Evacuation by elevators: who goes first?

Proulx, G.

Publisher's version / Version de l'éditeur:

Workshop on Use of Elevators in Fires and Other Emergencies [Proceedings], pp. 1-13, 2004-03-01

Evacuation by elevators: who goes first?

Proulx, G.

NRCC-46298

A version of this document is published in / Une version de ce document se trouve dans :
Workshop on the Use of Elevators in Fires and Other Emergencies, Atlanta, Georgia, March 2-4, 2004, pp. 1-13

Workshop on the Use of Elevators in Fires and Other Emergencies, March 2-4, 2004, Atlanta, ASME. http://www.asme.org/cns/elevators/papers.shtml

Evacuation by Elevators: Who Goes First?

Guylène Proulx, Ph.D.

Senior Researcher
Fire Risk Management Program
National Research Council Canada
Ottawa, Ontario Canada K1A 0R6

ABSTRACT

This paper takes the stand that elevator evacuation is inevitable in highrise structures to ensure a fast and efficient evacuation of occupants during emergencies. Assuming that all technical issues are solved, the procedure to use elevators during an actual fire emergency becomes the most critical element to consider. Highrise building occupants are considered capable of following an elevator evacuation procedure as long as instructions are readily available in the building, regular training takes place and information is provided to the occupants during an emergency to support their use of elevators. A research agenda to measure the efficacy of such a procedure is proposed since no evacuation plan should be implemented without proper evaluation by a competent researcher.

Introduction

Highrise buildings are a reality of modern cities. Very few North Americans can claim having never set foot in a highrise structure. Highrise buildings for residential, office, hotel or entertainment purposes are part of our environment and will continue to be built in the future despite alarmist concerns voiced following the events at the World Trade Center (WTC) on September 11, 2001.

Evacuation of highrise buildings has always been a subject of concern. Although passive and active fire protection systems, which meet current codes, provide a very high level of life safety in highrise structures, plans for occupants' movement

to an area of safety in case of fire are essential. Full evacuation is usually not practical in highrise buildings. This is particularly true in high-density buildings, such as office buildings, where limited stairwell capacity would result in congestion, long delays, and could potentially prevent the safe egress of people most at risk: occupants of the fire floor. The standard evacuation procedure for buildings over 25 storeys in building height is rarely a full evacuation. Most highrise buildings are planning for a phased-evacuation or the "stay-in-place" approach and several have refuge areas, staging areas or refugee floors to support these approaches. These approaches have generally been well accepted by occupants as well as fire safety officials and have proven their efficiency in most fires and emergency situations. In theory, these strategies imply that during a fire, not all occupants would evacuate at once from the building but only the occupants in the vicinity of an immediate risk would move to an area of safety. For the phased-evacuation, occupants of the floor where the alarm has been activated, sometimes the floor below and one or two floors above the floor in alarm, would move to the ground or to a refugee floor. Occupants of other floors would initially stay-in-place and might be asked to leave their floor if judged necessary by the fire department. Alternatively, in the stay-in-place approach, all occupants would remain in their compartment, protecting themselves, while only the occupants of the compartment of fire origin would evacuate. The addition of refuge areas, sometimes a specially-designed room but more often a protected elevator lobby, or staging areas located inside the stairwells, are planned for occupants with mobility impairment to wait for rescue.

A decade ago, the potential use of elevators for evacuation was studied in detail and despite the fact that most technical issues seemed solvable, not much progress to implement this alternative for the evacuation of occupants was made in the following years (Klote et al. 1992; Klote & Tamura, 1991). This was the case until the WTC events of September 11th 2001. From that day on, people who work, live or visit, even on rare occasions, highrise structures, became concerned with the possibility of escaping such buildings in case of an

emergency. The significant number of highrise buildings which were totally evacuated on minimal cues in the weeks following September 11th, testifies to the heightened risk perception occupants have now developed. This was an exceptional trigger to revisit the use of elevators for occupant evacuation. Although most physically fit adults can travel down 20 storeys of stairs, it seems that descending 70 or 90 storeys is exceeding the physical capability of many people, particularly when the stairwells are hot and crowded. Full evacuation of highrise buildings over 25 storeys is not only strenuous for occupants, the time required to complete such an evacuation is extremely long. The means to accelerate and increase the efficiency of full occupant evacuation in highrise buildings is to use safe elevators. The future is here. It is now time to discuss how to implement safe elevators. This paper is not aimed at discussing the technical issues but at proposing an occupant interface to ensure the successful use of elevators by occupants during an emergency.

