

Lifts for Evacuation – Human Behaviour Considerations

Emma Heyes^{1*} and Michael Spearpoint²

¹Arup Fire, Australia

²University of Canterbury, New Zealand

ABSTRACT

The concept of using lifts for evacuation from high rise buildings in fires and other emergency events is gaining momentum around the world, with the recent inclusion of clauses in the International Building Code (IBC) to regulate the design of such lifts and a growing number of buildings incorporating this new technology. To predict the time that a building will take to be fully evacuated in an emergency and to design lift systems capable of dealing with the demand, building designers need an understanding of the likely exiting behaviour of occupants.

Due to the inherent difficulties of carrying out research in human behaviour, a number of approaches have been used to try to address these issues. These include carrying out a number of surveys and comparing results to data from past fire events where the lifts have been used for evacuation. The results from this work suggest that the split of occupants using the stairs or lifts to evacuate is governed predominantly by floor level of the occupant. In addition, it has been shown that it is unreasonable to expect that occupants will wait indefinitely for a lift to arrive in an emergency situation if they are given no information about the likely waiting time. The drop-off in the percentage of occupants that will continue to wait for a lift with increasing waiting time also appears to be dependent on floor height.

It is expected that these results will allow building designers to make more realistic assumptions when designing evacuation strategies incorporating lifts. In addition, it is hoped that a better understanding of the reservations that building users may have about using lifts for evacuation in emergency situations will allow occupant training programmes to be developed to address these concerns.

INTRODUCTION

As buildings become taller and the populations of many countries age and become increasingly obese, lifts used in combination with stairs are seen as a practical way of evacuating large numbers of people efficiently. Recent examples of buildings designed in this manner include the Eureka Tower, Melbourne; The Shaft, London and Stratosphere Tower, Las Vegas. However, there has been very little research carried out on how building occupants will react to the opportunity to use lifts to evacuate from their building in the event of an emergency. Building occupants have been trained for many years that it is not safe to use the lift in the event of a fire, and as such, many may be reluctant to utilize this new technology.

To predict the time that a building will take to be fully evacuated and to design lift systems capable of dealing with the demand, building designers need an understanding of the proportions of occupants using the lifts or the stairs to exit. To date, assumptions have been required to be made about the number of occupants likely to use the lifts versus the stairs with no real basis for the values used. Furthermore, an implicit assumption is that occupants will be willing to wait indefinitely for a lift until it arrives, which may not reflect the actual behaviour of people in such situations. A fuller understanding of the way that occupants will make their exit choice decision and a better grasp of the current attitudes of people towards

the use of lifts for evacuation should be useful to building designers, building managers and those designing evacuation training programmes.

This paper summarises the results found from a research project carried out at the University of Canterbury. The reader is referred to the project report for full details of the project¹.

Research Questions

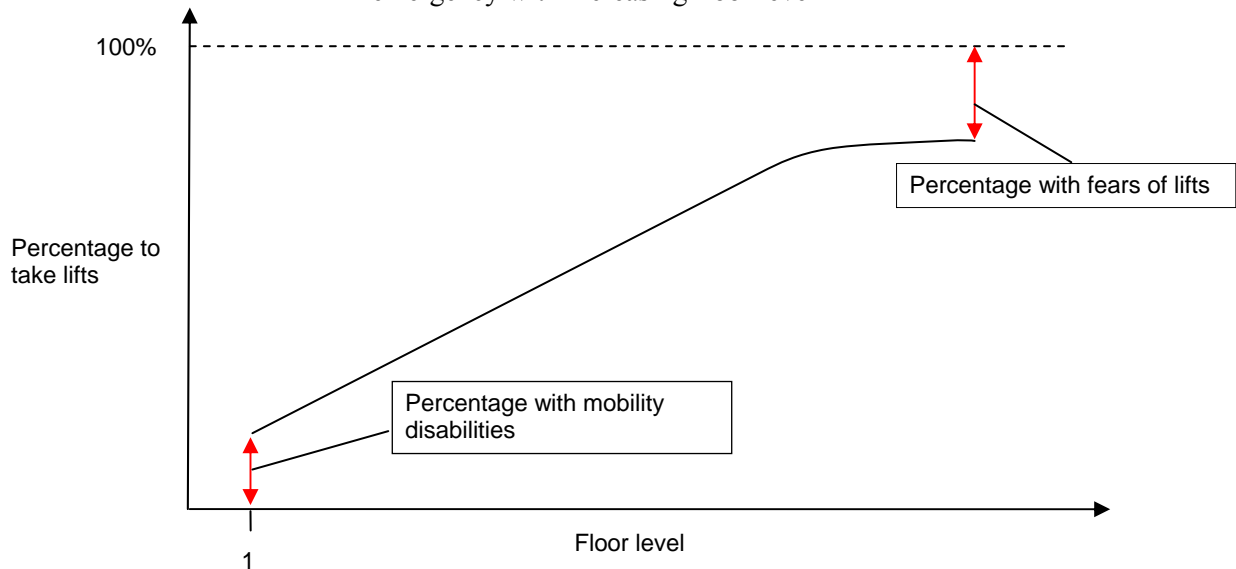
The objective of this project was to explore the likely evacuation behaviour of building occupants in a fire event, and determine the psychological barriers to the use of lifts in a fire. In addition, it was intended to develop parameters that can be used in the design of evacuation systems using lifts and to develop realistic assumptions that can be utilised for evacuation modelling. The project also explored the steps that can be taken by both building designers and building owners to ensure that occupants within a building are provided with sufficient information during a fire event to make an informed choice about their evacuation route.

