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DIFFERENCES IN THE EVACUATION BEHAVIOUR OF OFFICE AND APARTMENT BUILDING OCCUPANTS

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ABSTRACT

An experiment was designed to observe evacuation times and occupant movement in two office buildings during a simulated fire emergency and to compare these results with previous studies of evacuation drills in apartment buildings. The first office building was six storeys high with approximately 160 occupants and the second one was seven stories high with approximately 500 occupants.

The evacuation drills were recorded using video cameras located throughout the buildings. The results were analyzed with respect to occupant behaviour, occupants' time to start to evacuate, occupants' time to reach an outside exit, and the occupants' speed while traveling in the stairways. A comparison of the results from this office building study with previous studies involving evacuations of midrise and highrise apartment buildings reveals many interesting differences. The physical organization of the buildings, evacuation strategies, and the occupants' characteristics, behaviour and movement are discussed.

INTRODUCTION

In 1992, 401 Canadians perished in fires. Yet, the number of people who die in office building fires in Canada annually is almost insignificant, with only two office building fire fatalities in 1992, and none in 1991. While 44% of the total number of fires occurred in residential buildings, 86% of fire deaths occurred in people's homes (Association of Canadian Fire Marshals and Fire Commissioners, 1993). One is compelled to ask why such a disproportionate number of fire deaths occur in residential buildings and why so few in office building fires. Firstly, office buildings tend to have more fire protection equipment such as sprinklers and smoke control systems. Part of the difference also results from the fact that the different buildings are intended for different activities and there is much more cooking, smoking and use of portable heaters in apartment buildings, all of which are major causes of fire. A large part of the answer, however, lies in an understanding of both the characteristics of occupants and the level of education and fire safety training to which occupants are exposed.

In apartment buildings, occupants may be asleep at the time a fire starts and the alarm sounds, while office occupants are awake at all times. While buildings in which people sleep appear to be inherently more dangerous than those used only during the day (Klem, 1992; Abrahams, 1994), other factors must be examined. Occupants in office buildings are trained through regular fire drills and educated through literature distributed at the workplace. Fire drills are not required in most residential buildings, nor is fire safety information readily available. In addition, office buildings tend to have a fairly homogeneous population of adults, while housing includes people of all ages, from young children to seniors. It has been found that people learn about fire safety primarily at work or at school, and not in the home (Proulx, Pineau, Latour and Stewart, 1995).

The study of evacuation drills in office and apartment buildings is essential to understand the factors that contribute to people's evacuation and to devise plans of action to educate and train people about fire safety.

METHODOLOGY

Before each drill, the researchers met with building security and fire safety personnel and obtained a copy of the building evacuation procedures. In addition, an attempt was made to identify any occupants with limitations that could impede their evacuation. Those identified as having limitations were contacted by researchers prior to the drill but all indicated that they would have no difficulty participating in the drill. Other than these occupants, and the building security and fire safety personnel, no occupant of the office building was informed of the upcoming evacuation drill.

The research involved collecting real data on evacuation times for occupants of office buildings. During each drill, data were collected through 30 video cameras. The cameras recorded such events as the time to respond to the alarm, the location of occupants, occupant movement in the staircases, and occupant behaviour throughout the evacuation. The data

collected from these videotapes was recorded in a transcript and statistical analyses were performed.

The local fire department participated in the drill according to a predetermined fire scenario. The fire was located on the fifth floor, and a designated occupant pulled the alarm on that floor when instructed to do so by the principal researcher. Firefighters arrived in full gear with their trucks. They performed their duties according to their normal procedures for such buildings, locating the origin of the fire alarm and ensuring that all occupants evacuated the building. At this point, the captain gave the 'all clear' signal and occupants were allowed to return to their offices.

After the evacuation drills, a questionnaire was distributed to all occupants of the buildings. Occupants were asked questions pertaining to their initial reaction to the alarm, their evacuation route, and their general level of knowledge about fire safety procedures within the building.

EVACUATION STUDY OF TWO OFFICE BUILDINGS

The two office buildings studied were heritage buildings of 6-7 storeys, located in London and Ottawa, Ontario. A central, single-stage fire alarm system with pull stations on all floors was available in both buildings. Both drills took place on weekday afternoons between 14:00 and 14:15, in order to have the largest possible number of occupants in the buildings. The evacuations were carried out in early Fall of 1995. Both evacuations occurred on overcast days that were seasonably warm.

In the London building, there was a mix of open concept office space and closed private offices. It was essentially rectangular in design and had three staircases. The Ottawa building consisted almost entirely of closed private offices and was designed as a square with two inner courtyards and four staircases, one at each corner of the building. In addition, the London building had a very low occupant load with approximately 180 occupants although it had a floor area of 7544m^2 that could accommodate at least 500 people, while the Ottawa building had about 600 occupants, with a floor area of 18500m^2.

