



Risk Management Series

Incremental Seismic Rehabilitation of School Buildings (K-12)

Providing Protection to People and Buildings

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Incremental Seismic Rehabilitation of School Buildings (K-12)

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Executive Summary

Earthquakes are a serious threat to school safety and pose a significant potential liability to school officials and to school districts. School buildings in 39 states are vulnerable to earthquake damage. Unsafe existing buildings expose school administrators to the following risks:

- *Death and injury of students, teachers, and staff*
- *Damage to or collapse of buildings*
- *Damage and loss of furnishings, equipment, and building contents*
- *Disruption of educational programs and school operations*

The greatest earthquake risk is associated with existing school buildings that were designed and constructed before the use of modern building codes. For many parts of the United States, this includes buildings built as recently as the early 1990s.

Although vulnerable school buildings need to be replaced with safe new construction or rehabilitated to correct deficiencies, for many school districts new construction is limited, at times severely, by budgetary constraints, and seismic rehabilitation is expensive and disruptive. However, an innovative approach that phases a series of discrete rehabilitation actions implemented over a period of several years, **incremental seismic rehabilitation**, is an effective, affordable, and non-disruptive strategy for responsible mitigation action. It can be integrated efficiently into ongoing facility maintenance and capital improvement operations to minimize cost and disruption. The strategy of incremental seismic rehabilitation makes it possible to get started now on improving earthquake safety in your school district.

This manual provides school administrators with the information necessary to assess the seismic vulnerability of their buildings, and to implement a

program of incremental seismic rehabilitation for those buildings. The manual consists of three parts:

Part A, Critical Decisions for Earthquake Safety in Schools, is for superintendents, board members, business managers, principals, and other policy makers who will decide on allocating resources for earthquake mitigation.

Part B, Managing the Process for Earthquake Risk Reduction in Existing School Buildings, is for school district facility managers, risk managers, and financial managers who will initiate and manage seismic mitigation measures.

Part C, Tools for Implementing Incremental Seismic Rehabilitation in School Buildings, is for school district facility managers, or those otherwise responsible for facility management, who will implement incremental seismic rehabilitation programs.

To get the most out of this manual:

- Communicate the importance of assessing your district's risks and pass this manual on to the staff members responsible for facility management, risk management, and financial planning. Specify that they develop an analysis of the current seismic risk of your buildings and a strategy for risk reduction.
- Promptly initiate a program of earthquake risk reduction in the district's buildings located in an earthquake-prone zone that were not designed and constructed to meet modern building codes.
- Consider incremental seismic rehabilitation as a cost-effective means to protect the buildings and, most importantly, the safety of students, teachers, and staff, because it is a technically and financially manageable strategy that minimizes disruption of school activities.

Foreword

The concept of seismically rehabilitating buildings in discrete segments, as resources become available or as part of a structural renovation program, was pioneered by FEMA and a Virginia Polytechnic Institute/Building Technology Inc. team that, in the early 1990s, published *Existing School Buildings – Incremental Seismic Retrofit Opportunities*, FEMA 318. Lack of resources at the time, however, restricted application of this promising concept to a few states in the Pacific Northwest and to a single occupancy or use category: schools. FEMA is therefore now pleased to make available an updated version of the manual on schools (K-12). Further, the team is also preparing a series of manuals that will address seven additional building uses: hospitals, retail establishments, multi-family dwellings, office buildings, emergency management facilities, warehousing/distribution centers, and hotels/motels. A separate manual will serve the needs of design professionals and building officials and will be applicable across all occupancy categories.

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The Federal Emergency Management Agency

Preface

This manual is intended to assist school administration personnel responsible for the funding and operation of existing school facilities across the United States. This guide and its companion documents are the products of a Federal Emergency Management Agency (FEMA) project to develop the concept of incremental seismic rehabilitation—that is, building modifications that reduce seismic risk by improving seismic performance and that are implemented over an extended period, often in conjunction with other repair, maintenance, or capital improvement activities.

The manual was developed after analyzing the management practices of school districts of varying sizes located in various seismic zones in different parts of the United States. It focuses on the identified concerns and decision-making practices of K-12 public and private school managers and administrators.

This manual is part of a set of manuals intended for building owners, managers, and their staff:

- *Incremental Seismic Rehabilitation of School Buildings (K-12)*, FEMA 395
- *Incremental Seismic Rehabilitation of Hospital Buildings*, FEMA 396
- *Incremental Seismic Rehabilitation of Office Buildings*, FEMA 397
- *Incremental Seismic Rehabilitation of Multifamily Apartment Buildings*, FEMA 398
- *Incremental Seismic Rehabilitation of Retail Buildings*, FEMA 399
- *Incremental Seismic Rehabilitation of Hotel and Motel Buildings*, FEMA 400
- *Incremental Seismic Rehabilitation of Storage Buildings*, FEMA 401
- *Incremental Seismic Rehabilitation of Emergency Buildings*, FEMA 402

Each manual in this set addresses the specific needs and practices of a particular category of buildings and owners, and guides owners and managers through a process that will reduce earthquake risk in their building inventory.

