| 1 |


:: FPE Summer 2006 ::

# Emerging Issues in High-Rise Building Egress

*By: David A. de Vries, P. E. , CSP*

Traditional high-rise evacuation strategies that have been incorporated into model codes in the U.S. have been based on defend-in-place and/or partial evacuation and relocation. Based on the assumption that only a limited number of building occupants would be immediately affected by an event, typically a single fire, and that others entering from below will have already moved down, the capacity of vertical means of egress elements, primarily stairs, has been sized to accommodate the largest occupant load of a single floor of the floors served. Events in the past 15 years where full evacuation of high-rise buildings was deemed necessary, or actually occurred, have caused a reconsideration of these strategies and assumptions. High-rise building occupants, as well as building designers, now recognize that there are vulnerabilities beyond the single fire scenario, including bombings, catastrophic power failures, toxic chemical releases, and biological agent releases, that would likely entail complete evacuations. Even where no actual need for a complete evacuation exists, there remains a public perception of potential for catastrophic events and a predisposition to evacuate.

Complete evacuations of large high-rise buildings have occurred in the World Trade Center incidents, both 1993 and 2001, Oklahoma City's Murrah Federal Building in 1995, Chicago's Cook County Administration Building in 2003, and Chicago's LaSalle Bank Building in 2004. Fatalities occurred in all these events except the LaSalle Bank Building, though not necessarily related to the evacuation. These evacuations have been studied extensively and have formed the basis for changes in the way engineers conceptualize evacuation in addition to generating many recommendations for proposed changes to model codes and local ordinances. Ongoing efforts on this subject include the National Fire Protection Association's (NFPA) High-Rise Building Safety Advisory Committee. The International Code Council (ICC) is also addressing some of these issues through their Code Technology Committee. Both code organizations are receiving extensive input from many interested entities.

### Egress Width

Modeling of the evacuation of the World Trade Center in 2001 found that assumptions about the rate of movement of people on stairs may have been greatly overestimated or that other fundamental assumptions may need adjustment. [1] Changes have already taken place in the 2006 edition of the *Life Safety Code* ®.[2] Rather than sizing stairs for just a basic minimum and the floor with the highest occupant load, the *Life Safety Code* ® now requires that the cumulative total of occupants served be considered. Where a stair, or portion thereof, serves a be 1420 mm (56 inches).

**Photoluminescent Markings**
As a result of the truck bomb that exploded in the parking deck below grade of the World Trade Center in 1993, the emergency generators for the buildings were disabled. Emergency lighting within the buildings' stair towers was non-existent and the evacuation took place largely by flashlight, if not in darkness. The New York City response was to require installation of photoluminescent markings within the stairs that "charge" from the normal, ambient lighting and discharge gradually, enabling stair users to see the handrails, stair nosings, and other essential features, even without emergency lighting.

During this same period, the American Society for Testing and Materials (ASTM) initiated a project to develop a standard and guide for photoluminescent markings. Their efforts resulted in two documents: ASTM E2072[3] and ASTM E2030.[4] Proposals to require photoluminescent stair markings were considered by the NFPA Means of Egress Technical Committee during the development of the 2006 edition of the *Life Safety Code*, [2] but were not accepted. The 2006 edition did add language specifying the size and location of contrasting marking of stairs, if applied, whether photoluminescent or of another type. Where installed, such markings must be a material integral with the stair tread or a coating. The Annex advises that surface-applied, adhesive products should not be used since the material could come loose and present a tripping hazard. Future developments in adhesive technology and testing of its durability may lead to recognition of surface-applied strips in the model codes.

**Elevator Use for Evacuation**
Elevators are subject to disruption and failure due to the heat produced by fires or the water that may be applied to extinguish or control the fire, while the passengers can succumb to smoke that may be drawn into the elevator shaft by stack effect and elevator movement. Furthermore, if disabled in midcycle, passengers can be left stranded in an elevator cab with no means of movement to a place of safety. Consequently, the traditional approach to multiple-story building evacuation has been to use stairs as the sole means of vertical movement. Much effort has gone into educating building occupants to use the stairs instead of the elevators during emergency evacuations and reserving their use, if at all, to emergency responders.

