Will Occupants of Tall Buildings Obey Instructions From Wardens in Staged Evacuations?

The Design Dilemma Post September 11

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Abstract
From the devastating events of September 11, newspaper and television media highlighted to the general public that those occupants who disobeyed the formal instructions to remain in the buildings, appeared to survive.

Post September 11 building managers, owners and occupants are questioning whether a staged evacuation system is still a workable and practical solution for tall buildings, as occupants with a heightened perception of risk may choose to disobey instructions from evacuation controllers, for the staged evacuation process. A building designed for staged evacuation cannot effectively evacuate occupants simultaneously.

A review of various building code prescriptive requirements shows that staged evacuation is the normal evacuation method for tall buildings. A survey of tall building occupants has also shown that the staged evacuation process may not be obeyed, as occupants choose to undertake evacuation by their own time frames, based on the risk perception.

Design solutions are explored for increasing occupant safety during an emergency evacuation, especially with regard to existing buildings. Regular audits and repairs to smoke and fire sealing, pressurisation system upgrades and potentially the use of lifts can increase escape route safety.

Keywords: Tall buildings, Evacuation Methods, Existing Buildings, September 11

1.0 Overview of the Impact From Media Coverage of September 11

There was significant media coverage of the evacuation processes that occurred on September 11, within the twin towers of the World Trade Center (WTC). Evidence of the decision-making that saved the lives of many occupants has been published in all forms of the press, including CNN, Time, New York Times, Financial Times, South China Morning Post, BBC etc.[1].

The media have highlighted to the general public that the decision to remain in the building during the emergency event proved to be fatal for many occupants. From this extensive media coverage, the general public have gained a perception that occupants obeying instructions from "building controllers" made fatal decisions, that occupants obeying instructions to return to their office floors lost their lives and that occupants who did not leave immediately after initial cues lost their lives. Some examples are: Shin Cho, Bank of America office on 81st floor of WTC north tower. As Mr Cho and others rushed to nearby floors to help people to the stairwell, he saw people panicking and others insisting it was best to follow instructions and stay put "if they wouldn't move, what could I do?" (www.special.scmp.com/aua)

John Howard who works for Morgan Stanley on the 60th floor of WTC 2 said the plane crash into building 1 shook his offices. During the evacuation he said there was a guy with a bullhorn telling us "don't panic --you are safer in the building than leaving it." People were in full-fledged panic. We all ran over the guy with the bullhorn to get out... (www.newsday.com/)

"Between the 80th and 70th floors, heard a PA announcement that South Tower was safe and occupants could return to work. Kept going down the stairs" - Magdalena Brown; "Getting Out Immediately was the best decision" - Dharam Pal (September NFPA Journal)[2]

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Friends and colleagues, each offering a version of expertise or calm, debated the wisdom of leaving. Amid the uncertainty about what was the best thing to do, formal announcements inside the south tower instructed people to stay put, reassuring them that the building was sound and the threat was limited to the other tower. Some left, others stayed. Some began the climb down and, when met with more announcements and other cautions to stop or return, went back up. The decisions made in those instants proved momentous, because many who opted to stay were doomed when the second jet crashed into the south tower, killing many and strand[ing] many more in the floors above where the jet hit. (NY Times)

The media exposure has highlighted that those who left quickly at the start of an emergency, ignoring instructions to stay, survived. This information has been discussed and well promoted within the media, often to provide an angle of "mismanagement" or to reinforce that the scene was in chaos after the first tower strike. The occupants of tall buildings within Australia and in many other countries would appear to now be very aware of this aspect and occupants have a heightened perception of risk.

2.0 Definition of Controlled and Uncontrolled Evacuation

Due to the significant numbers of occupants in tall buildings, evacuation is typically carried out through a staging process. The staged evacuation process is one of controlling which floors evacuate, to limit the number of floors exiting and hence the number of occupants. The floor of fire origin is evacuated initially, followed by other adjacent floors. The process is carried out either automatically or manually through a building controller. By limiting the number of occupants who enter a stairwell, the evacuation process is efficient, especially for those most at risk on the floor of fire origin. The process is referred to as staged for this paper, but can also be called controlled or phased.

