



*project development  
architectural considerations*

## **Design of Schools to Resist Violent Attack**

*referenced to publications of  
the Federal Emergency Management Agency*

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# Foreword

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The safety of students, teachers, staff, and visitors to school campuses has always been a major concern across our state and nationwide. Recent events have re-emphasized the need to ensure that schools remain havens of safety as well as centers of learning.

School administrators and school facility designers have many – often conflicting – criteria to evaluate in the course of designing or operating a school. This publication is presented for the purpose of refining and focusing attention on various aspects of safety design. It is not a one-solution-fits-all mandate, but rather a catalyst for the development of solutions based on local needs and circumstances. We hope you find it useful.



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## DESIGN OF SCHOOLS TO RESIST VIOLENT ATTACK AN OVERVIEW

In a post-9/11 nation, there is much energy and money devoted to mitigate the threat of terrorist attack. While this is a critical concern, it is also true that many of the safe-guards seen as "anti-terrorist" also serve to mitigate a wide range of other catastrophes as well, ranging from destructive weather forces to incidents of individual violence. It is that "multi-threat" approach that forms the basis of this document.

Even with unlimited funding, it would be hard to imagine the elimination of all risk. With even the most perfect fore-sight, could we plan for every condition that might possible occur?

In a real-world situation, Boards of Education, school administrators, and school designers are challenged to balance many factors in the design of a school. Not the least among these is the cost of the building. (Consider not only the "first cost", but also the long term cost of maintaining the facility.) Obviously, meeting the educational program of the school is mandatory; and aesthetics of the campus is high among the priorities of the architect. The ease and safety of circulation are balanced against the "hardening" of the building and other procedures of a similar, protective nature. However, even when funding is tight, it is possible to incorporate a significant level of safeguard with a relatively modest expenditure.

Responses to threats (from whatever the source) can take any combination of these four activities, and perhaps others:

- Threat Exclusion -- Barriers
- Situation Observation -- Knowledge
- Intervention Before the Act -- Proactive (requires Knowledge)
- Response After the Act -- Reactive (demands Planning)

Using "Barriers" as an example, it is possible to deter a harmful act without actually knowing that it, specifically, was about to occur. Also, the possibility that someone is observing an area does much to discourage acts of vandalism or violence there. The most basic of all safeguards, then, can be abbreviated as...

### LOCK IT AND WATCH IT

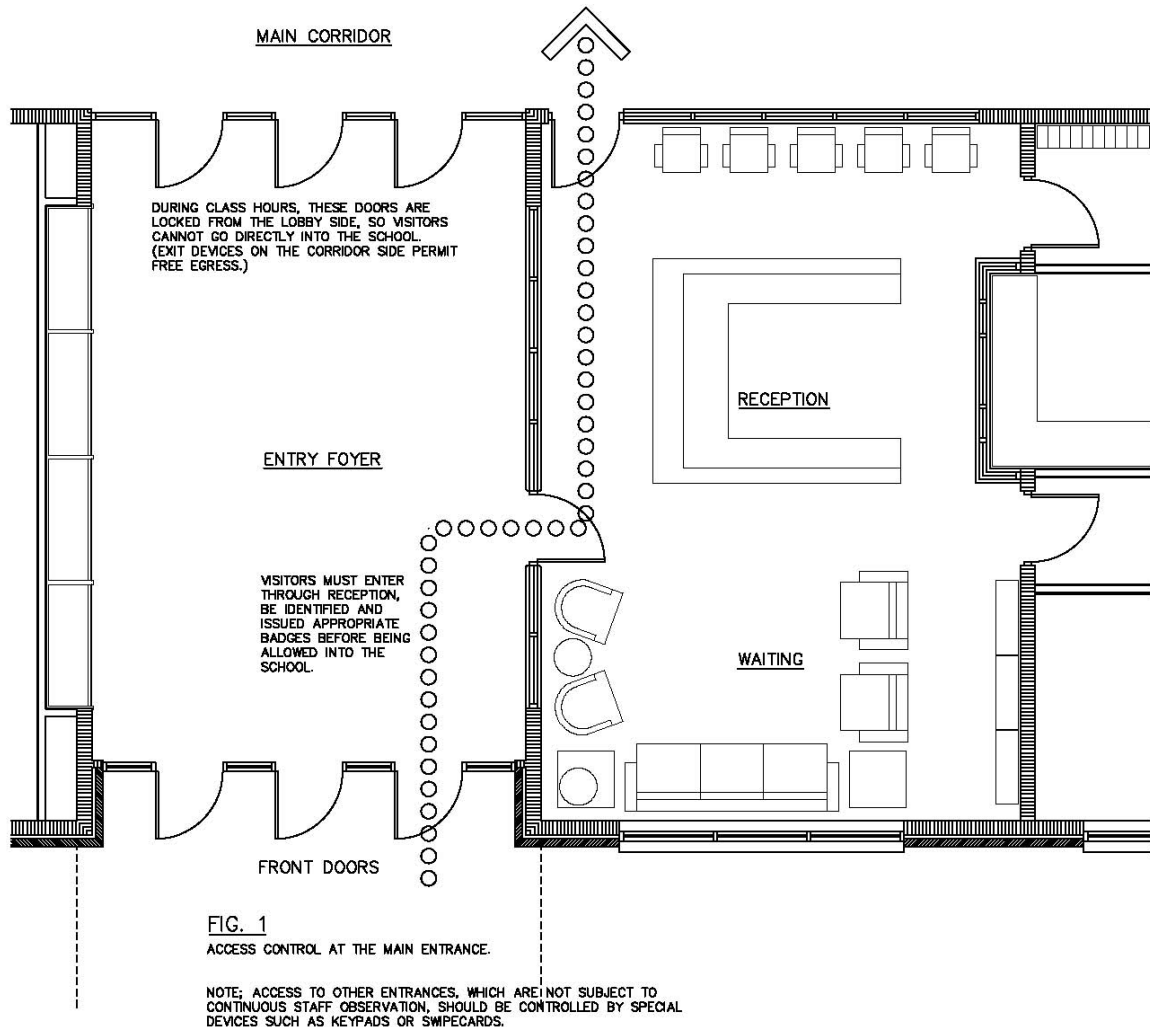
Obviously, access into the building must be controlled, so that visitors may be excluded or directed as appropriate. All secondary entrances should be locked from the outside, if school functioning allows, but still open for emergency egress as required by code. Exterior access control devices include keyed locks, key-pad entry, "swipe-card" locks, and others. This applies especially where adult supervision would be problematic. Also, doors not subject to supervision where someone could block the door open or hold the door open to allow unauthorized persons to enter, should be monitored by alarm. In certain instances, the building code may permit a delayed-action unlocking mechanism, which allows the administration a brief time to respond to a door alarm before the door can be opened.

