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CONFLICTING REQUIREMENTS OF EXIT DOORS

by **B. M. Johnson**

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SOMMAIRE

La conception des portes de sortie en fonction de la sécurité, de la sécurité-incendie et de la vocation d'un bâtiment exige une analyse basée sur l'usage qu'on en fait. Des recherches canadienne récentes on entraîné une meilleure compréhension des caractéristiques des bâtiments à vocation particulière (spectacle, éducation, détention). Il en résulte une stratégie qui permet de concilier des exigences contradictoires, mais qui dépend de la disponibilité des équipements et de procédés de gestion appropriés.

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Conflicting Requirements of Exit Doors

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ABSTRACT: The design of exit doors to meet the requirements of security, fire safety, and building operations necessitates analysis based on building occupancy. Recent Canadian research has led to clearer understanding of building operations for specific occupancies such as spectator, educational, and correctional facilities. The result is a strategy designed to resolve conflicting requirements, but it depends on the availability of appropriate hardware and management procedures.

KEY WORDS: exit doors, security, fire safety, building security

In the recent past there have been several instances where lives have been lost in fires as a result of safety measures taken to counteract crime. Various types of building were involved, including supermarkets, theaters, and offices. At the same time, some buildings have had high rates of theft or vandalism where fire exits have been available for illegal entry or escape. This conflict became apparent during a series of seminars held at the Division of Building Research, National Research Council of Canada (DBR/NRC), in 1977. The problems of crime prevention in housing, office buildings, schools, and arenas were specifically discussed, and the subsequent search for a strategy to resolve the conflicting requirements of exit doors focused on these occupancies.

Approximately 90 percent of all crime is committed by amateurs and is best counteracted by improved security measures. In housing, where the opportunistic nature of crime has been well documented [1],² it can greatly reduce crime rates. Installation of improved hardware on windows and doors without jeopardizing evacuation [2] is the primary means of improving defense. The concept of defensible space, propounded most notably by Newman [3], seems effective against this type of crime mainly by reducing opportunity. Although the concept has been restated many times [4], there has been little effort to extend such analysis beyond Newman's basic outline. One of the few examples of elaboration has been work by McKenzie [5] in which the require-

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² The italic numbers in brackets refer to the list of references appended to this paper.

ments for viewing entrances were explored in relation to the conflicting requirement for privacy.

Defensible space concepts are not completely effective in occupancies where the problem is to provide protection from professional criminals. These concepts can lead to building design and installation of hardware that may reduce the number of emergency exits. The hardware tends to be more sophisticated and is often intended to prevent escape. As a consequence, it can impede evacuation under some circumstances.

Analysis of the occupancy patterns and operation of buildings is designed to clarify the conflicting demands of security and ease of exit in the event of fire or other emergency. Concepts of crime prevention through environmental design have been discussed widely [6] and recommendations made for specific occupancies.

Building Security and Fire Safety

Those concerned with building evacuation naturally wish for as many exits as are economically possible, whereas those concerned with security want as few as possible. This is the basis of the issue. Both groups have compromised, especially security personnel, despite increasing life and property losses resulting from crime in recent years. The complexity of some building types has compounded the security problem. Office and hotel complexes with underground parking, subway connections, heliports and commercial malls present substantial security problems. Even buildings such as schools become difficult to handle because of evening classes, unplanned additions, and after-hour use of outdoor playgrounds.

Over the past five years DBR/NRC has investigated the movement of spectators in places of assembly such as theaters, arenas, and grandstands. These studies were concerned with evacuation time, safety, and convenience. Throughout, security procedures that affected evacuation were identified. These were most apparent at the Olympic Games in Montreal when all exits were constantly surveyed and complex arrangements made for the protection of dignitaries.

Places of assembly are usually concerned only with preventing unpaid entry, either by guarding the exits or locking them during performances. Guards, however, are expensive because of the number required. Even where exits are close together at least one guard may be required at each door. In one Canadian arena two guards are needed for hockey games or rock concerts to ensure that groups of spectators inside do not assault solitary guards and let friends in.

Where regulations permit, exit doors can be locked either by manual latches or solenoid holders. The solenoids have the obvious advantage of allowing rapid release from a central control, overcoming many of the problems associated with manual latches; but they need to meet strict (in some cases impos-

sible) regulations to prevent electric shock or failure to function. In addition, a manual lock must be installed to ensure that doors remain locked during power failure. This type of occupancy presents further problems that will be discussed under Topology of Exits.

Several factors have contributed to the rising rate of theft from office buildings. Increased size and open working arrangements make it possible for strangers to walk unchallenged through work areas, steal an article, and escape by way of exit stairs. Calculators, electric typewriters, and specialty equipment are prime targets. Very often security systems have been designed to prevent illegal entry for the purpose of industrial espionage or similar crime, but petty theft is a greater problem, possibly of the order of \$75 000 for every ten stories of office space (10 000 m²) every year. Security was early seen as a marketable feature by Cole [7] and others. In Canada, as elsewhere, government agencies require provisions for security in the design of all new buildings [8].

