why they had to be told about the fire. They did not, however, have significantly different opinions when evaluating the volume of the alarm in the different zones of the building (i.e., apartment, corridors and staircases).

The occupants' fire safety knowledge was different between age groups. First of all, the respondents aged 65 and over were significantly more likely to be aware of the building evacuation procedure than those 18 to 40 years old. When examining respondents' previous knowledge of fire safety, none of the age groups is significantly more likely to have had previous information, however, people of different age groups had a tendency to obtain information from different sources. Most respondents aged 65 and over obtained fire safety information in publications or from other non-specified sources and 24% had not had any previous information. People between the ages of 41 and 64 usually had access to information at work and the majority of respondents aged 18 to 40 were given information at school or through multiple sources. Only 15% and 16% of respondents aged 18-40 and 41-64, respectively, had not obtained any previous information on fire safety.

The language spoken at home was an important aspect, as it was shown to be linked to the occupants' access to information. Of the people speaking a language other than English, 42% had not had any previous information on fire safety, compared to only 15% for the English speaking group. The occupants' awareness of the building evacuation procedure was also affected by the language spoken at home. Only 8% of non-English speaking residents were aware of the procedure, having read about it, in

English, on notices posted in the hall. Of the English speaking residents, 31% were familiar with the procedure.

13.2 Location of the Occupants in the Building

To facilitate analysis of the results, the building was divided into six floor blocks and four quadrants (refer to Figure 2). Residents of the different floor blocks and the different quadrants were compared considering a number of aspects to determine if the location of the respondent's unit had an effect on his or her behaviour during the event.

At the very beginning of the event, excluding the 5th floor block, the time of being alerted and the initial interpretation of the situation was not different from one block to another. On the 5th floor, however, all occupants immediately realized that there was a real fire and took the situation very seriously.

The evacuation routes chosen were different among the various areas of the building. Almost all the residents of the 5th floor and floors below used the stairs to evacuate and did so without waiting for help from rescue personnel. Respondents living between the 17th and the 21st floors were also more likely to use the stairs to evacuate. No apparent explanations for that observation are available, except that many of them tried to evacuate via the stairs early in the morning but had to stop and seek refuge due to the smoke in the staircases. They were evacuated by rescue personnel later in the day.

The lower the resident lived in the building, the more likely this person was to have used the stairs prior to the day of the fire. Of the people using the stairs on that day, 90% took the staircase closer to their apartment and 94% went down the stairs. Four of the six people going up the stairs had to do so because of the smoke. Respondents living above the 16th floor were more likely to have to turn back while in the stairs and go back to their apartments or take refuge in another apartment.

Overall, 75% of all residents heard the building fire alarm but the alarm was not perceived uniformly throughout the building. The most important finding is that only 57% of the occupants of Units 03, 04, 09 and 12 heard the alarm. These apartments are situated in the corners of the building. Sound measurements in the building a few days after the fire showed that the alarm had a sound level of less than 45 dBA in the bedrooms of the corner units. When considering the other units, excluding corner units, 84% of occupants heard the alarm. Although the four alarm bells located in the corridors had a sound level of over 100 dBA, it appears there was a problem of sound attenuation in the corner units.

The respondents' appreciation of the sound level of the alarm was different; people living above the 16th floor were more likely to think that the alarm was not loud enough in their apartments. Overall, 43% of occupants thought the alarm was not loud enough in their apartments and only 3% thought it was too loud. In the corridors, 23% of

respondents thought the alarm was not loud enough and 12% thought it was too loud but there is no statistical difference among floors for that finding. In the staircases, 34% of users thought the alarm was not loud enough and only 4% thought that it was too loud.

The fire alarm stopped at one point during that morning, however, it was impossible to determine with relative accuracy the time at which the alarm stopped from the responses of the occupants.

Only 10 respondents (5%) heard the P.A. messages but the messages were unclear for 40% of them. A total of 27 respondents or 12% heard the firefighters' bullhorn messages but those messages were unclear for 21 of them or 78%. The firefighters' bullhorn messages were delivered from the outside of the building, coming from the ground floor around the north-east corner of the building. Statistical analyses showed no difference between the areas of the building, implying that people in the higher parts of the south-west wing mentioned hearing the message just as well as the residents in the lower north-east corner. It is possible however, that some people travelled through the building before finding refuge in another unit and heard the messages from there rather than from their own unit location, which was used for this analysis.

A greater proportion of residents of the 5th floor to the 16th floor noticed that the lights were off in their corridor and in the staircase while people living above the 16th floor were more likely to notice that the lights were on. Residents on the west side of the building were also more likely to notice the absence of lights. Overall, 82% of respondents reported that the lights were on in the corridors and 65% said that they were on in the stairs. All residents of the 5th floor reported the absence of lights. Only 23% of respondents noticed the exit signs located in the staircases and corridors.

Respondents living on the 22nd floor and above were much more likely to wait in their apartments until they were evacuated by rescue personnel, rather than to evacuate on their own. In many cases, however, they tried to evacuate on their own at the beginning of the incident but had to go back to their apartments or to another unit before they were evacuated a few hours later. The occupants of Floors 22 to 30 were also the most likely to receive help from rescue personnel. People living on the 10th floor and below, however, were more likely to meet rescue personnel in the staircases.