The main entrance should be situated so that observation is possible at all times. Vestibule design can channel visitors into a reception room where their identity and reason for visit is confirmed; uncontrolled access from the front door into the school corridor should be forestalled. (See Fig. 1.)

While our intuitive choice is to be proactive (preventing loss) rather than reactive, we will not always have that luxury. Although planning for proper reaction to an emergency situation is the topic of many other publications, it may be appropriate here to suggest that school officials develop a relationship, and plan for emergencies, with many organizations and entities represented locally. Among these are the following:

Emergency Management Office	Health Department
Law Enforcement	Mental Health Department
Fire Department	Business (Hazardous Waste, etc.)
Military or Governmental entities in the vicinity	

There is a wealth of information pertaining to threat deterrence (terrorism and otherwise) available on the internet. For example, see the website of the School Planning Section of DPI at [www.schoolclearinghouse.org](http://www.schoolclearinghouse.org). Under "Publications by School Planning," access the *Safe Schools Facilities Planner*, 1998. See also "Publications / Other Entities" for links to other documents of interest.





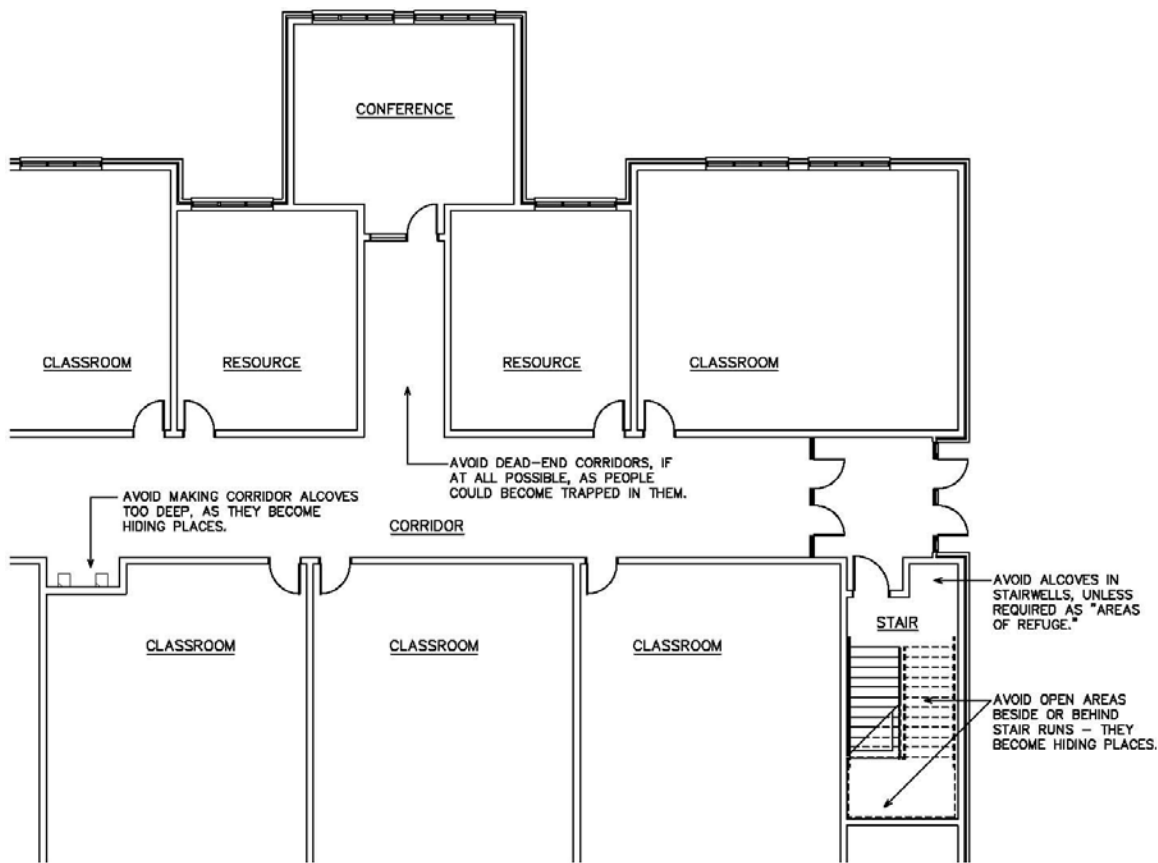


FIG. 2  
CONFIGURE CORRIDORS, STAIRS, AND OTHER CIRCULATION PATHS  
TO AFFORD MAXIMUM VISIBILITY, AND TO ELIMINATE PLACES WHERE  
INTRUDERS COULD HIDE.