The other method of evacuation is the "uncontrolled" or simultaneous method whereby all floors are alarmed at once and all persons exit via the stairs at once. Most low and medium rise buildings have a simultaneous evacuation process, as it is simpler and does not require significant warden input or communications infrastructure. Some tall buildings also have simultaneous evacuation.

Staged evacuation systems rely wholly on occupants following formal instructions, based on a disciplined hierarchy, with regular drills and training for wardens and building operators[3]. The staged system works by floors being prepared to evacuate and then on a signal from a central control, the floor evacuates via the nominated stairs.

Uncontrolled evacuation is often rare today in tall buildings, due to the advantages that a controlled evacuation process provides[4]. The process of staged evacuation is considered to have many advantages:

1. Relieves congestion in stairs by limiting the occupants entering, therefore the risk of occupants getting injured through crowding is significantly reduced
2. Reduces business interruption as tall buildings can be zoned such that only a limited number of floors are evacuated in an alarm, which is relevant for false alarms
3. Reduces the number of stairs in a building as the stairs need only cope with three or four floors evacuating at one time
4. Staged evacuation also reduces the width of the stairs required (in some instances) as the number of occupants within the stair is limited by the floors evacuating
5. By reducing the number of stairs required in a building, there can be more room for lettable area, so a building becomes more economically viable to build
6. Allows for emergency services to evacuate a tower in a methodical method

The governing factor for use of staged evacuation is the reduction in stair numbers required in a tall building, therefore reducing core area and increasing net lettable area for the entire tower.

3.0 What Happens if Staged Evacuation Goes Wrong?

Tenants in tall buildings are now aware of the time factor involved with evacuation, illustrated very clearly by the well-publicised events of September 11. There is a perception that those who evacuated quickly survived, whilst those who stayed on their floors or obeyed the instructions from the PA systems, perished[5]. Whilst September 11 was an extreme event, occupants of tall buildings now have
a different perception of their own personal safety and the option of waiting to evacuate by many occupants may not be considered as a desirable option. Occupants may start to evacuate under their own time frame, based on their perceived risk.

If there are multiple fire cues, there is a greater perception of danger and a connection is made between the threat they perceive and the stark and disturbing images portrayed in the media, from September 11. Tall building occupants who would normally await the instructions of wardens and controllers are now considering disobeying these commands and evacuating immediately, due to their awareness of the evacuation events in the WTC.

This situation has become apparent to many building owners, operators and designers, since the tragic events of September 11, whereby a tall building with a staged evacuation system, may become uncontrolled. This has been labeled (unofficially) as a “September 11 effect”.

Most tall buildings have a low-level podium, typically containing retail tenancies. If a fire was to occur within this podium area, there is the potential for this fire to produce sizable quantities of smoke, which would be very obvious from the upper levels of a tall building – especially if the smoke exhaust system is located on the roof of the podium. If smoke is visible, then the reaction of occupants at the higher levels may well be to start evacuation immediately and even more likely if an alarm sounds also, due to the perceived threat. Once some occupants start to evacuate themselves and disobey a warden or instructions, then it is expected that others may follow.

Thus, there is the potential for an uncontrolled evacuation in a building designed for a controlled evacuation. Stairways, transfer floors and refuge areas that are not designed for the large volumes of occupants trying to descend may start to jam, leading to frustration, panic and injuries – all occurring when there is probably no actual risk to occupants from a fire, but due to the perceived risk of the emergency occupants choose to evacuate. The issue of risk perception and management strategies for evacuation in tall buildings was raised in the 2002 CIB / BRE Summit on Tail Buildings[8].

3.1 Evidence of the Problem

In working with building managers and operators over the last 12 months, the authors of this paper have received substantial feedback from concerned management regarding the issue of staged evacuation and its control. Building operators are requesting that fire safety engineers and building certifiers (AHJ’s) investigate different methods to evacuate their existing or future tall buildings that does not involve staged evacuation. Area wardens, Chief wardens and occupants are notifying building management that they are not comfortable with the “wait for instructions” process of a staged evacuation. Tall building operators have a very real concern that an emergency will arise and a staged evacuation has to occur in earnest, but their employees may chose to evacuate at the first cues, ignoring the staged procedures.

A report by the NFPA "Strategies in Building Evacuation Messages"[7] recently noted “The concept of a "defend in place" evacuation process has been widely accepted within the US and many other countries as a workable concept for evacuation. Authorities, Fire Brigades and designers all consider the method to be an acceptable process. Unfortunately, the occupants of many tall buildings may have decided that they will undertake an evacuation process that is different.”