Changing the Policy

Although the public education message has been very consistent over the past 30 years on instructing occupants 'not to use the elevator in case of a fire', changing this policy is possible. Most occupants of buildings equipped with elevators seem to be aware that they are not supposed to use elevators in the case of a fire (Levin & Groner, 1994), however they very rarely know why the use of elevators is forbidden. Some wild ideas of elevator cables burning sending the cabin crashing down are common beliefs for the interdiction of using elevators during fires. Because of this lack of a rational explanation for the interdiction of using elevators, providing an accurate explanation for why and when elevators can be used should help convince the occupants that this new approach is acceptable in specific circumstances.

As an anecdote, during the Forest Laneway fire (Proulx et al., 1995), in a highrise residential building in Toronto, the tenant of the apartment of fire origin and 4

neighbours of the fire floor used an elevator to escape. During the Coroner's inquest they explained that after trying to fight the fire, which became out of control, they ran to the elevator lobby, called the elevator, waited for 'a while' for the car to arrive and rode the elevator down from the 5th floors! They admitted knowing that you shouldn't use an elevator during a fire but since 'it came up' they took it. It is not known if it is the public education and signs posted next to elevators that deter people from attempting to use elevators during fires or the control system that automatically recalls most elevators to the ground upon alarm that prevents people from using elevators during fires. Researchers at the National Research Council Canada, observed in several buildings, occupants who pressed the elevator call button in an attempt to evacuate through that means during evacuation drill studies conducted in midrise and highrise residential and office buildings. In one residential building where the automatic recall of the elevator didn't work ,15% of the evacuees used the elevator to evacuate the building (Proulx et al. 1995).

A preliminary analysis of survivors' media accounts from the WTC in the South Tower on September 11th show that 81% used the stairs to evacuate, 6% used elevators and 13% used a mix of stairs and elevators (Proulx, 2003). The use of elevators took place in the 16.5 minutes of elapse time between the two airplane attacks. At the time, there was no fire in Tower 2 and some occupants judged it safe to use the elevators.

Definitively, there are occupants prepared to use elevators to evacuate buildings right now. This number should easily increase if people are told that it is an acceptable and safe means of egress and if they are trained in this procedure.

The change in policy and message shouldn't be too difficult. Firstly, since most individuals don't understand why they should not be using elevators, it should be possible to change this learned rule by providing a clear message with the rationale for the use or non-use of elevators. Secondly, elevators are the familiar

way in and out of highrise structures, occupants are used to elevators they know how to operate and they will feel comfortable applying a well-run decision plan that they use regularly to exit the building. Thirdly, many occupants of highrises don't want to experience the strain, effort and time necessary to use the stairwells; they would rather use the elevator if they were sure it is safe. Public education and training will be necessary to transfer the knowledge that elevators could be safe during fires: after initial incredulous reactions, it is expected that people will rally pretty easily to this new technology that meets with what individuals want to do.

Elevator Use During Fires: Automatic or Staffed

Some advocates of elevator use during fires have expressed concern regarding civilians operating the elevators. It was felt that lack of training and discipline might be an issue. This is a narrow-minded assessment of occupants' behaviour during an emergency. Several studies on human behaviour have demonstrated that occupants make rational decisions during fires and evacuate in a calm and orderly manner. Properly trained and educated individuals can do an excellent job during an emergency even if they don't face such situations on a regular basis. The important issue here is to adapt the procedure and use of elevators in accordance with well-researched human factors.

Waiting for firefighters to arrive at a highrise building to take control of the elevators is not efficient. Such a delay would waste precious time while occupants on the fire floor are at a very high risk. The fire department's arrival time to the building could be 4-10 minutes after they receive the warning; this is the time when evacuation of the occupants on the fire floor is crucial. Once the fire department arrives at the building, all occupants on the fire floor should be on a fire safe floor or at ground level (Groner & Levin, 1992).

