Reducing Earthquake Risk in the Classroom and Beyond

Seismic Mitigation of Nonstructural Hazards in Schools

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Estructure
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Welcome

- Objectives for Today
  - Learn about nonstructural components and why they matter in earthquakes.
  - How to recognize and identify common nonstructural hazards in K-12 schools.
  - Review strategies for mitigating common hazards, including understanding when an engineer/technical consultant should be engaged.
  - Become empowered to reduce earthquake risks in your school.
- Intended Audience
  - Primary: Facilities managers of K-12 schools
  - Secondary: K-12 school administration, teachers

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Training Overview

Part 1 - Setting the stage: What are nonstructural components and why they matter
Part 2 - Introduction to earthquake hazards
Part 3 – What happens to nonstructural components in earthquakes
BREAK #1
Part 4 - Identifying vulnerable nonstructural components
Part 5A - Strategies for protecting vulnerable components
BREAK #2
Part 5B - Strategies for protecting vulnerable components – Complex Systems
BREAK #3
Part 6 - Implementing nonstructural seismic mitigation
Part 7 - Maintaining a safe school environment

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Part 1 – Setting the stage

Why is this important?

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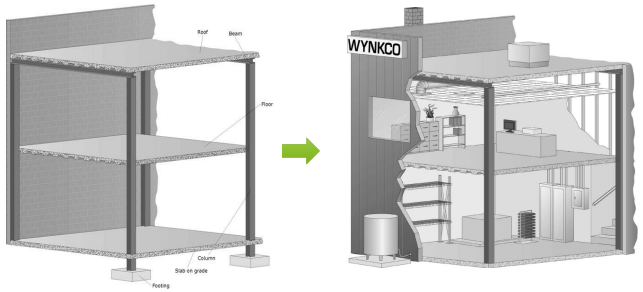
What are nonstructural components?



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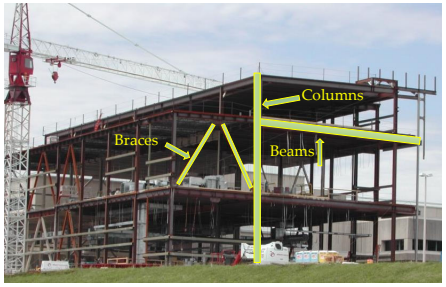
Structural Components

- Roof
- Floors
- Beams
- Columns
- Foundation
- Braces
- Concrete or Masonry Walls



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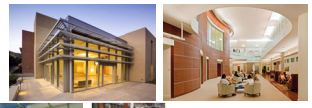
Nonstructural Components

Architectural

Mechanical, Electrical and Plumbing (MEP)

Furnishings
Contents



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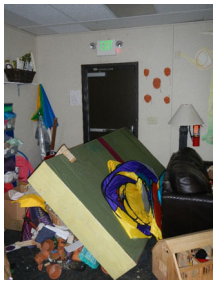
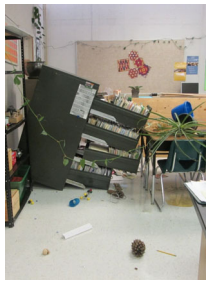
2014 South Napa EQ (M6.4)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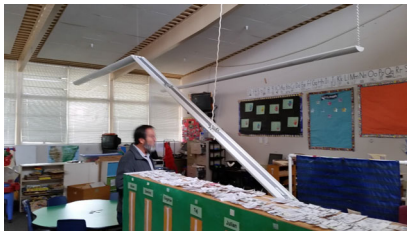
2014 South Napa EQ (M6.4)



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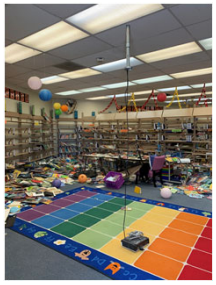
2019 Ridgecrest EQ (M7.1)



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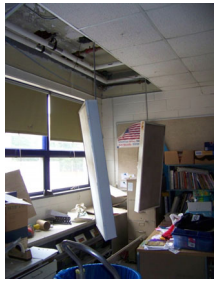
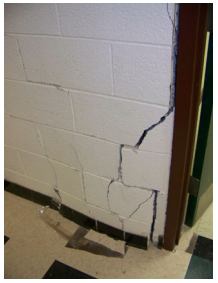
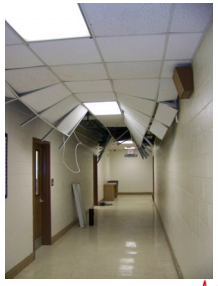
2011 Mineral Virginia EQ (M5.8)







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2011 Mineral Virginia EQ (M5.8)

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2010 Mexicali EQ (M7.2)

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2010 Mexicali EQ (M7.2)

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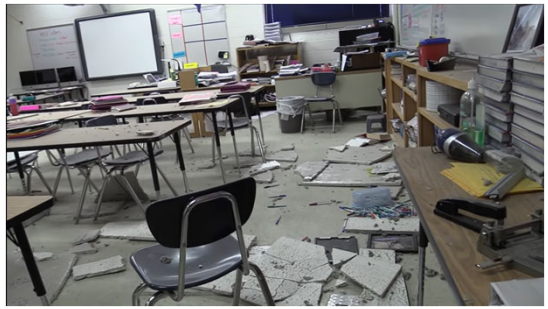
2018 Alaska EQ (M7.1)



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https://youtu.be/wfe50E5bgqI

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Every Earthquake!

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Every Earthquake!

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Why be concerned about nonstructural EQ damage?

1. First things damaged in an earthquake
2. Damaged in small earthquakes
3. May cause injury or loss of life
4. Can prevent school from reopening quickly or serving as shelter
5. 80% of the cost of a building is nonstructural
6. Most financial losses are nonstructural
7. Seismic protection is required by the building code

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Damaging Earthquakes in the US last 50 years

Year	Event	Magnitude	Day & Time
2020	Magna, Utah	5.7	Wednesday, March 18, 7:09 am (COVID)
2020	Puerto Rico	6.4	Tuesday, January 7, 4:24 am
2019	Ridgecrest, California	7.1	Friday, July 5, 10:30 am
2018	Anchorage, Alaska	7.1	Friday, November 30, 8:29 am
2014	South Napa, California	6.0	Sunday, August 24, 3:20 am
2011	Mineral, Virginia	5.8	Tuesday, August 30, 1:51pm
2010	Baja California	7.2	Sunday, April 4, 3:40 pm
2010	Eureka, California	5.7	Saturday, January 9, 4:27 pm
2003	San Simeon, California	6.5	Sunday, December 22, 11:15 am
2002	Denali, Alaska	7.9	Sunday, November 3, 1:12 pm
2001	Nisqually, Washington	6.8	Wednesday, February 28, 10:54 am
1994	Northridge, California	6.7	Monday, January 17, 4:30 am
1989	Loma Prieta, California	6.9	Tuesday, October 17, 5:04 pm
1987	Whittier Narrows, California	5.9	Thursday, October 1, 7:421983 am
1983	Borah Peak, Idaho	6.9	Friday, October 28, 6:06 am
1980	Mammoth Lakes, California	6.2	Sunday, May 25, 9:33 am
1971	San Fernando, California	6.7	Tuesday, February 9, 6:01 am

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You can reduce earthquake risk

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Questions?

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Part 2 – Earthquake Hazards

How Engineers think about earthquakes

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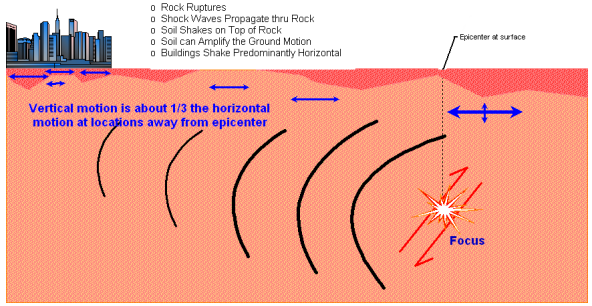
What are Earthquakes?

- Rock Ruptures
- Shock Waves Propagate thru Rock
- Soil Shakes on Top of Rock
- Soil can Amplify the Ground Motion
- Buildings Shake Predominantly Horizontal



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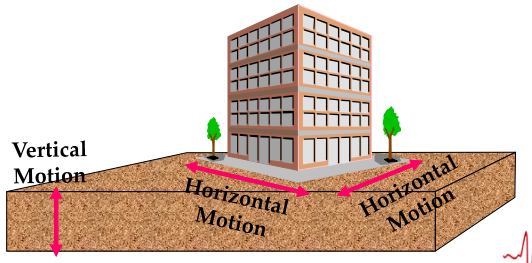
Ground Shaking

- Most earthquake damage results from ground shaking



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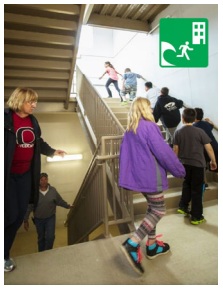
Other Earthquake Hazards


Surface Faulting


Liquefaction


Landslide


Tsunami



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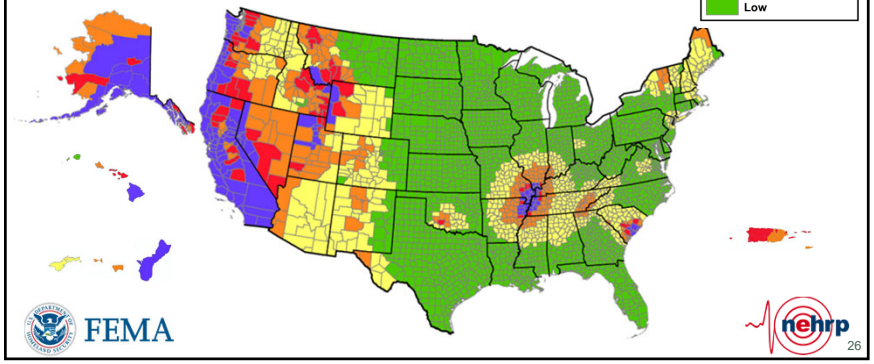
Seismic Hazard Level Across the US and US Territories



