A GUIDEBOOK TO

FEMA 178 - NEHRP HANDBOOK FOR THE SEISMIC EVALUATION OF EXISTING BUILDINGS

FOR USE IN THE EVALUATION OF SCHOOL BUILDINGS

JULY 1994

Prepared by

Building Technology Inc.
1109 Spring Street
Silver Spring, MD 20910

THIS MATERIAL WAS DEVELOPED UNDER CONTRACT #EMW-91-C-3636 WITH THE FEDERAL EMERGENCY MANAGEMENT AGENCY

PREFACE

Building Technology Inc. (BTI) has prepared this document in support of its efforts under Federal Emergency Management Agency (FEMA) Contract #EMW-91-C-3636, *Technology Transfer on Seismic Rehabilitation of Existing Buildings*, awarded September 1991. Under this contract BTI has been responsible for the promotion and conduct of general audience and targeted audience workshops, the development of materials (including lectures, slides, videos, and publications) in support of these workshops, the preparation and delivery of presentations under a speakers bureau, and the distribution of the entire series of FEMA publications regarding the subject of seismic mitigation of existing buildings.

This document was prepared for BTI by Mr. Melvyn Green, P.E., president of Melvyn Green and Associates, subcontractor, and reviewed by Dr. Frederick Krimgold of the Virginia Polytechnic Institute and State University, consultant.

In addition, BTI gratefully acknowledges the valuable assistance and cooperation provided by Ms. Marilyn MacCabe, Project Officer, Federal Emergency Management Agency.

Introduction

This guidebook is a companion publication to be used in conjunction with the Federal Emergency Management Agency's document *FEMA 178 - NEHRP Handbook for the Seismic Evaluation of Existing Buildings*. This guidebook is intended for use by school facility administrators, staff and consulting architects and engineers.

The FEMA 178 Handbook is intended for use by engineers and architects. It provides technical guidance in how to evaluate existing buildings for seismic safety. While this may be undertaken at any time, it is often done after a building has undergone the Rapid Screening Procedure. The intent of the handbook is to provide engineers and architects with a structured, but not rigid, technical evaluation procedure to determine whether a building or selected component requires seismic rehabilitation.

The FEMA-178 Handbook provides important guidance in the seismic evaluation of school buildings. While the handbook is written with the engineer in mind, some sections will also assist school facilities managers by providing a better understanding of their building stock.

This guidebook augments the FEMA 178 Handbook because:

- It may be difficult for a non-technical person to effectively understand an engineering text.
- Elaboration of certain sections of the Handbook could make them more valuable in assisting facilities managers in understanding the seismic issues that may affect their buildings.
- School buildings are a unique stock of structures a limited number of structural types. A common set of problems that school buildings face in seismic retrofit can be described and resolved, making it easier to improve the buildings.

This Guidebook refers to section numbers within FEMA 178 Handbook. At the end of the guidebook is a chart displaying these sections recommended for the facilities manager and the engineer respectively.

It is anticipated that FEMA 178 and this Guidebook will be used by school districts to support the initiation of an incremental seismic retrofit program. There are several companion documents to this Guidebook relating to incremental seismic retrofit. One document, entitled *Facilities Management in Existing Buildings----Two Models,* suggests how seismic evaluation using FEMA 178 and this Guidebook can be integrated into the school facilities management process. Another document entitled *Incremental Seismic Retrofit Opportunities,* contains a summary of seismic rehabilitation techniques and details and guidance on how to incorporate them into an incremental seismic retrofit program.

Chapter 1 - Introduction

1.1 Purpose of this Handbook

This section provides an overview of the document's intent. It provides the user with an understanding of seismic rehabilitation procedures. FEMA 178 discusses a "design earthquake" which is the earthquake load specified by the building code. Evaluation will often use a smaller load, since the goal of the evaluation is life safety. It is important to understand that the building code is intended to keep the building standing during the largest credible earthquake in a region. However, between large earthquakes many small earthquakes may occur, each with the potential for structural and nonstructural damage.

A program of incremental seismic retrofit is capable of achieving the life safety implied in FEMA 178 after all the increments are accomplished. However, while each increment may fall short of this goal, it would nevertheless be capable of contributing to improving safety to life in the smaller earthquakes. FEMA 178, by focusing on the "design earthquake" does not specifically anticipate this approach to seismic risk reduction.

1.2 Essential Facilities

Building codes have traditionally recognized that essential facilities, defined as those structures which are necessary for emergency operations subsequent to a natural disaster, should be designed to a higher standard than other facilities. This is usually accomplished by employing an importance factor which in effect increases the design loads on essential facilities.

Schools are not considered to be essential facilities in most building codes. However, the emergency plans of many communities designate schools as shelters and distribution centers in a post-disaster situation. Some school districts may take this designation into account when they consider the structural design criteria applicable to their facilities. Section 1.2 points out that "although the procedures in the handbook can be used to evaluate the life-safety of such essential facilities, their applications will not necessarily assure continued post-earthquake use." Users of this Handbook should take this into account when they apply it to school buildings.

1.3 Scope and Limitations

The methodology utilized in the FEMA 178 is based on a "life safety approach" and does not address other objectives such as damage control and continuity of use. The incremental strengthening approach, discussed in this Guidebook, does not bring the building up to the strength level anticipated by the building code. Users should not consider their building strengthened when undertaking these incremental strengthening techniques. However, each retrofit measure suggested will be part of any complete strengthening project. Therefore there is no waste of construction dollars.

1.3.2 Force Level for Analysis

The seismic loads recommended in the Handbook are less than those required for new buildings. The seismic evaluation criteria is intended to provide for an acceptable level of protection to life. This is generally accepted as a regulatory approach to existing buildings.