The research focused on high rise office buildings in which the lifts are designed to be used for evacuation by the majority of building occupants, and not just for those that are unable to use the stairs. The following research questions were addressed in the project:

- What percentage of occupants will use the lift to exit, and what percentage will use the stairs?
- How does this percentage vary with the height of the floor above ground?
- How long are occupants prepared to wait for a lift, given that they are in no immediate danger?
- What factors influence an occupants' decision to use the lift or the stairs?
- What are the main concerns that people have about using lifts for evacuation?

It is hypothesized that the percentage of people that use the lift to evacuate will increase with increasing floor height, as it becomes increasingly difficult to evacuate using the stairs. One part of the proportion of building occupants that will use the lift to evacuate will be those that experience difficulty in walking down many flights of stairs. The other proportion of the building occupants that uses the lift have a genuine choice between the two exit options available to them, and there appears to be little or no information about how many people may choose to use the lift to evacuate. It is also likely that the percentage of people that will use the lift will reach a maximum level at some point, which will be the percentage of people that have a phobia of using lifts or strongly believe that using a lift in a fire or emergency event is unsafe. As such, the hypothesized relationship between floor level and percentage of people to use the lift to evacuate is shown in Figure 1.

Figure 1 - Theoretical distribution of occupants to use the lift to evacuate in an emergency with increasing floor level



In the literature the importance of context on the behaviour of occupants in an emergency situation has been well established. Evaluating the behaviour of occupants in a number of different emergency scenarios was not possible within the scope of the project, and therefore a number of assumptions have been made which are considered to reflect the likely situation of the majority of the occupants in a high rise building in the event of a fire. It is assumed that the occupants work in the building and are familiar with the emergency procedures and location of exits. The occupants are assumed not to be on the fire floor, and are aware that either the lift or the stairs may be used in an emergency. It is assumed that fire wardens are present who instruct the occupants to use either the lift or the stairs, but that they cannot use a combination of the stairs and the lift. Occupants are unable to see fire or smoke, but are alerted to the fire by the occupant warning system and they can see fire brigade appliances arriving at their building.

Due to these assumptions, the results obtained will be limited in their applicability to other situations. Predicting individual responses of occupants in a fire was not the aim of the research, rather an indication of the percentage of respondents that will choose a certain action was determined.

LITERATURE REVIEW

There is very little experimental research that has been carried out on the subject of using lifts for evacuation. Whilst many in the fire engineering community have expressed opinions on the likely behaviour of building occupants where given the opportunity to evacuate using lifts, this has not yet been confirmed by experimental data.

Past Research

NIST carried out interviews with employees at 13 air traffic control towers in the mid-1990's to determine whether occupants would be willing to use lifts for evacuation. It was found that nearly all those interviewed expressed a strong preference for using stairs as the first choice escape route². Occupants did indicate that they would use lifts if required, but the level of hesitation and concern over using the lifts varied significantly between respondents.

Whilst the research carried out by Levin and Groner² on the preferences of FAA tower operators is useful, it is not directly relevant to the scenario of occupants evacuating from a high rise office building in a fire. There are obvious differences between these types of buildings and the type of occupants that work in

them. Also, occupants of a building control tower would only be expected to use the lift for evacuation as a last resort if the stair was unavailable. In the situation of evacuating office towers, it is required to encourage a significant proportion of the occupants to use the lifts so that the whole building can be evacuated more quickly, even if the stairs are available, to limit overcrowding of the stairs and long evacuation times. Despite these limitations to the applicability of this research, Levin and Groner's findings are still the most relevant work done in this area.

Levin and Groner² found that the perceived reliability of lifts in the building control towers had a significant effect on the expressed willingness to use the lifts in an emergency situation. Where the reliability of the lifts had been poor in the past, occupants were unwilling to rely on emergency lifts even when the types of features that would make a lift safe to use in the event of a fire were described. As such, they recommend that in buildings where lifts are to be used for evacuation, the lifts should have a minimum of down time and scheduled maintenance which is publicly announced in advance to increase trust in the machinery.

Levin and Groner also found that there were significant individual differences in the willingness of respondents to use a lift to evacuate from an FAA control tower. Some stated that they would use a lift with little hesitation if the stairway was unavailable, whilst others stated that they would prefer to wait for possible helicopter rescue, use the catwalk, or climb down ladders if available. The majority indicated that they would use the lifts if the stairs were unavailable with little delay but with considerable concern. Many stated that they would prefer to use the stairs even if they contained considerable smoke at the time they entered.

