Risk Management Series

Safe Rooms and Shelters

Protecting People Against Terrorist Attacks

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FOREWORD AND ACKNOWLEDGMENTS

OVERVIEW

This manual is intended to provide guidance for engineers, architects, building officials, and property owners to design shelters and safe rooms in buildings. It presents information about the design and construction of shelters in the work place, home, or community building that will provide protection in response to manmade hazards. Because the security needs and types of construction vary greatly, users may select the methods and measures that best meet their individual situations. The use of experts to apply the methodologies contained in this document is encouraged.

The information contained herein will assist in the planning and design of shelters that may be constructed outside or within dwellings or public buildings. These safe rooms will protect occupants from a variety of hazards, including debris impact, accidental or intentional explosive detonation, and the accidental or intentional release of a toxic substance into the air. Safe rooms may also be designed to protect individuals from assaults and attempted kidnapping, which requires design features to resist forced entry and ballistic impact. This covers a range of protective options, from low-cost expedient protection (what is commonly referred to as sheltering-in-place) to safe rooms ventilated and pressurized with air purified by ultra-high-efficiency filters. These safe rooms protect against toxic gases, vapors, and aerosols (finely divided solid or liquid particles). The contents of this manual supplement the information provided in FEMA 361, *Design and Construction Guidance for Community Shelters* and FEMA 320, *Taking Shelter From the Storm: Building a Safe Room Inside Your House*. In conjunction with FEMA 361 and FEMA 320, this publication can be used for the protection of shelters against natural disasters. Although this publication specifically does not address nuclear explosions and shelters that protect against radiological fallout, that information may be found in FEMA TR-87, *Standards for Fallout Shelters*.

This guidance focuses on safe rooms as standby systems, ones that do not provide protection on a continuous basis. To employ a standby system requires warning based on knowledge that a hazardous condition exists or is imminent. Protection is initiated as a result of warnings from civil authorities about a release of hazardous materials, visible or audible indications of a release (e.g., explosion or fire), the odor of a chemical agent, or observed symptoms of exposure in people. Although there are automatic detectors for chemical agents, such detectors are expensive and limited in the number of agents that can be reliably detected. Furthermore, at this point in time, these detectors take too long to identify the agent to be useful in making decisions in response to an attack. Similarly, an explosive vehicle or suicide bomber attack rarely provides advance warning; therefore, the shelter is most likely to be used after the fact to protect occupants until it is safe to evacuate the building.

Two different types of shelters may be considered for emergency use, standalone shelters and internal shelters. A standalone shelter is a separate building (i.e., not within or attached to any other building) that is designed and constructed to withstand the range of natural and manmade hazards. An internal shelter is a specially designed and constructed room or area within or attached to a larger building that is structurally independent of the larger building and is able to withstand the range of natural and manmade hazards. Both standalone and internal shelters are intended to provide emergency refuge for occupants of commercial office buildings, school buildings, hospitals, apartment buildings, and private homes from the hazards resulting from a wide variety of extreme events.

The shelters may be used during natural disasters following the warning that an explosive device may be activated, the discovery of an explosive device, or until safe evacuation is established following the detonation of an explosive device or the release of a toxic substance via an intentional aerosol attack or an industrial accident. Standalone community shelters may be constructed in neighborhoods where existing homes lack shelters. Community shelters may be intended for use by the occupants of buildings they are constructed within or near, or they may be intended for use by the residents of surrounding or nearby neighborhoods or designated areas.

BACKGROUND

> For additional information on CBR and explosives, see FEMA 426 and other Risk Management Series publications.

The attack against the Alfred P. Murrah Federal Office Building in Oklahoma City and the anthrax attacks in October 2001 made it clear that chemical, biological, radiological, and explosive (CBRE) attacks are a credible threat to our society. Such attacks can cause a large number of fatalities or injuries in high-occupancy buildings (e.g., school buildings, hospitals and other critical care facilities, nursing homes, day-care centers, sports venues, theaters, and commercial buildings) and residential neighborhoods.

Protection against the effects of accidental or intentional explosive detonations and accidental or intentional releases of toxic substances into the air or water represent a class of manmade hazards that need to be addressed along with the protection that may already be provided against the effects of natural hazards such as hurricanes and tornadoes. Although there are a wide range of scenarios that may create these manmade hazards, to date they are extremely rare events. However, although scarce, these events warrant consideration for passive protective measures. These passive protective measures may be in the form of a safe room in which occupants of a building may be sheltered until it is safe to evacuate. The effectiveness of the safe room for protecting occupants from manmade threats is dependent on the amount of warning prior to the event and its construction. For example, in Israel, a building occupant may expect a 3-minute warning prior to a Scud missile attack; therefore, the shelter must be accessible to all building occupants within this time period. Note that such advance warning rarely accompanies the explosive vehicle or suicide bomber event; in this case, the function of the safe room is to protect occupants until law enforcement agencies determine it is safe to evacuate.

