Risk Management Series

Design Guide

for Improving School Safety in Earthquakes, Floods, and High Winds

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FOREWORD AND ACKNOWLEDGMENTS

BACKGROUND

Our society places great importance on the education system and its schools, and has a tremendous investment in current and future schools. Currently, approximately 53 million kindergarten to grade 12 (K-12) students attend over 92,000 public schools and it is estimated that the public student population will have reached 54.3 million by 2004[1]; to this figure must be added the substantial population of private school students. The sizes of these school facilities range from one-room rural schoolhouses to citywide and mega schools that house 5,000 or more students. The school is both a place of learning and an important community resource and center.

This publication is concerned with the protection of schools and their occupants against natural hazards. These hazards must be recognized as part of the natural environment and as extensions of phenomena that designers have always considered. Natural hazards can be reduced to extreme phenomena related to the four elements (i.e., earth, water, wind, and fire). Earthquakes are highly accelerated and exaggerated forms of motion that are always occurring in the earth and floods occur when rivers overflow or the wind stirs up the ocean along coastal waters. High winds and tornadoes are an extreme form of the beneficial breezes that freshen the air. Fire has been a threat to buildings for centuries and was one of the first threats to be the subject of regulation. Because of its familiarity and the extensive provisions for fire protection in building codes, it is not a subject for detailed consideration in this publication. However, some considerations relating to the fire protection of schools are presented in Chapter 3, Section 3.4.

Architects and engineers deal with these natural elements all the time; building codes always have provisions for protection against fire and wind and the local building code (if adopted by the com-

[1] U.S. Department of Education, National Center for Education Statistics, *Baby Boom Echo Report*, 2000.

munity) will also dictate whether earthquakes or floods must be considered as design parameters. However, the major decisions in reducing flood damage may be in site selection and layout, not in building design.

This manual introduces two core concepts: multihazard design and performance-based design. Neither is revolutionary, but represents an evolution in design thinking that is in tune with the increasing complexity of today's buildings and also takes advantage of developments and innovations in building technology:

- The concept of multihazard design is that designers need to understand the fundamental characteristics of hazards and how they interact, so that design for protection becomes integrated with all the other design demands.

- Performance-based design suggests that, rather than relying on the building code for protection against hazards, a more systematic investigation is conducted to ensure that the specific concerns of building owners and occupants are addressed. Building codes focus on providing life safety and property protection is secondary: performance-based design provides additional levels of protection that cover property damage and functional interruption within a financially feasible context.

This publication stresses that identification of hazards and their frequency and careful consideration of design against hazards must be integrated with all other design issues, and be present from the inception of the site selection and building design process. Although the basic issues to be considered in planning a school construction program are more or less common to all school districts, the processes used differ greatly, because each school district has its own approach. Districts vary in size, from a rural district responsible for only a few elementary schools, to a city district or statewide system overseeing a complex program of all school types and sizes, including new design and construction, renovations, and additions. A district may have had a long-term program of school construction and be familiar with programming, financing, hiring designers, bidding procedures, contract administration, and commissioning a new building, but another district may not have constructed a new school for decades, and have no staff members familiar with the process.

SCOPE

This publication is intended to provide design guidance for the protection of school buildings and their occupants against natural hazards, and concentrates on grade schools (K-12); the focus is on the design of new schools, but the repair, renovation, and extension of existing schools is also addressed. It is intended as the first of a series of publications in which hospitals, higher education buildings, multifamily dwellings, commercial buildings, and light industrial facilities will be addressed.

The focus of this publication is on the safety of school buildings and their occupants, and the economic losses and social disruption caused by building damage and destruction. The volume covers three main natural hazards that have the potential to result in unacceptable risk and loss: earthquakes, floods, and high winds. A companion volume, *Primer to Design Safe School Projects in Case of Terrorist Attacks* (FEMA 428), covers the manmade hazards of physical, chemical, biological, and radiological attacks.

The intended audience for this manual includes design professionals and school officials involved in the technical and financial decisions of school construction, repair, and renovations. A short brochure based on this manual will also be available for school district and school board decision-makers.

ORGANIZATION AND CONTENT OF THE MANUAL

Chapters 1-3 present issues and background information that are common to all hazards. Chapters 4-6 cover the development of specific risk management measures for each of the three main natural hazards.

Chapter 1 opens with a brief outline of the past, present, and future of school design. Past school design is important because many of these older, and even historic, schools are still in use and their occupants must be protected.

Chapter 2 introduces the concepts of performance-based design in order to obtain required performance from a new or retrofitted facility. Chapter 3 introduces the concept of multihazard design and presents a general description and comparison of the hazards, including charts that show where design against each hazard interacts with design for other hazards. This latter section includes fire and building security in its considerations.

Chapters 4, 5, and 6 outline the steps necessary in the creation of design to address risk management concerns for protection against earthquakes, floods, and high winds, respectively. Information is presented on the nature of each hazard and its effect on vulnerability and consequences of building exposure. Procedures for risk assessment are outlined, followed by descriptions of current methods of reducing the effects of each hazard. These vary, depending on the hazard under consideration. A guide to the determination of acceptable risk and realistic performance objectives is followed by a discussion to establish the effectiveness of current codes to achieve acceptable performance.

Appendix A contains a list of acronyms that appear in this manual.

The information presented in this publication provides a comprehensive survey of the methods and processes necessary to create a safe school, but is necessarily limited. It is not expected that the reader will be able to use the information directly to develop plans and specifications. The information is intended to help designers and facility decision-makers, who may be unfamiliar with the concepts involved, to understand fundamental approaches to risk mitigation planning and design. By so doing, they can move on to the implementation phase of detailed planning, involving consultants, procurement personnel, and project administration, from a firm basis of understanding.

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Principal Authors:

Christopher Arnold, Building Systems Development, Inc.

Jack Lyons, School Facilities Consultant

James Munger, James G. Munger and Associates

Rebecca C. Quinn, Consultant

Thomas L. Smith, TLSmith Consulting

Contributors:

Milagros Kennett, FEMA, Project Officer, Risk Management Series Publications

Eric Letvin, Greenhorne & O'Mara, Inc., **Consultant Project Manager**

John Plisich, FEMA

Mike Robinson, FEMA

Joe Agron, American School and University

Connie Deshpande, Department of Education

Randy Haslam, Jordan, Utah, School District

Danny Kilcollins, Florida Department of Community Affairs

Fred Krimgold, World Institute for Disaster Risk Management

Tom Kube, Council of Educational Facility Planners International

Bill Modzeleski, Department of Education

Jack Paddon, Williams and Paddon Architects and Planners

Bebe Pinter, Harris County Department of Education

John Sullivan, Portland Cement Association

Jon Traw, Traw Associates

French Wetmore, French and Associates

Deb Daly, Greenhorne & O'Mara, Inc.

Wanda Rizer, Greenhorne & O'Mara, Inc.

Julie Liptak, Greenhorne & O'Mara, Inc.

Bob Pendley, Greenhorne & O'Mara, Inc.

This primer will be revised periodically and EP&R welcomes comments and feedback to improve future editions. Please send comments and feedback via e-mail to riskmanagementseriespubs@dhs.gov

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