Olley and Freed³ state that their experience has shown that when given the choice to use either lifts or stairs to evacuate, about half of the occupants of tall buildings choose to use the lifts. It is understood that this statement is based on trial evacuations carried out on high rise office buildings in London, where building occupants were warned before the event that a fire drill was to be carried out. As such, whether these results will hold in an actual emergency event is unknown.

Typical Assumptions used in Evacuation Analyses

With the lack of data about the proportion of the building population likely to use the lift or the stairs where both are available in the event of an emergency, assumptions are required to be made by building designers and researchers carrying out evacuation modelling. It was found that a number of papers available in the literature do not provide details of the assumptions made about the percentage of occupants that are assumed to use either the stairs or the lifts. The assumptions used in papers that have provided details of percentage of occupants that are designated to use either the lift or the stairs are outlined here.

In some evacuation modelling, the effect of varying the percentages of occupants that use the lift or the stairs has been tested. For a 36 storey building, Kuligowski and Bukowski⁴ found that the optimal evacuation time was calculated with 3% of occupants on Floors 1 – 13, 100% of occupants on Floors 11 – 14, and 65% of occupants on Floors 15 - 36 using the lifts. For the 13 storey, 18 storey and 7 storey buildings also modelled, it was found that optimal evacuation times were achieved with 100% of occupants from upper storeys using the lifts, and 100% of occupants from lower storeys using the stairs. The extent of the effect of different proportions of occupants using the lift or the stairs on the overall evacuation time was not discussed.

In other cases, the proportion of occupants using the lifts and the stairs is assumed to be equally split, such that 50% of the building occupants use the lifts, and 50% use the stairs⁵. Another approach used is to assign the percentage of the population that is either traditionally classified as mobility impaired, or is a “slow mover” and incapable of evacuating down a large number of flights of stairs to use the lifts.

MacLennan et al.⁶ use a value of 30% of the population that will use the lift, and all others to use the stairs.

In the cases discussed above, the evacuation modelling was carried out to demonstrate the potential effect that using lifts for evacuation would have on overall evacuation times, and not necessarily for design of an appropriate system of an actual building. In design firms, it is understood that typical practice is to assume a proportion of the population to use the lift and the stairs at each level of the building, and then to run sensitivity cases with 100% of the population using the stairs and 100% of the population using the lifts to determine the effect of the assumptions of lift/stairs split. This is considered to be a conservative approach which will address all possible scenarios; however, having an understanding of the likely percentage split will allow designers to determine the effect of an additional lift or additional stair on egress capacity and overall evacuation times.

EXPERIMENTAL METHOD

Due to the inherent difficulties in carrying out experimental work in the field of human behaviour in fire, the proposed methodology for this work utilised four approaches to attempt to address the research questions. Each approach has its own strengths and limitations, but the triangularisation approach allowed overall trends in the use of lifts for evacuation to be uncovered. The four approaches are outlined below.

Post Evacuation-Drill Survey

The University of Canterbury carries out yearly evacuation drills for each of the buildings on campus, to ensure that all staff and students are familiar with the evacuation procedure. Following an evacuation drill, building occupants were asked to complete a questionnaire about their experience of evacuating the building. In addition, this questionnaire also asked questions about whether they would be willing to use lifts to evacuate a building if they were designed for this purpose. It was considered that people that had just participated in an unannounced building evacuation might be better placed to predict their behaviour in a similar situation where lifts were available for evacuation.

The majority of respondents to the survey questionnaire were University of Canterbury students, although some staff also responded to the survey. Of the 100 questionnaires that were distributed at the two buildings where the survey was carried out, 91 of the questionnaires were filled in and returned.

Evacuation Event Simulation Survey

An evacuation event simulation survey was presented to University of Canterbury students at the completion of their lecture. This survey introduced participants to a theoretical ambiguous event by using a PowerPoint presentation which showed pictures of the event and told the event story. It was considered that this might provide a representative response by allowing occupants to think about the information that they would have in such an event. Images were given as the story progressed in an attempt to make it easier for the participants to picture themselves in the situation. Participants were asked to record what actions they would take at different stages in the story.

Participants were assigned to imagine that they worked on the 5th floor, the 30th floor or the 60th floor of a high rise commercial building, and were asked to make responses based on the floor level that they worked on. They were also divided into two groups (educated and uneducated), with the fire safety systems that are used in buildings with lifts for evacuation explained to the “educated” group prior to completing the survey. The participants in the survey were first year engineering students at the University of Canterbury. Overall 229 students participated in this survey.

Online Survey

An online questionnaire was developed to determine respondents' attitudes towards the use of lifts for evacuation, and this was sent to employees of Arup that worked in the Perth, San Francisco and Singapore offices. The questionnaire asked respondents to judge the actions of imaginary characters in a story about an ambiguous potential emergency situation. In addition, the questionnaire also asked about the respondent's own understanding of the emergency procedures in their building, the number of flights of stairs that they would be capable of evacuating down and their main areas of concern in evacuating by either stairs or lifts.