EVACUATION STUDIES OF APARTMENT BUILDINGS

Two other series of evacuation studies were conducted in 1993-1995 collecting real data on time and movement during evacuation drills in midrise and highrise apartment buildings (Proulx, Latour and MacLaurin, 1994; Proulx, Latour, MacLaurin, Pineau and Hoffman, 1995). These studies were undertaken by the National Research Council Canada and Canadian Mortgage and Housing Corporation. The studies looked at four midrise and three highrise apartment buildings. The results of these residential building evacuations are compared to the results of the office building evacuations.

The same methodology was used in conducting all the evacuation drills. The differences between office and apartment building evacuations that could affect the results are included in the results and discussion.

RESULTS: TIME AND SPEED COMPARISONS

Three different evacuation times were calculated: a) Time to Start, b) Time to Exit, and c) Time to Move. The Time to Start represents the amount of time elapsed between the start of the alarm and the moment when one starts to evacuate the building by exiting one's office or apartment. The Time to Exit represents the amount of time elapsed between the start of the alarm and the moment when one exits the building. The Time to Move is the difference between the Time to Start and the Time to Exit; this provides an indication of the time taken by occupants to travel from start to finish, regardless of when and where they started their evacuation. Table 1 summarizes the Times to Start, Exit, and Move as well as the mean speed in the stairs for the apartment and office buildings.

Table 1: Apartment and Office Buildings - Comparisons of Times and Speeds

Type of Building	Building	Mean Times (min)			Mean Speed (m/s)
		Start	Exit	Move	
Midrise Apartment Building	1	2:30	3:05	1:05	0.52
	2	8:22	9:36	1:17	0.54**
	3	9:42	10:57	1:15	0.62
	4	3:08	4:38	1:07	***
Highrise Apartment Building	A	1:30*	3:07	1:43	1.07
	B	2:48	4:34	1:46	1.05
	C	5:19	6:14	1:19	0.95
Office Building	London	0:36	1:47	1:09	0.78
	Ottawa	1:03	2:40	1:44	0.93

* Times are for an evacuation that was stopped prematurely at 5:18 min
** Estimated stair dimensions
*** Unable to determine stair dimensions

The average Time to Start varied tremendously between buildings, with values ranging from 0:36 min to 9:42 min. Evacuation times for the two office buildings were found to have statistically significant differences. Time to Start was much faster in London than in Ottawa, partly because the cooler weather during the Ottawa evacuation caused people to get their coats prior to starting their evacuation and because Ottawa occupants worked primarily in private closed offices while London occupants were in open concept offices and thus immediately observed co-workers starting to evacuate. When comparing the three types of buildings, it appears the fastest Times to Start were clearly found in the office buildings. One explanation is that, in apartment buildings, people are more likely to have to get dressed and locate other people and their valuables prior to evacuating. Questionnaire analysis shows that the primary reason for residents' delay in evacuating apartments is the tendency to gather as a group and locate everyone, such as children and pets, prior to evacuating. In addition, in apartment buildings, people spend a great deal of time searching for information about the alarm and trying to determine what is the best course of action under the given circumstances. In an office building, occupants are relatively prepared to evacuate, with such items as valuables close at hand and clothing such as shoes already on. Most notably, office occupants do not have a responsibility for family members and pets. They also can easily see others evacuating so less time is spent deciding

whether evacuation is the appropriate course of action. Floor fire wardens in office buildings also encourage workers to evacuate quickly.

Variations in the Time to Start can also be accounted for by such things as whether occupants heard the fire alarm, whether occupants heard fire trucks approaching, and the level of fire evacuation procedure knowledge that occupants possessed prior to the drill. Questionnaire results showed that only four people in the office buildings could not hear the fire alarm from their offices. In the midrise apartment buildings, questionnaires showed that, in three of the four buildings, between 17% and 25% of occupants reported that the alarm was not loud enough. Thus, the poor audibility of the alarm in apartment buildings is a cause of the longer start times.

The Times to Move also show some variation, although it is less dramatic than that which is observed in the start times. The fastest consistent Times to Move are found in the midrise apartment buildings. This is understandable since the limited number of storeys meant the occupants did not have far to travel, and the limited number of occupants meant that crowding was not a problem. The slowest consistent Times to Move are found in the highrise apartment buildings. This is also understandable since, while these occupants did not experience crowding, they had the longest mean distance to travel along their evacuation path. The office buildings show the largest variation in Times to Move ranging from a value close to the fastest midrise building, to a value close to the slowest highrise. As a result of the greater delay in starting, and the longer required travel distance from start to exit, the occupants in Ottawa took longer to evacuate than the London occupants. The mean distances traveled in the corridors and the staircases were greater in the Ottawa buildings than in the London building, which substantially increased Ottawa evacuees' Time to Move, compared to London evacuees.