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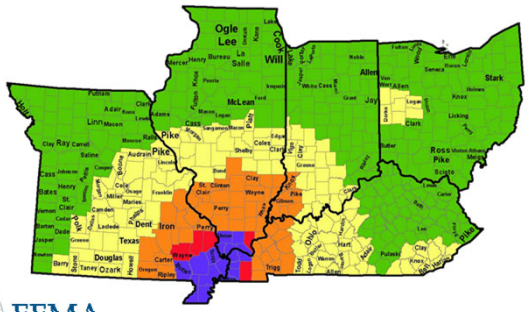
Regional Seismic Hazard Map

Illinois, Indiana, Kentucky, Missouri, Ohio



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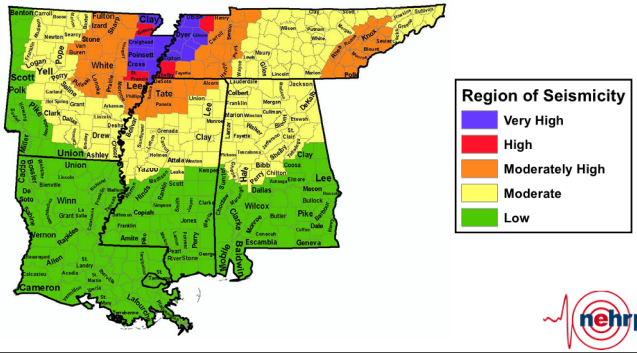
Regional Seismic Hazard Map

Alabama, Arkansas, Louisiana, Mississippi, Tennessee



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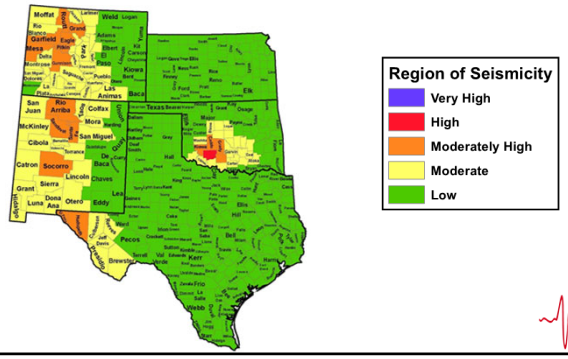
Regional Seismic Hazard Map
Colorado, Kansas, New Mexico, Oklahoma, Texas



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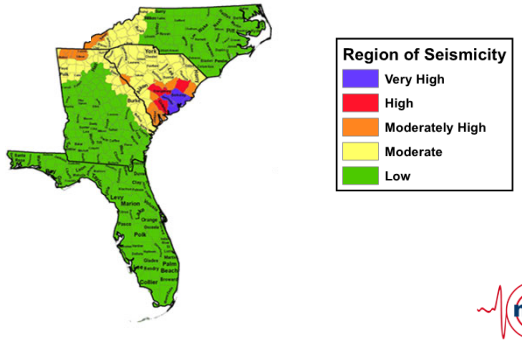
Regional Seismic Hazard Map
Florida, Georgia, North Carolina, South Carolina



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Seismic Hazard for your school

- If your school district is in a PURPLE or RED zone on the map:
  - Earthquakes are one of the most significant risks facing your facilities
  - Take immediate action - undertake a comprehensive vulnerability assessment
- If your school district is in an ORANGE or YELLOW zone on the map:
  - Probability of severe earthquake is sufficiently high to require consideration
  - Assign responsibility for vulnerability assessment
  - Pay particular attention to school buildings used as shelters
- If your school district is in a GREEN zone on the map:
  - Earthquakes are unlikely
  - Consider implementing common sense measures where practical

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Building Code Requirements for Schools

- Code History
  - California Field Act (1933) - first earthquake design legislation for schools – primarily addressed structural collapse
  - Building codes generally "learn from earthquakes" – later is better
  - Starting in the late 1990's, codes generally meet societal standards for safety

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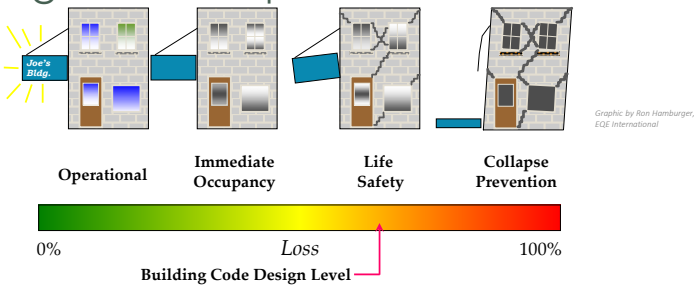
Building Code Requirements for Schools



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Building Code Requirements for Schools

- However,
  - The newest codes aren't always adopted by local agencies
  - Code enforcement varies throughout the nation, especially for nonstructural design
  - Construction and inspection practices vary
  - New components are continually installed in schools often by owners and contractors without design or inspection

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Building Code Requirements for Schools


On wheels


On desk


Less than 6' tall

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Are Your Buildings' Contents Safe?

- "New" becomes "existing" as soon as the occupancy permit is issued
- Safety in existing school buildings is the responsibility of owner/operator. That means you!

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Questions?

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Part 3 – What happens to nonstructural components in earthquakes?

Understanding the basics

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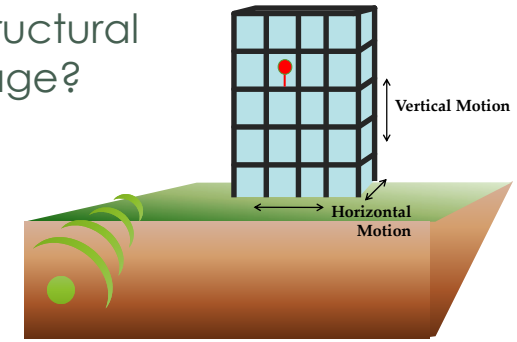
What causes nonstructural damage?



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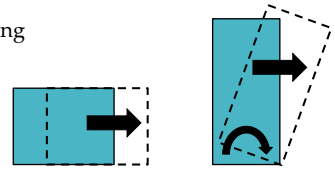
Causes of Nonstructural Damage

- Inertial or shaking effects can cause
  - Sliding
  - Rocking
  - Overturning



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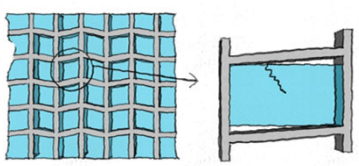
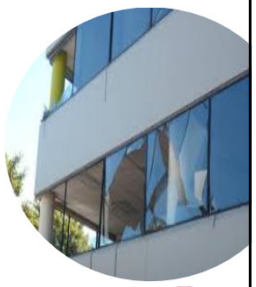
Causes of Nonstructural Damage

- Building deformations cause damage to interconnected nonstructural components





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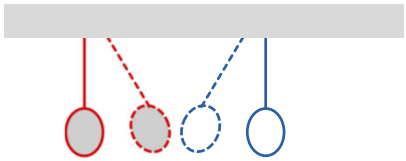
Causes of Nonstructural Damage

- Interaction between adjacent nonstructural components cause damage



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Consequences of Nonstructural Damage

Risk to Life Safety
- Deaths or casualties

Property Loss
- Dollar loss

Loss of Use
- Downtime

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Risk to life safety – Overturned Furnishings

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Risk to life safety – Heavy Dislodged Components


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Risk to life safety – Loss of fire protection


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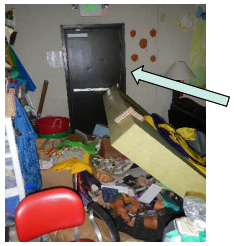
Risk to life safety – Blocked Egress

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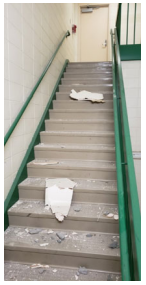
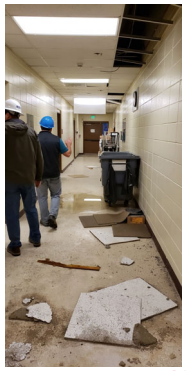
Property loss

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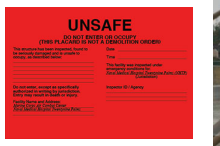
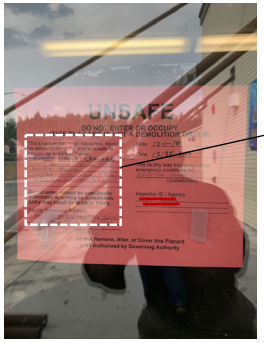
Loss of Use





- Masonry walls cracked inside
- Hanging ceiling tiles
- Possible asbestos
- Possible boiler damage & leaking
- Pipes, gas and water shut-off

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Loss of Use

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YouTube link

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Quiz #1

Which school building is likely to have some nonstructural risks:

A. 10-year old school building in a High seismicity area
B. New school building in a Moderate seismicity area
C. Recently retrofitted school building in a Very High seismicity area
D. All of the above

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Questions?