The survey was sent on a link via email to Arup employees in the Perth, Singapore and San Francisco offices. Overall, 138 people responded to the survey, with 38 responses from Perth, 60 responses from San Francisco and 44 responses from Singapore. The overall response rate varied between 22 – 39% of the staff in each office. The majority of respondents were engineers, but not fire engineers.

Bomb Threat Incident

On Wednesday 30th of July 2008, a suspicious package was reported to the police in a car park in Christchurch, New Zealand. As a result, the police cordoned off the street, and a number of buildings were evacuated whilst the package was investigated. It was later determined that the package was not a bomb, but this was not established until several hours after the evacuation of a number of buildings. Building occupants from two of the buildings evacuated were interviewed five days after the incident to determine whether they used the lift or the stairs to evacuate, and the basis for their choice.

Forty-five people were interviewed, representing only between 7.4% and 53% of people on each floor, due to differences in the willingness of companies in the buildings to participate. Not all companies in the buildings chosen agreed to take part in the survey, and it is unknown what the overall response rate for each of the buildings was.

RESULTS

Concerns affecting the use of lift or stairs for evacuation

The concerns that people have about using either the lift or the stairs to evacuate seem to be universal across different population groups tested in Australia, New Zealand, Singapore and the USA via the methods outlined above. The concerns about each evacuation method were relatively consistent regardless of the location of the participants, the stage of life of the respondent (student or professional) and the methodology for asking questions about their concerns.

The most common concerns that occupants cited about using the stairs for evacuation were that smoke or fire would enter the stairs, the stairs would be very crowded, that they may become trapped in the stairs, that the stairs would be slow moving and it would take a long time to reach ground level, that they might slip or trip in the stairs and that the stairs may be dark and difficult to see.

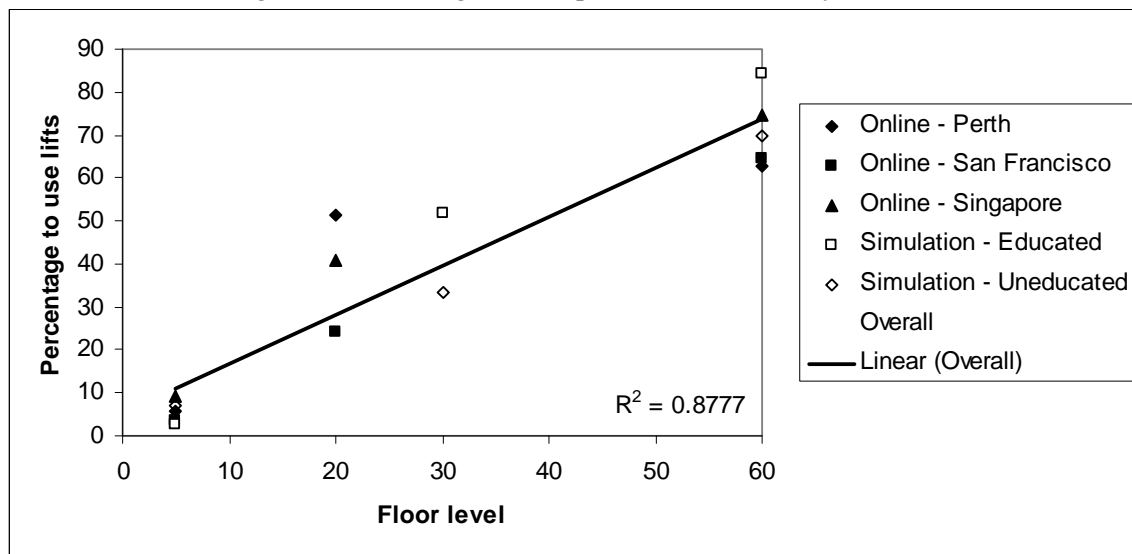
The most common concerns that occupants cited about using the lifts for evacuation were that they could be trapped in the lift, that there could be a power failure, having to wait too long for the lift, that fire or smoke could enter the lift, that one of the components of the lift would fail and that the lift car could fall.

It is considered that these potential hazards associated with lifts for evacuation are already being addressed on the engineering side, but that the mitigation measures and safety features of lifts for evacuation may need to be communicated to the public for them to trust this new technology and to understand why lifts can be used in some buildings and not others.

Percentage of occupants to use the lift to evacuate by floor level

The percentage of occupants to use the lift by floor level has been plotted in Figure 2 for the results of the online survey and the evacuation event simulation survey. It can be seen that there is a clear relationship that with increasing floor level, the number of people that would choose to use the lift to evacuate increases. The results from the online survey and the simulation survey show fairly similar results, especially when it is considered that the data comes from quite different population groups (i.e. students in Christchurch compared to professionals in Perth, Singapore and San Francisco) and from surveys with different question formats and answer response options.

Figure 2 - Percentage of occupants to use the lift by floor level.



