Selecting appropriate egress strategies

The selection of an appropriate egress strategy requires a good understanding of the building and its occupants, the protection measures in place, and the expected emergency response.

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Safe, robust, intuitive egress systems that account for human behavior are an essential component of any building design. It is important that egress system strategies be developed in concert with the overall fire and life safety program. Effective egress strategies reflect the facility, how it is used, and the characteristics of its occupants. They are designed to be appropriate for the facility's size and complexity, location of stairs and exits, fire and life safety systems, security features and arrangements, and hazards within the facility.

In general, egress systems are designed to allow occupants who are not intimate with the initial incident—the incident impacting the building—to escape the area of immediate hazard in order to reach a place of relative safety.

From a basic prescriptive building code approach, fire is the most common incident of concern. However, a building and its occupants can be subjected to a range of incidents, including natural hazards, such as tornados, hurricanes, snow or ice storms, floods, and earthquakes; technological events, such power outages, vehicle impacts, gas releases, and explosions; and deliberate events, such as civil disturbances, bomb threats, and acts of terrorism. Depending on the facility, evacuation strategies may need to fulfill some or all of these objectives.

The concept of protecting those “not intimate” with the incident is important. For instance, it is not reasonable to expect that any egress strategy can guarantee to help a person who falls asleep while smoking in bed and subsequently starts the bed on fire. However, it is reasonable to provide an egress strategy that will work for those persons not in the bedroom of fire origin.

Egress strategies can range from evacuating all occupants (simultaneous full evacuation), to evacuating some of the occupants (partial evacuation), to defending occupants in place. In some cases, this is accomplished simply by evacuating people to the exterior of the building. In other cases, they may be relocated to a safe portion of the building.

Strategies must be based on the specific hazards expected to threaten the facility. For some buildings, a single response for all events is appropriate. For others, a scalable approach that escalates from protect-in-place to simultaneous full building evacuation may be necessary. An overview of the range of possible strategies follows.

Protect-in-place

Protect-in-place strategies are also known as defend-in-place and shelter-in-place strategies. The concept of protecting in place is to provide sufficient safety features to allow occupants to remain in place during the event.

This strategy is used in facilities in which occupants have a limited ability to be moved, either because they are incapacitated or they are immobile due to medical or other reasons. Protect-in-place strategies also are used for a portion of the population when phased strategies are employed.

Obvious examples of facilities that use protect-in-place strategies are hospital surgical suites or intensive care units. In these facilities, it may be difficult—if not impossible—to move patients without significantly jeopardizing their safety. Protect-in-place strategies typically rely on a combination of active and passive fire protection features, along with management procedures, to provide an appropriate level of safety for the occupants to stay in the initial compartment. Typical features include automatic sprinklers and fire-rated compartments to reduce smoke and fire spread, along with enhanced smoke detection to provide early warning of fires, emergency lighting, and emergency power for safety and critical care equipment.

Relocate to a safe place

The concept of relocating occupants from an area of potential hazard to a protected area of refuge or other safe place within a building is a variation on the protect-in-place strategy. As with protect-in-place strategies, relocation requires special attention to management procedures and may require special detection and warning systems or other life safety features and procedures. Examples of facilities that might use this strategy include hospitals; nursing homes; and detention, correctional, and institutional facilities. These facilities typically employ horizontal exits or smoke barriers to allow evacuation from one fire compartment to another.

The relocating strategy also can be used in tall buildings. In this scenario, occupants are relocated to lower floors. Thus, floor and shaft fire ratings are critical, as the lower floors create a safe area. In addition, the structural fire protection must match the expected hazards, as people will not be immediately escaping the building.

Horizontal exits are convenient but often misunderstood exiting features. Horizontal exits allow occupants to move away from a fire or other incident to a protected area. Codes require a two-hour fire-resistive barrier to completely divide floors employing the horizontal exit concept into separate fire compartments. Upon crossing the boundary formed by these walls and door openings, occupants are considered to have exited the space, just as they would after crossing the threshold of an enclosed stairwell.