Whether concern is for illegal entry or for theft, the objective must be to supervise all exits in some manner. Obviously, if all stairs and elevators from upper stories terminate in the main lobby, then everyone has to pass security personnel either to exit directly outside or indirectly through parking or service areas. Most building authorities, however, require at least one exit stair directly to the outside and this makes it difficult to prevent "grab-and-run" techniques. One solution for such stairs would be to construct an emergency door in the stairwell at lobby level that, if opened, would activate an alarm to give security personnel sufficient time to apprehend the thief. (A later discussion of hardware questions the success of such systems.)

The direct exit is required for its assumed usefulness in evacuations, but some research has found that during evacuations 40 percent more people, on average, use the stair that terminates in the main lobby than the stair that does not [9]. There are several possible explanations for this, but the main one is familiarity, a conclusion that is reinforced by other studies [10]. Pauls recommends that the lobby stair be designed to encourage normal use as well as efficiency during evacuations [9]. In buildings with central service cores, exit stairs often pass through the basement if they do not terminate at the lobby. As fires frequently start in the service area beneath the lobby level, it is worth reexamining requirements that result in exits through basements.

Another problem with offices results from ease of movement between floors by means of stairs or elevators, particularly after hours (that is, during silent hours). It is suggested that passage by means of an elevator should be made more difficult by enclosing and locking each elevator lobby when no one is on the floor. An exit stair off the elevator lobby would be required, and it could be designed for smoke-pressurization to provide temporary refuge in the event of fire for anyone having difficulty using the stairs. The importance of control at elevator lobbies has long been recognized and specific recommendations have been made [7]. Unauthorized movement by means of the stairs could be con-

trolled by installing partitions in the stairs, each zone relating to the operational unit or tenants in the building. The partitions would be moveable to allow for changes in tenancy profile.

Nonemergency use of exit ways results in the common problem of exit doors being held open, allowing smoke movement in the event of fire. Although this problem is not related to security, it emphasizes the importance of understanding and planning for the desired traffic patterns in buildings. This means that integration of fire emergency systems and security systems is essential, as advocated by Fitzpatrick and Ruchelman: "Rather than operating as separate activities, the two functions must be seen as comprising a total security package for high-rise buildings" [11]. In the interest of security or fire safety, attempts have sometimes been made to prevent movement between floors at exit ways. Such restrictions have been often thwarted by the occupants themselves, and the resulting situations have sometimes been more dangerous than those the restrictions were designed to improve.

In several types of buildings the complexity of the activity patterns creates problems. Schools are one example, mainly because of the diverse nature of their use. Nighttime use presents significant problems. Vandalism rates are surprisingly high even where schools are used only by adults in the evening. As with office buildings there is value in analyzing activities and zoning the building so that everyone does not have free run after hours when few supervisory staff are present. Zeisel [12] has made recommendations on design and hardware selection that allow designers to produce good buildings provided proper consideration is given to the occupancy patterns of the schools.

In penal or correctional institutions the conflict between security and evacuation needs is paramount, and recent disasters have made it imperative to reconcile them. The Division of Building Research has initiated a study, under contract, of the nature of such facilities as a first step in developing a strategy for resolving this dilemma. The National Fire Protection Association plans to include a chapter on Detention and Correctional Occupancies in the 1981 edition of its Life Safety Code.

A relevant issue is the ease of opening emergency doors, especially for those with physical disabilities. Recent work at the Division has indicated that the force required to open a door should be lower than is generally allowed if a door closer is installed. For doors leading to exit stairs the greater force required for smoke pressurization can still be overcome by most of those with physical disabilities if no door closer is installed. Without a door closer, however, doors will not automatically close and lock, and breaches of security may occur.

Security Hardware

There are two basic types of security hardware: passive and active. The former attempts to delay or discourage an intruder by presenting obstacles. Active hardware announces an intrusion or retaliates. This type is often advo-

cated, however, without adequate recognition of the inherent difficulties. Many types of active hardware, such as electric fences, can be dangerous and may make a building owner liable to an extent greater than his potential loss would justify. As well, alarm systems depend on having someone to react in time. They are frequently installed on exit doors to deter thieves from grab-and-run techniques. Although no definitive studies have yet been done, it seems probable that in most cases these installations will be ineffective. Security personnel can seldom react fast enough to reach an exit in time to apprehend the culprit. The same seems true of preventing illegal entry. By the time security personnel can reach the door there will probably be no sign of the intruder, although it is relatively certain that the alarm was not activated as a result of malfunction or hard knocking. Video cameras can be useful in providing observation of an entrance when an alarm sounds, but this is a very expensive technology and would only be warranted where the risk is very great.

