# SECTION A - BACKGROUND INFORMATION

## Introduction

- Purpose
- Nonstructural Elements of A Building
- Benefits of Strengthening Nonstructural Elements
- Limitations of the Nonstructural Protection Guide
- School Emergency Preparedness
- Getting Help
- Nonstructural Manual Content

## Washington Earthquake Hazards

- What Is an Earthquake?
- Why, How Big, And Where Do We Have Earthquakes In Washington?
- How Often Do Washington Earthquakes Occur?
- How Is Earthquake Size Measured?

## Earthquake-Induced Damage To Washington Schools

- Introduction

## Causes Of Earthquake Damage

- Introduction
- Why Be Concerned About Nonstructural Damage

## District Nonstructural Protection Program

- Introduction
- Guiding Principles
- Summary of Program Steps
- Financing

## School Site Teams

- Introduction
- Initiation
- Summary of Site Team Activities
- Training
- Management
SECTION A - FIGURES

Figure 1. Nonstructural And Structural Components Of A Typical Building (FEMA 1994)

Figure 2. Imposed Deformation Diagram. Vertically Oriented Built-In Nonstructural Components, Such As Full-Height Partitions Or Windows, Are Vulnerable To Deformation Imposed By The Drift Of The Structure As It Undergoes Lateral Loads During The Earthquake. (Graphic Credit: EERI, FEMA)

Figure 3. Broken Windows, Close-Up View. A Graphic Example Of The Result Of Severe Drift Experienced By A Concrete Structure In The 1964 Alaska Earthquake And The Resulting Failure Of The Glass Panes. (Photo Credit: EERI, John F. Meehan)

Figure 4. Fallen Light Fixture. These Light Fixtures, Which Were Supported By The Hung Ceiling, Fell When The Ceiling Distorted In The 1971 San Fernando Earthquake. The Typical Safety Measure For Fluorescent Fixtures Such As These Is To Attach Back-Up Safety Wires To Them And Anchor These Wires To The Floor Or Roof Structure Above, So That Even If The Ceiling Grid Distorts Or Collapses, The Light Fixture Will Not Fall. (Photo Credit: EERI James L. Stratta)

Figure 5. Escape Hole Made Through Partition And View Of Jammed Door. In The 1979 Imperial County, California Earthquake, The Door To This Office In The Imperial County Services Building Was Jammed Shut By The Distortion Of The Structure. The Occupant Was Trapped Until Co-Workers Broke Through The Sheet-Rock Clad Metal Stud Partition Wall. (Photo Credit: EERI, Christopher Arnold)

Figure 6. Diagram Of Shear And Overtwining. Inertial Forces Generated Within Unanchored Nonstructural Objects Cause Them To Overtwinform If They Are Slender And To Slide If They Are Stocky. This Generalization Is Modified By The Distribution Of Mass – Some Pieces Of Equipment Are Top-Heavy And More Prone To Overtwining Under Lateral Loading Than Their Proportions Would Indicate – And Also By The Amount Of Friction At The Base – Sliding Is More Likely As The Friction Decreases. Seismic Codes Specify Seismic Nonstructural Component Coefficients That Are Multiplied By The Weight Of The Object To Produce Lateral Design Forces. Depending Upon The Applicable Code Or Analysis Method, Factors Are Used In This Calculation Process To Increase Design Forces For Components That Are: Especially Hazardous Or Essential, Located At An Upper Story Level, Or Have Flexible Mountings Rather Than Rigid Bolted Anchorage (Graphics Credit: EERI, Federal Emergency Management Agency)

Figure 7. Overturned File Cabinet. File Cabinets Are Prone To Overtwining Because Of Their Slenderness, And They Are Even More Vulnerable When Unlatched Drawers Can Slide Out. This Photo Of The Santa Clara County Administration Building After The 1984 Morgan Hill Earthquake, Shows That Desks Proportions Make Them Unlikely To Overtwinform And Thus They Provide Good Protection Against Nonstructural Damage If Occupants Are Trained To Quickly Take Cover. (Photo Credit: EERI, Wesley Van Osdol)