1.3.4 Other Standards

This section reviews the evaluation standards issue.

1.4 Handbook Methodology

The Handbook uses a series of questionnaires, called evaluation statements. A general set of evaluation statements is contained in the Handbook, Appendix A, and a series of model building evaluation statements in Appendix B.

It is suggested that schools may, for the most part, be more easily evaluated by using the General Statements in Appendix A. The reason for this is that few school buildings come under the standard model building types. Further the General Statements contain specific sections for Nonstructural Elements, which are of great importance for schools.

1.5 Handbook Contents

As noted in 1.4 the handbook is very useful for facility administrators and practicing architects and engineers. However, Appendix B will be useful for only a small percentage of the school building types.

Chapter 2 - The Evaluation Process

2.0 Introduction

This section summarizes the evaluation process. It is valuable in understanding the procedures used.

2.1 Site Visit and Data Collection

This section contains the seismic risk maps and will give an idea of the seismic zone for a specific location. Usually the local building department or state geologists can provide this information if it is not clear.

2.2 Selection and Review of the Evaluation Statements

2.2.1 Using the General Procedure

With the exceptions noted in 2.2.2, the General Evaluation Statements may be the most useful section for schools.

2.2.2 Using the Lists for the 15 most common building types

The model building types may be applicable for certain school buildings. Specific examples include gymnasiums, multipurpose facilities, warehouses and office buildings.

Chapter 3 - Procedures and Commentary for Building Systems

School buildings often have had several additions over their lifetime and this should be kept in mind when evaluating school building construction.

3.1 Load Path

This section discusses the need for a continuous load path. Field observation indicate that sometimes the load path is not considered when vertical additions to a school are made.

3.3 Configuration

The configuration of buildings is reviewed in this section. The Handbook suggests that various horizontal and vertical conditions may affect the dynamic behavior of a building. Section 3.3 also mentions horizontal irregularities. This condition is frequently noted in school buildings. Chapter 3 of the *FEMA -149 Seismic Consideration-Elementary and Secondary Schools* discusses this in greater detail. *(*See Appendix A of companion document *Guidebook to FEMA 154 For Use in the Screening of School Buildings.)*

3.4 Adjacent Buildings

This section brings up a critical point for school buildings. Adjacent buildings tend to "pound" into each other during an earthquake, potentially causing failure. While the Handbook considers the issue of adjacent buildings on adjoining property, school structures often have multiple additions, each of which creates the condition of adjacency.

Chapter 4 - Procedures and Commentary for Moment Resisting Frames

Chapter 5 - Procedures and Commentary for Shear Walls

Chapter 6 - Procedures and Commentary for Braced Frames

Chapter 7 - Procedures and Commentary for Diaphragms

Chapter 8 - Procedures and Commentary for Connections

Chapter 9 - Procedures and Commentary for Foundations and Geologic Hazards

Chapter 10 - Evaluation of Elements that are Not Part of the Lateral Force Resisting System

This Chapter may be one of the most important for facility managers. It discusses nonstructural components such as ceilings and lights and provides a discussion on the issues relative to safety.

10.3 Life Safety Concerns

It is suggested that this section, along with 10.4, be read by facility administrators.

10.4 Nonstructural Elements

Section 10.4 is related to nonstructural elements in buildings. This is a common area of damage in small to moderate earthquakes, especially in school buildings.

10.5 Evaluation Statements and Performance Characteristics

10.5.1 Partitions

Special attention should be paid to hollow clay tile and other masonry partitions that are frequently used in corridors, in the evaluation of a school's nonstructural element. These partitions could collapse and block exits under moderate shaking.

Section 10.5 also contains information on ceiling systems and lights, cladding and building mechanical equipment.

Appendix A

Appendix A contains the General Evaluation Statements. As noted earlier, since school buildings typically do not fall into one of the model building types, this section may provide the best guidance for the engineer and architect doing the evaluation. Also in this section are the evaluation statements for nonstructural components and geotechnical site hazards.

Appendix B

Appendix B contains the model building evaluation statements. These will be applicable in some cases where the school building fits the model building type, and may make the evaluation more direct.

An example might be school buildings of wood construction. They typically have longer spans than that anticipated by the W1 model type which is intended for apartments and small commercial structures. Type W2 is for industrial, long span, type structures. Schools buildings are neither of these. Similar examples can be made for many of the other model building types.

When a model building type is used the evaluator must still do the geologic site hazard and nonstructural sections in Appendix A.

Sections of FEMA-178 Recommended for Review

Handbook Section	Facility Manager	Engineer (Note 1)
1.1 Purpose of this Handbook	✔	✔
1.2 Essential Facilities	✔	✔
1.3 Scope and Limitations	✔	✔
1.3.1 Criteria	✔	✔
1.3.2 Force Level for Analysis	✔	✔
1.3.3 Demand vs. Capacity	✔	✔
1.3.4 Other Standards		✔
1.4 Handbook Methodology		✔
1.5 Handbook Contents	✔	✔
Chapter 2		✔
2.0 Introduction	✔	
Chapter 3		✔
3.1 Load Path		
3.3 Configuration		
3.4 Adjacent Buildings	✔	
Chapter 4		✔
Chapter 5		✔
Chapter 6		✔
Chapter 7		✔
Chapter 8		✔
Chapter 9		✔
Chapter 10		✔
10.3 Life Safety Concerns	✔	✔
10.4 Nonstructural Elements	✔	✔
Appendices		✔

Note 1 - The engineer should be familiar with all sections of the Handbook to effectively evaluate buildings for seismic safety.