The physical realities of presentday society dictate a need to review the underlying assumptions of nonuse of elevators. Many people who are otherwise relatively mobile simply do not have the physical capability to descend numerous flights of stairs. High-rise building occupants who cannot traverse stairs without special equipment and/or assistance must be presumed. Furthermore, the assumption that the reason for an emergency evacuation also threatens the integrity of elevators must be challenged, since several types of incidents pose no significant risk to the operability of elevators, even as currently equipped.

Within the U.S. model codes, an elevator as a means of egress achieved official recognition in the 1997 edition of the *Life Safety Code*, but was limited to use in towers and only as a second means of egress. To be approved for such use, the elevator system must meet the following criteria:

- Elevator lobbies at every floor served with a capacity of 50 persons or more;
- The lobbies separated from the balance of the floor by one-hour fire resistance-rated barriers, suitable as smoke barriers;
- One-hour self-closing or automatic-closing fire doors at all openings to the lobby;
- Power and control wiring protected from fire for at least one hour of operation;
- Two-way communication between a central control location and both the elevator car and lobbies; and
- Building elements that restrict exposure of the elevator equipment to water.

It should be noted that even before the 1997 *Life Safety Code* was published, elevators were used for evacuation while under fire department or other emergency responder control. Once the emergency situation has been sized up and a determination has been made as to what elevators can be used safely, elevators can be a viable means for evacuation and particularly useful for moving persons with disabilities from an area of refuge (rescue assistance) out of the

Since the 2001 World Trade Center-incident, NFPA and the American Society of Mechanical Engineers (ASME), who publishes ANSI/ASME A17.1, *Safety Code for Elevators and Escalators*, [5] have a sponsored symposia to study the feasibility of expanding the use of elevators for evacuation from the current, limited application to more generalized use. Follow-up work, including detailed hazard analyses, is ongoing and may result in changes to the elevator code and the model codes in the future.

**Supplemental Evacuation Equipment**

Beyond the widely accepted vertical means of egress components consisting of stairs and ramps, only fixed ladders, fixed slides, fire escape stairs, elevators, and alternating tread devices have had any specific, though limited, recognition in the U.S. model codes. The prevaling view regarding supplemental evacuation equipment was that it was not suitable for traditional egress components. This has changed somewhat with the image of building occupants trapped above the aircraft impact points in the 2001 World Trade Center attack, causing renewed interest in supplemental means of evacuation. Although some developers have suggested such devices as personal helicopters, helium balloons, and parachutes as the solution to high-rise evacuation when all other options are unavailable, the focus of development has been with three categories of equipment: flexible chutes, controlleddescent devices, and powered platform systems.

Though used in Asia for several decades and even recognized in Japan as a means of egress, flexible chutes have had limited acceptance in the U.S. Most noteworthy has been their use as supplemental evacuation equipment for aircraft control towers. The premise for their use is providing a means for limiting the rate of descent, which is accomplished by friction between the chute material and the user. Two mechanisms are generally used: angling the chute away from the building and configuring the chute so that it closes around the user. As the user descends to the bottom in the first case, the angle of the chute gets smaller and the user slows down as he or she reaches the end. In the second case, the friction between the user and chute simply limits the rate of descent as the user forces open the chute below. The angled variety of chute is limited by the space available around the building, and when first deployed, it requires a person on the ground to fix the base of the chute to an anchoring mechanism. Though the collapsing variety of chute can be deployed in a much more limited space and has even been marketed in Europe for use within a building shaft, it still requires dedicated space for deployment. Both varieties require care to limit the rate of entry of users so that each can safely leave the chute at its discharge before the next user arrives.

