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A Comparison of the 1993 and 2001 Evacuations of the World Trade Center

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Introduction

After the World Trade Center in New York City was bombed in 1993, the National Fire Protection Association (NFPA) and the National Research Council of Canada (NRCC) undertook a study of the evacuation of the towers. This study involved a survey of the participants in the fire safety plan for the towers, including particularly the floor fire wardens. Surveys were sent to a total of 1,598 employees, with over 400 responding. These surveys were the basis of several papers published on the actions and reactions of the occupants of the towers during that evacuation.

Immediately after the attack on the World Trade Center on September 11, 2001, the authors began compiling first-person accounts from the media describing the evacuation of the two towers that day. Although media accounts are not necessarily reliable accounts of events, and certainly do not provide the scientific rigor of a proper study, they do provide important insights into the events of the day. Of particular interest was the role that improvements made after the bombing in 1993 may have had in the evacuation in 2001.

Summary of 1993 Evacuation

On February 26, 1993, a bomb in a truck parked on a basement level below the World Trade Center plaza exploded, killing six people who were on the basement level. The resulting fire was confined to 25-30 vehicles, but smoke and dust migrated throughout the two towers. The complex's emergency communication systems were damaged in the fire and the power was disrupted. Occupants of both towers evacuated, in some cases taking hours to make their way out of the darkened building.

The NFPA and NRCC, with additional funding from the National Institute of Standards and Technology (NIST), undertook a study of the evacuation of the towers. The goals of the study were to:

- use a scientific approach to gain an understanding of the dynamic interaction of human behavior, the physical environment and the products of combustion;
- identify and quantify escape modes and routes taken;
- document the hazardous conditions as perceived by the occupants; and
- develop findings for fire safety procedures and educational efforts.

With the support and cooperation of the Port Authority of New York and New Jersey, the authors were able to contact the 1,598 members of the fire safety team of the two towers. Because they could not be contacted until they had moved back into their offices in the towers, the surveys were not distributed until 5-6 months after the event. A total of 406 usable surveys were returned.

The results of the study have been summarized in several papers and only some key findings will be listed here[1]:

- There were significant differences in perception of severity of the incident initially from occupants of the two towers;
- There were no significant differences in perception and response according to gender or age;
- People were found to be prepared to move through smoke even if they thought they might be heading toward the fire;
- Most occupants evacuated in total darkness;
- The mean time to start evacuation after initial awareness of the incident was 15 minutes for Tower 1 occupants and 35 minutes for Tower 2 occupants; and
- Less than 10 percent of the occupants had participated in drills.

After the bombing incident, many improvements were made in the World Trade Center towers, including:

- Voice communication on each floor was improved;
- Photoluminescent paint was used to mark the stairs and to illuminate the travel paths in the stairwells and crossovers;
- Photoluminescent signs in the stairs indicated the floor level and the location of the nearest unlocked doors onto the floors;
- Battery packs were added to the emergency lights on the stairs;
- Drills were held every six months with staff training;
- Evacuation chairs were provided for each disabled employee in the building;
- A backup power supply was added for emergency systems; and
- A fire command post was positioned in each tower lobby.

Summary of 2001 Evacuation from First-Person Accounts

On September 11, 2001, an estimated 10-14 thousand workers were in the twin towers of the World Trade Center when they were struck by commercial airliners. Although there had been strong indications that a study using a questionnaire-based survey similar to the one used in 1993 would be funded, the authors undertook the compilation of as large a number of first-person accounts as possible so that at least a summary, overview study would be completed.

Information on the evacuation of the towers that day was obtained from newspapers, radio, television, websites and email exchanges. There has been excellent, extensive reporting in both the *New York Times* and *USA Today*. A documentary film was broadcast on CBS[2] and many interviews can be found on websites such as CNN. More than 250 of these first-person accounts were obtained by the authors.

Before discussing the information obtained from these media accounts, some limitations on the use of media accounts must be described. First and foremost, journalism is not research. We do not know the questions that were asked in the interviews. The questions will vary from journalist to journalist and interviewee to interviewee. There is no way to know how much or how little of the information gleaned in the interview was left unreported. Many media outlets emphasize sensationalism over details. It is impossible to know how accurate the reporting is. Many anecdotes may be reported, but there is no context with which those experiences can be generalized. Sometimes essential information, such as the floor or the tower where the person was located, is missing from the story. Finally, it can be difficult to separate "facts" from speculation.

None of this is meant to imply that more rigorous research methods, including both surveys and interviews, are foolproof. But there are controls in place that are meant to provide consistency. The samples are selected so that reported data can be generalized over the larger population. The same questions are asked so that the same information can be obtained from every study subject. The questions are designed to be unbiased and are asked carefully so that the subject is not led to follow a certain line of thought.

One of the best overall summaries of the evacuation was published in *USA Today*.[3] That report showed where the fatalities in the two towers occurred, and included additional first person accounts. The *New York Times* has also published a detailed piece on the experiences of building occupants trapped above the points of impact in the towers.[4] CNN's website (www.cnn.com) has had numerous accounts and video clips of interviews available for viewing.