There is variation in Times to Exit among buildings. This could be expected since the time to exit is entirely dependent on the combination of Time to Start and Time to Move and the variations in these times have already been discussed. The office buildings show the fastest evacuation times, and this is primarily a result of their fast Times to Start.

Statistical analysis also showed that the mean speed in the stairs was faster for the occupants in Ottawa than those in London. This result is somewhat unexpected since the staircases in Ottawa were much more crowded than those in London. Observation of the video recordings from the staircases shows that while the Ottawa staircases tended to be more crowded, they also tended to have wider steps which allowed for more people to descend on the same step, and also facilitated the integration of those entering the staircases at various floors into the downward flow of people (Pauls, 1980).

The mean speed in the stairs also shows interesting variations among the three types of buildings. The occupant characteristics of the apartment buildings included many children, elderly residents, and residents with limitations which were not seen in the office buildings. In the apartment buildings, people tended to travel in groups of family and/or friends. In office buildings, although many occupants waited for colleagues at first, they often separated later during the evacuation. The population characteristics of apartment building occupants, and their tendency to travel in groups resulted in very slow mean speeds. The speed of occupants of the

midrise buildings was further reduced as they appeared to know each other well, and were often observed to stop and chat with neighbours. In the highrise buildings, less familiarity was evident between residents and thus people descended at a faster rate. While the office buildings showed little tendency for people to travel in groups and did not have any elderly adults or young children to slow down other occupants, the extreme crowding evident in some stairs caused the mean speeds in the office buildings to fall between those of the midrise and highrise apartment buildings.

DISCUSSION

The comparison of the office building evacuations with previous apartment building evacuations leads to some interesting conclusions. The occupants in apartment buildings took longer than those in office buildings to start their evacuations for a number of reasons. It took apartment residents longer to realize an evacuation was occurring and they spent longer preparing to exit by gathering family, friends, and valuables. The readily audible alarm system in offices is in sharp contrast with the situation in apartment buildings where the poor audibility of the alarm was another cause of the longer start delays.

Occupants in an office building tend to be less reluctant to leave their desks and work than are apartment residents to leave the comfort of their homes where they are engaged in such activities as watching television, cooking or bathing. As well, apartment building occupants might not want to leave until they are properly dressed.

Once people had started to evacuate, the slowest mean speeds in the stairs were found in the midrise apartment buildings where the diverse population included slower children, elderly residents, and people with limitations, and where people tended to pause to chat with neighbours. The fastest speeds were found in the highrise apartment buildings, where crowding was not a factor, and people were able to travel at a constant speed down the stairs. In addition, the highrise occupants did not show the same tendency to chat with neighbours as did the midrise occupants. The mean speeds in the stairs of the office buildings fell between the speeds in midrise and highrise apartment buildings. Although the office buildings did not have children, elderly occupants, or people with limitations to delay others in the stairs, nor did people tend to stop and talk in the stairs, there was crowding which reduced travel speeds in the office buildings.

In the office buildings, the occupants ranged in age from approximately 20 to 60 years of age. There were no significant differences in speed between the adults less than 40 years and over 40 years. In the apartment buildings, however, there were young children and elderly occupants who showed significantly slower speeds than the adults. The mean speeds in the apartment buildings were reduced by the presence of children and the elderly.

The occupants in the apartment buildings often showed a tendency to travel in groups. This caused some people to exit much slower than they would otherwise. Groups tend to travel at the speed of the slowest member and as a result a group with a child or elderly person in it would travel quite slowly. In the office buildings, most people did not travel in groups.

In both office buildings, it was impossible to identify any occupants who were impeded by a visible limitation that could affect their evacuation; in the apartment buildings many such

limitations were observed. It was seen that those with limitations tended to travel slower than those without limitations and this reduced the mean speed of apartment building occupants.

As a result of education and training, people in office buildings tended to start their evacuation faster. In addition, the use of trained occupants as floor fire emergency officers to direct occupants to the exits and encourage them to evacuate quickly was also a contributing factor to the fast evacuation times. The office buildings tended to have a more structured evacuation plan than did the apartment buildings and occupants seemed more aware of proper procedures. Office occupants experience fire drills regularly and many had received instruction in such things as the need to exit immediately upon hearing the alarm, the importance of taking the stairs rather than the elevators, and the identification of the closest exit. While many apartment residents tried to evacuate by the elevators, none of the office occupants did so. This study confirms previous findings that show that people who have received instruction and training are able to evacuate faster and in a more orderly manner than those who are unaware of emergency procedures for the building. This effect is clearly seen in contrasting the office building evacuations with those in the apartment buildings. Nevertheless while some office occupants were clearly well informed, and started evacuating immediately using the closest route of egress and directing others along the way, other occupants spent much time talking to friends and often chose to exit by the most familiar rather than the closest route. In addition, there was some confusion as to the location of the outside meeting point. There is still much room for improvement in the area of fire safety education and training in both apartment and office buildings.

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