Another important result concerns the exit to the roof during a fire emergency situation. Prior to the fire, 39 or 19% of the respondents thought that they could exit onto the roof of the 2 Forest Laneway building. Of those 39 people, 79% were residents of the 17th to the 30th floors. The roof of this building is not accessible, as some discovered on that day.

13.3 Smoke Conditions in the Building

The smoke conditions in the building varied considerably from one area of the building to another. The smoke conditions, as perceived by a respondent, cannot be separated from the location of that respondent when the observation was made. A number of known properties of smoke movement in a highrise building confirm what respondents observed in this fire. The first finding is that all the respondents from the 5th floor saw smoke in their units, in the corridor and in the stairs, when they used them.

Each highrise building has a neutral plane in terms of stack effect, usually situated at mid-height. In the case of the 2 Forest Laneway building, this neutral plane should correspond to the 16th floor level, since there is no 13th floor. Given this neutral plane, with the exception of the 5th floor (the fire floor) where there should have been substantial amounts of smoke, and the 6th floor depending on the amount of leakage, there should be very little smoke from the 1st floor to the 4th floor. The largest amount of smoke should be found on the upper floors, from the 16th floor to the top floor or above the neutral plane. The building was divided into the six floor blocks described earlier to facilitate this comparison of smoke density.

The results obtained from the respondents show that, with the exception of the 5th and 6th floors, the floors below the 15th had significantly less smoke than the floors situated above (refer to Figure 11). Above the 15th floor, over 80% of the respondents observed smoke in their units and the higher the respondents were, the more likely they were to notice smoke in their units. Even between the 7th and 14th floors, more than 40% of respondents indicated that they saw smoke in their units, which denotes the possibility of leakage.

In this fire, it has been shown that both staircases were filled with smoke very early in the incident. Since 65% of the respondents who saw smoke reported that the smoke entered their units around the door, it is likely that the smoke was quite dense in the corridor and that it was partly coming from the staircases, since every time someone tried to use the staircases, they opened the door to the stairs, allowing a substantial quantity of smoke to enter the corridors. Of the people who saw smoke in their units, 13% thought it came in through the ventilation system.

Residents located on the fire side, in the north-east quadrant, were more likely to see smoke in their apartments than the others. Residents on the side opposite the fire side, in the south-west quadrant, were the least likely to see smoke. In more than 64% of units where residents saw smoke, the smoke appeared at or before 5:20 and in 83% of cases, it appeared at or before 5:30. Residents located closer to the fire floor were no more likely than others to see smoke at an earlier time.

In the corridors of the building, 165 people or 81% of respondents saw smoke. More than 50% of them saw it at or before 5:15 and 86% saw it at or before 5:30. With the exception of the 5th floor, where everyone saw smoke in the corridor, the higher the

resident was, the more likely this person was to see smoke in the corridor. Of the people who saw smoke in the corridors, 69% reported being able to see less than 10 feet through the smoke. When comparing floors above the 5th floor, it appears that residents of the 6th to the 10th floors were more likely to see the smoke earlier than the others, generally between 5:00 and 5:14, compared to 5:30-5:44 for people on Floors 11 to 16 and 5:15-5:29 for residents of the 22nd to the 30th floors. Unfortunately, no information was collected to determine whether the smoke was still present in the corridors when the rescue personnel asked occupants to evacuate the building later in the day, generally after 10:00.

Of the 87 people who reported the time at which they saw smoke in the staircases, 80% said it was between 5:10 and 5:30. In this case as well, residents living above the 16th floor were more likely to see smoke in the staircases. All people using the Fire Staircase reported seeing smoke in the stairs. Of the people using the Other Staircase, 91% saw smoke during their attempt to evacuate. Four people did not see any smoke in the Other Staircase, but three of those four smelled the smoke and, because of that, two of them decided to turn back. The fourth person apparently made his way down from the 7th floor 5 minutes after hearing the alarm without encountering any sign of smoke.

Only 8 respondents encountered heat in their units, three on the 5th floor, two on the 6th floor, one on the 7th floor and two on the 28th floor. The source of heat on the 28th floor has not been clearly identified. During the evacuation, 12 people encountered heat that forced three of them to turn back.

A battery operated smoke alarm was present in the apartments of 93% of the respondents. Only 15% of them were activated. The proportion of activated smoke alarms is higher on the upper floors: 20% for 22nd to 30th floor, compared to 12% for the 2nd to the 21st floor. Smoke alarms in units located on the fire side, in the north-east quadrant, were more likely to be activated, which is consistent with the finding that a higher proportion of people in these units observed smoke in their apartments.

13.4 Time of Evacuation

In all time-based analyses used in this study, it is difficult to determine the accuracy of the results. All respondents filled in the questionnaire approximately three weeks after the incident and while many remembered numerous details about the situation, specific times may not be absolutely accurate. The respondents seem to have rounded off times when answering the questions. As well, the occupants were involved in a fire emergency and may not have given much consideration to the time, rather concentrating their energies on finding safe solutions to the problem at hand. The large number of responses, however, compensates for the lack of accuracy. The time estimates, even if not perfectly accurate, are very useful in evaluating the chronology of the event.