Controlled-descent devices consist of a cable-supported harness or personal enclosure, typically fabric, in which the individual user is secured and a control mechanism attached to the building. Various designs using friction brakes, air-resistance governors, and other means for limiting the rate of descent of the user are currently on the market. Some devices are portable and designed to be set up when needed, while others are permanently attached to the building structure. All have the inherent limiting factor of accommodating only one, or perhaps two, evacuees per descent, though most can be retrieved for additional use.

Platform-based systems operate on the exterior of the building and have an advantage over the other types of devices based on their ability to evacuate multiple persons per round trip. One such system with a single platform is deployed to the building on a truck and operated from grade on previously installed fixed tracks, while another system is permanently fixed to the roof structure and can deploy multiple platforms accommodating up to 150 evacuees per trip. Technologically much more sophisticated than the chutes and controlled-descent devices, the platform systems require trained operators to deploy and control them. They also have a significant initial cost and require more sophisticated inspection, testing, and maintenance than the controlled-descent devices and chutes. One distinct advantage-of the platform systems over the others is their ability to transport emergency responders and their equipment to upper floors of the building on the return leg of a round trip.

Recognizing their potential and the need for design and performance criteria for certifying their usability, in 2004 ASTM initiated a new project to write standards for these three categories of supplemental evacuation equipment. At the current time, two of the three standards are in the balloting stage. A proposal to establish *Life Safety Code* criteria for installation of such equipment was initially accepted in principle by the Technical Committee on Means of Egress, 2005 NFPA Technical Meeting. This action automatically places the subject on the agenda for the next revision cycle.

**Areas of Refuge/Rescue Assistance**
Over the decade of the 1990s, the model code communities made a concerted and successful effort to mainstream the accessibility requirements of the Americans with Disabilities Act, known as the ADA Accessibility Guidelines (ADAAG), into their respective codes. As such, those codes now incorporate requirements for areas of refuge that provide for a presumably safe place for persons who cannot use the stairs to await assistance. One such area that is recognized by model codes and the ADAAG is a floor of a building where the floor or building, respectively, is equipped throughout with an approved sprinkler system.

The community of persons with disabilities is now looking for changes to the model codes and the Americans with Disabilities Act that will affect two key concepts: that it is acceptable to leave persons with disabilities behind while those without disabilities evacuate the building and that a sprinklered floor of a building provides sufficient protection to be considered an area of refuge. While the issue with the first concept is one of equity, the second one is stated in recognition that not all incidents requiring evacuation, such as catastrophic power failure, are ameliorated by sprinkler protection and that sprinkler protection should not be depended upon as the sole means of protection while awaiting assistance.

The resolution of this issue is likely to tie in with either the provision of elevators suitable for evacuation or supplemental evacuation equipment. As an interim measure, and one that can be applied to many existing buildings, is the provision of stair descent devices to which persons with mobility impairments can transfer and, with assistance from coworkers or building staff, can evacuate via the stairways with other occupants. Products suitable for this use are on the market, but no comprehensive means for evaluating their capability has been available. In the near future, this will change with the development of a standard for such devices under the auspices of the Rehabilitation Engineering Society of North America.

*David A. de Vries, P.E., CSP, is with Firetech Engineering Incorporated.*

**References**

1. NIST NCSTAR 1: *Federal Building and Fire Safety Investigation of the World Trade Center Disaster: Final Report of the National Construction Safety Team on the Collapses of the World Trade Center Tower,* National Institute of Standards and Technology, Gaithersburg, MD, 2005 (download at http://wtc.nist.gov/reports_october05.htm).
2. NFPA 101-2006, *Life Safety Code* ®, National Fire Protection Association, Quincy MA, 2006.
3. ASTM E2072-04, *Standard Specification for Photoluminescent (Phosphorescent) Safety Markings*, ASTM International, West Conshohocken, PA, 2004.
4. ASTM E2030-04, *Guide for Recommended Uses of Photoluminescent (Phosphorescent) Safety Markings*, ASTM International, West Conshohocken, PA, 2004.
5. ANSI/ASME A17.1-2004, *Safety Code for Elevators and Escalators*, American Society of Mechanical Engineers, New York, 2004.