Based on the limited number of data points, a linear relationship between floor level and percentage to use the lift seems to be appropriate, and the correlation coefficient of all results is calculated to be 0.88. The linear relationship between floor level and percentage to use the lift which is considered to be valid only in the range tested is:

$$p = 1.14f + 5.3 \quad 5 \leq f \leq 60 \text{ floors}$$

p = Percentage of occupants to use the lift (%)
 f = Floor level of the building

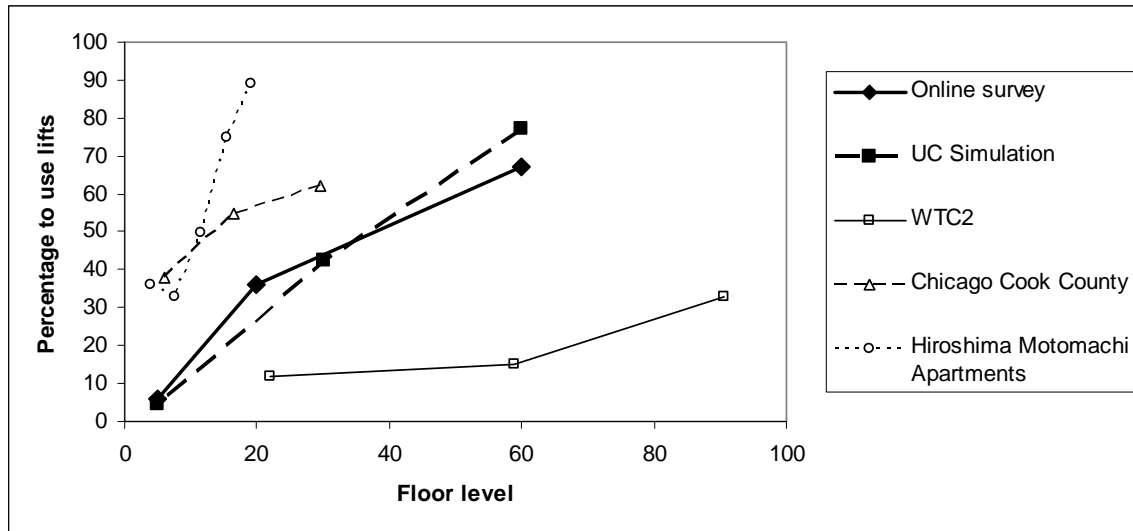
It should be noted that a linear relationship may not be appropriate as the number of floor levels increases above 60. It is possible that with increasing floor level the percentage to choose to use the lift may increase more sharply, and the relationship between floor level and percentage to use the lift may no longer be linear.

The line of best fit suggests that over 50% of occupants would be likely to use a lift to evacuate the building above the 40th floor. In using the line of best fit to predict the percentage of occupants that would use the lift from the first floor, the percentage is calculated as 6.44%. This is within the range that would be expected for the number of occupants with a mobility impairment that typically work in office environments, which was established to be between 3%⁷ and 7%⁸.

The number of people to use the lift to evacuate from different floor levels in the surveys carried out as part of this work have also been compared to the data from actual fire events and these have been plotted in Figure 3. As the literature only provided the percentage of occupants to use the lift or stairs in a range

of floors (i.e. on floors 6 – 9) the mid-floor level has been used to plot these on the same graph as the data from this work. The use of the mid floor level would be appropriate if it can be assumed that there is a linear relationship between the number of people to use the lift and the floor level. In this graph, the results from different groups in the online survey and in the simulation survey have been combined as hypothesis testing generally showed that a significant difference could not be found between these groups.

Figure 3 - Percentage of occupants to use the lift by floor level compared to literature review^{8, 9, 10}