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BREAK #1

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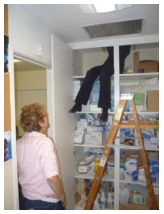
Part 4 – Identifying Vulnerable Nonstructural Components

The Hazard Hunt



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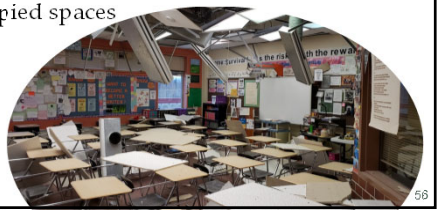
Recall what happens to nonstructural components in earthquakes

- Unanchored items can shift or overturn
- Walls and cladding can crack or become dislodged and fall
- Suspended or wall-mounted items can drop
- Equipment can be damaged and fail to operate
- Lights and ceilings can fall in occupied spaces
- Egress can be blocked
- Pipes can leak or break



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Searching for Components that can…

- Fall and cause injury

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Searching for Components that can…

- Fall and cause injury
- Block egress

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Searching for Components that can…

- Fall and cause injury
- Block egress
- Contain hazardous materials

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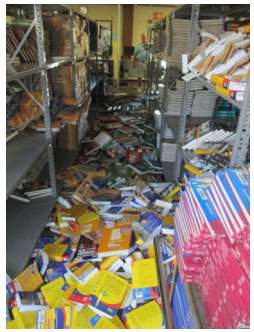
Searching for Components that can…

- Fall and cause injury
- Block egress
- Contain hazardous materials
- Result in property loss



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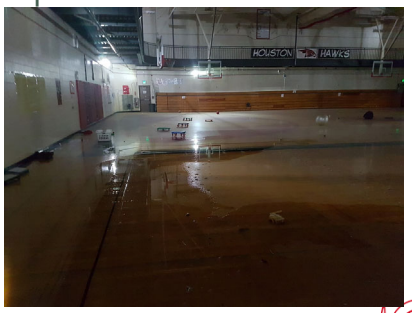
Searching for Components that can…

- Fall and cause injury
- Block egress
- Contain hazardous materials
- Result in property loss
- And, those whose failure can make a building unusable



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School Earthquake Hazard Hunt

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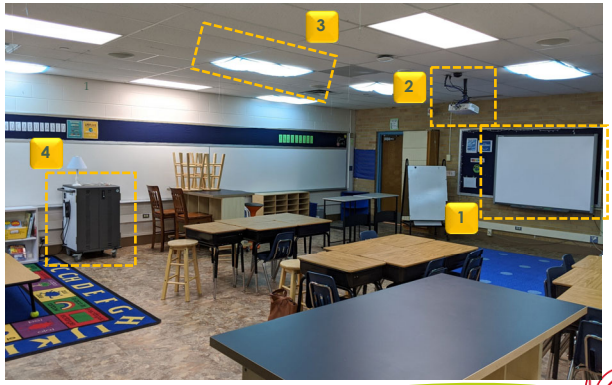
In the Classroom

1. Wall mounted smartboard
2. Suspended projector
3. Suspended lights and ceilings
4. Computer storage cart



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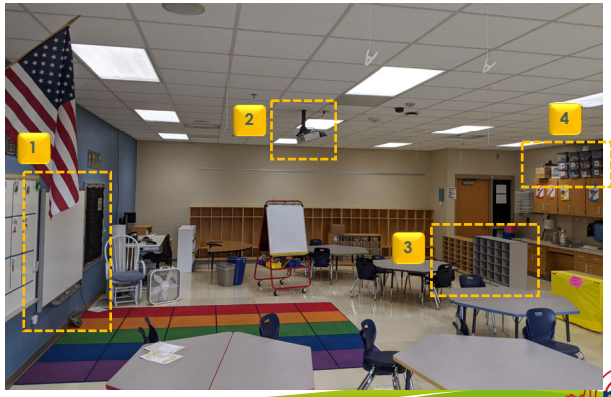
In the Classroom

1. Wall mounted smartboard
2. Suspended projector
3. Free standing bookshelves
4. Items stored on top of casework



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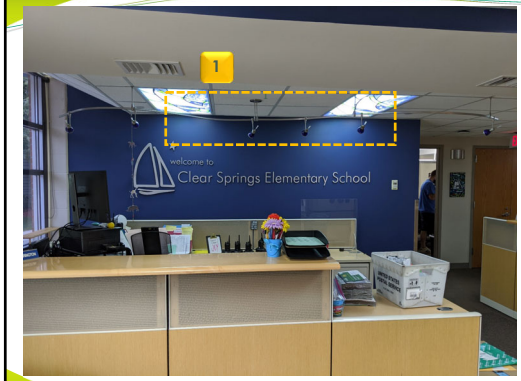
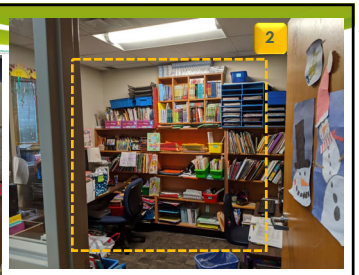
In Offices





1. Suspended lights and ceiling
2. Bookshelves and contents

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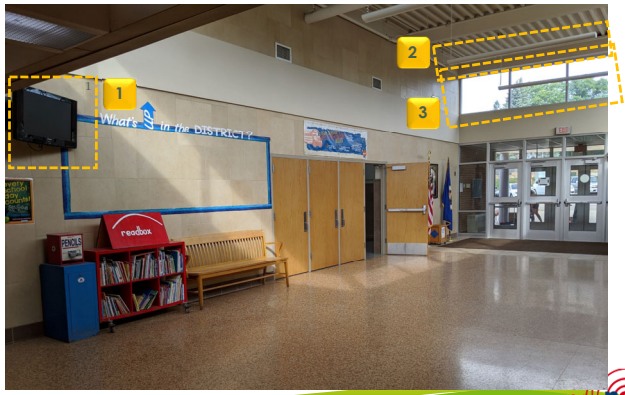
In the Entryway

1. Wall mounted monitor
2. Suspended lights
3. Large glass panes over exits



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In the Hallway

1. Stacked printer
2. Computer cart
3. STEM cart
4. Bookshelf

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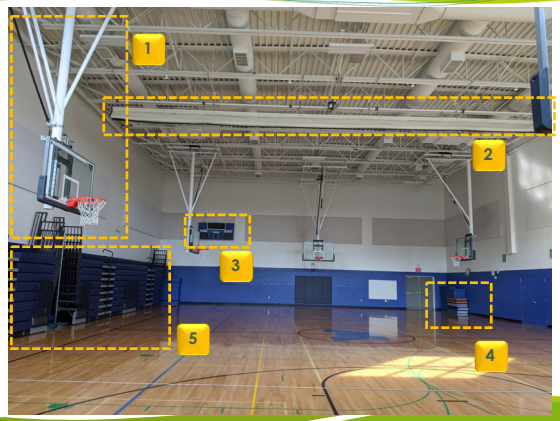
In the Gym

1. Suspended basketball hoop
2. Hanging room divider
3. Wall mounted scoreboard
4. Stacked mats
5. Telescoping bleachers



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In the Staff Lounge

1. Refrigerators
2. Upper cabinetry
3. Vending Machines

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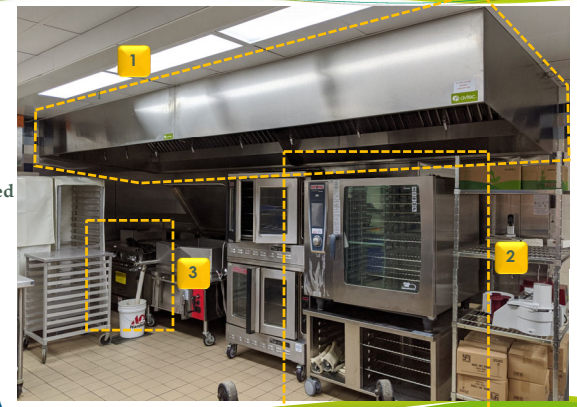
In the Kitchen

1. Overhead fume hood
2. Heavy/stacked equipment
3. Range connected to gas line



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In the Shop

1. Tall heavy equipment
2. Specialty equipment
3. Suspended lights

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In Storage Rooms

1. Heavy shelving
2. Hazardous materials
3. Shelving near doors

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In the Equipment Room

1. Water Heater
2. Electrical Panels
3. Compressor

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In the Equipment Room

1. Air Handlers
2. Pipes, ducts, and conduit

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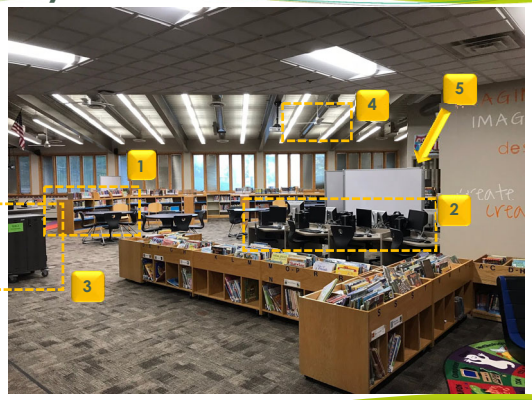
In the Library