According to the *USA Today* article mentioned above, no one located above the point of impact in Tower 1 survived. According to the article, there were 5,000 to 7,000 people in each tower, and 99 percent of those located below the impact points were able to escape. Tower 1 was struck at 8:46 between the 92nd and 98th floors and collapsed one hour and 42 minutes later. Occupants in the tower below the impact point began to evacuate promptly. The three stairwells were not used proportionally, and crowding reportedly began to occur around the 30th floor. Occupants reported a strong smell of fuel, and said they encountered water on the stairs on lower floors. Some floors had no lights. Many occupants of Tower 1 were never aware of the events involving Tower 2. Among the survivors from the highest floor (91st), a 63-year-old man left the building in about one hour.

Tower 2 was struck at 9:03 between the 78th and 84th floors and collapsed 56 minutes later. Many of the occupants began their evacuation immediately after the first aircraft struck Tower 1, giving them one hour and 12 minutes to escape before Tower 2 collapsed. Voice communication messages told occupants, before Tower 2 was struck, that the building was secure and that they could remain in the building, but few occupants heeded the announcement and returned to work. Crowding reportedly began to occur at around the 50th floor and water was reported on the stairs on the lower floors. As in Tower 1, the three stairwells were not used proportionally. Reportedly, one of the stairwells was unobstructed by damage and debris, but unfortunately, only a few people were able to use that stairwell to escape from above the impact point.

Comparison of the 1993 and 2001 Evacuations

This paper will focus on a small number of issues for which useful levels of details are available from the first-person accounts. These include: initial awareness of the event, perception of severity, announcements, delay times and evacuation times.

Initial Awareness of the Event and Perception of Severity

In 1993, the explosion was the first cue for the majority of occupants in both towers (84.0 percent in Tower 1 and 73.9 percent in Tower 2). Only 28 percent of the occupants of Tower 1 and 18 percent in Tower 2 thought the situation was extremely serious. At the same time, 33 percent of the occupants of Tower 1 and 44 percent in Tower 2 thought the situation was no more than slightly serious.

As mentioned above, although there were significant differences in perception of severity of the incident initially from occupants of the two towers, there were no significant differences according to gender, age or location in the tower. However, respondents were more likely to

consider the incident serious if they were first alerted by the explosion than if their first cue was the loss of electrical power.

On September 11th, the occupants of both towers were presented with more powerful cues. Occupants in Tower 1 were most likely to report the impact, explosions and building swaying as their first cues. Occupants in Tower 2 were more likely to report the explosion, fireball or flames and debris. The cues reported seemed to vary with the location of the occupants in the tower, with those closer to the impact point reporting far less ambiguity and more awareness of the seriousness of the situation. But many occupants reported that they did not fully realize what had happened until they were outside the building, unless they had access to information from the media. Many reported believing that a commuter plane or helicopter had struck the building.

Interestingly, even some occupants on fairly high floors in Tower 2 did not see or hear anything to indicate a problem. One worker on the 93rd floor of Tower 2 happened to look past the receptionist, out the window, and was surprised to see paper floating in the air that high up. Immediately after that, he heard other building occupants moving in the stairwells and realized that people were evacuating.

Some of the variation in response can be explained by the variety of floorplan layouts in use through the towers. Some of the floors had offices around the perimeter of the floor, leaving little view out windows for those located closer to the core. Other floors used an open floorplan with workers in cubicles, allowing easier visual access out the windows throughout the floors.

Announcements

In 1993, no announcements were made to the building occupants, because the communications system on one of the basement levels had been destroyed in the bomb blast. The occupants had been trained to go to the voice annunciator in an emergency and await further instructions. That day, those instructions never came.

On September 11th, announcements were made over bullhorns and voice communication systems. In Tower 2, sometime between the moment Tower 1 was struck and before Tower 2 was attacked, a message came over the public address system telling people that the problem was confined to Tower 1 and that it was safe for them to return or stay in their offices. The exact wording of the PA announcement was not published in the media, and there were wide variations reported in interviews. In most cases, people continued on their way out of the building and reported that most people around them did the same.

”Commitment" is an occupant factor frequently reported as affecting an individual's response to fire cues.[5] For example, a person who has just been served dinner in a restaurant will be reluctant to abandon his meal to evacuate the building when an alarm sounds. On September 11th, the people who had decided to evacuate Tower 2, already knowing that an event affected Tower 1, may have been committed to their decision and, if so, were not deterred by the announcement so they carried on. Others who either stayed at their desks, or began to evacuate with some reluctance or reservation, may have felt that the announcement reinforced their decision to stay or gave them the "permission" they needed to return to work.

Delay times

In 1993, building occupants in Tower 1 reported delays of as long as four hours, and in Tower 2 of 3 hours, from the time they first became aware of the fire, until they began their evacuation. The median delay times were five minutes in Tower 1 and 10 minutes in Tower 2. The combination of ambiguous cues, lack of information and instruction, smoke and crowdedness in

the stairwells and lack of lights contributed to the delay. Some building occupants were instructed by their company management to wait for assistance.