Relying on trained staff in the building to control the movement of the elevator is not a very good solution for most buildings. A floor fire warden or a security guard should not be imposed with such a responsibility of controlling elevator movement. An operator controlling the movement of the elevator from a remote location does not seem to be a much better alternative. For an operator to make decisions based on information provided by panels and computer screens could become fairly complex during an emergency and might lead to errors.

Proposed Management of the Elevator

Here is an automated procedure that seems relatively simple for occupants to use elevators efficiently by themselves during an emergency, which should work for most buildings. All running elevators in the highrise would be programmed to return to the ground floor upon a fire alarm activation to download any occupants already in place in the elevator at the time of alarm activation. A recorded message would be issued inside the elevator to let occupants know that they have to vacate the elevator on the ground floor. Once everybody has exited the elevator, the elevator would automatically move to the fire floor, if the call button has been pushed on that floor and if heat and smoke detectors located in the elevator lobby on the fire floor have not been activated. If smoke or heat detectors are activated in the elevator lobby, a recorded message should be issued telling the occupants on that floor “the elevators will not stop on this floor, proceed to the stairwell”. If the fire floor elevator lobby is safe, the elevator doors will open, letting occupants in. Once the door closes, the elevator would automatically return as an express elevator to the ground floor or sky lobby (refugee floor) without stopping on its way down. The two floors above the fire floor would be served next, then the floor below the fire floor, each time only if the call button has been activated on these floors and if the smoke and heat detectors of the elevator lobbies are not activated. After that, all the floors above the fire floor could be served successively. Floors below the fire floor would be

served last since occupants below the fire floor are unlikely to be at immediate risk.

Elevator Movement Panel

It is very important that the elevator lobby be equipped with a panel showing the elevators' movement so that occupants can visualize the location of each elevator and assess the time to be served. This display could alleviate the impatience and worry of occupants who will want to know if the elevators are moving, where the elevators are and if they are soon to arrive.

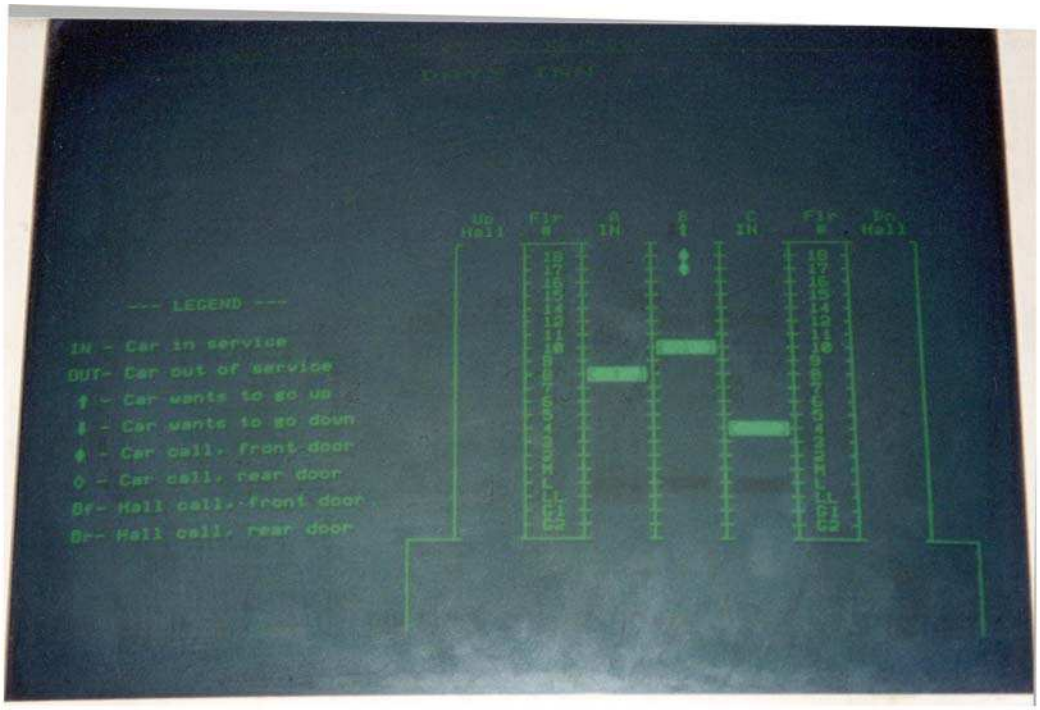

Figure 1: Computer screen displaying the elevator cars' movement to occupants waiting for the elevator. Holiday Inn Midtown, New York City 2003.