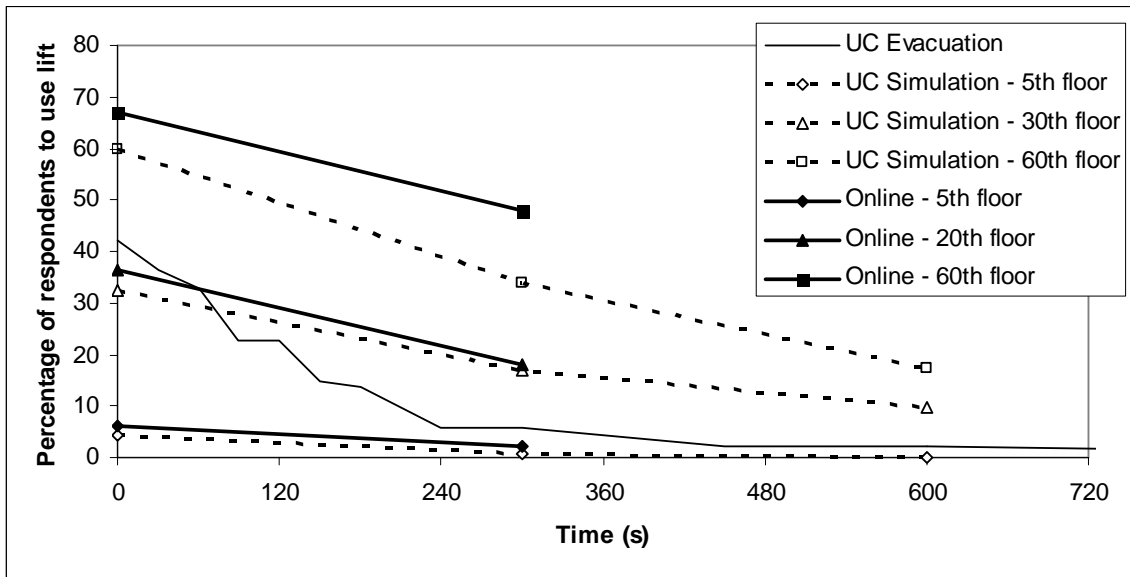
From Figure 3 there are obvious differences between the results from different sources. In all cases, the number of people to use the lift increases with increasing floor level, but there are significant vertical shifts in the percentages of occupants that choose to use the lifts. This difference is likely to be an indication of the importance of the context in determining people’s behaviour in a fire event. The scenario presented to participants in the online survey and the evacuation event simulation survey most closely mimics the Chicago Cook County fire⁸, in that the fire occurred in a commercial office building, the fire alarm sounded, and in the initial stages most occupants did not have any other fire cues and as such were unaware of whether the situation was a real fire or a drill. From the comparison of the results in Figure 3, it can be seen that the data from the Chicago Cook County fire more closely matches that of the simulation surveys than the results from the Hiroshima Motomachi Apartments⁹ or from World Trade Center 2¹⁰.

From the comparison with the available literature, it is clear that the context of the situation plays a large influence on the actions of occupants in a building in an emergency situation. In addition, the results from the bomb threat incident suggest that perhaps the proportion of occupants to use the lift is based not on actual floor level, but their relative floor height compared to the height of the building. Additional work would be required to confirm this. On this basis, it is recommended that engineers designing lifts for evacuation run a number of sensitivity cases to determine the effect of the distribution of occupants using the lifts to evacuate varying on overall evacuation time.

Acceptable waiting time

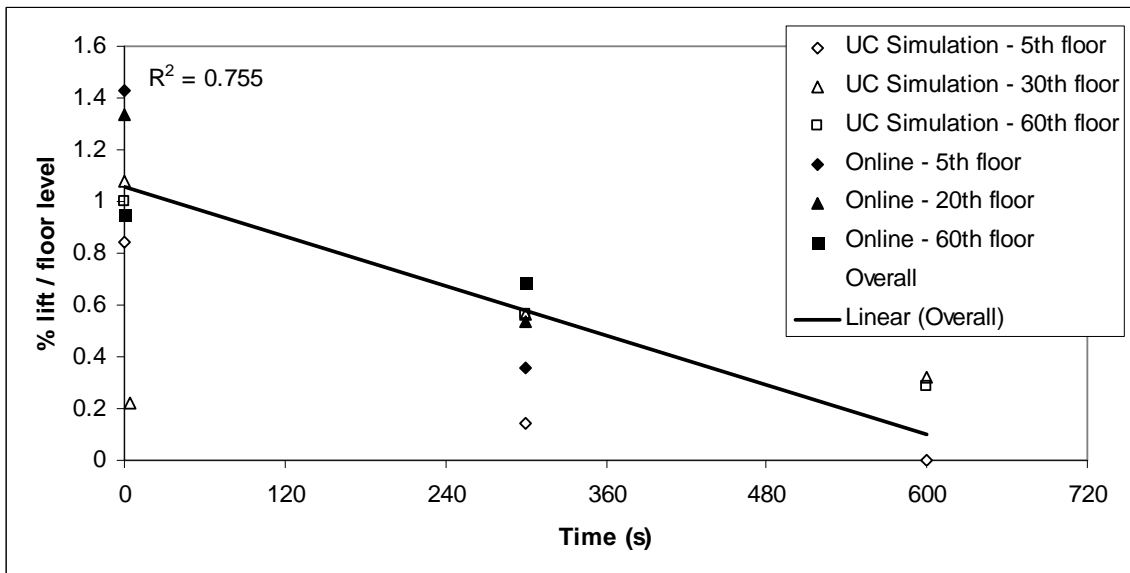
The results of the post-evacuation questionnaire, the online survey and the evacuation event simulation survey have been compared to see how increased waiting time affects the likelihood of occupants using the lifts. In all three cases, the number of people that were prepared to use the lifts to evacuate decreased with increasing waiting time as shown in Figure 4.

Figure 4 - Percentage of people that will use the lift after waiting time.



A curve that estimates the drop in occupants prepared to wait for the lift with increasing waiting time that is independent of floor level would be useful for engineering design calculations. Figure 5 gives the percentage of respondents that indicated that they would use the lift divided by the floor level and plotted against waiting time. It can be seen that an approximately linear relationship can be found, but where all data was included the correlation coefficient is only 0.67. With removal of the data from fire engineers and engineers from the online survey results a better correlation coefficient of 0.76 is obtained.