Two factors played key roles in determining whether an occupant was able to evacuate the building early in the morning or whether the occupant had to wait to be evacuated by rescue personnel much later in the day. The first factor is the location of the occupant's apartment and the second is the time at which the occupant attempted to evacuate. Both of these factors are very important, mostly because they are related to the spread of smoke throughout the building. When examining the evacuation possibilities of the occupants, it is impossible to dissociate the departure time, departure location and the spread of the smoke through the building.

All respondents using either of the staircases from below the 5th floor at any time did not have any smoke-related problems when evacuating. Their evacuation, however, if attempted after the arrival of the firefighters, was sometimes impeded by firefighting equipment.

Anyone using the Fire Staircase from above the 5th floor after the alarm sounded had to travel through smoke. Only people using the stairs very early after the start of the fire were able to get to the ground level without having to turn back or to find refuge. Only three people succeeded, one from each of the 10th, 16th and 20th floors. All three started their descent early, at 5:00 for the occupant of the 20th floor and at 5:10 for the other two people. Sixteen more occupants tried without success to evacuate using the Fire Staircase, all starting at 5:10 or after, except one who left the 23rd floor at 5:05. It is clear that an early start was essential to go down the Fire Staircase successfully before the smoke made it impassable.

In the case of people using the Other Staircase from above the 5th floor, 30 people had to return to their units or find a refuge while five people successfully reached ground level, two of them apparently starting as late as 5:20. Of the people who had to turn back, the average starting time was 5:16, with people from almost all floors attempting to evacuate.

Many occupants had to seek refuge or offer refuge to others during this fire. Of the 44 respondents who had to take refuge in someone else's unit, 21 or 48% did not know the people with whom they took refuge. The 23 others moved to be with people they knew, such as neighbours, friends or relatives. This altruistic behaviour of helping others and offering refuge agrees with the findings of previous similar studies.

It is clear that the considerable propagation of the smoke impeded the evacuation of many people and increased the risk to their lives. It is impossible, however, to determine precisely the location and time at which the situation became intolerable and prevented any further evacuation. An early attempt, preferably through the Other Staircase, gave the best chance for a safe evacuation of the building through the stairs.

14.0 CONCLUSIONS

The results of this human behaviour study during the 2 Forest Laneway Fire raise a number of general issues for improving occupants' fire safety in buildings. Providing information to occupants appears as the leading aspect to improve fire safety. Information on fire safety must be readily available to the population at large. There is a large spectrum of means by which this information can be provided, from fire safety signs to posted evacuation procedures, brochures, training classes and publicity campaigns. It seems important to use multiple means to communicate fire safety information to ensure that the message reaches the building users and that everyone has access to the information.

Fire safety information should be accessible to the increasing number of immigrants to Canada, who are sometimes not fluent in either of the two official languages. In some cases, these new residents have not received any fire safety training at school or at work in their country of origin. Particular attempts must be made to convey fire safety information to these people.

Most people learn about fire safety at school and in the workplace, however, older people or people who spend most of their time at home do not have access to that information. Special efforts must be made to reach these occupants and provide them with appropriate fire safety information.

When providing information on fire safety in highrise buildings, a number of points need to come across very clearly. With a few exceptions, most occupants seem to know that they should not use the elevator during a fire. Many, however, do not fully understand the dangers of smoke and the importance of sealing their units and closing windows and doors. This should be emphasized in fire safety information. Another point that needs reinforcement is the fact that, in almost all apartment buildings, there is no access to the roof, even in a fire situation. Finally, in a fire situation, rescue can take a long time. If occupants are not in immediate danger, they should be prepared to wait for as long as a few hours before rescue personnel can assist them to evacuate; this fact should be made clear to occupants.

Once fire safety information has been provided, one of the best ways to assess occupants' understanding of what they are expected to do during a fire is to carry out evacuation exercises. Regular drills are an excellent means to educate and raise occupants' awareness about fire safety and evacuation procedures. A fire drill gives occupants the opportunity to recognize the sound of the alarm system, to assess the intelligibility of the PA system, if present, to locate the closest exit, to experience using the staircases and to identify the staircase exit locations. Building management, at the same time, can assess the efficiency of the evacuation procedures and identify potential problems.

The 1983 "Public Inquiry into Fire Safety in Highrise Buildings" [13] found that many people turned to the television or radio for information during a fire but often found the information provided to be useless.. At that time, a recommendation was made for members of the Canadian Association of Broadcasters and the Radio and Television News Directors Association to voluntarily modify their procedures during fire situations. Many residents of the 2 Forest Laneway building reported that they turned to the television or radio during the fire only to find, once again, useless information. Further, occupants who listened to the media while still in the building explained that the media information was increasing their anxiety. The emphasis was on the number of casualties discovered so far, suggesting that more might be found, leaving them thinking that they might not survive. Occupants expected to obtain information on appropriate actions to take. An effort must be made to improve this situation by including the media as a means of providing information to the people inside the building during a fire.