Protection against explosive threats depends to a great extent on the size of the explosive, the distance of the detonation relative to the shelter, and the type of construction housing the shelter. Although there may be opportunities to design a new facility to protect against a specified attack scenario, this may be of limited feasibility for the retrofit of an existing building. The appropriate combination of charge weight and standoff distance as well as the intervening structure between the origin of threat and the protected space is very site-specific; therefore, it is impractical to define a design level threat in these terms. Rather than identify a shelter to resist a specified explosive threat, this document will provide guidance that will address different types of building construction and the reasonable measures that may be taken to provide a secure shelter and a debris mitigating enclosure for a shelter. This approach does not attempt to address a specific threat because there are too many possible scenarios to generalize a threat-specific approach; however, it does allow the user to determine the feasible options that may be evaluated on a case by case basis to determine a response to any postulated threat. For protection against assault and attempted kidnapping, a level of forced entry and ballistic resistance may be specified. Several different organizations (e.g., the American Society for Testing and Materials (ASTM), H.P. White, Underwriters Laboratories (UL), the Department of Justice (DOJ), etc.) define performance levels associated with forced entry and ballistic resistance that relate to the different sequence of tests that are required to demonstrate effectiveness of a given construction product. This document will not distinguish between the different types of testing regimes.

Protection against airborne hazardous materials may require active measures. Buildings are designed to exchange air with the outdoors in normal operation; therefore, airborne hazardous materials can infiltrate buildings readily when released outdoors, driven by pressures generated by wind, buoyancy, and fans. Buildings also tend to retain contaminants; that is, it takes longer for the toxic materials to be purged from a building than to enter it.

The safe room may also shelter occupants from tornadoes and hurricanes, which are the most destructive forces of nature. Since 1995, over 1,200 tornadoes have been reported nationwide each year. Approximately five hurricanes strike the United States mainland every 3 years and two of these storms will cause extensive damage. Protection from the effects of these natural occurrences may be provided by well designed and amply supplied safe rooms. The well designed safe room protects occupants from the extremely rare, but potentially catastrophic effects of a manmade threat as well as the statistically more common, but potentially less severe effects of a natural disaster.

SCOPE AND ORGANIZATION OF THE MANUAL

This document will discuss the design of shelters to protect against CBRE attacks. Fallout shelters that are designed to protect against the effects of a nuclear weapon attack are not addressed in this publication. The risks of death or injury from CBRE attacks are not evenly distributed throughout the United States. This manual will guide the reader through the process of designing a shelter to protect against CBRE attacks. The intent of this manual is not to mandate the construction of shelters for CBRE events, but rather to provide design guidance for persons who wish to design and build such shelters.

The design and planning necessary for extremely high-capacity shelters that may be required for large, public use venues such as stadiums or amphitheaters are beyond the scope of this design manual. An owner or operator of such a venue may be guided by concepts presented in this document, but detailed guidance concerning extremely high-capacity shelters is not provided. The design of such shelters requires attention to issues such as egress and life safety for a number of people that are orders of magnitude greater than those proposed for a shelter designed in accordance with the guidance provided herein.

The intent of this manual is not to override or replace current codes and standards, but rather to provide important guidance of best practices (based on current technologies and scientific research) where none has been available. No known building, fire, life safety code, or engineering standard has previously attempted to provide detailed information, guidance, and recommendations concerning the design of CBRE shelters for protection of the general public. Therefore, the information provided herein is the best available at the time this manual was published. Designing and constructing a shelter according to the criteria in this manual does not mean that the shelter will be capable of withstanding every possible event. The design professional who ultimately designs a shelter should state the limiting assumptions and shelter design parameters on the project documents.

This manual includes the following chapters and appendices:

- Chapter 1 presents design considerations, potential threats, the levels of protection, shelter types, siting, occupancy duration, and human factors criteria for shelters (e.g., square footage per shelter occupant, proper ventilation, distance/travel time and accessibility, special needs, lighting, emergency power, route marking and wayfinding, signage, evacuation considerations, and key operations zones).

- Chapter 2 discusses the structural design criteria for blast and impact resistance, as well as shelters and model building types. Structural systems and building envelope elements for shelters are analyzed and protective design measures for the defined building types are provided.

- Chapter 3 describes how to add chemical, biological, and radiological (CBR) protection capability to a shelter or a safe room. It also discusses air filtration, safe room criteria, design requirements, operations and maintenance, commissioning, and training required to operate a shelter.

- Chapter 4 discusses emergency management considerations, Federal CBRE response teams, emergency response and mass care, community shelter operations plans, descriptions of the responsibilities of the shelter team members, shelter equipment and supplies, maintenance plans, and commercial building shelter operation plans. Key equipment considerations and training are also discussed.

- Appendix A presents the references used in the preparation of this document.

- Appendix B contains a list of acronyms and abbreviations that appear in this document.

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