1. Freestanding bookshelves
2. Computers
3. Computer cart
4. Ceiling fan
5. Smartboard



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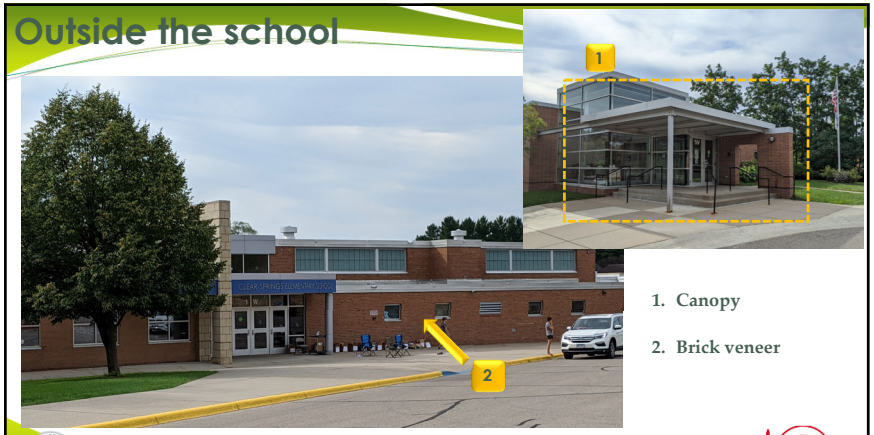
Outside the school



1. Canopy
2. Brick veneer

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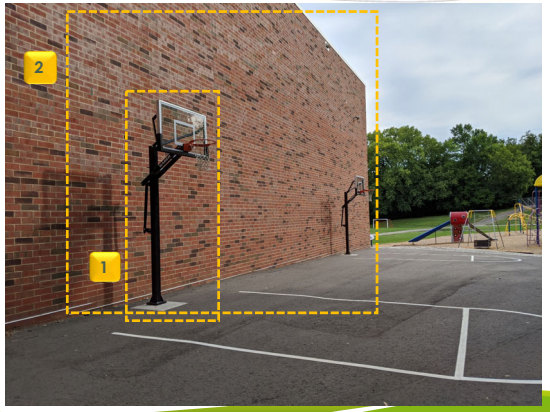
Outside the school

1. Basketball hoop
2. Brick veneer



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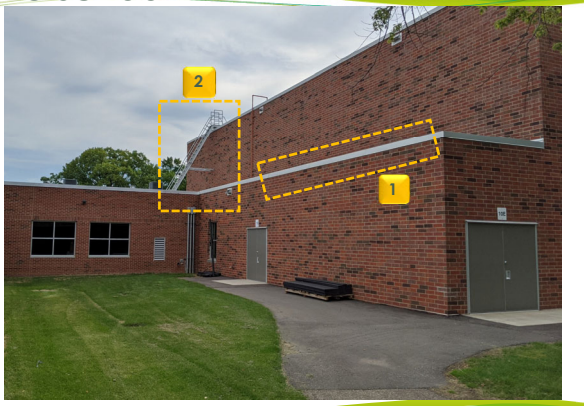
Outside the school

1. Roof parapet
2. Stairs



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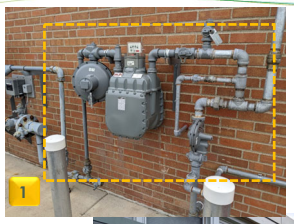
Outside the school

1. Gas lines
2. Electrical cabinet
3. AC unit



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Sorting Vulnerabilities

Confirmed Hazards

- Gas w/o shutoff
- Rolling Cart
- Tall Bookcase

Additional Investigation Required

- Canopy
- Veneer
- Pipes & Ducts
- Ceilings

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Questions?

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Part 5 – Strategies for Protecting Vulnerable Components

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Making seismic improvements

1. **Common sense measures** – Simple tips to reducing risk. No engineering or construction required!
2. **Do-it-yourself** – Improvements that can generally be undertaken with in-house resources and without specialized skills or equipment.
3. **Contractor may be required** – Measures that may require a contractor with specialized skills
4. **Design professional may be required** – Designs requiring engineering and, in some cases, a building permit to implement

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Making seismic improvements

1. **Common sense measures** – Simple tips to reducing risk. No engineering or construction required!

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Common Sense Measures

- Relocate tall or heavy objects to not block exits
- Rearrange shelving so heavier items are on the bottom and lighter ones are near the top
- Separate incompatible chemicals to prevent mixing
- Move rarely used files or materials to an offsite storage facility
- Back up important electronic files
- Remove items no longer serving a useful function

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Earthquake Engineering Rules of Thumb

The more an object weighs, the more forcefully it moves in an earthquake.

A water heater weighing 400 pounds requires much stronger restraint than a lightweight bookshelf unit.

Source

FEMA

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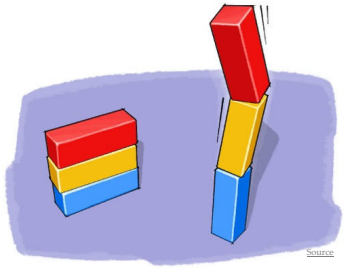
Earthquake Engineering Rules of Thumb

The more slender the object, the more likely it is to tip over.

Objects at least one and one-half times taller than their narrowest base dimension are the most likely to tip over in earthquakes. Thus a four-drawer file cabinet will be more likely to overturn than a stockier two-drawer model wher they are shaken.



Source

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Earthquake Engineering Rules of Thumb

An anchorage or restraint is only as strong as its weakest link.

When anchoring furnishings to a wall, connect directly to the wall structure: the 2x4 studs in wood frame construction, metal studs, or concrete or masonry walls. If the connection is made to the drywall or other finish material, the screw or bolt can easily fail.

Source

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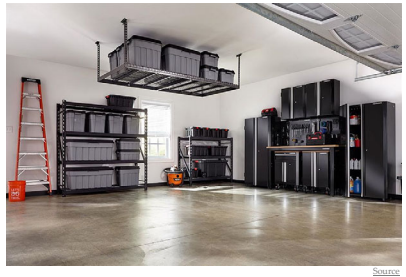
Earthquake Engineering Rules of Thumb

The higher the object, the greater the hazard.

An object such as a heavy storage on a shelf six feet off the floor is a greater hazard than the same item located on a shelf only two feet high.



Source

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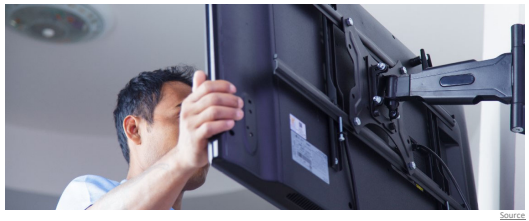
Earthquake Engineering Rules of Thumb

A rough test of the adequacy of a restraint: You should be able to pull horizontally on the object with a force equal to its weight.



Source

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Making seismic improvements

2 Do-it-yourself

Improvements that can generally be undertaken with in-house resources and without specialized skills or equipment.

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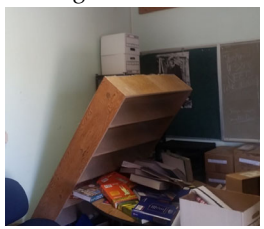
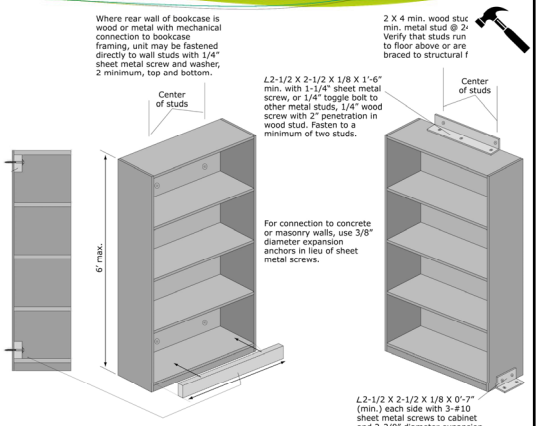
Equipment and furnishings

- Bookcases, cabinets and storage closets





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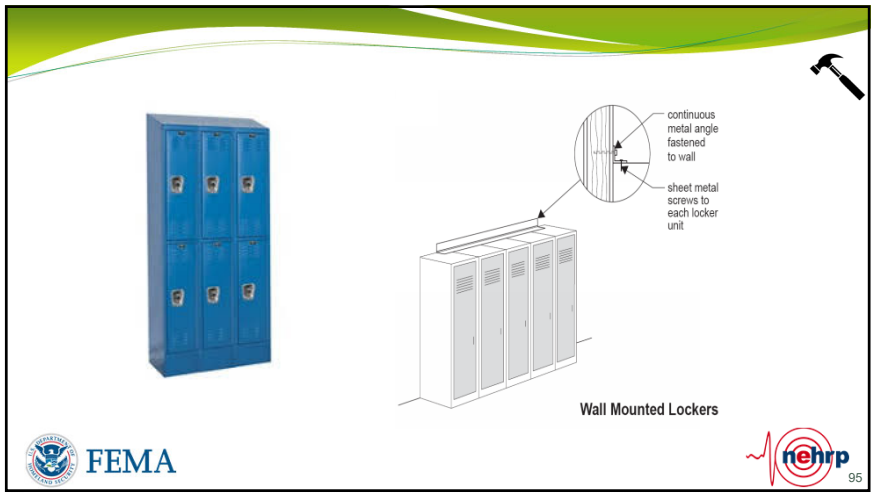