Two essential communication devices were shown to be ineffective and unreliable during the 2 Forest Laneway Fire. First, the building fire alarm was very useful in alerting a number of people but the sound level was insufficient in some areas of the building, especially in the corner units. The low sound level of the fire alarm inside apartments in apartment buildings has been observed in a variety of buildings throughout Canada [21, 22]. In apartment buildings where alarm bells are installed only on corridors walls, the sound level of the alarm is often overpowering in the corridors and too low to be perceived in some apartments. Older occupants in any location were less likely to hear the fire alarm. This could be due to the high frequency of the alarm and to the non-modulation of the signal. It is known that older adults, with normal hearing for their age have difficulty hearing sounds with a primary frequency over 2000 Hz. Fire alarms tend to have their main frequency around 4000 Hz, which makes them difficult to hear for older people or for those with a mild hearing loss [23]. Some research suggests that alarm sounds with a primary peak at 500 Hz with a fast modulation could help improve alarm detection [24].

The second means of reaching occupants during an emergency, the building P.A. system, was not efficient in providing residents with information. Some people heard sounds but could not understand the messages. Should this system be intended for use in an emergency, it should be tested, inspected and maintained in order to ensure that messages are intelligible. Voice communication and P.A. systems remain the best way to provide information during an emergency to occupants of a large building. These systems are flexible means of communicating information because it allows the person in authority to give out live messages that can be directed to particular groups of occupants and can be specific in its information content. To make it a useful tool, however, its intelligibility must be improved to make sure that occupants can hear and understand the information.

The 2 Forest Laneway Fire has corroborated a fact now acknowledged in the fire safety community: people are prepared to move through a certain quantity of smoke to evacuate. Occupants who saw smoke did not panic, freeze or became hysterical. Rather, they had a look at the smoky staircase and still tried to make it down. The fact that

occupants often try to evacuate, even if there is smoke, emphasizes the importance of leaving the staircase doors unlocked to allow for re-entry on any floor. Given people's normal reaction to move away from a location when conditions become threatening, ideally, the roof should also be accessible as an area of refuge. Accessibility to the roof should be made possible if other safety requirements can be met, otherwise it is important that occupants be made aware of the fact that the roof is not accessible, even during an emergency. If the roof is not accessible, it should be stressed in fire safety information and practice drills, coupled with appropriate signs in the building.

Researchers have emphasized for the last 20 years the fact that panic behaviour is rare during a fire emergency [25, 26]. This study was consistent with previous findings; people did not panic during the 2 Forest Laneway Fire. Many of the occupants felt fearful and anxious, but none of the respondents to the questionnaire acted in an irrational, thoughtless or careless way, which is characteristic of panic. Even though occupants themselves sometimes reported their reactions as "I panicked", they are usually describing sudden fear and stress, but not irrational behaviour. Occupants of the 2 Forest Laneway did not panic during the January 6th fire. Overall, they tried to make what they judged to be the best decisions, with respect to what they knew about fire safety and what they understood of the situation in the building that morning.

15.0 REFERENCES

1 Fire Marshal of Ontario, 1995, "Residential Fire Deaths in Ontario," Accessible on database only, Office of the Fire Marshal of Ontario, North York, Ontario.

2 Yung, D. and Hadjisophocleous, G.V., 1993, "The use of the NRCC Risk-Cost Assessment Model to apply for code changes for 3-storey apartment buildings in Australia," Proceedings of the Symposium on Computer Applications in Fire Protection Engineering, Society of Fire Protection Engineers, Boston, Mass, pp. 57-62.

3 Office of the Fire Marshal of Ontario, December 1993, "Fire Ground Staffing and Delivery Systems within a Comprehensive Fire Safety Effectiveness Model," Office of the Fire Marshal of Ontario, North York, Ontario.

4 Shaughnessy, J. J. and Sechmeister, E. B., 1994, Research Methods in Psychology, Third Edition, McGraw-Hill, New York, 500 pages.

5 Bryan J. L., 1983, "An Examination and Analysis of the Dynamics of the Human Behavior in the MGM Grand Hotel Fire," National Fire Protection Association, Quincy, Mass, 86 pages.

6 Bryan J. L., 1983, "An Examination and Analysis of the Dynamics of the Human Behavior in the Westchase Hilton Fire, Houston, Texas, March 6 1982," National Fire Protection Association, Quincy, Mass, 139 pages.

7 Bryan J. L. and Dinenno, P. J., 1979, "An Examination and Analysis of the Dynamics of the Human Behavior in the Fire Incident at the Georgia Towers on January 9, 1979," Center for Fire Research, National Bureau of Standards, Washington, D.C., 33 pages.

8 Bryan J. L., Milke, A. J. and Dinenno, P. J., 1979, "An Examination and Analysis of the Dynamics of the Human Behavior in the Fire Incident at the Thurston Hall on April 19, 1979," Center for Fire Research, National Bureau of Standards, Washington, D.C., 33 pages.

9 Proulx, G. and Fahy, R. F., 1995 "A study of the New York World Trade Center evacuation," Asiaflam '95, Hong Kong, InterScience Communications Limited, London, pp. 199-209.

10 Fahy, R. F. and Proulx, G., 1995 "A study of the New York World Trade Center evacuation," NFPA Journal, Vol. 9, No. 2, March/April 1995, Quincy, Mass, pp. 59-67.