The manuals answer the question, as specifically as possible, “what is the most affordable, least disruptive, and most effective way to reduce seismic risk in existing buildings?” By using the process outlined in these manuals, building owners and managers will become knowledgeable clients for implementing incremental seismic rehabilitation specifically geared to their building use category.

In addition to this set of manuals, there is a companion manual, *Engineering Guideline for Incremental Seismic Rehabilitation*, FEMA 420. It is intended to assist architects and engineers who provide services to building owners and contains the information necessary for providing consulting services to owners for implementing incremental seismic rehabilitation. Architects and engineers using that handbook will be effective consultants serving a knowledgeable owner. Together they will be in a position to implement an effective incremental seismic rehabilitation program.

You may be liable for earthquake deaths and injuries in your older school buildings.

The 1933 Long Beach, California Earthquake destroyed at least 70 schools and damaged 420 more, 120 of them seriously. As a direct response, California enacted the Field Act, which established strict design and construction standards for new schools in California. But what about all the existing schools that were vulnerable to earthquakes? It took over 30 years to solve this problem, but more than just the passage of time was required.

In 1966 the Attorney General of California issued an opinion indicating that school boards were responsible for ensuring non-Field Act buildings were examined, and if schools were found to be unsafe and the board did not make the necessary corrections to make them safe, the individual school board members were personally liable. The opinion received widespread media attention. School boards, then realizing the gravity of the situation, became quite concerned about the structural condition of their pre-Field Act public school buildings. Legislative action soon followed. The Governor signed the Greene Act in 1967, which relieved the individual school board members of personal liability *only once the board initiated the process of examining existing buildings and established an intent to carry through to completion all the steps necessary for their replacement or repair.*

You too may be liable for earthquake deaths and injuries in your older school buildings, but can you wait 30 years to act? This manual provides you with the tools to assess your vulnerability and to find cost-effective ways to reduce your liability today.

Introduction

Schools, Risk, and Liability

School administrators face a wide array of risks. These risks range from playground accidents to armed attack. Risk management for schools is typically driven by experience and individual and group perceptions of danger; we recognize the need for seatbelts on school buses and sanitary precautions in the cafeteria, but the risk of catastrophic loss due to a damaging earthquake is more difficult to understand or to anticipate. Earthquakes are low-probability high-consequence events. Though they may occur only once in the life of a building they can have devastating, irreversible consequences.

Moderate earthquakes occur more frequently than major earthquakes. Nonetheless, moderate earthquakes can cause serious damage to building contents and non-structural building systems, serious injury to students and staff, and disruption of building operations. Major earthquakes can cause catastrophic damage including structural collapse and massive loss of life. Those responsible for school safety must understand and manage these risks, particularly those risks that threaten the lives of students, teachers, and staff.

Earthquake risk is the product of hazard exposure and building vulnerability, as shown in the following equation:

$$\text{RISK} = \text{HAZARD} \times \text{VULNERABILITY}$$

To manage earthquake risk in existing school buildings one must understand the earthquake hazard and reduce school building vulnerability.

This manual is designed to give decision makers the framework and information for making informed decisions about investing in earthquake risk management measures. It is structured to follow the decision making process of existing planning and management practices and will help you evaluate financial, safety, and educational priorities.

School districts vary greatly in size, resources, and technical capability. Some have comprehensive long-term facility management, maintenance, and development plans. Some have none. The successful implementation of improved earthquake safety should be part of a comprehensive approach to building safety and multi-hazard mitigation.

Failure to address earthquake risk leaves the school district exposed to potential losses, disruption, and liability for deaths and injuries. While purchasing insurance may protect the school district from financial losses and liability, it still leaves the district susceptible to disruption as well as deaths and injuries. Only building rehabilitation can reduce losses, deaths and injuries, and control liability and disruption. However, single-stage seismic rehabilitation can be expensive and disruptive. Incremental seismic rehabilitation can reduce that cost and disruption.

Considering Incremental Seismic Rehabilitation

The incremental rehabilitation approach to seismic risk mitigation focuses on improvements that will decrease the vulnerability of school buildings to earthquakes at the most appropriate and convenient times in the life cycle of those buildings. The approach clarifies, as specifically as possible, what is the most affordable, least disruptive, and most effective way to reduce seismic risk in your buildings.

Prior to initiating a program of incremental seismic rehabilitation, a school district must first address the following three questions:

- Are your buildings located in a seismic zone?
- Are your school buildings vulnerable to earthquakes?
- What can you do to reduce earthquake risk in existing vulnerable school buildings?

This manual will help you find the right answers.