Phased evacuation

Phasing strategies combine evacuating or relocating a portion of the occupants—those who are in most danger— while allowing occupants remote from an incident to protect-in-place. This allows optimizing exit efficiency, as only those in immediate danger use the exits. A fundamental assumption is that an event will not affect occupants outside of the affected zone while occupants in the zone safely evacuate. Phased evacuation is appropriate in a wide range of facilities, including high-rise buildings, hospitals, and large assembly spaces.

In hospitals, phasing may be necessary for larger incidents if such incidents might compromise adjacent evacuation zones. Large assembly spaces also may allow remote occupants to remain, while those closer to and intimate with the incident immediately escape. Assembly examples include large convention centers with multiple event halls; if the halls are appropriately separated, it may be possible to phase the evacuation using individual halls as evacuation zones.

Phased evacuation is the traditional approach for high-rise buildings and is permitted by the International Building Code (IBC). Occupants on the event floor, and one or two floors above and below the event floor, are evacuated either to the exterior or to a lower floor. Occupants on other floors use a protect-in-place strategy. In theory, this allows occupants on the fire floor unobstructed use of the exit stairs, thus reducing the evacuation time for those on the affected floor or floors.

This concept works well for traditional fire events, such as a sprinkler-controlled fire, because automatic suppression systems in high-rise buildings are designed with a degree of resilience and have proven to be effective in controlling or suppressing fires. Fire-rated floor separations, along with the systems in place, minimize the hazards and risks to occupants on the unaffected floors.

When using the phased evacuation approach, it is important to notify occupants remote from the event floor as well as those in the evacuation floor zones. Occupants outside of the affected zone are notified of the incident and told to remain in place pending further instructions. Occupants not on the evacuation floors use the protect-in-place strategy. Thus, the features critical to protect-in-place strategies must be provided.

Risk perception post-Sept. 11, 2001, adds complexity to phased evacuation. In the event of a disaster, occupants might ignore “standby” messages and instead immediately exit the building. People tend to trust live voice messages over recorded messages. However, building personnel who are allowed to provide live messages must be well trained so as not to create undue concern when giving the message. Designers may wish to consider these issues, as the events of concern, needs of the owner and occupants, and occupant characteristics differ from building to building.

Simultaneous evacuation

Simultaneous full building evacuation has been the norm for small buildings for many years. However, this strategy has emerged as an alternative solution for large, tall, or iconic facilities, particularly when designing for extreme events. In January 2008, *Consulting-Specifying Engineer* author Scott Siddens noted in “Rethinking high-rise egress, top to bottom” that one of the recommendations from the National Institute of Standards and Technology (NIST) Sept. 11 study called for tall buildings to be designed to accommodate timely full building evacuation. In most cases, buildings designed for extreme events may require immediate simultaneous evacuation of the entire building.

For tall buildings or other facilities that will require full building evacuation to address extreme events, a performance-based engineered approach—during the design phase or a specific analysis of as-built conditions—should be used to evaluate the impact of evacuating a large number of people simultaneously on the egress system.

Particular concern should be given to notification signals and their effectiveness, assumptions regarding time to begin evacuation, occupant characteristics and assumptions regarding mobility and evacuation time, and physical building features that could restrict or impede occupant flow (choke points, narrow doors or corridors, transition spaces, and other potential flow obstructions). In many cases, it may be necessary for simultaneous full building evacuation to be coordinated and directed by the responding local fire authorities.

Protected elevator evacuation

Walking down many flights in tall buildings can be difficult for many occupants and may be impossible for some. Elderly, disabled, occupants with medical issues like heart conditions, or those with mobility-impairing injuries may have difficulty negotiating stairs or be incapable of evacuating using stairs. Changes in technology, an aging population, universal design concepts, and the events of Sept. 11 have converged to make elevators a viable option for emergency evacuation. Protected evacuation elevators can now provide a safe and effective alternative to walking down many flights of stairs.

In theory, the use of elevators can speed evacuation within tall buildings. This has been proven in real events. For example, reports indicate that 16% of occupants of Tower Two of the World Trade Center escaped through the elevators before the second airplane struck the building (Averill, 2005).