Documents by the Federal Government include the following:

- Safe School Initiative: *The Final Report...* and *Threat Assessment in Schools*: [www.secretservice.gov/ntac\\_ssi.shtml](http://www.secretservice.gov/ntac_ssi.shtml).
- *Early Warning, Timely Response*, US Department of Education: [www.ed.gov](http://www.ed.gov).
- *Practical Information on Crisis Planning*, US Dept of Education.

Other national publications include the following:

- *Safeguarding Schools Against Terror*, National School Safety Center; [www.nsscl.org](http://www.nsscl.org).
- *School Safety in the 21st Century*: [www.nationalstrategy.com](http://www.nationalstrategy.com)
- *Protecting Building Environments from Airborne C.B.R. Attacks*, National Institute for Occupational Safety and Health (accessible through the School Planning Website).
- *A Biosecurity Checklist for School Foodservice Programs*, US Dept of Agriculture

and many more.

One agency of interest is the National Clearinghouse for Educational Facilities at <http://www.edfacilities.org>. In their *Safe Schools Facilities Checklist*, one can find a document useful in evaluating either a proposed school still being designed, or an

existing school which may need renovation to address security matters. Its extensive checklist of potential problems serves as a reminder of many details that might be overlooked. For example, one item is...

2.11b Dumpster enclosures are positioned so they cannot be used  
for gaining access to the school roof.

☐yes ☐no ☐not applicable ☐further study

Notes:\_\_\_\_\_

The full list can be printed to use in a walking inspection.

The remainder of this document will focus on a publication of the Federal Emergency Management Agency (FEMA) entitled *Design of Safe School Projects in Case of Terrorist Attacks*, FEMA 428. This very extensive design "primer" addresses both basic and advanced (read "expensive") methodology for protecting a school against potential terrorist attack. However, as noted earlier, many provisions to mitigate terrorism also serve well in the lessening of storm damage, or reduction of vandalism, or security against other forms of individual violence. It is therefore useful even in geographic areas where the threat of terrorism may not be especially heightened. The FEMA document may be downloaded free as a .pdf, from the website [www.fema.gov/plan/prevent/rms/](http://www.fema.gov/plan/prevent/rms/). A print copy can also be ordered free (for employees of schools or government entities) from the same website, or the general public may obtain a copy through the government printing office.

FEMA 428 was prepared by a division within the Department of Homeland Security. Permission has been coordinated for reference to and quotation from that document.



From the Preface of FEMA 428: *"This document is intended for use by schools who feel that they are at risk to terrorist attacks.... Not all schools are at risk of terrorist attacks. The decision-makers in each school district should use current and available threat information from the proper sources to make this determination...."*

The following is an attempt to annotate the FEMA "primer" to discuss certain selected recommendations. Excluded are criteria which are excessively costly or inappropriate. The "pros" and "cons" of the various recommendations are discussed; they are evaluated against current building codes, and compared to the published criteria of the School Planning Section of DPI.

## **DESIGN OF SAFE SCHOOL PROJECTS IN CASE OF TERRORIST ATTACK**

### **Risk Assessment.**

There are a number of potential concerns facing every individual school facility, each having its own likelihood of occurrence (probability) and potential for injury and damage (severity) if it occurs. These concerns include forces of nature (wind, flood waters, lightning, etc.), “small scale” man-made threats (ranging from bullying, vandalism, school violence, and abuse, to shootings, etc.), and “large scale” man-made threats (grouped together as “terrorism”).

Threat Rating = probability X severity

*In the document FEMA 428, this and subsequent criteria were quantified as...*

Threat Rating, range: 1(very low threat) to 10 (very high threat)

Each asset may be invulnerable to a specific threat, or exhibit various degrees of vulnerability.

Vulnerability Rating --- range: 1 (nearly invulnerable) to 10 (very high vulnerability)

Furthermore, each asset may be assigned a subjective value, from high to low. Obviously, protection of high-value assets (students, faculty, visitors, etc) should have precedence over protection of low-value assets (outbuildings, etc.).

Asset Value --- range: 1 (very low value) to 10 (very high value)

**RISK = (ASSET VALUE) X (VULNERABILITY RATING) X (THREAT RATING)**

The FEMA publication 428, in Chapter One and related Appendix, describes this process in detail, for “terrorism” threats only.