Since occupants will have to wait for an elevator, they need a safe environment shut off from the rest of the floor by a fire door. This door should be equipped

with a window so that waiting occupants can have a look at the status of the corridor leading to the elevator lobby without having to open the door. This elevator lobby should also have an adjacent stairwell equipped with a fire door and a window allowing a view of the conditions in the stairs and for the stairwell users to see the conditions in the elevator lobby. In the elevator lobby, a two-way communication system will be essential, as well as, a few chairs and a cabinet with a first-aid kit.

Who Can Use the Elevator?

The occupants of the fire floor are the occupants at the highest risk and should be the ones to be evacuated first by the elevators. In particular, occupants with mobility limitations should be evacuated by the elevators; admittedly these occupants cannot use the stairs to reach an area of safety, therefore, they have to be carried down by co-workers or remain in-place to be rescued. If the fire is on that floor, occupants who can physically evacuate are very likely to leave immediately by the stairs. Nevertheless, any occupant who wants to use the elevator to evacuate should be allowed to do so. It should be expected that occupants who are physically able to move down the stairs will want to use the stairs to leave and it should be the privileged procedure for them. However, anyone who wants to evacuate by elevator should be allowed to do so. The organized, calm and altruistic demeanor people have demonstrated during major emergencies, such as the evacuation of the twin towers at the WTC, demonstrate that it is very unlikely that occupants insist on using the elevator if they can evacuate by other means.

The occupants on the floors where the only cue of an emergency is the sound of the fire alarm signal, the visual strobe and possibly some instructions to evacuate by the voice communication system, might be the floors where many occupants decide to wait for the elevator. Such cues are considered not particularly urgent

by most people, which may justify a decision to wait, even for several minutes, for the elevator to leave the easy way.

Assessing the Evacuation Strategy

The evacuation strategy of a building is based on three elements: the occupants' characteristics, the building characteristics and the fire scenario considered. Among the characteristics of the occupants that will have an impact on the evacuation procedure are the density, familiarity with the building, physical capabilities, etc. These characteristics are described in the SFPE Engineering Guide on Human Behavior in Fire (2003). Further, the building characteristics will be considered. The type of occupancy, number of floors, number and width of stairwells as well as fire safety features such as sprinklers, fire doors, refuge areas etc, all need to be taken into account when developing the evacuation strategy (Proulx, 1999). Finally, fire scenarios will be devised to assess the potential efficiency of an evacuation strategy when varying the type and location of incidents, the time of occurrence, the potential for system failure, etc. Rarely before the events at the WTC on September 11, 2001, was considered a scenario requiring immediate full evacuation of all occupants in a highrise structure. It is now a scenario that should be contemplated among other scenarios. Developing an evacuation strategy that considers the use of elevators as a means of egress should still consider the three elements of the equation: the occupants' characteristics, the building characteristics and several emergency scenarios.

Research Agenda

This proposed evacuation strategy using elevators to evacuate highrise buildings has not been completely researched and even less tested. Before implementation, some studies need to be completed.

Initially, occupants of highrise buildings should be surveyed regarding their actual knowledge regarding the interdiction of using elevators for evacuation and their potential willingness to accept using elevators if they were specifically-designed to ensure a safe egress. An educational message should be developed to explain that some buildings have safe elevators and others do not. Furthermore, several field studies should be conducted in actual buildings to measure the effectiveness of the procedure. Occupants should be educated and trained, then announced and unannounced evacuation drills should take place. Readjustment of the strategy might require several reiterations of the drills for different types of occupancy and occupants.

The success of evacuation by elevators relies on one essential element: communication. Communication should take place in the form of training, evacuation procedure manual and signs posted in the elevator lobby and inside elevator cars. Further communication takes place during actual evacuation drills and practices where all systems are put in function and every occupant participates. Finally, communication takes place during an actual emergency. Voice communication is used to inform occupants of the situation and the elevator movement control panel allows occupants to visualize the location of each elevator car.