Figure 5 - Percentage of respondents that would take the lift over floor level as a function of waiting time with data from fire engineers and engineers removed from the online survey results



The equation that has found to link the percentage of respondents to use the lift as a function of floor level and waiting time for the data with the results of fire engineers and engineers removed is:

$$p = (-0.0016t + 1.06) \cdot f \quad 5 \leq f \leq 60 \text{ floors ; } 0 \leq t \leq 600 \text{ seconds}$$

p = Percentage of occupants to use the lift (%)

f = Floor level of the building

t = waiting time (s)

This equation should be used with caution based on the scatter found with the results, and should only be used for floor levels between 5 and 60, and for times between 0 and 600 seconds. Overall, the results indicate that the number of occupants prepared to wait for the lift will decrease with increasing waiting time.

Factors affecting evacuation choice

It was hypothesised that two of the main factors that may influence respondents' evacuation choices would be the fastest evacuation option, and/or the perception of which is the safest evacuation option. Results from the online survey, the evacuation event simulation survey and the bomb threat incident were examined to determine whether these factors did influence evacuation decisions. It appears that respondents were more likely to make evacuation choices that were consistent with their perceptions of which was the fastest evacuation route, as compared to perceptions of which evacuation route was the safest or the least prone to failure.

Approximately three-quarters of respondents from the online survey who felt that one evacuation route would be faster than the other made an evacuation choice consistent with that perception, and this was consistent across all floor levels and office locations. A little over half of the respondents that judged one evacuation option to be safer than the other made evacuation choices consistent with this judgement, and this relationship seems to be unaffected by floor height or office location. The number of respondents that made evacuation choices consistent with their perceptions of which evacuation option had least probability of failure decreased with increasing floor height. This difference between consistency with the safest choice and least risky choice is believed to be due to approximately equal numbers of respondents believing that the lift or the stairs would be the safest option, as opposed to a clear majority of respondents believing that the stairs would be the evacuation choice least at risk of failure. Overall, it seems that the majority of occupants make an evacuation decision consistent with their perception of the fastest route.

The results from the evacuation event simulation survey agree with this finding. For those respondents that stated that they would use the lift to evacuate, the most common reasons given were because their floor level was a long way from the ground, or that the lift would be quicker. Perceptions that the lift was a safer option or a concern about whether the situation was a real emergency and their personal levels of fitness were less likely to be given as reasons that the lift was chosen. Similarly, for those that indicated that they would use the stairs to evacuate, the most commonly cited reason for this choice was that the stairs would be the quickest evacuation route. The perception that the stairs would be safer or more reliable was a reason given by fewer respondents.

However, an evacuation route being the quickest means of escape was not a common reason for their evacuation choice given by those that were surveyed following the bomb threat incident. In fact, only one respondent that used the stairs stated that they had made this decision on the basis that the stairs were the quicker evacuation route. The majority of those that used the lift to evacuate stated that they did so either because the situation was not a fire event or because the situation was in another building, and the majority of those that used the stairs to evacuate did so on the basis that the use of the stairs was part of the emergency procedure for their building. 12% of the respondents that used the stairs to evacuate did mention that they did so out of fear of the consequences if they did use the lift and something went wrong.

It is possible that the difference in the predominant factors that influenced respondents' evacuation route decisions could be due to the different types of scenarios. For the online survey and the evacuation event survey, the scenario represented an ambiguous event where the occupants of the building could hear the fire alarm but could not see smoke or fire and were therefore unsure of whether the situation was a real emergency. In comparison, it is understood that the majority of the occupants who were evacuated due to the bomb threat were aware of the details of the situation when they carried out their evacuation. This knowledge may have meant that they considered different factors more carefully than others. In addition, from the results of the bomb threat incident, it was found that a significant number of occupants, 17% of lift users and 30% of stair users, stated that their evacuation choice was made by "following others". This shows that occupants' decisions are not made in isolation, and highlights the importance of social influence on the evacuation decisions made by occupants.

Alternatively, the lack of respondents from the bomb incident survey to state that they chose an evacuation route because it was faster might be because the buildings were not tall, and the difference between the times to evacuate using the stairs or the lifts may have been perceived to be marginal and therefore not a major factor to be considered. A final consideration might be that the finding that the perceived time to evacuate via each evacuation choice was affecting the evacuation route chosen may be artificial and induced by the experimental methodology. This may not be the primary consideration of occupants in an actual emergency event.

CONCLUSION

Based on the results of this work, it appears that commercial building occupants will be prepared to use the lifts to evacuate from a high rise building if they are given sufficient training and information about the systems that have been put in place to protect them. The percentage of occupants likely to use the lift to exit as opposed to the stairs was found to be strongly dependent on the context of the situation.