There are three choices of how to address the risk posed by terrorism threats:

1. Do nothing and accept the risk.
  2. Perform a risk assessment, and manage the risk by installing reasonable mitigation measures to achieve a desired level of protection.
  3. Harden the building against all threats to achieve the least amount of risk.
- (pg 1-19)

### **Risk Management.**

In addition, for every combination of asset and threat, there is a potential for avoiding or preventing the threat, ranging from “easy to prevent” to “nearly impossible to prevent.” This leads, for each method of threat prevention, to a cost, ranging from “minimal” to “very high.” The process of risk management then becomes the analysis of

- Risk
- Cost of mitigation measures
- Frequency with which the threat may be expected to occur
- Deterrence or preventive value of the mitigation measures
- Expected lifespan of the mitigation measures and the time value of money.

A terrorist attack aimed directly at a school is an atrocity at present beyond our comprehension. However, schools could be indirectly threatened by collateral damage from a terrorist attack directed at nearby facilities. On September 11, 2001, four elementary schools and three high schools were located within six blocks of the World Trade Center. All were exposed to debris and/or dust clouds from the collapsing buildings. Also, specific schools have been terrorist targets in other countries, so it is not impossible for the same to happen here.

Other forms of impact on a school facility involve the school becoming an emergency center for crisis management, or a staging area, or the like, during and after a terrorist attack.

**Site-specific Evaluation.**

Probably, the risk to a school facility because of its adjacency to “high profile targets” is greater than the risk to the school as a primary target (for “large-scale” terrorist attack).

The appropriate authority should examine potential “adjacencies” that may exacerbate school vulnerability, for example...

1. Public or private utilities such as power plants (especially nuclear), dams, telephone or other communication hubs, etc.
2. Sites that manufacture, handle, or store hazardous materials; roads, railroads, etc. by which hazardous materials are transported.
3. Military installations, classified sites, and the like.
4. Shipyards, harbors, major airports, other transportation facilities.
5. Government offices.
6. Financial centers, or centers for electronic data handling and routing.

Implementation of design methodology meant to mitigate terrorist attack might, in some instances, enhance security or strengthen the facility against other threats as well.

Certain terrorist threats, specifically nuclear, biological, and chemical agents, can be spread from “target” to peripheral areas by...

Wind	Birds, insects, animals
Surface water	People
Ground water	

and the pattern of circulation of such vectors must be considered in formulating a facility’s plan for terrorism mitigation.

## I. Layout and Site Planning

### A. Interior arrangement

*Clustered* key functions in one area:

- Pro: Can help to maximize stand-off distance from the perimeter.
- Can help to reduce the number of access points.
- Can minimize the size of perimeter needing protection.
- Con: Creates a “target-rich environment.”
- Creates potential for one threat to destroy multiple assets.

*Dispersed* key functions in multiple areas:

- Pro: Reduces the risk of collateral impact on other critical functions.
- Con: Can reduce effectiveness of on-site surveillance.
- Can increase complexity of security system.
- Can create a less defensible space.

Code impact: Neutral

School Planning comment: Consolidate functions that have compatible functions and similar threat levels, and separate higher risk areas from higher value areas. For example, visitor entrances and materials receiving/loading docks should be physically separated from key functions such as main operational areas or concentrations of students.

### B. Building / Site Interface

Strong, windowless walls facing parking area, street, or adjacent site:

- Pro: Can help protect people and operations from blast threat.
- Con: No opportunity to monitor activities outside and take timely action.
- Forms an inhospitable image for students and community.

Code impact: Exit doors; windows for egress and ventilation.

School Planning comment: Designers determine acceptable level of risk and design accordingly, early in the design process. Consider the psychological impact resulting from loss of views and of daylight, and the energy cost implications of reducing daylighting.

### C. Open space around building

- Pro: Easier to monitor and detect intruders.
- Distance from potential site of bomb blast (road or parking) reduces damage.

- Con: Cost of land
- Land scarcity in urban areas

Code Impact: Pervious open space reduces need for drainage culverts and storm water retention basins.

School Planning comment: Consider environmental and aesthetic amenities. Consider walking distance from parking lots, and from loading/unloading areas for cars and buses.

- D. Infrastructure – communications, electrical power, gas, water, sewer, etc.  
All critical lines should have at least one layer of redundancy, or backup, with maximum physical separation between primary line and backup line.

Pro: Eliminates single-point vulnerability

Enhances usability as emergency shelter (hurricanes, etc.).

Con: Cost

Code Impact: Neutral

School Planning Comment: Neutral

## II. Access Control

### A. Adjacent Roads and Vehicular Ingress

Design entry roads so that vehicles do not have straight-line approach to the main building. Utilize appropriate devices to keep vehicles from gaining enough speed to penetrate barriers.

Minimize the number of access roads into a school campus.

If warranted by the potential threat level to the school, an entry control point or guard building provides for the required levels of screening and control. Design the area so that approaching vehicles can be adequately assessed. Provide inspection areas that are not visible to the public; utilize appropriate landscaping or other screening. Provide pull-over lanes so that suspect vehicles can be inspected without blocking other traffic.

Provide a drop-off/pick-up lane for buses only. Designate an entry for commercial, service, and delivery vehicles, preferably away from key school areas and functions.

Consider appropriate paths for walking students and for bicycles. Minimize the number of driveways or parking lots that students will have to cross to get into the school building.

Pro: Many of these policies also enhance day-to-day safety

Con: Can detract from the “welcoming” aesthetic of the school

Can increase the size of site required

Code Impact: Neutral

School Planning Comment: Separation of bus traffic, visitor traffic, and student circulation is always desirable. A “loop” drive for vehicles that are picking up or dropping off students is needed.