11 Proulx, G, Latour, J. C. and MacLaurin, J. W., 1994, "Housing Evacuation of Mixed Abilities Occupants," Internal Report, IRC # 661, Institute for Research in Construction, National Research Council of Canada, Ottawa, Ontario, 50 pages.

12 Proulx, G. and Veitch, J. A., 1994, "Questionnaire to Evaluate Evacuation Drills and Emergency Procedures," Client Report for Public Works and Government Services Canada, A-4080.1, Institute for Research in Construction, National Research Council of Canada, Ottawa, Ontario, 22 pages. Restricted circulation.

13 Webber, J. B., 1983, Report of the Public Inquiry into Fire Safety in Highrise Buildings, Vol. 1&2, Queen's Printer of Ontario, Toronto, Ontario, 408 pages.

14 McCall, R. B., 1994, Fundamental Statistics for Behavioral Sciences, Sixth Edition, Harcourt Brace College Pub, Orlando, FL, 469 pages.

15 National Research Council Canada, 1995, Research Involving Human Subjects: Guidelines for Institutes, NRCC, Ottawa, Ontario, 48 pages.

16 Klote, J. H. and Milke, J. A., 1992, Design of Smoke Management Systems, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, GA, 223 pages.

17 Tamura, G. T., 1994, Smoke Movement and Control in Highrise Buildings, National Fire Protection Association, Quincy, Mass, 280 pages.

18 Statistics Canada, 1992, 1991 Census Handbook Reference, Catalogue 92-305E, Statistics Canada, Ottawa, Ontario.

19 Statistics Canada, 1992, Dwellings and Households, Catalogue 93-311, Statistics Canada, Ottawa, Ontario.

20 Canter, D., 1985, "Studies of Human Behaviour in Fire: Empirical Results and their Implications for Education and Design," Building Research Establishment, Department of the Environment, Borehamwood Herts, UK, 29 pages.

21 Proulx, G. 1994, "The time delay to start evacuating upon hearing a fire alarm," Proceedings of the Human Factors and Ergonomics Society 38th Annual Meeting, Nashville, TN, 24-28 October 1994, Vol. 2, HFES, Santa Monica, CA, pp. 811-815.

22 Sultan, M. A. and Halliwell, E. R., 1990, "Optimum location for fire alarms in apartment buildings," Fire Technology, Vol. 26, No. 4, pp. 342-356.

23 Proulx, G., Laroche, C. and Latour, J. C., 1995, "Audibility problems with fire alarms in apartment buildings," Proceedings of the Human Factors and Ergonomics Society 39th Annual Meeting, San Diego, CA, 9-13 October 1995, in press, HFES, Santa Monica, CA.

24 Huey, R. W., Buckley, D. S. and Lerner, N.D., 1994, "Audible Performance of Smoke Alarm Sounds", Proceedings of the Human Factors and Ergonomics Society 38th Annual Meeting, Vol. 1, HFES, Santa Monica, CA, pp. 147-151.

25 Sime, J. D., 1980, "The Concept of Panic," Fires and Human Behaviour, John Wiley & Sons, USA, pp. 63-81.

26 Keating, J. P., 1982, "The myth of panic," Fire Journal, May, pp. 57-61.

ANNEX 1: Letter to the Occupant and Questionnaire

National Research Council Canada
Conseil national de recherches Canada

Institute for Research in Construction
Institut de recherche en construction

Ottawa, Canada
K1A 0R6

National Fire Laboratory
Phone: (613) 993-2204
FAX: (613) 954-0483

NRC·CNRC

25 January, 1995

Occupants
2 Forest Laneway
North York, Ont.
M2N 5X7

Dear Occupants,

We are requesting your cooperation in completing the enclosed questionnaire about your experience during the Forest Laneway high-rise apartment fire on January 6, 1995. There is very limited knowledge on human behaviour during severe fire condition in apartment buildings. Therefore, it is very important that you share your experience with us because it is the best way for us to learn and understand what really happens during a fire. The information you will provide is extremely valuable, it will help us find ways to prevent the recurrence of such tragedies by examining fire safety equipment in buildings, evacuation procedures, fire safety education and regulations.

Please rest assured that your identity and your unit number will be kept strictly confidential. We need to know, however, your location during the fire for analyses purposes. This is why we have already noted your unit number on the questionnaire; if this number is wrong, please correct it.

If you do not want to fill out the questionnaire and would rather have a face-to-face interview in your preferred language, please contact the principal researcher to arrange a meeting: Dr. Guylène Proulx, call collect at, 0-613-993-9634.

This research on the human behaviour during the Forest Laneway fire is a project of the National Fire Laboratory at the National Research Council of Canada. This research will result in a report which will be used by the Office of the Fire Marshal of Ontario and the National Research Council of Canada in their mandate to enhance occupants fire safety.

We thank you for your willing cooperation. If you wish to receive a free copy of the report on the findings of this study, please provide your address at the end of the questionnaire.

Sincerely,

Guylène Proulx, Ph. D.
Research Associate

Canada

Unit:_____

Occupants of 2 Forest Laneway
Questionnaire Regarding the Fire on January 6, 1995

Instructions to fill out the questionnaire:

1- If you were not in the building at the time of the fire on January 6, 1995, tick the box underneath and sent back the uncompleted questionnaires in the prepaid envelope.