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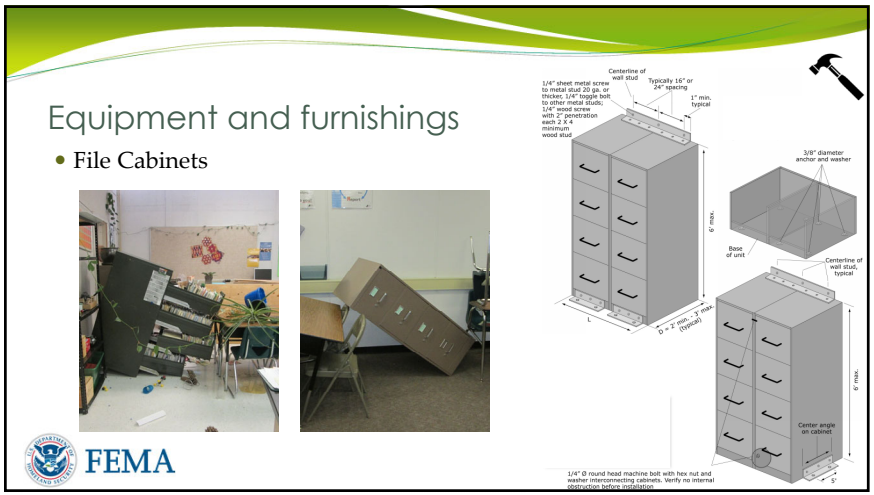

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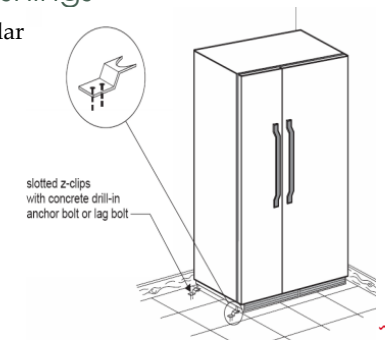
Equipment and furnishings

- Small refrigerators and similar



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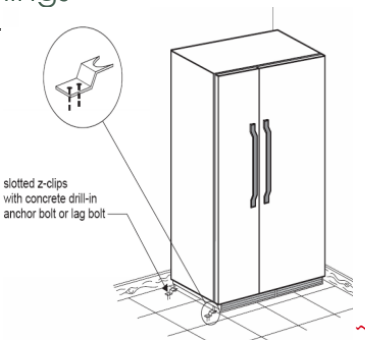
Equipment and furnishings

- Small refrigerators and similar



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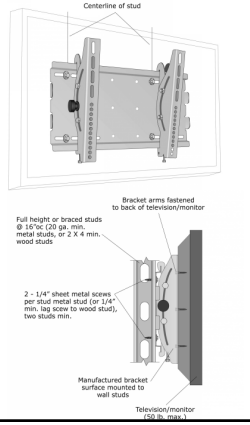
Wall-mounted Items

- Monitors (Weight ≤ 50 pounds)

Source



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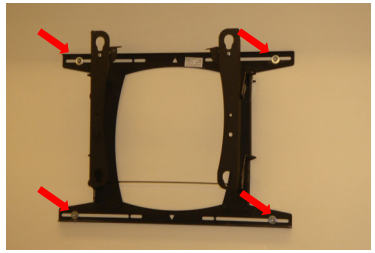
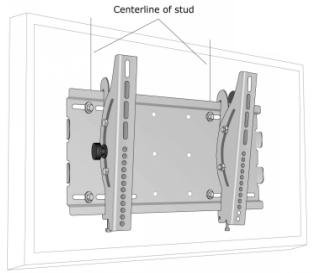
Wall-mounted Items

- Monitors (Weight ≤ 50 pounds)





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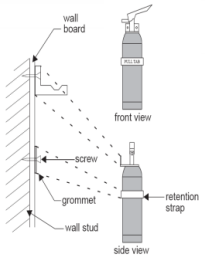
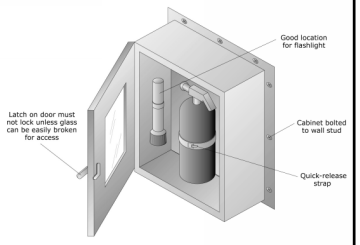
Equipment and furnishings

- Fire extinguishers

Source



With Mounting Bracket



In Cabinet

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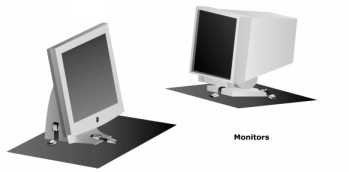
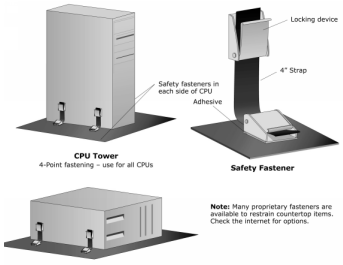
Equipment and furnishings

- Desktop computers and monitors





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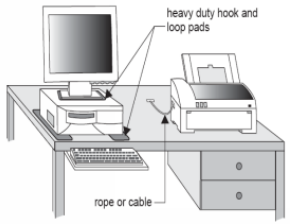
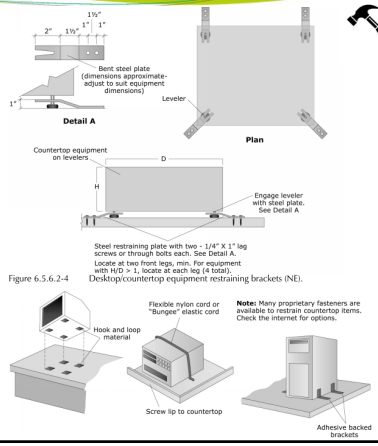
Equipment and furnishings

- Desktop computers and monitors





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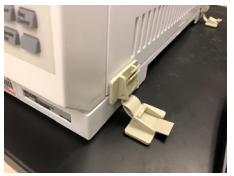
Equipment and furnishings

- Desktop computers and monitors



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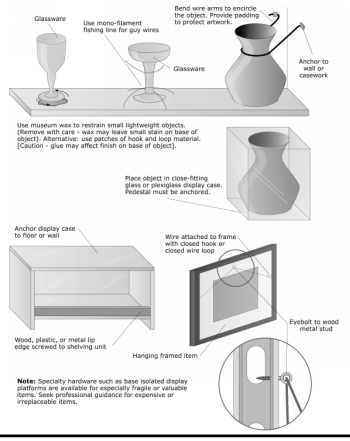
Contents

- Shelved items



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Quiz #2

- True or False

  To reduce nonstructural hazards in your classroom it is necessary to hire an engineer.

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BREAK #2

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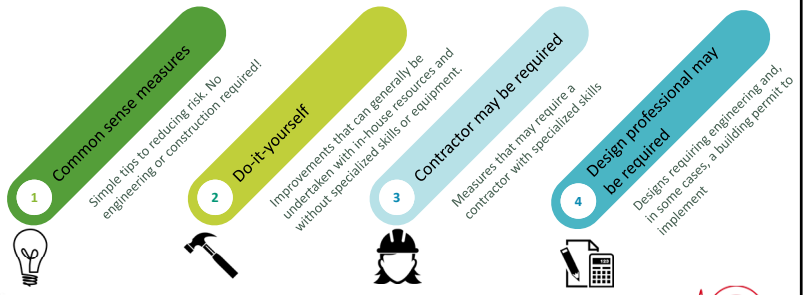
Making seismic improvements



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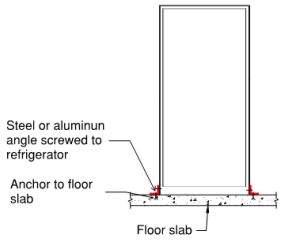
Equipment and furnishings

- Large refrigerators and similar

Source



Anchorage to Floor

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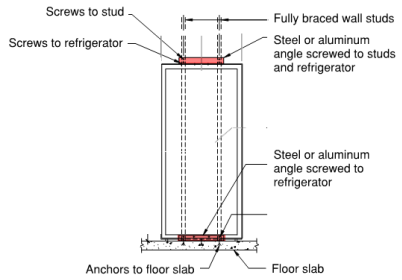
Equipment and furnishings

- Large refrigerators and similar

Source



ELEVATION

Anchorage to Wall

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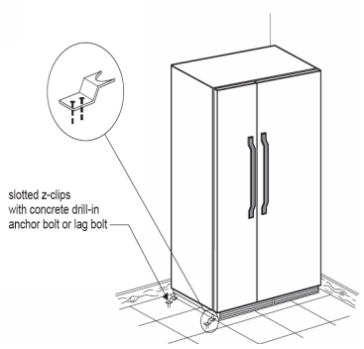
110

Equipment and furnishings

- Vending machines

Source

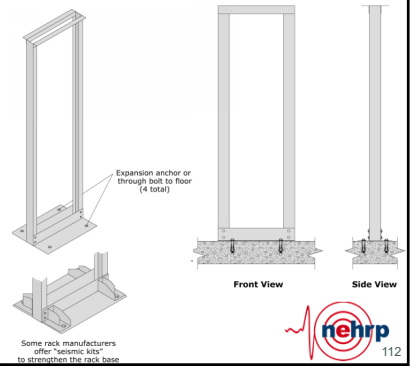


FEMA

111

Equipment and furnishings

- Computers and monitors
  - Data racks



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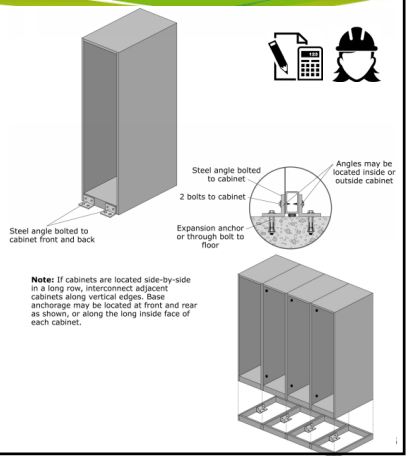
Equipment and furnishings