## B. Controlled Access and Stand-off Distance

Defensive procedures are selected after *assessment of risk* of the particular school (see above) and are directly impacted by available land area.

Controlling access into an area of campus ensures that visitors have a legitimate purpose in being there. For very high-risk situations, this is accomplished upon leaving the public right-of-way. Typically, it occurs somewhere “closer” within the school campus. Confirmation and further enforcement is accomplished via visitor badges and faculty/student ID.

The concept of stand-off distance recognizes that the force of an explosion decreases rapidly over distance. The goal is to place as much distance as possible between the school and a possible location of a car bomb or other explosive device. Obviously, this also requires methods of access control to prevent the device from crossing the stand-off distance to an unauthorized proximity to the building.

For maximum benefit, this concept is used in conjunction with building hardening. This involves wall and roof reinforcement, and judicious placement of glazed openings.

In areas of high density, coordination with local authorities may be required to redirect sidewalk traffic, restrict or eliminate public parking and loading zones, and even close existing streets.

Pro: Also reduces risk of student / vehicle interaction

Con: Increased staffing implications

Potentially requires more land area

May impact or limit future building expansion

Cost of building hardening

Code Impact: Separation between building and lot line could allow types of construction of “lower” fire ratings.

School Planning Comment: For reasons of day-to-day safety, it is highly desirable to separate bus traffic, visitor traffic, and student circulation. Schools should present a “welcoming” appearance; direct access to the main entry point is desired.

## C. Vehicular and Pedestrian Circulation

Straight roadways are more conducive to higher speed travel; serpentine roads tend to reduce speed. Lower vehicular speeds are desirable not only for general safety, but also to reduce the opportunity for a purposeful crash through protective barriers and penetration into the building.

Other speed-calming strategies include raised crosswalks, speed humps or speed tables, differing pavement surfaces, and traffic circles. Creating a more pedestrian-friendly environment has the additional advantage of increasing observation of and awareness of the vicinity.

Vehicular approach should be parallel to the building face, not perpendicular. Measures useful to prevent vehicles from departing the roadway include berms, high curbs, trees, and bollards.

Pro: Discussed above

Con: Cost impact

Code Impact: ADA requirements for location of handicapped access, parking, and walkways

School Planning Comment: Be aware of possible impact on emergency response vehicles, including maneuverability of large fire-fighting apparatus. In certain counties, snow removal is also a concern.

#### D. Landscape and Urban Design

Landforms, water features, and vegetation should be planned not only for aesthetic enhancement, but also to deter or prevent hostile surveillance or unauthorized access. Trees and berms generally cannot replace setbacks as methods of blast mitigation; however, these features do offer supplementary protection.

Avoid dense vegetation in close proximity to a school building, where it could screen illicit activity. Avoid ground cover over 4 inches tall, which could conceal weapons or bombs. Screens at utilities, such as transformers or trash dumpsters, should be designed to minimize concealment opportunities for people and weapons.

Be aware of “lines of sight,” both from the school to adjacent areas, and from aggressors on-site and off-site into the school. In addition to higher surrounding terrain and unsecured buildings owned by unknown parties, surveillance of the school may be accomplished from adjacent treelines, drainage channels, ditches, and culverts.

Pro: Opportunity to add functionality to elements associated primarily with aesthetic design.

Con: Potential threat is difficult to quantify

Code Impact: Neutral

School Planning comment: Neutral

### III. Building and Site Services

#### A. Parking

Location and arrangement of parking facilities to reduce potential threats to the school will often mean less convenience for the faculty, students, and visitors. (Ideally, vehicle parking areas would be located away from school buildings, to minimize blast effects from potential vehicle bombs.) It is the responsibility of the designer to evaluate the situation of each individual school and determine the best compromise solution.



Following are suggestions that would mitigate risk with little or no negative impact on day-to-day operations.

- Provide separate parking lots for students, for faculty/staff, and for visitors. This allows the student lot to be closed off during the school day.
- Locate visitor parking in areas that provide the fewest security risks to school personnel.
- Consider one-way circulation within a school parking lot to facilitate monitoring for potential aggressors.
- Locate parking within view of the occupied building, while maintaining the maximum stand-off distance possible.
- Issue parking permits so that unauthorized vehicles can be identified.
- Provide emergency communications systems (intercom or telephone) within parking areas, to permit direct contact with security personnel.
- Install CCTV cameras and adequate lighting.

Remember also to consider parking on adjacent sites, in regard to school building location, and provide hardening of the building, or intervening berms, etc., as appropriate.

Pro: Also enhances general safety of site.

Con: Could require more acreage; cost increase.

Code Impact: ADA requirements for travel distance from handicapped-accessible parking to main entrance of the building.

School Planning Comment: Minimize student (foot) traffic crossing driveways. Increased distance from parking to entry door makes supervision more difficult, and makes access during inclement weather more problematic.

## B. Loading Docks

Normally designed to be out of sight, loading docks are especially vulnerable to intruders. Consider CCTV surveillance of the area. Provide signage to clearly mark separate entrances for deliveries. Depending on the risk assessment of the project, blast damage from a vehicle bomb could be a concern. If so, separate (by at least 50 feet) the loading docks and shipping/receiving areas from all utility rooms, utility mains and service entrances – including electrical, telephone, data, fire alarm, fire suppression water mains, cooling and heating mains, etc.