Passive hardware may also present difficulties. The home owner particularly is faced with the difficult problem of deciding just what quality (cost) of hardware he needs. In this regard several books on home security are valuable [13]. Institutional hardware is only slightly less difficult to choose. For exit doors the required panic bar is very unsuitable for security. Tests have shown that it is easily cheated unless special door frames are installed, and if used frequently it breaks down because people often exert force on the door before the bolt can react. Studies at the Division of Building Research indicate also that those with disabilities can open a paddle-type device more easily than the conventional panic bar, and that the incidence of delays from pushing the wrong side of a panic bar are significant.

In general, there should be no hardware on the outside of a door (Class IV, according to NILECJ [14] standard, or Grade 40 of ASTM Tests for Security of Swinging Door Assemblies (F476 - 76) and interior doors should have hardware installed according to the operation requirements of the building (that is, according to zone). This raises the issue of master keys and the need to institute a method of control. This is not within the scope of this paper, but it has been examined by Lesniak [15].

Exit Door Design: Analysis

To simplify security and fire exit problems requires analysis of the occupancy/management relation and the topology of exits. Most occupancies can be described by the following categories, but as with all classification systems instances exist where the situation does not clearly satisfy any classification heading. The following designations should be considered only as a starting point for analysis.

Occupancy/Management Relations

Most buildings have several types of occupant and, as a result, several types of relation between management and occupancy. The predominant occu-

pancy type determines the building classification, for it will determine the level of security (risk).

Hostile Occupants—Despite the emotive strength of this term, there are many occupancies where the occupants would not try to prevent a crime. The inmates of correctional institutions are, in general, hostile to the management or administration. Less obviously hostile are those who use public assembly buildings, yet seldom will a visitor or spectator try to prevent a criminal action in these surroundings. Other occupancies such as schools and universities are a matter of discretion and are subject to circumstance. As a general rule, one might even question whether occupants should be expected to prevent a crime. In most instances hostile buildings require some security staff to protect either the building or its occupants from other occupants. If either illegal entry or exit is the main security problem, then large numbers of security staff may be needed.

Responsible Occupants—Occupants of this type would in the majority of cases be held responsible if they did not sound an alarm or question doubtful behavior. Most office buildings fall marginally into this category. Generally, the number of security personnel is few and the occupants are implicitly expected to perform this function, although they have not been given clear directives or training. Residential buildings also belong to this category, where the peer pressure or guilt would be great if a person allowed someone else to commit a crime without taking some action. A consequence of this criterion is that residential complexes where people cannot or will not challenge intruders should be considered to belong to the hostile category. Occupants' reasons for not accepting responsibility might include risk to themselves in challenging intruders or lack of opportunity to alert authorities.

Security Conscious Occupants—Few buildings have occupants trained to take definite action towards someone committing a crime. Military establishments and similar occupancies are of this type, but they face little risk of the type of crime that can be prevented by environmental design. Other occupancies where people perceive intervention to be in their interest might include airports, owing to the common fear of terrorist action, or banks where fear of financial loss might prevail.

Topology of Exits

The aforementioned categories help to define how occupants use entrances and exits of buildings and their attitudes towards them. Frequent use of an exit door and failure to ensure that it is properly closed can allow an intruder to enter illegally. This often happens in office or apartment buildings where considerable caution is, at the same time, being taken to ensure that garage doors are kept locked. The problem of exit doors requires a classification scheme for the topology of exit doors.

Open Exits—These are generally the main or front entrances of buildings.

They are locked or unlocked according to the amount of supervision available and the general level of security. They can be often observed from a desk or from the road (that is, from patrol cars). Ironically, these doors have received the greatest attention for security, yet they are probably the least vulnerable. (A problem beyond the scope of this paper concerns the requirement for determining who should be allowed to enter, one of the greatest problems in crime prevention.) In many instances front entrances may need to be only Class I or Class II, according to the NILECJ (76) classification system [14] (Grade 10 or 20 of ASTM Methods F 476.).

Enclosed Exits—Most buildings contain several exit stairs that are completely enclosed, exiting directly outside. They can only be surveyed by cameras, prohibited from normal use, or given special security treatment. The problem with such exits is manifold: easy escape for thieves, occupants using the stair to travel to prohibited floors or to avoid being questioned by receptionists, occupants using the exit on a day-to-day basis (thereby wearing out hardware that later allows entrance to unauthorized persons), and persons who cheat the exit door from the outside. This latter problem of unauthorized entry concerns both door hardware manufacturers (that is, to produce hardware that cannot easily be defeated) and designers of security systems in trying to design a system that reacts quickly to illegal intrusion. These exits should be at least Class III of the NILECJ classification system, but if there is no external hardware they can easily be built to Class IV [14] (Class III is equivalent to Grade 30 and Class IV to Grade 40 of ASTM Methods F476).