The NFPA report states that until a “sense of comfort” returns, simultaneous evacuations may need to be invoked for all buildings. The NFPA report acknowledges that in the short term, there is expected to be a change in public attitude towards evacuation, when a building emergency takes place. Thus, NFPA is recognising there is an issue and that occupants will feel more comfortable in tall buildings with a simultaneous evacuation. The problem is, what if the building is only designed for staged evacuation?

The UK Home Office[6] has published a study into tall buildings stating that one of the most important considerations was how to get everyone out of a tall building simultaneously. The report also recommended that tall buildings be designed with a set maximum evacuation time, comparing a tall building to a football ground, where the fire safety guidance in the UK requires all occupants can be evacuated in eight minutes. The report also highlights that if lifts were fire and impact proof, they could be used for rapid evacuation, especially if combined with stairs.
The Building and Fire Research Laboratory has initiated a research programme entitled "Research and Development for the Safety of Threatened Buildings"[9] to investigate all aspects of building safety with the threat of terrorist attacks, including methods of occupant egress.

NRC Canada (Proulx) has presented evidence of the 1993 and 2001 evacuations of the WTC[10]. A summary finding from this paper was whether occupants are still prepared to comply with procedures and instructions in an evacuation.

One of the first aspects to realise for tall building operators is that many of their tenants may have these fears of waiting during a staged process. This issue must be recognised and canvassed.

4.0 Survey of Occupants Within a Tall Building

A simple survey has been undertaken by the authors to investigate the present state of mind with regard to evacuation, for some tall building occupants. All occupants surveyed were not trained as wardens. Whilst the number of persons surveyed is not significant and method of survey is fairly rudimentary, the results provided some interesting insights in people's thinking, post September 11.

The survey was carried out between July and August, 2002, for 60 occupants on floors 50 and 51 of a central city office building. The building has a staged evacuation system, with two stairs serving the office building. The building has a lower level podium retail area. Three questions were asked of each individual.

Q1: If you could see smoke rising from the lower levels of this building and could see the fire brigade had arrived, would you choose to

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<tr>
<td>a) Await wardens instructions</td>
<td>52%</td>
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<td>b) Choose to evacuate by the stairs immediately</td>
<td>44%</td>
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<td>c) Use a lift to evacuate</td>
<td>4%</td>
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Q2: If the "alert" tones sounded and instructions were to wait until the evacuation order was given, would you

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<td>a) Await the evacuation instructions</td>
<td>42%</td>
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<tr>
<td>b) Choose to evacuate by the stairs immediately</td>
<td>53%</td>
</tr>
<tr>
<td>c) Use a lift to evacuate</td>
<td>5%</td>
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Q3: If other persons on this floor choose to disobey the instructions of the wardens and used the stairs straight away, would you

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<td>a) Await wardens instructions</td>
<td>28%</td>
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<tr>
<td>b) Also evacuate by the stairs immediately</td>
<td>53%</td>
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<tr>
<td>c) Encourage others to leave by the stairs also</td>
<td>19%</td>
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The results of this survey show that people in a tall building, faced with the realistic possibility of a fire in their building, will not wait to be told when to evacuate. As the building surveyed has a staged evacuation system within in it, it can be concluded that a fire emergency could render the stairs inoperable and result in panic and confusion as people attempt to leave, without consideration of the warden controlled evacuation that is expected.

5.0 Overview Of Present Regulations / Codes – Evacuation Control

A review of various building code means of escape requirements has been carried out to ascertain the extent of countries utilising staged evacuation versus a simultaneous evacuation process.
5.1 **Australia**

The Building Code of Australia\(^{[11]}\) prescriptive requirements state a building must have at least two exits, if it is over 25m. Refuge areas are not required, but stairs are required to be pressurised to ensure smoke does not enter the stair. Buildings over 25m are to have a staged evacuation scheme, with live voice messages and warden intercom points at each floor, known as an EWIS (Emergency Warning and Intercommunication System). AS3745\(^{[17]}\) is used to provide guidance for evacuation procedures, training and drills. Buildings below 25m have simultaneous or "all out" evacuation, regardless of type.