I was not in the building during the fire ☐

2- Every one over 14 years old, who were in your unit at the time of the fire should fill out a questionnaire. Please give the second copy of the questionnaire to another person who was in your unit. If you need extra copies call collect, Dr. Guylène Proulx at (0-613-993-9634). If you don't need the second copy of the questionnaire simply discard it.

3- While filling out the questionnaire, if you need more space to write down your anwsers simply use the back of the sheet.

4- After filling out this questionnaire, if you feel that some essential element of your experience has been left out, feel free to contact the principal researcher at the NRC. We will be pleased to accept collect call charges if you call (0-613-993-9634) and ask for Dr. Guylène Proulx.

5- Please send back all the completed questionnaires from your unit in the same prepaid envelope enclosed.

SECTION 1: Your Profile

1. Please, state your sex, age and occupation. Add any limitation that may have had an impact on your evacuation, such as, blindness, deafness, use of wheelchair, asthma, pregnancy, having a cast, using a cane, etc.

① ☐ M ☐ F Age ____ Occupation _____ Limitation _____

Language used at home: _____

2. State the sex, age, occupation and possible limitation of all the other persons who were in your unit at the time of the fire. If you need more space use the back of this sheet.

② ☐ M ☐ F Age ____ Occupation _____ Limitation _____

③ ☐ M ☐ F Age ____ Occupation _____ Limitation _____

④ ☐ M ☐ F Age ____ Occupation _____ Limitation _____

⑤ ☐ M ☐ F Age ____ Occupation _____ Limitation _____

Canada

SECTION 2: Initial Actions

3. How did you first become aware that there was something unusual occurring in the building?

4. What time was it? How sure are you of the time?

5. What were you doing at that time?

6. How serious did you believe the situation to be at first?
   - ☐ not at all serious
   - ☐ only slightly serious
   - ☐ moderately serious
   - ☐ extremely serious

7. What did you do first?

8. How did you become aware that it was a real fire?

9. Once aware that there was a fire in the building, did you...
   - Call 911? ☐ Yes ☐ No
     If yes, what instruction did you receive?_____
   - Call the fire department directly? ☐ Yes ☐ No
     If yes, what instruction did you receive?_____
   - Operate a fire alarm pull station? ☐ Yes ☐ No
     If yes, where was that?_____ Did it work?_____
   - Alert other occupants? ☐ Yes ☐ No
     If yes, how _____
   - Telephone friends or relatives? ☐ Yes ☐ No
   - Watch television or listen to radio? ☐ Yes ☐ No
     If yes, what was the information you received? _____
   - Other:

10. If you stayed in your unit rather than trying to evacuate right away, why?

11. While staying in your unit, what did you do?

12. Did all the occupants of your unit stay with you? ☐ Yes ☐ No
    If someone left, give the occupant(s) number(s) as listed in question 2: _____

13. Did you provide refuge for other occupants? ☐ No ☐ Yes How many _____
    These people were from which unit?

14. Did you go on your balcony? ☐ Yes ☐ No
    If yes, did you leave the balcony door open? ☐ Yes ☐ No
    While on your balcony, was there... ☐ smoke ☐ heat

15. At what time did you leave your unit? How sure are you of the time?

16. When you left, was your unit door locked? ☐ Yes ☐ No

17. Did you take your key? ☐ Yes ☐ No

SECTION 3: Evacuation of the Building

18. How many people left your unit with you? ____
    Give the occupant(s) number(s), as listed in question 2: _____

19. If you left as a group, did you remain together throughout the evacuation? ☐ Yes ☐ No
    If not, where were you separated and who left the group? _____
    Why?

20. Before leaving the building, did you try to meet someone from another unit? ☐ Yes ☐ No
    If yes, where did you meet?

21 Did you try to use the elevator? ☐ Yes ☐ No
    If yes, did it work?

22 Did you use the stairs to evacuate? ☐ Yes ☐ No
    Which staircase door did you use to evacuate?
    ☐ Exit door on the side where units have odd numbers, next to the garbage chute.
    ☐ Exit door on the side where units have even numbers.

23. When in the staircase, did you go... ☐ up ☐ down
    If you went up, why?

24. Did you have to change staircases during your evacuation? ☐ Yes ☐ No
    If yes, why?

25. Approximately how many people did you encounter in the corridor?

26. Approximately how many people did you encounter in the staircase?

27. On your way down, did you have to turn back up? ☐ Yes ☐ No
    If yes, why? _____
    Did you go back to your unit? ☐ Yes ☐ No

28. During your evacuation, did you take refuge in someone's else's unit? ☐ Yes ☐ No
    If yes, why? _____
    Where did you take refuge? floor _____ unit_____
    Did you know the persons where you took refuge? ☐ Yes ☐ No
    How many people were there? _____
    How long did you stay there?

29. Did you have any difficulty opening the staircase door? ☐ Yes ☐ No ☐ N/A
    If yes, where was that?

30. At what time did you finally reach ground level?

31. Did someone help you to evacuate, such as:
    ☐ someone from your unit ☐ other occupants ☐ firefighters
    ☐ police officers ☐ ambulance people ☐ don't know

32. Which exit at ground level did you use to leave the building?

33. That morning, did you re-enter the building after your evacuation? ☐ Yes ☐ No
    If yes, why?

SECTION 4: Alarm and Public Announcement

34. During this emergency, did you hear the building fire alarm? ☐ Yes ☐ No
    If yes, where were you when you first heard it?