Conclusions

Although passive and active fire protection systems, which meet current codes, provide a very high level of life safety in highrise structures, plans for occupants' movement to an area of safety in case of fire are essential. The standard phased-evacuation procedure which was to move occupants of the fire floor, the floor above and the floor below to a lower floor without proceeding with the simultaneous evacuation of all building occupants is questioned by the public. It is important to stress that this phased-evacuation procedure is still the best approach for most fire emergencies in terms of time, efficiency and safety to the

overall occupants. However the WTC events have marked the imagination of the public who no longer wants to apply the phased-evacuation in a highrise building if there is a fire or even a suspected fire somewhere. The approach to 'protect in place' which is probably safer than evacuation in most highrise residential or hotel fires, may not work either since the events of September 11, 2001 (Proulx, 2001). If there is a potential emergency, the public has decided that they want to leave the building no matter its size or height. It is important to take this public demand into account otherwise the strategies in place might very well be disregarded during an actual emergency which could lead to a disastrous outcome. Further, building owners and occupants might decide to buy these parachutes, ropes or slides which will give them a false sense of safety and may lead to foolish accidents if used.

Evacuation by elevator, or a combination of elevators and stairs, are the only efficient methods to completely evacuate a building if full highrise evacuation is to be planned and implemented (Kuligowski, 2003). Full evacuation by stairs only is neither practical nor workable in buildings over 25 storeys in building height. Increasing the stairwell width by a few centimeters or inches is generally not enough to dramatically change the overall evacuation time, particularly if the width of the exit doors is not enlarged accordingly. It is usually not financially viable to consider increasing the number of stairwells to 3, 4, or 5 stairwells, which is the approach that could truly make a difference in evacuation time. However, two properly-sized stairwells, with the use of elevators to evacuate a highrise building, could end up in a fast, efficient and safe evacuation for all occupants.

REFERENCES

Groner, N.E., Levin, B.M., 1992, Human Factors Considerations in the Potential for Using Elevators in Building Emergency Evacuation Plans, National Institute of Standards and Technology, U.S. Department of Commerce, Gaithersburg, MD, NIST-GCR-92-615.

Klote, J.H., Alvord, D.M., Levin, B.M. and Groner, N.E. 1992, Feasibility and Design Considerations of Emergency Evacuation by Elevators, National Institute of Standards and Technology, Gaithersburg, MD, NISTIR 4870.

Klote, J.H., & Tamura, G. T., 1991, Design of Elevator Smoke Control Systems for Fire Evacuation, ASHRAE Transactions, Vol. 97, No. 2, pp. 634-642.

Kuligowski, E., 2003, "Elevators for Occupant Evacuation and Fire Department Access", Proceedings of the CIB-CTBUH International Conference on Tall Buildings, 20-23 October 2003, Kuala Lumpur (to be published).

Levin, B.M., Groner, N.E., 1994, Human Factors considerations for the Potential Use of Elevators for Fire Evacuation of FAA air Traffic Control Towers, National Institute of Standards and Technology, U.S. Department of Commerce, Gaithersburg, MD, NIST-GCR-94-656.

Proulx, G., 2003, " Researchers Learn form World Trade Center Survivor's Accounts", Construction Innovation, March 2003, Vol. 8, No. 1, http://irc.nrc-cnrc.gc.ca/newsletter/v8no1/survivors_e.html

Proulx, G., 1999, 'Occupant Response to Fire Alarm Signals', Bunker & Moore (Eds), National Fire Alarm Code Handbook, NFPA 72, NFPA, Quincy MA, pp. 403-412.

Proulx, G, Pineau, J, Latour, J. C, Stewart, L, 1995, "Study of the Occupants' Behaviour During the 2 Forest Laneway Fire in North York, Ontario on January 6, 1995", IRC-IR-705, Internal Report, Institute for Research in Construction, National, Research Council Canada, Ottawa, 74 p

Proulx, G, Latour, J.C. McLaurin, J.W., Pineau, 1995, "Housing Evacuation of Mixed Abilities Occupants in Highrise Buildings", IRC-IR-706, Internal Report, Institute for Research in Construction, National, Research Council Canada, Ottawa, 92 p

SFPE Engineering Guide, Human Behavior in Fire, June 2003, Society of Fire Protection Engineers, Bethesda MD.