Increased hardening of the nearby structure may be indicated.

Pro: Also could reduce vandalism damage.

Con: Costs.

Code Impact: Neutral.

School Planning Comment: Control of access to Loading / Utility Area is preferred.

### C. Utilities

Damage to utility systems by the shock of an explosion could cause harm (i.e. preventing safe evacuation) disproportionate to the damage to the building itself. Consider the following measures, as appropriate to the specific project:

- Provide underground, concealed, and protected utilities.
- Provide redundant or looped systems, especially electrical service and fire-protection water supply.
- Provide quick connects for portable utility backup systems if redundant systems are not available.
- Protect drinking water from contaminants by securing access points, such as manholes.
- Minimize signs identifying critical utilities. Provide fencing to prevent unauthorized access and use planting to conceal aboveground systems.
- Locate storage tanks downslope from occupied buildings, if possible. Locate fuel storage at least 100 feet from buildings. Above-ground fuel storage tanks can be vulnerable to attack.
- Decentralize communications resources, when possible. Multiple, redundant networks will enhance the system's ability to withstand damage.
- Place trash receptacles as far from the building as possible – min 30 ft.
- Provide a school-wide public address system, for interior and exterior.
- Provide a school-wide CCTV surveillance system with recording capability.
- Route critical utilities so they are not on exterior walls or on walls shared with mailrooms.
- Secure all access to crawl spaces, utility tunnels, etc. Secure manholes or tunnels where site utilities enter the school site.

Pro: Many of these provisions will also improve survivability in the event of storm or other natural disaster.

Con: Added costs.

Code Impact: Neutral

School Planning Comment: Many of the above suggestions will increase costs and/or requirements for size of the site. Location of trash receptacles is one factor in controlling the extent of littering, and of course impacts the ease or difficulty of collecting trash.

## IV. Lighting and Way-finding

### A. Site Lighting

Security lighting can be provided at site entry locations, roadways, parking lots, and walkways from parking to buildings. Consider sports activities and non-traditional uses of the buildings. Also consider paths of access to the buildings

that could be taken by non-authorized persons. If CCTV is provided, ensure that adequate lighting is designed for it.

Pro: Also enhances safety and vandalism prevention.

Con: Costs.

Code Impact: See applicable codes for minimum foot-candle requirements.

School Planning Comment: Highly desirable, but control “spillover” onto adjacent property. (Note: absolute darkness also works as a deterrent.)

#### B. Signage

Sign text should prevent confusion over site circulation, parking, and entrance location. Unless otherwise required, signs should not identify sensitive or high risk areas. However, signs should be erected to indicate areas of restricted admittance.

Consider using street addresses or building numbers instead of detailed descriptive information inside the school grounds. Coordinate signage system with local firefighting and rescue personnel.

Pro: Informative signage enhances appropriate usage.

Con: None

Code Impact: Neutral

School Planning Comment: Designer should integrate sign design into total project design.

#### V. Crime Prevention Through Environmental Design (CPTED)

...is the process of “creating a climate of safety in a community by designing a physical environment that positively influences human behavior.”

CPTED focuses on three strategies --

- Territoriality: Using buildings, fences, pavement, signs, and landscaping to express ownership.
- Natural Surveillance: Placing physical features, activities, and people to maximize visibility
- Access Control: The judicious placement of entrances, exits, fencing, landscaping, and lighting

For additional information about CPTED and about the International CPTED Association (ICA), see the website [www.cpted.net](http://www.cpted.net).

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### **Building Design Guidance and Safety Plans**

Chpt. 3

#### I. Introduction.

This chapter addresses explosive blast and Chemical / Biological / Radiological (CBR) concerns from terrorist attacks. After the site design considerations of Chapter 2,

additional building design measures, such as “hardening” and CBR mitigation measures, should be considered to protect school occupants. Historically, the majority of fatalities that occurred in terrorist attacks directed against buildings were due to building collapse. Also, a high number of injuries can result from flying glass fragments and debris from walls, ceilings, and non-structural elements.

## II. Architectural Design.

The shape of the building can contribute to its resistance to damage. For example, “U” or “L” shaped buildings tend to trap shock waves, which may exacerbate the effect of explosive blasts. Therefore, it is recommended that “inside” corners be avoided, or used in conjunction with appropriate fenestration patterns and site stand-off distances. In general, convex rather than concave shapes are preferred. Also, a long low building has more resistance than a tall structure. Other considerations are...

- Elevate the ground floor to prevent vehicles from being driven into the building.
- Avoid eaves and overhangs, which become points of high local pressure and suction during blasts. If used, these elements should be designed to withstand blast effects. *Counterpoint: eaves and overhangs are useful for rain protection and sun protection.*
- Avoid exposed structural elements (especially columns) on the exterior.
- Locate glazing away from public streets and roadways (but utilize windows for their surveillance benefits over student gathering areas). *Counterpoint: Astute site planning is required to prevent an incompatibility.*
- Eliminate hiding places within the school building.
- Provide reinforced walls in foyers and public entries. Offset interior and exterior doors from each other in airlocks.
- Locate stairs as remotely as possible from areas where blasts might occur. Do not discharge stairs into lobbies, parking, or loading areas.
- Use interior barriers to differentiate levels of security within the building. Create internal buffer zones using secondary stairwells, elevator shafts, corridors, and storage areas between public and secured areas.