Special Exits—Special exits are those at which users can expect to be challenged, for example, exits from workrooms, basements, or perhaps such facilities as freight doors. Use of such exits would require good knowledge of the building. Generally they share the problems of enclosed exits, but have the advantage of being isolated when the building is unoccupied and perhaps even when it is occupied. They can easily be determined by consideration of the level of risk and the occupant/management relation.

Requirements of Exit Doors

If an analysis is undertaken of occupancy/management relations and the topology of exit doors, the requirements stated in Table 1 can be used to develop specific design recommendations for individual buildings. A series of patterns can be drawn and taken by the designer to produce hard-line drawings. This technique of pattern drawing was strongly advocated by Alexander [16] as a method of expressing requirements.

The use of patterns of requirements is shown in Figs. 1 through 3 for a hypothetical high school. Several topologies and functions of exits are analyzed. The occupancy/management relation is considered hostile, primarily because of the number of students with this attitude. The main concern, however, is

TABLE 1—Requirements for exit door design.

Topology of Exits	Occupancy/Management Relations		
	Hostile	Responsible	Security Conscious
Open exits	easily opened in confirmed emergency but otherwise controlled hardware should give good security when building unoccupied	door needs surveillance but entry/exit is uncontrolled may be required for evacuation of crowds hardware should give good "silent-hour" security	usually needs to be controlled method of detecting "unwanted" visitors may be required may require 24-h "guarding" or alarm
Enclosed exits	surveillance required when building occupied easily inspected from outside, should be very secure	surveyed or set with alarms that allow adequate response no exterior hardware in some locations may be locked unless confirmed emergency	alarm on exit is needed possible surveillance by cameras
Special exits	isolated from main building unless controlled secure hardware, possible alarms	should be controlled when building occupied and locked or isolated when unoccupied	to be avoided unless doors are locked by remote control

BUILDING: High-School**CONTEXT OF PATTERN:** Main Doors

REQUIREMENTS	RECOMMENDATIONS	PATTERNS
<p>Easily opened in confirmed emergencies, otherwise controlled</p> <p>Allow frequent use without large air loss</p> <p>Hardware should give good security when building unoccupied</p> <p>Class I, NILECJ Grade 10, ANSI/ASTM F476-76</p>	<ul style="list-style-type: none"> - Doors placed on view from office area - No doors open into unsupervised areas even during evening use - Draft lobby - Have deadbolt, key-operated latches with emergency release - Doors could be glass - Doorframe should prevent cheating - Strong mullion needed

FIG. 1—Requirements of main doors.

CONTEXT OF PATTERN: Emergency Exit-Doors From Workshops, Gym.

REQUIREMENTS	RECOMMENDATIONS	PATTERNS
Separated from main building	<ul style="list-style-type: none"> - Secure, key-operated locks to main building - Alarm on exterior doors 	<p>Diagram illustrating a workshop layout with lockable doors leading outside and a corridor.</p>
Secure hardware, and possible alarms	<ul style="list-style-type: none"> - Firm steel frames and mullions - No exterior hardware 	<p>Diagram illustrating a mullion and a door frame with no exterior hardware, labeled CLASS III.</p>

FIG. 2—Requirements of exit doors.

BUILDING: High-School**CONTEXT OF PATTERN:** Emergency Exit-Door From Stairs

REQUIREMENTS	RECOMMENDATIONS	PATTERNS
Surveillance required when building occupied	<ul style="list-style-type: none"> - Glass doors to stairwell to allow doors to be seen - Alarm on opening
Easily viewed from outside	<ul style="list-style-type: none"> - Position facing road
Very secure, class III NILECJ, Grade 30 ANSI/ASTM F476-76	<ul style="list-style-type: none"> - Firm frames - No exterior hardware 	

FIG. 3—Requirements of service doors.

illegal entry plus theft or vandalism rather than illegal entry alone (for example, at dances) or uncontrolled escape during school hours. It is further assumed that the school is used in the evening despite the management problems this creates.

In the development of these patterns the NILECJ classification system [14] was used for describing the level of resistance of the doors. It has the advantage of ready use in producing a specific statement of what should become established tests on doors. To some extent, however, it must be admitted that the classification system did not relate well to the problems of the types of door in the example chosen, primarily because of its apparent orientation to domestic situations.

Concluding Remarks

This discussion has suggested an approach to the design problems of exit control. In many ways its success is dependent upon the usual procedures of the designer. It is hoped that those using this or similar methods to design secure buildings will communicate to the author their experiences in resolving the requirements of security and emergency evacuation.

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