There are several strategies for the use of protected evacuation elevators. With appropriate design, it may be possible to allow protected elevators for a large segment of the building population. Alternatively, with good training and stringent controls during emergency evacuations, it may be possible to limit the use of elevators to those who cannot walk down many flights of stairs or those injured during the incident. Another strategy is to allow occupants to descend stairs from the fire floor to a refuge floor (perhaps to a specially designed sky lobby), then choose to use the elevator from that floor or continue down the stairs. These strategies need to be well-defined, engineered, and coordinated by the building personnel and the local fire officials. Special care is necessary to help educate and train occupants in the use of such systems.

When employing any of these approaches, elevators must be protected. Appropriate fire and life safety features, appropriate signage and way-finding, and a well-constructed evacuation plan with training are required.

As taller buildings are constructed around the world, protected elevators will be become more important. Both the IBC and the Life Safety Code (NFPA 101) allow elevators to serve as one means of egress in towers. The 2006 IBC requires elevators to serve as an accessible means of egress in non-high-rise facilities. The dependence on elevators, along with recent code advancements, will likely lead to greater acceptance of these systems. Ultimately, it appears that codes will evolve to allow protected elevators as part of typical tall building design. Until that time, engineers must use performance-based approaches to implement evacuation elevators.

Event-based evacuation

With event-based evacuation, conditions dictate the specific actions and egress strategy. Situations are assessed and a decision is made based on that assessment to determine which strategy is appropriate. For example, consider a fire event on a single floor—relocating and protecting in place might be appropriate for this event. For the same building, a severe wind event may require full building relocation to an underground parking floor. For a wind event, elevators may be appropriate.

This event-based strategy is especially useful for facilities that may be exposed to a range of events, particularly when those events can take place both inside and outside of the building. Events occurring outside the building may require a very different response than those occurring inside. This strategy places a large burden on the decision makers and the decision-making process. Decision makers need relevant information and the authority to make critical decisions.

Flexibility can be a benefit. However, simplicity breeds reliability. Substantial prior training is required to minimize confusion when event-based strategies are in place. It is imperative to create appropriate systems and methods for quickly obtaining credible information about the event and to empower decision makers with the appropriate authority to make egress decisions based on that information.

Performance-based approaches

Prescriptive codes provide egress design guidance for a broad range of uses. Design flexibility is compromised in order to create such a comprehensive set of code provisions.

In contrast, performance-based approaches combine first-principles fire engineering with evacuation estimates to assess whether occupants will be able to safely exit buildings for a range of fire conditions. Performance-based approaches require safety systems to be designed to meet specific fire safety goals for a range of fire events. This approach can result in design flexibility, as it affords the opportunity to align fire safety systems with overall building objectives. With this flexibility, however, comes an additional design burden, as analysis demonstrating that occupants can safely exit under the design scenarios is necessary.

Performance-based approaches rely upon state-of-the-art knowledge of human behavior and movement during emergency incidents. John Klote, in his article “Smoke Control and Fire Evacuation” published in *Heating/Plumbing/Air Conditioning Engineering*, gives an overview of evacuation calculations (Klote, 2008). This topic is covered in more detail in “Egress Design Solutions: A Guide to Evacuation and Crowd Management Planning.”

Selecting options

The selection of an appropriate egress strategy requires a good understanding of the building and its occupants, the protection measures in place, and the expected emergency response. Strategy selection also hinges upon the possible emergency scenarios. It also is important to consider the messaging strategy.

The strategy needs to match the ability, activity, and responsiveness of the occupants, as well as the staff's ability to assist in the process. Other considerations include the number of people who will need to evacuate, whether all occupants within the facility will be exposed to hazardous conditions, the occupants' familiarity with the exits and egress routes, whether reliable staff will be available during an emergency, and what events will be considered. The answers to these questions provide critical information needed to select the strategy.