Pro: Co-ordinate with aesthetic decisions

Con: Some costs implications

Code Impact: Neutral

School Planning Comment: See *counterpoints* noted above.

### III. Building Envelope

#### A. Exterior Wall Design.

As a minimum, the objective of design is to ensure that the walls fail in a flexible mode rather than in a brittle mode such as shear. Beyond that, the walls may be designed to resist the actual pressure levels of the defined threat. This decision is based on many factors, including available stand-off distance, and perceived risk at the location.

Wall materials selected for blast resistance are...

1. Poured-in-place, reinforced concrete provides the highest level of protection.
2. Pre-cast concrete panels: minimum thickness 5" with two-way reinforcing bars spaced not-to-exceed panel thickness. Connections into the structure should provide straight-line load transfer when practical, using as few connecting pieces as possible.
3. Concrete Masonry block: minimum 8" thick, fully grouted with vertical reinforcing in each cell. Connections into the structure should resist the ultimate lateral capacity of the wall.
4. Metal studs, using two studs back-to-back and mechanically attached, to minimize lateral torsion. To retain exterior cladding fragments, a wire mesh attached to the exterior side of the stud is recommended. Wall supports should resist the ultimate lateral capacity of the system.

*Counterpoint: The above types of construction are very costly compared to more usual school construction methods.*

In certain situations, the following criteria may be implemented:

- Design exterior shear walls to resist the actual blast load predicted from the threat specified. Consider shear walls that are essential to the lateral and vertical load-bearing system, and those that also function as exterior walls, to be Primary Structures.
- Reinforced wall panels can protect columns and also assist in preventing progressive collapse, by carrying the load of a damaged column.
- Consider use of a sacrificial exterior wall to absorb blast.

*Counterpoint: The above provisions will increase cost compared to more usual methods of school construction.*

#### B. Window Design.

Although windows in a school cannot be designed to resist the full force of a large explosive blast, hardened window systems can provide significant protection for students, faculty, and staff. Preferred systems include:

1. Blast Curtains,
2. Laminated thermally tempered glass,
3. Laminated heat strengthened or laminated annealed glass, and
4. Thermally tempered glass with a security film installed on the interior surface.

Glazing systems that do not provide any protection include: untreated monolithic annealed or heat-strengthened glass, and wire glass.

The designer will consider the surrounding area and the potential threat to the school in determining the size, quantity, and location of openings. The amount of blast entering a space is directly proportional to the amount of openings in the façade.

*Counterpoint: This may be incompatible with the functional design – and the aesthetics – of the building.*

Theoretically, window frames would be designed to have compatible capacities to other elements of the window system, and would therefore fail at the same pressure-pulse levels. In this way, the damage sequence and extent of damage are controlled.

#### C. Doors.

Exterior doors in high-risk locations should be designed to withstand the maximum dynamic pressure and duration of the load from the (assumed design threat) explosive blast. Otherwise, the following general considerations apply:

- Provide hollow steel doors or steel-clad doors with steel frames. Ensure the strength of the latch and frame anchor equals that of the door and frame.
- Permit normal entry and egress through a limited number of doors; but provide emergency egress as required by code.
- Exterior doors should open outward. This facilitates egress and also allows the door to seat into the door frame in response to an explosive blast, increasing the likelihood that the door will not enter the building as hazardous debris. [On the other hand, in-opening doors may be less susceptible to burglary. Select hardware as required.]
- Consider using solid doors or walls as a backup for glass doors in foyers.

#### D. Roof Systems.

The most important design consideration is to deny roof access to everyone except authorized personnel. Provide access internally in the building, and lock roof access hatches from the inside. If external access exists, make roof ladders removable, retractable, or lockable. Do not position screen walls around equipment or service yards to allow easy access to the roof or upper windows.

Based on the potential threat perceived at the site, the designer could

- Provide pitched roofs, which better deflect an explosion, or
- Provide a sacrificial sloping roof that is above a protected ceiling.

*Counterpoint: Very costly*

Pro: Generally, measures that mitigate effects of blasts also increase storm resistance.

Con: Greater resistance means greater first costs.

Code Impact: Requirements for doors and windows for egress.  
School Planning Comments: See *counterpoints* noted above.

#### IV. Structural and Non-structural systems.

All new schools should be designed with the intent of reducing the potential for progressive collapse as a result of an abnormal loading event (bomb blast, for example). “Progressive collapse” is a situation where local failure of a primary structural component leads to the collapse of adjoining members which, in turn, leads to additional collapse. Hence the total damage is disproportionate to the original cause. (FEMA document 428 lists several references for structural design.)

Incorporation of the following features will decrease the potential for progressive collapse.

- Redundancy of lateral- and vertical-force resisting systems.
- Ductile (flexible) structural elements and detailing, in which both the primary and secondary structural elements are capable of deforming well beyond the elastic limit without structural collapse.
- Capacity for resisting load reversals, of both the primary and secondary systems.
- Capacity for resisting shear failure. If shear capacity is reached before flexural capacity, a sudden, non-ductile failure of the element could potentially lead to progressive collapse of the structure.
- Provision for components to resist loading in directions for which they were not designed, such as due to negative pressure (upward loading of elements) and dynamic rebound of members. Making steel reinforcement (positive and negative faces) symmetric will address this issue.