35. In your opinion, was the sound of the building fire alarm...
    - in your apartment ☐ too loud ☐ loud enough ☐ not loud enough
    - in the corridor ☐ too loud ☐ loud enough ☐ not loud enough
    - in the staircase ☐ too loud ☐ loud enough ☐ not loud enough

36. Did you hear the fire alarm stop? ☐ Yes ☐ No
    If yes, where were you when it stopped?_____
    What time was it? How sure are you of the time?

37. Did you have a battery operated smoke alarm in your unit? ☐ Yes ☐ No
    If yes, did it activate during the fire? ☐ Yes ☐ No
    If yes, did you remove the battery to silence the alarm? ☐ Yes ☐ No

38. Did you hear any messages from the P.A. system? ☐ Yes ☐ No
    If yes, what was the message?_____
    Where were you at that time?

39. Did you hear any messages from the firefighters using a bull-horn? ☐ Yes ☐ No
    If yes, what was the message? _____
    Where were you at that time?

SECTION 5: Smoke Condition

40. Did smoke enter your unit? ☐ Yes ☐ No
    If yes, at what time? _____ How sure are you of the time? _____
    How did it enter? _____
    What did you do about it?

41. Did you see smoke in the corridor? ☐ Yes ☐ No
    If yes, at what time? _____ On what floor? _____
    What was the colour of the smoke? _____
    How many feet could you see through the smoke?

42. Did you see smoke in the staircase? ☐ Yes ☐ No
    If yes, at what time? _____ On what floor? _____ _____
    What was the colour of the smoke? _____
    How many feet could you see through the smoke?

43. Did you encounter any heat in your unit? ☐ Yes ☐ No

44. Did you encounter any heat during your evacuation? ☐ Yes ☐ No
    If yes, did you have to turn back because of this heat? ☐ Yes ☐ No

45. Did you notice any illuminated exit signs? ☐ Yes ☐ No
    If yes, where?

46. While leaving, were the lights on in the corridors? ☐ Yes ☐ No
    If no, where was it?

47. While leaving, were the lights on in the staircases? ☐ Yes ☐ No
    If no, where was it?

SECTION 6: Rescue Effort

48. Were you asked to evacuate by the firefighters? ☐ Yes ☐ No
    If yes, what time was it? _____ How sure are you of the time? _____
    What instructions did you receive?

49. During your evacuation, did you encounter firefighters in the corridor? ☐ Yes ☐ No

50. Did you encounter firefighters in the staircases? ☐ Yes ☐ No

51. Did the firefighting equipment impede your evacuation movement? ☐ Yes ☐ No
    If yes, where was that... ☐ corridor ☐ staircase At what level?

SECTION 7: Fire Safety Knowledge and Experience

52. Did you have previous information on actions to take in a fire situation?
    ☐ at school ☐ at work ☐ publication
    ☐ radio, TV ☐ other ☐ no information

53. How long have you been living in the Forest Laneway building?

54. Were you aware of the evacuation procedure for the building? ☐ Yes ☐ No
    If yes, where did you get this information?_____
    What was the evacuation procedure?_____