Figure 8. Overturned File Cabinet. The Hazardous Nonstructural Damage Pictured Here Occurred At Coalinga District Hospital In The 1993 Coalinga, California Earthquake (Photo Credit: EERI, Sawant Rinal)
Figure 9. Overturned Bookshelves. These Library Shelves In Seattle, Washington, Overturned During The Magnitude 7.1, 1949 Olympia Earthquake. Return To Normal Required Not Only Reinstalling The Shelves, But Also Sorting And Shelving The Books. (Photo Credit: Steinbrugge Collection, Earthquake Engineering Research Center, University Of California, Berkeley, Harlan Edwards)

Figure 10. Spilled Chemicals. Unrestrained Chemicals Can Fall, Their Containers Can Break, And Hazardous Reactions Can Occur, Even If The Cabinetry Itself Is Properly Anchored, As Shown Here In An Example From A High School’s Chemistry Lab In The 1971 San Fernando Earthquake. (Photo Credit: EERI, Chuck Wilton)

Figure 11. Broken Pipe. Earthquake Damage To Piping Is Most Frequently Observed At Joints. Although Damage To Small-Diameter Piping Has Been Observed In Recent Earthquakes, Lack Of Bracing On Larger Diameter Piping Typically Makes Them More Seriously Vulnerable. The Damage Here Occurred In The 1971 San Fernando Earthquake At The Original Olive View Hospital. (Photo Credit: EERI, J. Marx Ayres)

Figure 12. Water Pouring Down Stairs. Broken Piping Leads Not Only To Direct Property Loss -- The Cost Of Repairing The Piping-- But Is Also Often The Cause Of Leakage And Resulting Water Damage That Is More Costly To Repair. The Cascade Of Water Down These Stairs In An Industrial Building Occurred In The 1971 San Fernando Earthquake. (Photo Credit: EERI, J. Marx Ayres)
SECTION A - TABLES

Table 1. Modified Mercalli Intensity Scale

Table 2. Selected Damage In Washington Communities From 1949 Olympia Earthquake

Table 3. Damage To Selected Seattle School Buildings From The 1965 Seattle-Tacoma Earthquake

Table 4a. Option 1 - Use Regular District Staff To Manage The Nonstructural Earthquake Protection Program. Staff May Also Inventory Spaces And Implement These Protection Measures.

Table 4b. Option 2 - Use The School Site Team To Complete A Building Inventory And Implement Nonstructural Earthquake Protection Measures

Table 4c. Option 3 - Hire Special District Staff To Complete Inventory And Implement Nonstructural Earthquake Protection Measures

Table 4d. Option 4 - Hire Contractor(s) To Complete Inventory And Implement Nonstructural Earthquake Protection Measures

Table 5. Nonstructural Elements For Which Engineering Services May Be Required To Design Appropriate Earthquake Protection Measures

Table 6. School Site Team Tasks, Nonstructural Earthquake Protection Tasks Suitable For School Site Team
SECTION B - INVENTORY FORMS FOR NONSTRUCTURAL ELEMENTS

Inventory Forms for Nonstructural Elements

1. Normal Occupancies: Classrooms, Offices, And Library Spaces ........................................ B - 2

2. Assembly Occupancies: Multi-Purpose Rooms, Halls, Stairwells, Exits, Gymnasiums, And Auditoriums ......................................................... B - 7

3. Special Use Occupancies: Kitchens, Shops, Art Rooms, Science And Computer Laboratories, And Pool Rooms .............................................................. B - 11

4. Support Occupancies: Utility Rooms, Mechanical Rooms, Storage Rooms, And Penthouses .... B - 17

5. Exterior Spaces .................................................................................................................................. B - 20
## Table of Contents

### SECTION C - DETAILS FOR REDUCING NONSTRUCTURAL HAZARDS

**Nonstructural Protection Details**
Installation Note For The Details In Section C ........................................................................... C - 1