*Counterpoint: The above types of construction are very costly compared to more usual school construction methods.*

#### V. Mechanical System.

##### A. HVAC and Plumbing

The primary goal of a mechanical system after a terrorist attack is to continue to operate key life safety systems for school occupants. Smoke removal and control could be of paramount importance. Locate this equipment away from high risk areas; protect controls and power wiring; and connect to emergency power source as appropriate. Consider providing a reasonable amount of redundancy. Other specific considerations include the following:

- Avoid locating piping, lines, and equipment where it is easily damaged from outside the building (i.e., on roofs, on exterior walls).
- Avoid suspending equipment where it could become flying debris in an explosion.
- Reduce the number of utility openings, tunnels, etc. into the school building.
- Install locks on utility covers, manholes, etc.
- Maintain readily available (to emergency responders) diagrams and descriptions of ductwork and mechanical equipment.

Also consider measures appropriate to the local situation to mitigate the risk of CBR threats.

- Place air intakes as high as possible, covered with screens so that objects cannot be thrown into the intakes. Screens should be sloped to allow objects to roll or slide off.
- Control access into mechanical rooms to prevent introduction of hazardous materials in the duct system.
- Restrict use of outside service personnel.
- Consider providing filtered / purified air to an interior portion of the building, which can be used to “shelter in place.”
- Use ducted returns, rather than plenums or hallways.

See FEMA 426 and FEMA 427 for additional details.

#### B. Sprinklers

Fire protection (FP) systems are traditionally not designed to survive bomb blasts. Additional considerations include:

- Protect FP water line from a single-point failure. The incoming line should be encased, buried, or located 50 feet from high risk areas. All interior mains should be looped and sectionalized.
- Consider dual fire pumps, located away from each other.

### VI. Electrical Systems.

#### A. Power.

In addition to building code requirements for emergency lighting, consider provisions for camera surveillance and emergency communication. Other recommendations:

- Emergency and normal electrical panels, conduits, and switchgear should be installed separately, at different locations, and as far apart as possible.  
*Counterpoint: Costly.*
- Emergency generators (and fuel storage) should be located away from loading docks, entrances, and parking. Restrict access with locks, etc.  
*Counterpoint: May be impractical.*
- Make provisions for a trailer-mounted generator to be installed outside, and connected to the electrical distribution system.

#### B. Communications.

The following should be considered minimal requirements:

- Maintain a means of mass notification to all occupants and people in the immediate vicinity (intercom).
- Maintain a radio or wireless system for appropriate individuals, with necessary antennas.
- Provide empty conduits and power outlets for future installation of communications equipment.
- Alarm and information systems should not be collected, nor mounted in a single conduit. Circuits should be installed in at least two directions and/or risers.



- If possible, provide redundant communications via a second telephone service.

#### C. Security Systems.

For schools requiring greater security measures, see the National Institute of Justice Research Report NCJ 178265, *The Appropriate and Effective Use of Security Technologies in U.S. Schools*, September, 1999.

### VII. Emergency Management Plans and Training.

School building design should be optimized to facilitate emergency evacuation, rescue, and recovery efforts through effective site placement, through structural design, and through redundancy of emergency exits and critical mechanical and electrical systems.

See the DOE guide *Practical Information on Crisis Planning: A Guide for Schools and Communities*, May 2003.

The School Safety Emergency Management Plan developed by each school should address natural and manmade disasters, fire, and the potential threat of terrorist activity as appropriate for the individual facility. Staff training, especially for those with specific responsibilities during an event, is essential and should cover both internal and external events.

Appropriate planning, policies, and procedures can have a major impact upon school occupant survivability in the event of terrorist act.

#### **Explosive Blast**

**Chpt. 4**

This chapter discusses the potential threat of explosives in more technical terms, including ways to predict expected overpressure of a blast, given type of delivery vehicle and stand-off distance. Persons needing such detail should consult FEMA 428 directly, and the other references noted therein.

#### **Chemical, Biological, and Radiological Measures**

**Chpt. 5**

This chapter discusses the potential threat from CBR Measures in more technical terms, including disbursal, detection, filtration and pressurization, and personal protection equipment. Persons needing such detail should consult FEMA 428 directly, and the other references noted therein.

There are also fold-out charts listing “Chemical and Biological Agent Characteristics” in Appendix C of FEMA 428.

This chapter is noted as a “work in progress,” to be superseded by FEMA 442, in the future. Nonetheless, it is quite detailed and informative. Persons needing such information should consult the FEMA publication(s) directly.

*Counterpoint: a “Safe Room” large enough for the entire student population would be expensive.*

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**Final Word**

As previously mentioned, the criteria described herein are to be balanced against the budget, the programmatic needs, and the aesthetics of each school – based on an analysis of potential threat to that school.

Each designer and school administrator must weigh the various degrees of threat mitigation against the other criteria unique to that particular project. There is no solution appropriate to every case. However, significant protection can be achieved with little if any additional expenditure. The basic considerations are to form barriers to deny unauthorized access into the school (“lock it”) and to maintain observation of appropriate areas so that threats can be known and timely measures can be taken (“watch it”).

No one can afford to ignore totally the possibility of violence in schools. No one should say “It can’t happen here.”

End