5.2 **Sweden**

BBR (Bovarkets Bygg Regler) \(^{[13]}\) provides recommendations for egress. In the "Brandskydds Handboken" (Fire Protection Handbook) guidelines are provided that describe how to interpret the rules in BBR. The Handbook describes that a building of 17 stories or more is required to have two exits, fulfilling the highest restrictions on fire rated boundary construction and limitations for fire spread in materials. High rise buildings are based on an "all out" philosophy, on alarm.

5.3 **England and Wales**

For tall buildings, Approved Document B\(^{[14]}\) allows two design options – phased evacuation (staged) or simultaneous evacuation. Phased evacuation is normally designed for tall buildings (> 30m) with escape stairs also serving as fire fighting stairs. If simultaneous evacuation is chosen, then the building’s stairs must be designed to accommodate all occupants evacuating at once. Another good source of information for phased evacuation is the London District Surveyors Association (LDSA) Guide No.3. This is a guide, which is applied to office buildings in inner London that operate a phased evacuation strategy.

5.4 **USA**

Within the USA, differing states and cities have by-laws governing evacuation. Staged evacuation is described through model codes such as NFPA 101 Life Safety Code\(^{[15]}\), indicating Fire Drills are required and orderly evacuation training must be carried out. If required by the local building official (AHJ) a tall building requiring staged evacuation will have a fire control centre where fire department personnel can control the evacuation, with two-way communication and voice messaging. An exit stair maybe considered as a place of refuge.

5.5 **Denmark**

There are currently no specific guidelines for high-rise buildings in Denmark with all buildings above 45m being outside the normal Danish building regulations, requiring specific considerations. The prescriptive code Bygningsreglement (BR95) indicates that simultaneous or "all out" evacuation is typically used. Within Brandteknisk Vejledning 24, a phased evacuation scheme can be proposed, subject to the approval of the local authorities.

5.6 **Singapore**

Singapore means of escape requirements are governed by a prescriptive "Code of Practice for Fire Precautions in Buildings 2002". Evacuation procedures are not covered explicitly in the Fire Code, though an "all out" evacuation is considered normal, even for high-rise buildings. For all high-rise commercial buildings exceeding 60m and large commercial spaces, a Fire Safety Report is required, which will detail the evacuation procedures, which could detail a staged process.

5.7 **Japan**

Japan Fire Service Law\(^{[16]}\) requires a designated Fire Protection Manager, who has authority over the management of a building where a large number of people enter, work or live. The Fire Protection Manager is responsible for a fire action plan, including evacuation procedures and maintaining the escape. The Fire Protection Manager may determine that staged evacuation is advantageous for a
building, though many tall buildings have a simultaneous evacuation strategy.

5.8 Hong Kong

Means of escape is governed by ordinances and codes of practice published by the Government of Hong Kong Special Administrative Region. The "Code of Practice for the Provision of Means of Escape in Case of Fire" (1996) provides details, with a fire engineering approach being permitted, under a guidance note issued by the Buildings Department. Tall buildings are normally evacuated through an all out strategy, with occupants being able to relocate to refuge floors, which are large areas within the building, required every 20 to 25 floors. The high occupancy within buildings in Hong Kong is countered with larger stair widths and stair numbers, than other US or European buildings.

5.9 New Zealand

The New Zealand Building Code\textsuperscript{[17]} prescriptive requirements recommend all buildings above 25m are to have two exits. Stairs in tall buildings are required to be pressurised (over 36m). The NZBC recommends a phased evacuation strategy for buildings that are over 25m and contain sleeping or care purpose groups such as hospitals, hotels, and apartments. Commercial buildings do not require phased evacuation, with an "all out" strategy.

6.0 Proposed Solutions and Recommendations for Improvements

Buildings that are designed for staged evacuation cannot efficiently evacuate occupants in the uncontrolled situation. The key aspect is to look at how to design buildings so they are intrinsically safer for egress.

The most important design issue is to ensure that a fire does not achieve full development within a tall building, thus the likelihood of a perceived high-risk event is prevented. Comprehensive and well-maintained sprinkler protection is vital to lower the fire risk.