Coordination of safety features is critical to the success of the egress strategy during an event. For complex facilities, it is often necessary to develop an overall fire and life safety strategy to coordinate these features. Voice communication, suppression, and detection system zones need to match with the evacuation zones. Emergency lighting is necessary in exit pathways to allow safe movement. Exiting components will likely require appropriate fire ratings. In some cases, additional voice communication zones, two-way communication, message boards, or other communications systems may be necessary to provide occupants with an appropriate situational awareness and a general understanding of the incident. Zones require specific fire separations and structural fire ratings appropriate to the strategy. Other features also may be necessary: elevators may need to be protected and provided with special controls, stair door unlocking may be necessary, and life safety systems will likely need emergency power. All of these features must coordinate with security systems.

In addition to emergency lighting, the 2007 Supplement to the IBC requires exit pathway marking in a range of high-rise buildings (for example, assembly, business, educational, institutional, mercantile, and transient residential occupancies). These devices guide occupants along the intended evacuation path and help simplify confusing exiting arrangements. Exit marking can be accomplished through self-luminous, photoluminescent, or other approved materials. Marking is required on each step, and at the perimeter of stair landings and other floors areas within the stair enclosure.

Relaying messages to occupants of the affected floors is as important as relaying messages to those on the unaffected floors. People receive cues about an event through nontraditional means, such as cell phones, e-mail, and other electronic media. Nontraditional messages may prompt many people to exit a building unnecessarily. Messages must be audible, as well as intelligible, and provide clear, easy-to-follow instructions. Depending on the building's occupants, such messages may need to be given in various languages. In addition, messaging strategies must be appropriate for the hazards.

Again, it is critical that safety features be coordinated with the egress strategy. For strategies that require decisions, it is just as critical to provide accurate information to the people empowered to make informed decisions.

Project information	Goals and objectives	Performance criteria	Design scenarios	Develop design options	Evaluate and select design	Document design
The building design and construction details, site, geographic location, number of occupants, and occupant characteristics are identified. Other important considerations include: building's symbolic importance, consequences, operations and processes, criticality, and expected threats.	The goals and objectives are established by the stakeholders. Goals are global in nature, and can include protecting life, property, continuity of operations, heritage, and the environment. Objectives refine these goals; design and stakeholder objectives are identified.	Performance criteria are the metrics against which design objectives are assessed. For fire scenarios, performance criteria may include smoke temperature, upper-layer thermal radiation, smoke-layer depth, smoke visibility, and/or distance containment concentration.	A range of design scenarios are selected. Consideration may reflect probabilistic and deterministic considerations. For example: How likely it is the event will occur and, if it does occur, how it is expected to impact the building. Design scenarios are quantified into measurable engineering descriptions.	Design options are selected. This includes and overall strategy of components that will meet the design objectives. In most cases, a number of candidate design options are considered. In some cases, this may include comparisons with applicable prescriptive code requirements.	Options are evaluated for compliance with the design objectives and performance criteria. The evaluation process is iterative—mitigation measures are evaluated against the design loads and the design objectives. A suitable option is selected from all options as the final design.	The final step is to document the design and analysis. The Society of Fire Protection Engineers Guide states that at a minimum, the following should be included: project scope, designer's capability, goals and objectives, performance criteria, design fire scenarios, final design, evaluation, critical design assumptions, critical design features, and references.

Author Information

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Protected elevators

Elevator use in emergencies has been a topic of research for more than two decades (Klote et al., 1993). This research indicates that elevator use during emergency evacuation is practical and safe, provided that specific enhancements are made to the elevator systems. These enhancements include the following:

- Earthquake protection
- Emergency power supplies
- Emergency communication systems
- Smoke and heat protection
- Protection against suppression water infiltration
- Resistance to the spread of contaminants and gaseous agents
- Attention to human factors in management and occupant education/training, among other systems considerations.

ASME A17.1 organized two tasks groups, Task Group on Use of Elevators by Firefighters and Task Group on Use of Elevators for Occupant Egress, to review appropriate measures for protected elevators. After conducting a comprehensive analysis, it is expected that these task groups will develop a final set of elevator protection recommendations.

If elevators are part of a building evacuation plan, the plan must consider the needs of both exiting occupants and responding emergency workers. Occupants and firefighters must be properly trained in the evacuation plan, and control strategies must be defined and implemented. For instance, the evacuation plan may designate specific elevators to be used by responders only.