- Computers and monitors
  - Data racks
  - Server cabinets



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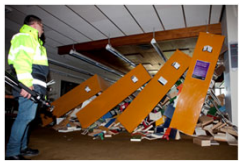
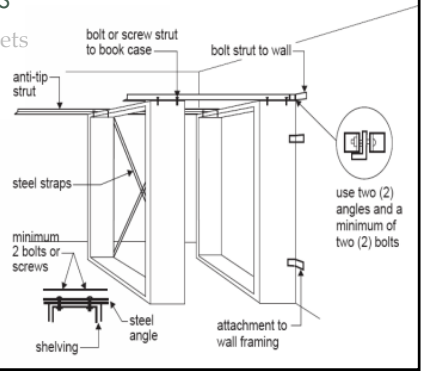
Equipment and furnishings

- Bookcases, cabinets and storage closets
- Library shelving





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Shake Table Test of Suspended Ceilings

YouTube link

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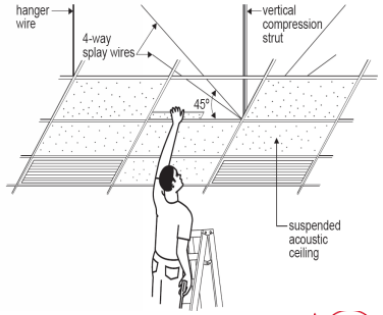
Suspended Items

- Ceilings
  - Acoustic tile



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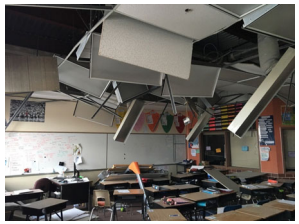
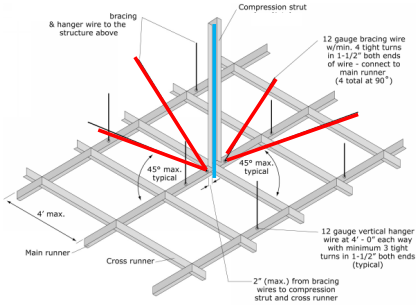
Suspended Items

- Ceilings
  - Acoustic tile





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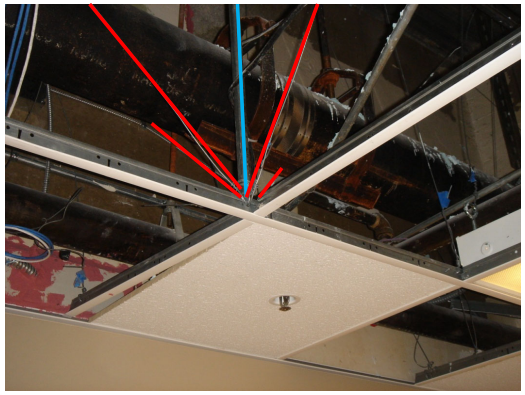

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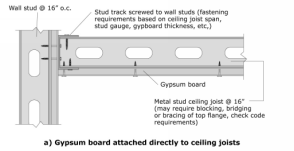
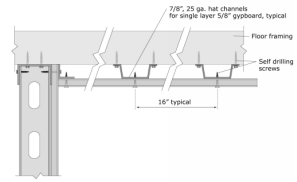
Suspended Items

- Ceilings
  - Acoustic tile
  - Framed gypsum wallboard



a) Gypsum board attached directly to ceiling joists



b) Gypsum board attached directly to furring strips (hat channel or similar)

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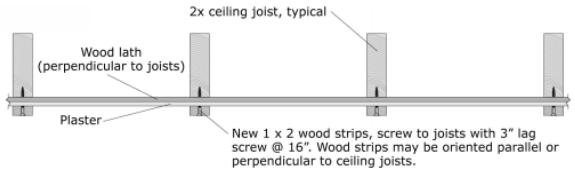
Suspended Items

- Ceilings
  - Acoustic tile
  - Framed gypsum wallboard
  - Lath and plaster



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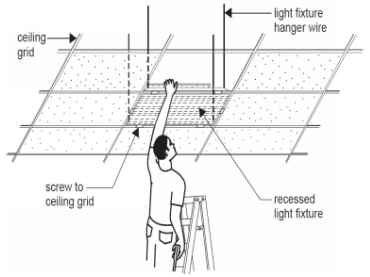
Suspended Items

- Lights
  - Recessed and surface-mounted



Recessed Light Fixtures at Suspended Ceiling

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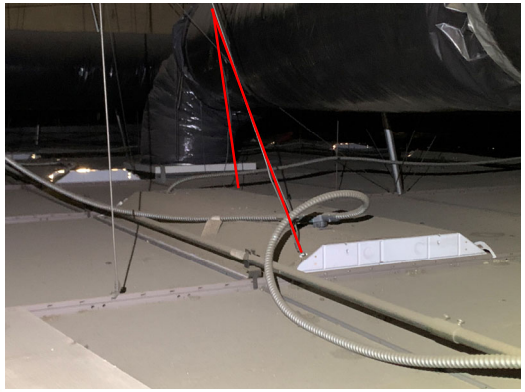

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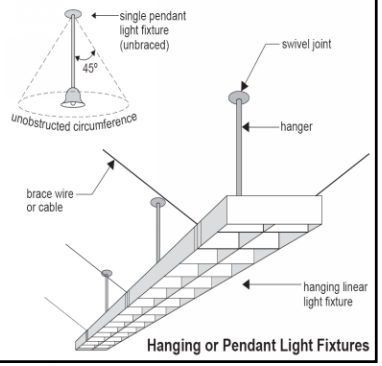
Suspended Items

- Lights
  - Recessed and surface-mounted
  - Pendant



Hanging or Pendant Light Fixtures

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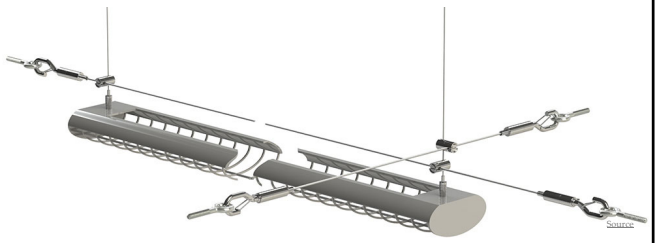
Suspended Items

- Lights
  - Recessed and surface-mounted
  - Pendant



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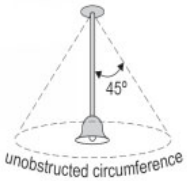

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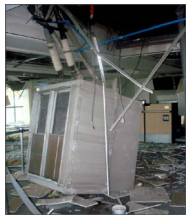
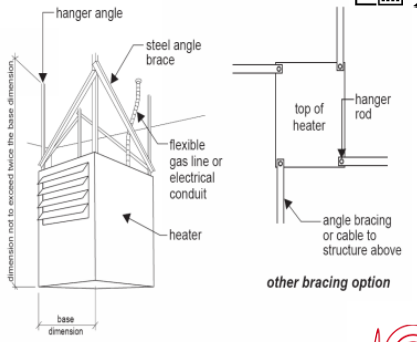
Suspended Items

- Space heaters





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Suspended Space Heater / AC Units

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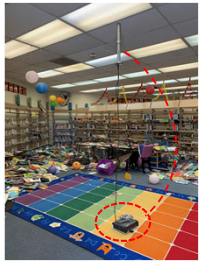
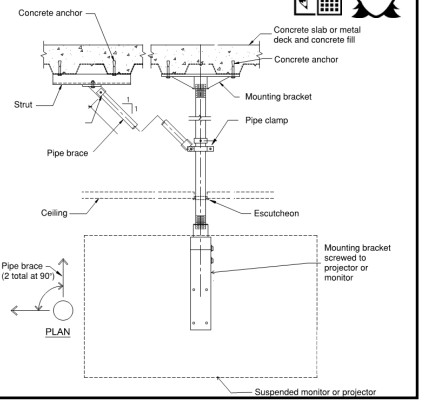
Suspended Items

- Monitors and projectors





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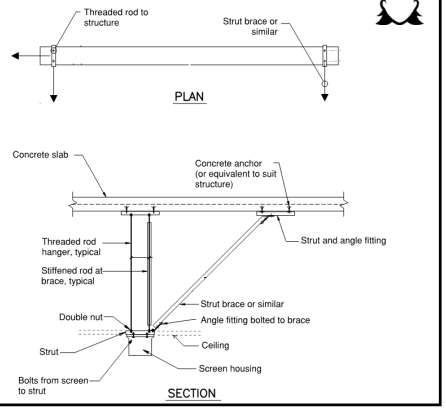
Suspended Items

- Screens, maps and displays

Source



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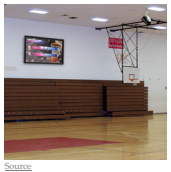
Wall-mounted Items

- Monitors (Weight ≤ 50 pounds)
- Monitors (Weight > 50 pounds)



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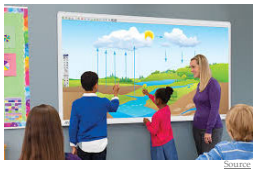

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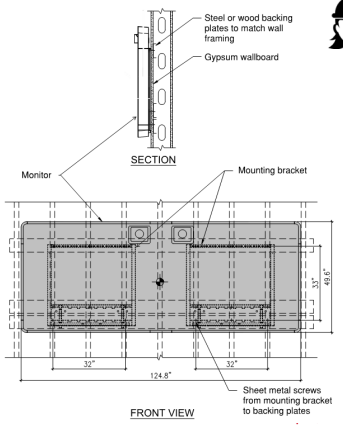

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Theater Components

- Lighting
- Catwalks
- Heavy equipment stored on catwalks
- Rigging
- Cloud ceilings