6.1 Recognition of the Problem

Building owners, operators and tenant managers need to recognise the situation of simultaneous evacuation occurring in a building designed for staged evacuation could occur and that alerting their wardens of this situation is now required. Education of the risks is also required to minimise the likelihood. Occupants need to be reassured that a small or controlled fire in their building will not result in a repeat of the events from September 11. The general public do not realise how safe a modern building is from a "normal" fire event. An NFPA Task Group\textsuperscript{[18]} was set up in 1997 to review public response to high-rise fires and this report states that the general public need to be reassured that evacuation strategies that are staged are still the best method.

6.2 Communication During Evacuation

Staged evacuation instructions being ignored by tenants must be recognised as a realistic risk for building managers. Messages from central command stations have been based in the past on providing occupants with minimal information. It would appear imperative to inform occupants of the situation and that correct procedures should be followed.

Messaging from alert systems must now be improved. Occupants should be told of the situation that is occurring and that emergency services are in control. Bland instructions will not suffice for occupants who can see smoke from a fire. Live voice messages telling occupants about the situation and the measures being undertaken can prevent panic or an uncontrolled situation. If all occupants are well informed, there is less chance for panic, especially if that information comes from a credible and knowledgeable source, such as a fire department senior officer.

There is the potential use other building technology to assist with evacuation, given the integration of security cameras with a building central control. CCTV security systems can be used to monitor occupant evacuation movements. This will require security and evacuation controls within the same control room and preferable at the same desk – which is not presently designed in many buildings.
6.3 **Stair Safety**

It is not practical to introduce more stairs to an existing building, but stairs can be upgraded to offer a greater level of protection. This can be through improvements to existing smoke and fire sealing, upgrades to pressurisation systems, providing smoke seals to doors, improving maintenance to self closers, improving emergency lighting and signage in stairs.

A key design upgrade can be to the stair pressurisation systems so that they do not fail to prevent smoke ingress if more than two doors are open. The present design methodology adopted from well-respected texts such as Kloe and Milke[19] are based on two doors being open simultaneously, for the systems to be effective. Low cost upgrades can be carried out to ensure that if multiple doors are open at once, smoke does not flow into a stair.

Other considerations for new buildings are to ensure the lift and stairs are within the same structural core, thus allowing greater protection to both. Also, the design of stairs should be considered on the basis of providing significant long-term protection to occupants and emergency services.

6.4 **Evacuation Drills**

Occupants should be made aware in their regular training that concerns over the staged evacuation process have been raised and that the level of safety for occupants in a lengthy evacuation has been addressed by building management.

Fire departments can potentially assist by having more staff trained in the use of emergency evacuation systems to ensure they are able to control evacuations in a more logical manner. Drills must be carried out regularly and all aspects of the escape recorded. Ex-education of wardens and employees to lower the risk sensitivity is an important design aspect.

7.0 **Significant Redesign of Evacuation - Use of Lifts With Stairs**

Since September 11 there has been a renewed interest in the use of lifts for evacuation. Emphasis has been provided by work carried out in the UK, where the use of lifts to evacuate persons with disabilities is more common and widespread. A lift within a protected lobby for evacuation of persons requiring assistance is a requirement of Approved Document B[18], for tall buildings.

If an existing building that is designed for staged evacuation is to be re-assessed for simultaneous evacuation, then the most logical method of ensuring faster overall evacuation is to utilise the lifts. The UK Home Office report[6] indicated that an evacuation drill by the Canary Wharf group involved 5469 occupants being evacuated out of a tower in 20 minutes, using lifts alone. The CIB / BRE Tall Buildings Summit[6] also recommended further work in the use of lifts for evacuation in the event of an emergency.

There is a present trend in countries such as Australia, US and the UK to investigate using lifts to rapidly increase the evacuation speed. Occupants with even minor health problems can be distressed in having to walk down 40 to 50 flights of stairs. There is also a concern with regard to heath of occupants, especially if a fire is occurring, in that the panic or stress caused by the situation may lead to a heart attack in occupants, as they descend stairs.

7.1 **Case Study**

A case study has been investigated for a 50 level office building where each floor of approximately 120 persons is served by two stairs and eight elevators. The building has an existing staged evacuation regime. The aim is to investigate the most efficient evacuation that can be carried out, utilising lifts and stairs, in combination. Design methods utilised were from BS 5588[20] and work by Kloe[21].
The design is based on a combined use of lifts and stairs, with lifts being utilised to some floors for evacuation and stairs being utilised to others, for a strategy of “all out”. The aim of the work carried out has been to find the optimal stair capacity and optimal lift capacity. Floors can then be chosen to evacuate by stair or lift concurrently to provide the best solution for evacuation, therefore minimising overloading stairs or the lifts.