On September 11th, many occupants in Tower 1 reported leaving "immediately" while others reported "routine" activities, such as gathering their belongings, or some other short delay. However, some delayed as long as 20 minutes or more before beginning evacuation. Some were floor wardens who searched their areas to make sure everyone had evacuated. Others were stopped by smoke conditions, or needed assistance of other employees to locate the stairs. Some people kept working, were told to wait or were waiting for instructions or more information.

Most of the accounts of people in Tower 2 reported that they left right after Tower 1 was struck. Only three of the accounts were from people who waited until the second plane hit their building. Once Tower 2 was struck, no one reported further delaying their evacuation. Of the three people who stayed after Tower 1 was struck, one had learned from television coverage that only Tower 1 was affected; and another returned to his office after the announcement that the building was safe.

Evacuation Times

In 1993, the evacuation movement time varied from a few minutes to more than 3 hours. The table below shows the reported evacuation movement times for the survey respondents. These times reflect the time it took them to leave the building once they began their evacuation; they are not the elapsed time from the onset of the incident. The movement times for the occupants in Tower 2 were generally shorter because so many waited until the situation was stabilized and the evacuation was better assisted.

Evacuation Movement Time for the Two Towers in 1993

Time	Tower 1		Tower 2		Total	
Less than 5 minutes	2	0.9 %	1	0.7 %	3	0.8 %
5 to 30 minutes	28	12.9	35	23.5	63	17.2
30 minutes to 1 hour	56	25.8	71	47.7	127	34.7
1 to 3 hours	114	52.5	42	28.2	156	42.8
Over 3 hours	17	7.8	0	0.0	17	4.8
Other	5	-	3	-	8	-
No answer	3	-	5	-	8	-
Total	225	100.0 %	157	100.0 %	382	100.0 %

Percentages exclude "Other" and "No answer" responses.

On September 11th, the occupants of Tower 1 had one hour and 42 minutes to leave the building before the collapse. People on the 90th and 91st floors reported leaving the building in as little as 45 minutes. In 1993, the median evacuation time from the 90th floor was 2.5 hours. No one evacuated in less than two hours. If conditions in the stairs had been the same as in 1993, far more people would have been killed.

In Tower 2, building occupants had less than one hour to evacuate after their building was struck. In 1993, many evacuated in an hour or less because they waited until conditions improved and evacuated under less difficult conditions than the occupants of Tower 1.

On September 11th, there were several reports of fairly rapid evacuations of even severely burned victims. One account from Tower 1 reported that hundreds of people in the stairs stepped aside so that she and the severely burned woman she was assisting could pass. She reported moving from the 78th floor to the outside in less than 20 minutes.

Conclusions

A review of the first person accounts in the media highlighted some of the changes in public perception of risk in high-rise buildings that will have to be addressed in the coming months. To what degree has the perception of the risk in high-rise buildings changed since September 11th? Are people willing to live and work in high-rise buildings? Will fears dissipate over time? Will there be a long-term impact on people's willingness to follow plans in their building for a phased evacuation or defend-in-place strategy? Will everyone want to evacuate a high-rise building at every hint of a threat, or an actual easily managed incident? Does the general public now believe that the collapse of a high-rise building is an inevitable consequence of fire? Will people follow instructions telling them to remain in their offices, or will they insist on leaving, no matter what? Will people be unwilling to serve as fire wardens or in other roles on their company's emergency response team?

If time shows that people are unwilling to comply with previously accepted procedures and instructions, that will have implications for the design of high-rise buildings. Maximum heights and occupancy loads will have to be reduced. A larger number of stairways will have to be provided, or capacity will have to be increased by changes in design. Elevator safe to use in fire situations will have to become commonplace. There will be a need for refuge areas and refuge floors in high-rise buildings so that people who cannot get all the way out of the building will be able to retreat to a secure area.

The review of first-person accounts also provided some positive information. The improvements made in the egress system of the towers appear to have helped. Movement out of the building continued under difficult conditions. Most people reported that others remained calm and demonstrated many altruistic behaviors.

A second study of the evacuation on September 11th is now underway, utilizing a structured questionnaire that will be sent to a small number of companies formerly located at three strata in the two towers. It is hoped that that study will build on the findings from the review of first-person accounts and provide more detailed information on what worked in the evacuation and what could be improved to make occupants of high-rise buildings safer in emergencies.

In conclusion, the comparison of the 1993 survey results and the September 11 media accounts indicate that:

- people judged the situation serious in both incidents although they did not know what exactly had happened;
- there was less delay in starting evacuation on September 11th, which proved to be a good decision. In 1993, occupants were better off to either start right away or wait a few hours for the crowds and smoke to clear;
- if the conditions of the 1993 evacuation had existed on September 11th, far more people would have perished; and
- the improvements made to the buildings, the training received, the behavior of the occupants, the visibility conditions along the evacuation routes, and the low occupancy

all contributed to allow nearly all of the occupants present below the impact points to escape on September 11th.

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