Some data for the situation of an ambiguous event in which occupants could not see fire or smoke but were aware that the fire brigade were arriving at their building was found. It was found that an increasing number of building occupants are likely to use the lift to evacuate from a high rise commercial building with increasing floor height. It appears that a primary factor in an occupant's choice of whether to use the lift or the stairs to evacuate may be the time that it is predicted that it would take to reach ground level via each evacuation route.

It was found that the concerns that respondents had about using the lifts for evacuation were relatively consistent across different locations and population groups. This finding will allow any education or training programme to teach building occupants about using the lifts for evacuation to address these concerns.

The results also suggest that building occupants will not be prepared to wait for an indefinite amount of time for the lifts to arrive on their floor. Evacuation modelling should take into account the drop-off in occupants prepared to wait for increasing time for a lift to give a realistic picture of how building occupants will evacuate in an emergency.

Based on the results, a number of recommendations are made for the design of lift systems for evacuation:

- It is recommended that evacuation modelling carried out for buildings in which lifts are available for evacuation should acknowledge the difference in the proportions of occupants that will use the lift or the stairs to evacuate at different floor levels. Modelling using a fifty-fifty split of occupants taking the lift and the stairs on each floor level is not considered to be representative of the exit choices that people are likely to make. The expected demand for the lifts at the upper levels of the building will require consideration of the way that lifts are programmed for emergencies and whether an adequate number of lifts are available to accommodate all the occupants that would prefer to use the lifts.

- Based on the scatter found in the results, and the strongly contextual influences on behaviour, it is recommended that those designing lifts for evacuation run a number of sensitivity cases to determine the influence of the proportion of occupants using the lifts and stairs changing.
- Those designing evacuation strategies should be aware that a number of occupants in the building will have strong preferences over which evacuation route, stairs or lifts, they will use to exit in an emergency. It is expected that evacuation strategies that designate all occupants on a floor to evacuate using either one method or another will be unsuccessful in achieving this.
- It is recommended that real-time information panels be provided on every floor adjacent to the lifts and the stairs to inform occupants of the likely time that it will take to evacuate using each method. This will allow occupants to make an informed decision on their optimal evacuation route, and may mean that those waiting for the lifts will be less likely to become tired of waiting and move to the stairwells.
- It is recommended that the lifts and at least one of the stairwells be positioned adjacent to one another to allow those that are not prepared to wait for the lift any longer to easily move to the exit stairs instead. This would also allow occupants waiting for the lifts to be able to see how quickly occupants in the stair are moving, and whether the stair is too crowded to use.
- It is recommended that a call-cancel button should be provided on each floor, so that if all occupants on a floor that had been planning to use the lift decide to use the stairs instead, they can cancel their request for a lift

ACKNOWLEDGEMENTS

The authors would like to acknowledge the support of Arup and the Bright Futures Enterprise Scholarship fund. The fire engineering programme at the University of Canterbury is supported by the New Zealand Fire Service Commission.

REFERENCES

1. Heyes, E. 2009. *Human behaviour considerations in the use of lifts for evacuation from high rise commercial buildings*. Masters of Engineering in Fire Engineering project report, University of Canterbury, New Zealand.
2. Levin, B., Groner, N. 1994. *Human factors considerations for the potential use of elevators for fire evacuation of FAA Air Traffic Control Towers*. NIST-GCR-94-656, National Institute of Standards and Technology, August 1994.
3. Olley, J., Freed, S. 2008. Evacuation of buildings in emergencies – Use of lifts in case of fire and other incidents. *European Lift Congress*, 23-24 September 2008, Heilbronn.
4. Kuligowski, E., Bukowski, R. 2004. Design of occupant egress systems for tall buildings. *CIB 2004*.
5. Siikonen, M. L., Hakonen, H. 2003. Efficient evacuation methods in tall buildings. *Elevator World*, July 2003, pp. 78 – 83.
6. MacLennan, H., Ormerod, M., Sivan, A., Nielsen, C. 2008. Will current high rise evacuation systems meet user needs in 2030? *Elevcon 2008*, 11th June 2008, Thessaloniki, pp. 257 – 267.
7. Pauls, J., Gatfield, A. J., Juillet, E. 1991. Elevator use for egress: The human factors problems and prospects. *Symposium on Elevators and Fire*, February 19-20, Baltimore, MD.
8. Proulx, G., Reid, I. & Cavan, N. 2004. *Human behavior study – Cook County Administration Building Fire October 17, 2003 Chicago Illinois*. Research Report No. 181. National Research Council Canada, Ottawa.
9. Sekizawa, A., Ebihara, M., Notake, H., Kubota, K., Nakano, M., Ohmiya, Y., Kaneko, H. (1999). Occupants' behaviour in response to the high rise apartment fire in Hiroshima City. *Fire and Materials*, 23, pp. 297 – 303.
10. Averill, J., Mileti, D., Peacock, R., Kuligowski, E., Groner, N., Proulx, G., Reneke, P., Nelson, H. 2005. *Federal building and fire safety investigation of the World Trade Center disaster – Occupant Behavior, Egress and Emergency Communications*. NIST NCSTAR 1-7. US Government Printing Office, Washington.