**Details for Protecting Nonstructural Elements**
Nonstructural Components........................................................................................................... C - 2
Nonstructural Component Evaluation ............................................................................................. C - 2
Communications / 1.0
  - Equipment Racks / 1.1 ........................................................................................................ C - 3
Data Processing / 2.0
  - Access Floors / 2.1 ........................................................................................................... C - 4
  - Computer Equipment: Fixed Anchorage / 2.2 ................................................................. C - 5
  - Computer Equipment: High Friction Skids / 2.3 ............................................................ C - 6
  - Computer Equipment: Motion Isolators / 2.4 ................................................................. C - 7
Electrical Systems / 3.0
  - Cable Trays / 3.1 ............................................................................................................. C - 8
  - Emergency Battery / 3.2 ................................................................................................ C - 9
  - Emergency Power System / 3.3 ...................................................................................... C - 11
  - Wires / 3.4 ..................................................................................................................... C - 13
Exiting / 4.0
  - Canopies / 4.1 .............................................................................................................. C - 14
  - Doors / 4.2 ................................................................................................................... C - 15
  - Stairwells / 4.3 ............................................................................................................. C - 16
Exteriors / 5.0
  - Chimneys / 5.1 ............................................................................................................. C - 17
  - Walls Anchorage: Concrete/Masonry / 5.3 ................................................................. C - 18
Furnishings And Equipment / 6.0
  - Desktop/Countertop Equipment / 6.1 ....................................................................... C - 20
  - File Cabinets / 6.2 ....................................................................................................... C - 21
  - Floor-Mounted Objects / 6.3 ......................................................................................... C - 22
  - Lockers And Storage Cabinets / 6.4 ............................................................ C - 23
  - Refrigerators / 6.5 ....................................................................................................... C - 24
  - Shelf Contents / 6.6 ..................................................................................................... C - 25
  - Shelf Units / 6.7 .......................................................................................................... C - 27
  - Vending Machines / 6.8 .............................................................................................. C - 29
  - Wall-Mounted Objects / 6.9 ....................................................................................... C - 30
  - Wheel-Mounted Furniture / 6.10 ............................................................................ C - 31
Glazing / 7.0
  - Glass / 7.1 ................................................................................................................ C - 32
Hazardous Materials / 8.0
  - Chemicals / 8.1 ......................................................................................................... C - 33
  - Gas Cylinders / 8.2 ................................................................................................. C - 35
  - Propane Tanks / 8.3 .................................................................................................. C - 36
Mechanical Systems / 9.0
  - Filtration Tanks / 9.1 ................................................................................................. C - 37
  - HVAC Units / 9.2 ...................................................................................................... C - 38
  - Rooftop Heating Unit/Duct / 9.3 .............................................................................. C - 39
  - Rooftop Mechanical Units / 9.4 ............................................................................. C - 40
  - Suspended Air Conditioning Units / 9.5 ............................................................ C - 41
  - Piping / 9.6 .............................................................................................................. C - 42
  - Water Heaters / 9.7 ............................................................................................... C - 43
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead Elements / 10.0</td>
<td></td>
</tr>
<tr>
<td>Suspended Ceilings / 10.1</td>
<td>C-44</td>
</tr>
<tr>
<td>Ceilings For Concrete And Steel Buildings / 10.2</td>
<td>C-45</td>
</tr>
<tr>
<td>Ceilings For Wood Buildings / 10.3</td>
<td>C-46</td>
</tr>
<tr>
<td>Ceiling-Mounted Lights And Ventilation Grills / 10.4</td>
<td>C-47</td>
</tr>
<tr>
<td>Pendant-Mounted Lights / 10.5</td>
<td>C-48</td>
</tr>
<tr>
<td>Ducts / 10.6</td>
<td>C-49</td>
</tr>
<tr>
<td>Space Heaters / 10.7</td>
<td>C-50</td>
</tr>
<tr>
<td>Partitions / 11.0</td>
<td></td>
</tr>
<tr>
<td>Full Wall Partitions / 11.1</td>
<td>C-51</td>
</tr>
<tr>
<td>Masonry Partitions / 11.2</td>
<td>C-52</td>
</tr>
<tr>
<td>Modular Partitions / 11.3</td>
<td>C-53</td>
</tr>
</tbody>
</table>
# SECTION D - APPENDICES

<table>
<thead>
<tr>
<th>D-1</th>
<th>References Cited</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-2</td>
<td>Vendor List</td>
</tr>
<tr>
<td>D-3</td>
<td>Seattle Pilot Test</td>
</tr>
</tbody>
</table>