This work is still being carried out at the time of writing this paper, but preliminary results have shown that evacuation can be optimised to produce a total evacuation time in the order of 15 minutes, utilising lifts and stairs. The present staged evacuation plan for the building results in complete evacuation in approximately 40 to 50 minutes, based on previous drills.

7.2 **Issues of Implementation**

Whilst the design option of using a combination of lifts and stairs may work in theory, implementation of this type of solution in practice will be difficult. The client involved with this building is still unsure if the proposed change to the method of evacuation will be implemented. Once in place though, it does allow a simpler method for controlled evacuation and speeds up overall evacuation.

Using lifts and stairs in combination for evacuation as an upgrade to existing buildings requires significant alterations in the operations and protection of lifts. There is also a substantial investment to up skill wardens and senior management as a change in mindset is required, as occupants do not perceive lifts as a safe alternative, thus substantial occupant “re-education”. Overall, the cost versus likely outcomes requires further review, as the issue of whether the system will actually be effective in practice is still a concern.

Lifts for evacuation is an expensive and generally untrialed method for evacuation, but can be considered as part of an overall plan for reducing risk to occupants, by substantially lowering the overall evacuation time.

8.0 **Refuge Areas**

Various codes require refuge spaces or floors as part of a tall building evacuation strategy. Refuges though are expected to come under greater scrutiny since September 11, as occupants perceive that waiting for further instructions could be lower their chances of escape.

Under the Hong Kong Means of Escape Code, a refuge floor is required in buildings over 25 levels, at not more than 20 levels and 25 levels respectively for industrial and non-industrial buildings from any other refuge floor. The reasons of providing refuge floors are essentially to act as a relief area for the evacuees to rest under fire situations, act as a sub-base for firefighting purposes, act as a command point by the rescue personnel to assist orderly evacuation of the building and as a place allowing the disabled or partially disabled to wait for assistance before being evacuate to a place of ultimate safety.

The use of refuge floors may need to be reviewed in light of the evacuation procedures that occurred in the WTC. Occupants are now unlikely to stay in refuge floors to await rescue.

Alternative approaches to refuge areas may need to be explored further. The New Zealand Building Code specifies refuge “areas” within the stairwells of tall buildings (> 58m). The refuge area is provided within the stairwell by an increased landing area each 3 levels. The refuge area allows for persons to rest and also to allow for faster persons to overtake slower persons, whilst they escape. NFPA 101 also provides information on refuge areas for persons with disabilities.

Small refuge floors, such as those recommended by NFPA 101 and NZBC would appear to be a sensible resolution for allowing resting and temporary refuge.

9.0 **Summary and Further Work**

This paper has explored the current life safety issue within tall buildings of occupants who are not
willing to obey the instructions of a staged evacuation regime, a situation that has always been assumed to occur. A heightened perception of risk by tall building occupants is now apparent, due to the extensive media coverage of the September 11 events, where occupants who escaped at the first sign of the emergency, survived. The problem will need to be recognised by building managers and evacuation procedures, training and implementation may need to be revised. Stair safety can also be upgraded to ensure occupants exit in a reliably tenable environment. Other aspects to be explored further with regard to tall building evacuation are:

- How long should it take for a tall building to evacuate? Should there be a time limit to evacuate all tenants in say 20 minutes. Is this an economically viable option?
- How can this time limit work for existing buildings?
- Is it a matter of determining that an extreme event cannot be designed for within a "normal" building?
- Designers and owners of tall buildings need to understand the risk. Behaviour of occupants is related directly to the perception of risk. Managing the risk is about managing the perception, not assessing the quantification.
- Is the use of a stair and lift in the one compartment safer and better?
- Who is qualified and competent to actually make the decision to evacuate and when evacuation occurs on floors. The level of training for staff or building operators / fire brigade controlling evacuation should be reviewed.

The events of September 11 have showed that the present evacuation methods within tall buildings can be very vulnerable and may not be as safe as first thought. The consideration of having an evacuation maximum time may indeed be a safety feature of the future.

References
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