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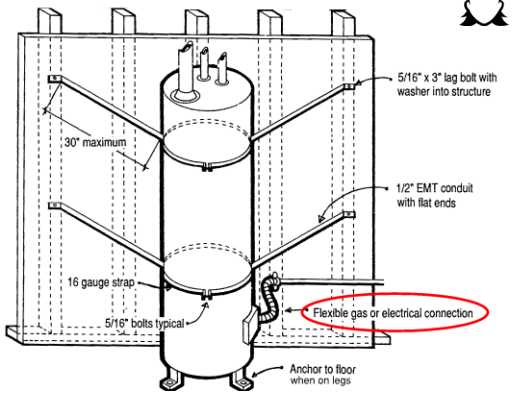
Infrastructure

- Water heaters



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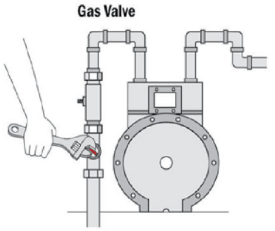
Infrastructure

- Gas shut-off valves



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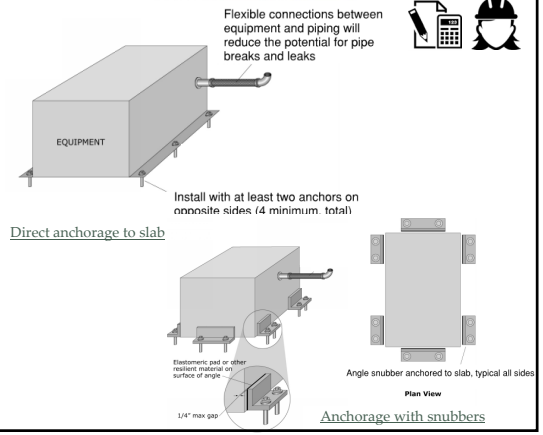
Infrastructure

- Furnace/heater



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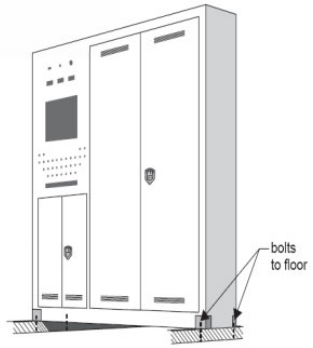
Infrastructure

- Electrical panels



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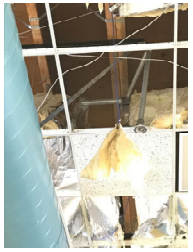
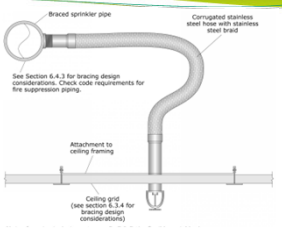
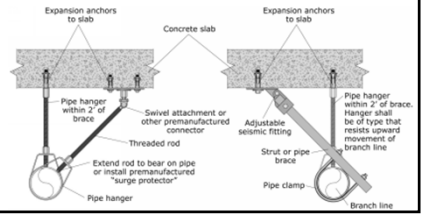
Infrastructure

- Fire sprinklers







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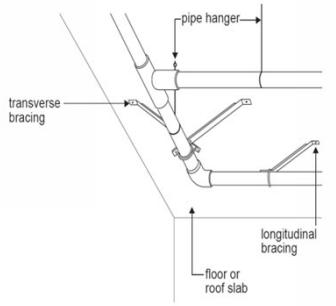
Infrastructure

- Piping and conduit



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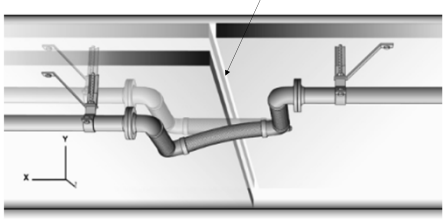
Infrastructure

- Piping at seismic joints



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Cladding, glazing, and walls

- Interior partitions
  - Heavy interior partitions


Options:
- Remove and replace
- Build wall in front of masonry wall

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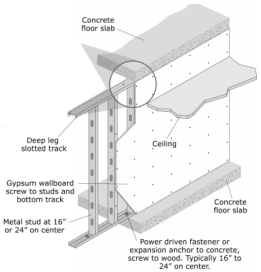
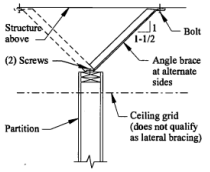
Cladding, glazing, and walls

- Interior partitions
  - Heavy interior Partitions
  - Light interior partitions



Full Height Wall



Partial Height Wall

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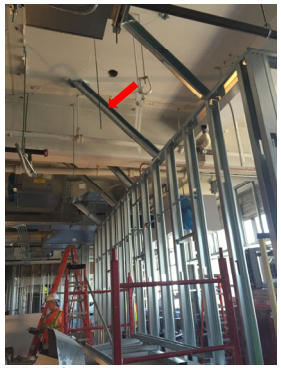


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Cladding, glazing, and walls

- Exterior cladding
  - Adhered veneer

Options:
- Add fastening to veneer
- Remove and replace with stucco or lightweight cladding
- Landscape to limit access below

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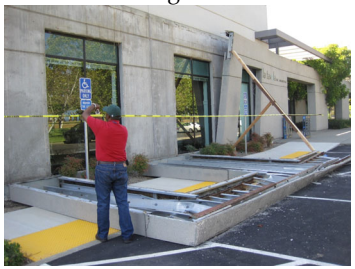
Cladding, glazing, and walls

- Exterior cladding



Engineering Evaluation Required

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Cladding, glazing, and walls

- Glass

Options:

- Replace glass with safety glass
- Add safety film on glass
- Landscape to prevent access below glass

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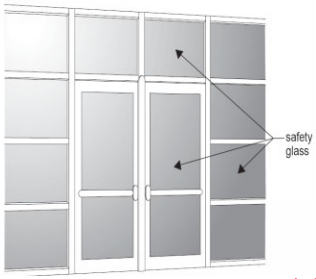
Cladding, glazing, and walls

- Glass



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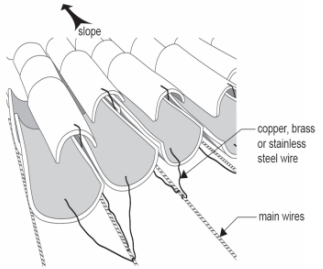
Exterior egress

- Tile roofing



Tile Roofing

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Quiz #3

The goal of nonstructural seismic mitigation in schools is to reduce the risk of injuries, reduce property loss, and prevent…

A. damage to the building foundation
B. extended school closures
C. impact on the environment
D. the appearance of damage

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Questions?

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BREAK #3

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Part 6 – Implementing Nonstructural Seismic Mitigation

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Mitigation Process

Create a Plan for Mitigation → Identify Vulnerabilities → Prioritize Vulnerabilities → Implement Mitigation Measures



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Create a Plan for Mitigation

Creating a Plan for Mitigation

- The plan should consider:
  - Nonstructural protection goals
  - Program manager
  - Funding needs
  - Schedule and Phasing
  - Expertise needed: training needed and whether to hire design professionals
  - How to maintain quality control
  - Monitoring progress
- The plan for mitigating nonstructural seismic hazards can be part of a school's comprehensive seismic mitigation plan.

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Create a Plan for Mitigation

Identify a Champion

- Identify an individual or a group who is responsible for championing the earthquake safety program
- PTAs can be allies in promoting an earthquake-safety culture.

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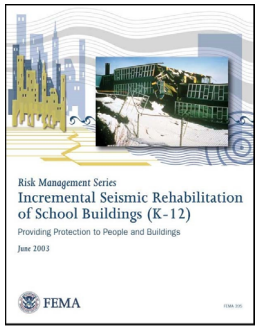
Create a Plan for Mitigation

Incremental Seismic Mitigation

- Reduces cost and minimizes disruptions
- FEMA 395 provides guidance for planning and managing this process
- Review the plan regularly and update with changes to school policies and procedures, and building and campus improvements



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Create a Plan for Mitigation

Incremental Seismic Mitigation

- Integrate mitigation with other projects and regular maintenance

Example: Reroofing

- Bracing of Parapets
- Bracing or Removal of Chimneys
- Anchorage of Rooftop Equipment

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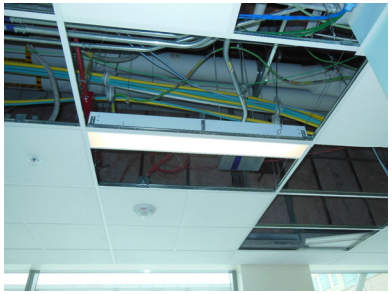
Create a Plan for Mitigation

Incremental Seismic Mitigation

Example: Fire Sprinkler Upgrades

- Bracing of Ceilings
- Bracing of Lights
- Bracing of Large Ductwork



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Create a Plan for Mitigation

Additional Resources

- FEMA 395, *Incremental Seismic Rehabilitation of School Buildings*, June 2003 (Link)
- FEMA P-1000, *Safer, Stronger, Smarter: A Guide to Improving School Natural Hazard Safety*, June 2017 (Link)
- FEMA P-424, *Design Guide for Improving School Safety in Earthquakes, Floods, and High Winds*, December 2010 (Link)
- FEMA E-74, *Reducing the Risks of Nonstructural Earthquake Damage-A Practical Guide*, December 2012 (Link)

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Mitigation Process

Create a Plan for Mitigation → Identify Vulnerabilities → Prioritize Vulnerabilities → Implement Mitigation Measures

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Identify Vulnerabilities

For Teachers

- Use a simplified checklist
- Focus on vulnerabilities within the classroom

Nonstructural Safety Checklist

This list is not all-inclusive but it does itemize the more common hazards. Deal with the most likely or potentially serious conditions first. The following checklist has been adapted from "Checklist of Nonstructural Earthquake Hazards in Child Care Facilities, produced by The Reitherman Company for the Southern California Earthquake Preparedness Project of the California Office of Emergency Services in 1990.

