Risk Management Series

Design Guide

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

FEMA 577 / June 2007

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About the Cover

Olive View Hospital Replacement Fares Well In 1994 Quake

The new Olive View hospital building shown on the cover performed well during the 1994 Northridge earthquake. This quake, of the same magnitude as the 1971 San Fernando Earthquake that nearly collapsed the original building, caused no serious damage. Built in 1970, the Medical Treatment and Care Building of the Olive View Hospital complex was designed to meet the earthquake provisions of building codes in place at that time. The hospital incurred heavy damage (at left) during the 1971 earthquake and was subsequently rebuilt to stricter design and construction standards.

Olive View Hospital After the 1971 Magnitude 6.7 San Fernando Earthquake

PHOTO CREDIT: E.V. LEYENDECKER, U.S. GEOLOGICAL SURVEY

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RISK MANAGEMENT SERIES

Design Guide *for* Improving Hospital Safety in Earthquakes, Floods, and High Winds

PROVIDING PROTECTION TO PEOPLE AND BUILDINGS

FEMA

BACKGROUND

The United States is currently in the middle of the biggest hospital construction boom in more than 50 years. According to data from the U.S. Census Bureau, spending for construction of new hospitals and other medical facilities increased 65 percent between 2000 and 2006. New scientific and technological innovations, as well as advancements in medical practice and the organization of health care, demand a physical environment different from the hospitals of the past. This demand is being met by the increasing use of evidence-based design, which relies on a combination of scientifically proven research and the evaluation of completed projects to make design and construction decisions that improve the safety and functionality of hospital buildings.

Architects and engineers now look at credible research related not just to structural and mechanical engineering, but also to clinical outcomes, behavioral science, the environment, and technology. New building designs are now seen as important components that can improve medical outcomes, patient safety, employee satisfaction, and even financial performance. The effective use of evidence-based design requires continuous and timely updates of the information that affects hospital design. As part of this effort, the Federal Emergency Management Agency (FEMA) has developed this Design Guide to provide the designers of new hospitals and retrofits to existing ones with the latest information and research results on the best practices to reduce the risks from natural hazards.

This publication is the latest addition to FEMA's Risk Management Series, which provides guidelines for mitigating the risks associated with multiple hazards. The series emphasizes mitigation best practices for specific

building uses and occupancies, such as schools, critical facilities, commercial buildings, and multi-family dwellings.

OBJECTIVE AND SCOPE

The objective of the "*Design Guide for Improving Hospital Safety in Earthquakes, Floods, and High Winds*" is to inform and assist design professionals, hospital administrators, and facility managers in implementing sound mitigation measures that will decrease the vulnerability of hospitals to disruptions caused by natural hazard events. The intent of the Design Guide is to provide its audience with state-of-the-art knowledge on the variety of vulnerabilities faced by hospitals exposed to earthquakes, flooding, and high-winds risks, as well as the best ways to mitigate the risk of damage and disruption of hospital operations caused by these events.

The information presented in this publication provides an exhaustive review of mitigation measures and design solutions that can improve the safety of hospitals in natural hazard events. However, this publication is not intended to be a comprehensive mitigation design manual that the reader can use to develop actual plans and specifications. It is intended as an introduction to the fundamental principles of natural hazard risk reduction, with an emphasis on mitigation planning and the design of hospital buildings. The information presented here is intended to help design professionals, hospital administrators, and facility managers understand the broad aspects of risk reduction methods and strategies, and integrate them into hospital designs.

ORGANIZATION AND CONTENT

The Design Guide is organized around three specific natural hazards: earthquakes, floods, and high winds. It comprises four main chapters.

Chapter 1 presents an overview of the principal considerations determining hospital design, from standard industry requirements to new developments that are transforming both hospital operations and organization of the physical environment. It highlights the known vulnerabilities of hospitals and the repercussions of damage caused by natural hazard events that frequently interfere with the operation of these facilities. The chapter concludes with a look at the multi-hazard approach to hospital design, and provides basic guidelines on the interaction between the responses of building components to various natural hazard risks.

Chapter 2 examines potential earthquake damage to hospitals, and how these facilities can most efficiently improve their performance. The

chapter opens with an introductory discussion on the nature and probability of earthquakes, and procedures for determining seismic risk to specific locations. Typical seismic damages, and the possible resulting effects on building functions or risk to occupants, are described and related to the standard damage states currently used in performance-based earthquake engineering design. The chapter ends with a review of the best practices in seismic design and seismic retrofit of hospital facilities.

Chapter 3 discusses the nature of flood forces and their effects on buildings. It outlines the procedures for risk assessment and describes the current mitigation measures for reducing flood damage. It emphasizes the benefits of avoiding construction of new hospitals in high-risk areas, describes regulatory design requirements that help reduce the exposure of hospitals that must be located in flood hazard areas, and encourages the application of appropriate mitigation measures to existing hospitals at risk of flooding.

Chapter 4 discusses the effects of wind forces on hospitals' structural and nonstructural building components. By reviewing numerous examples of wind-induced damage to these facilities, this chapter highlights the best mitigation practices for new hospital design and construction, and for the rehabilitation of existing facilities. It concentrates on the building components that are the most critical for maintaining uninterrupted operation of hospitals, and provides detailed guidelines for improving their design and construction.

At the end are Appendix A, which contains a list of acronyms, and Appendix B, which contains a glossary of terms that appear in the Design Guide.

ACKNOWLEDGMENTS

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This manual will be revised periodically, and FEMA welcomes comments and suggestions for improvements in future editions. Please send your comments and suggestions via e-mail to:
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