55. Did you participate in a fire drill in this building? ☐ Yes ☐ No
    If yes, when?

56. Have you been aware of false alarms in the building? ☐ Yes ☐ No
    If yes, how many during the last year?

57. Have you ever used the stairs prior to this fire? ☐ Yes ☐ No

58. How many separate staircases are there in the building at 2 Forest Laneway?

59. In general, do you think it is a good idea in a fire to try to exit to the roof? ☐ Yes ☐ No

60. Prior to that fire did you think you could exit onto the roof of your building? ☐ Yes ☐ No
    If yes, why?

61. Have you ever experienced a fire before? ☐ Yes ☐ No
    If yes, when was that?

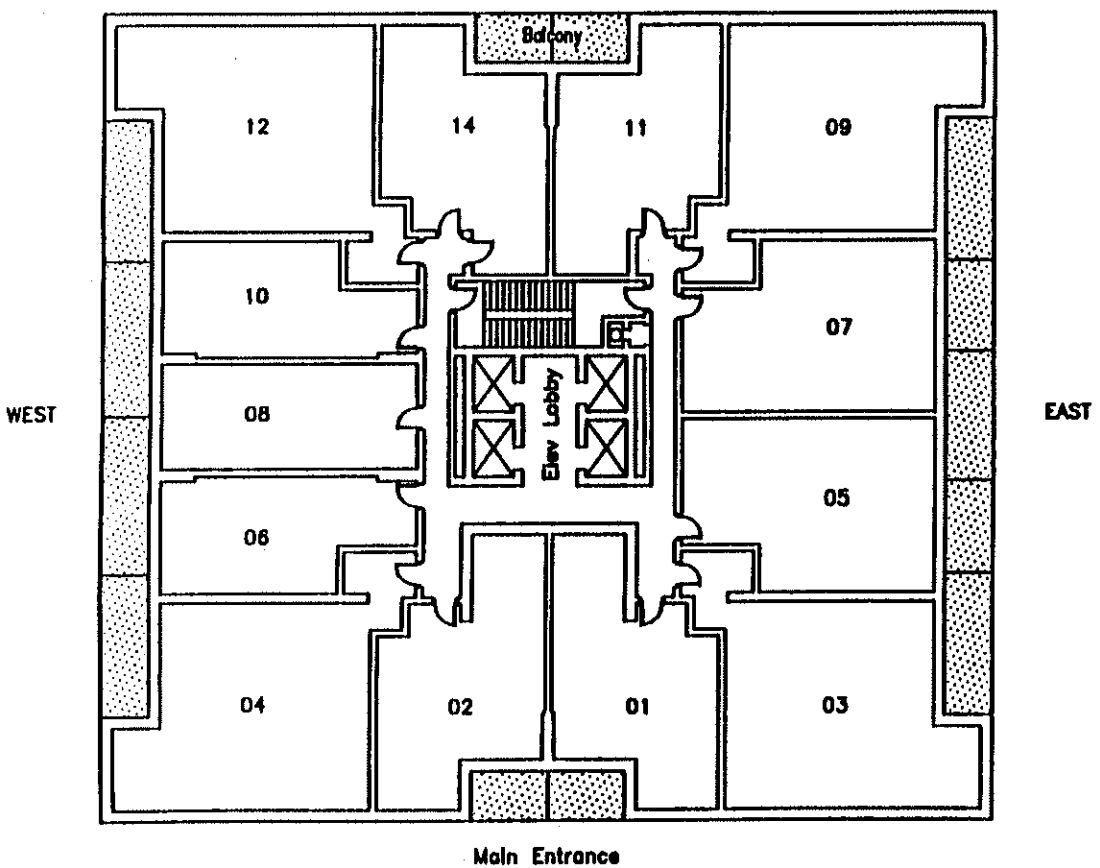
62. Were you or someone of your unit injured during this fire? ☐ Yes ☐ No
    If yes who was injured, give occupant(s) number(s) as listed in question 2:_____
    What was the injury?

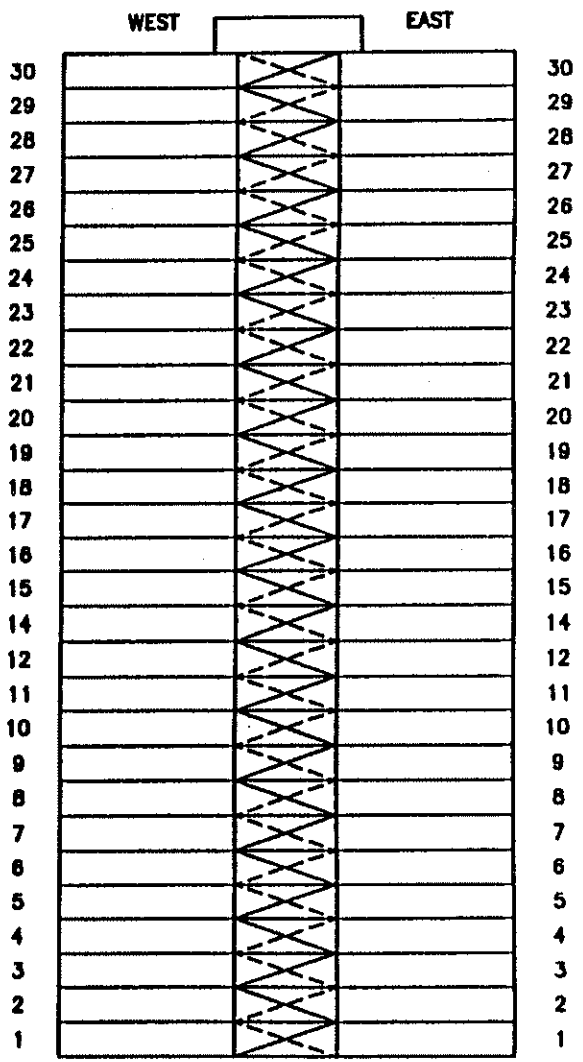
63. During this whole fire experience, how would you describe your feelings?
    ☐ not very concerned ☐ unable to decide what to do
    ☐ anxious, but in control ☐ panicky and unable to think clearly

64. Did you seek assistance to deal with the emotional stress of this event? ☐ Yes ☐ No
    For example: ☐ psychologist-psychiatrist ☐ medical doctor
    ☐ priest or spiritual counsellor ☐ other

SECTION 8: Your Evacuation Movement

Use the plans provided to draw your evacuation movement. Make sure you identify the location of the unit you left and the staircase you used to leave the building. Add any written comments that could make your sketch easier to understand. If you have difficulty using the building plans, simply describe how you evacuated the building on the back of the sheet.





Thank you for your participation.

If you wish to receive a free copy of the report on the findings from this Human Behaviour Study, please provide your name, address and phone number. The report will be sent to you in a few months, after the Coroner's inquest.

Tel. ( ) _____

_____

_____

_____

_____

Please return this questionnaire as soon as possible in the prepaid envelope enclosed.

Canada