EQUIPMENT AND FURNISHINGS

- **File Cabinets:** Are tall cabinets, approximately taller than desk height, secured to prevent overturning? As a second choice, cabinets should be bolted to each other to make a more stable or stocky combined shape. A stockier shape (wider footprint) makes an object less likely to overturn, and this technique could be considered partial protection. Teachers should be encouraged to place file cabinets against walls where facilities personnel could anchor them.
- **Shelving:** Are units securely attached to the wall?
- **Shelf Contents:** Heavy or sharp items are stored on shelves that have lips, elastic cords, or are sloped slightly backward. Put blocks and heavy objects on lowest shelves.
- **Television Sets, Computers:** Are these pieces of equipment restrained so they won't fall? Sturdy

OVERHEAD ELEMENTS

- **Suspended Ceiling Components:** In non-residential buildings with hung ceilings, does the ceiling have diagonal bracing wires? More importantly, are any light fixtures, air diffusers, or speakers resting on the suspended ceiling gridwork provided with the back-up support of two safety wires at diagonally opposite corners?
- **Pendant Light Fixtures:** Do light fixtures that are supported by stems (metal conduit or "pipe" about an inch in diameter) have safety wires extending up through the stem or otherwise attached to the fixture?
- **Spot Lights, Track Lights:** Are lights securely mounted so that when the fixtures shake they won't come off and fall?
- **Suspended Space Heaters:** Are these heaters, especially if supplied with natural gas, hung with

From "Nonstructural Earthquake Hazards and Schools" by Central United States Earthquake Consortium (CUSEC), July 2006

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Identify Vulnerabilities

For Facilities Managers

- Use comprehensive checklists
- Identify vulnerabilities room-by-room
- Identify type of mitigation measure

System Identifier	Evaluation Question	Evaluation Y or N or comment	Guidance	Data References
2	Architectural			
	Planning and Function			
	Are exit routes, including stairs, protected from damage and clear from nonstructural elements or contents that might fall and block exit ways?		Schools sometimes have large unbraced lockers in hallways, or store other materials, such as tall filing cabinets or bookcases, that may fall and block exits.	Inspection by district personnel ASCE 31, Section 4.8.11.
	Ceilings			
	Are suspended ceilings braced and correctly attached at walls?		Suspended ceilings easily distort (particularly in light and flexible frame structures), thus causing ceiling panels to fall if not properly designed and constructed.	ASCE 31, Section 4.8.2.
	Are heavy plaster suspended ceilings securely supported and braced?		Heavy lath and plaster ceilings in older schools are very dangerous if poorly supported.	ASCE 31, Section 4.8.2.
	Partitions and Space Division			
	Are partitions that terminate at a hung ceiling braced to the structure above?		Partitions need support for out-of-plane forces. Attachment to a suspended ceiling is inadequate.	ASCE 31, Section 4.8.1.

From FEMA P-424, Design Guide for Improving School Safety in Earthquakes, Floods, and High Winds, December 2010

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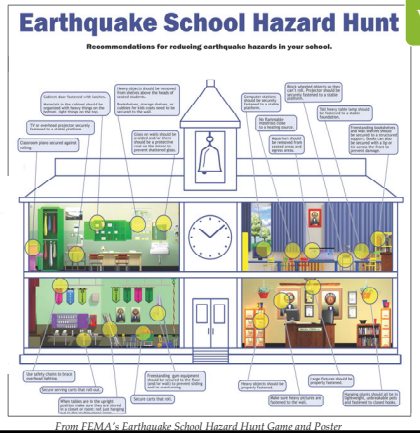
Identify Vulnerabilities

For Students

- Incorporate a Hazard Hunt into lessons or yearly ShakeOut



From FEMA's Earthquake School Hazard Hunt Game and Poster

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Identify Vulnerabilities

ShakeOut

- International ShakeOut Day is always the Third Thursday of October.
- ShakeOut earthquake drills are an opportunity to practice how to be safer during earthquakes.
- Resources at shakeout.org

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Mitigation Process

Create a Plan for Mitigation → Identify Vulnerabilities → Prioritize Vulnerabilities → Implement Mitigation Measures

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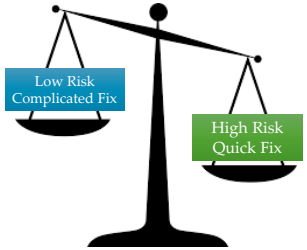
Prioritizing Vulnerabilities

- Severity of Risk
  - **Worst-first**
- Cost and Complexity of Mitigation
  - **Implement common sense measures first**



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Severity of Risk

Lowest Risk	Moderate Risk	Highest Risk
• Light falling hazards • Sparsely occupied space • Unlikely to result in school closure • Inexpensive to repair		• Heavy falling hazards • High occupancy space • Hazardous materials • Potential to block egress • Potential to result in long building closure

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Complexity of Mitigation

Most Difficult	Moderate Difficulty	Easiest to Mitigate
• Expensive to mitigate • Disruptive • Requires Design Professional		• Inexpensive or No cost • DIY fix available

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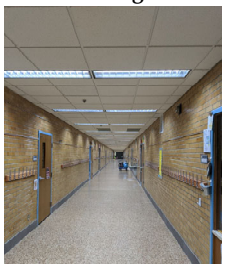
Prioritize Vulnerabilities

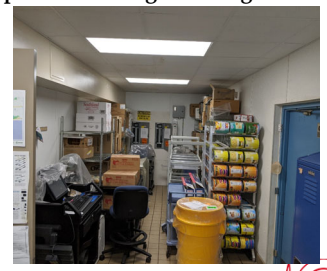
Example

Suspended Ceiling in Hallway



VS.

Suspended Ceiling in Storage Room



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Prioritize Vulnerabilities

Example

Entrance Canopy

VS.

Shade Canopy

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Prioritize Vulnerabilities

Example

Elevated water heater

VS.

Large water heater

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Prioritize Vulnerabilities

Risk to Life Safety

- Heavy suspended items
- Tall slender bookcases and cabinets
- Heavy cladding and entrance canopies

Property Loss

- Expensive contents such as machinery
- Building furnishings and finishes vulnerable to water

Loss of Use

- Ceilings
- Piping
- Mechanical Equipment

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Mitigation Process

Create a Plan for Mitigation → Identify Vulnerabilities → Prioritize Vulnerabilities → Implement Mitigation Measures

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Implementing Nonstructural Seismic Mitigation

Implement Mitigation Measures

- Start with Worst-First and Common Sense Measures
- Can have a big impact on making schools safer

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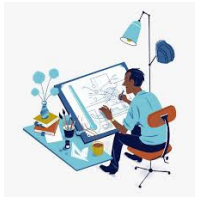
Design Professionals

Implement Mitigation Measures

- Architects and engineers can be valuable partners in helping to explain the fundamentals of building safety
- Professionals can determine vulnerabilities and provide recommendations for prioritizing actions for improving the safety of a school
- Professionals can clarify the relevant local building code rules
- Select engineers familiar with nonstructural design



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Quality Control

Implement Mitigation Measures

- Work needs to be done properly
- Requires oversight

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Implement Mitigation Measures

Quality Control

- Even DIY in-house work requires oversight

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Questions?

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Part 7 – Maintaining a Safe School Environment

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Installation of New Items

- Create a policy or guidelines for installation of new items
- Consider adding something like this to your School Facilities Manual or maintenance requirements:
  1. All newly installed wall-mounted or suspended items weighing over 20# shall be installed in accordance with an approved earthquake resistant detail.
  2. All newly installed floor-supported furniture, equipment or other components weighing over 400# shall be installed with an approved earthquake resistant detail.
  3. Installations of all new wall-mounted or suspended nonstructural components weighing over 20#, and all floor-mounted components weighting over 400# shall be inspected for earthquake safety prior to use.

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Earthquake Safety

- Foster a culture of earthquake safety
- Include Earthquake safety in the curriculum
- Local professionals can help educate students and community

Source

Utah's "Earthquake Lady" Maralin Hoff

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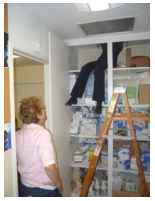
Annual Checks

- Make someone responsible for annual checks
- Engage outside entities like PTA to monitor
- Have a plan for how to respond to identified vulnerabilities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Summary/Conclusions

- Nonstructural seismic performance is important to protecting students and staff in an earthquake
- You can make schools safer by identifying nonstructural vulnerabilities and implementing mitigation strategies
- Common sense and DIY measures can go a long way toward reducing earthquake risk
- Nonstructural mitigation is an ongoing process needed throughout the life of your school building

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Acknowledgements

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  - Anchorage School District
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  - **FEMA P-1000**, *Safer, Stronger, Smarter: A Guide to Improving School Natural Hazard Safety*
  - **FEMA P-154**, *Rapid Visual Screening of Buildings for Potential Seismic Hazards*
  - **ATC-20**, *Postearthquake Safety Evaluation of Buildings*
  - **FEMA 395**, *Incremental Seismic Rehabilitation Of School Buildings (K-12)*
  - **FEMA B-526**, *Earthquake Safety Checklist*
  - **FEMA P-424**, *Design Guide for Improving School Safety in Earthquakes, Floods, and High Winds*
  - **FEMA 159**, *Earthquakes – A Teacher's Package for K-6*
  - **2011 Guide and Checklist for Nonstructural Hazards in California Schools**
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