Life-Safety Risks to Schools from Nonstructural Earthquake Damage

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School Safety!
Earthquake Hazards Affecting Central US

Presentation Outline

- Earthquake hazards affecting the Central US
- What are nonstructural components?
- Historical performance
- Benefits of mitigation
- Questions and answers
Probable Ground Motion Intensity

Central US Earthquake History

- 1811-1812: M7.7+, New Madrid, MO
- 1843: M6.0, Marked Tree, AR
- 1865: M5.0, Memphis, TN
- 1895: M6.6, Charleston, MO
- 1941: <M5.0, Covington, TN
- 1952: <M5.0, Dyersburg, TN
- 1956: <M5.0, Covington, TN

Little bldg damage has occurred
- Sparsely populated (early 1800s)
- Chimneys, windows, contents
Earthquake Damage

Mineral, VA: M5.8 (2011)  Even small EQs can be damaging

What are Nonstructural Components?
Structural Components

- Structural components resist gravity loads, lateral loads (wind & earthquake), and other types of loads
- Structural components include:
  - Roof
  - Floors
  - Beams
  - Columns
  - Braces
  - Concrete / masonry walls (Load bearing only)
  - Foundation

Nonstructural Components

- Nonstructural components include all portions of the facility that are not load-carrying / structural components

Ref. FEMA E-74
Categories of Nonstructural Components

Architectural Components

Mechanical, Electrical, Plumbing Components & Process Equipment

Furniture, Fixtures, and Contents

Architectural Components

- Parapets
- Partition walls
- Screen walls
- Ceilings
- Glazing
- Cladding
- Veneers
- Chimneys
- Stairs

*Interior contents and ceiling damage*
Mechanical, Electrical, & Plumbing

- Fire Protection Equipment
- Generators
- Chillers & boilers
- Distribution panels
- Transformers
- Fans & heaters
- Air handling units
- Ductwork & conduit
- Piping & plumbing

Diesel emergency generator (unanchored)

Furniture, Fixtures, & Contents

- Desks & chairs
- Bookcases & file cabinets
- Storage cabinets & racks
- Furniture
- Computers
- Smart boards
- Projection equipment

Lakeside School Library
Kern County Earthquake - 1952
Photo Credit – M. Knox
Structural & Nonstructural Components

- **Structural systems**
  - Designed by civil or structural engineer
  - Structural elements are shown on the construction drawings including the seismic lateral force resisting systems
  - Construction oversight to ensure bldg conforms to design drawings

- **Nonstructural systems**
  - Specified by design team (architect, mechanical / electrical engineer, interior designer, IT engineer, fire protection engineer, etc.)
  - Seismic design is via performance specifications TO BE IMPLEMENTED BY THE RESPECTIVE CONSTRUCTION TRADES
  - Performance specifications provide limited guidance on seismic design for contractor implementation
  - Little inspection or oversight to ensure proper installation

Nonstructural Component EQ Performance
Historic Performance

Earthquake Damage Concerns

Life Safety – Paramount: Children & Staff
• Could anyone be hurt by this building or component in an earthquake?

Property Loss
• Could a large property loss result?

Functional Loss – Community Shelter
• Could the loss of this building or component result in an outage, interruption or loss of use?
1933 Long Beach, CA Earthquake
Moderate Magnitude 6.3M
URM buildings heavily damaged
Property damage estimated at $40 million
115 fatalities
120 schools damaged
70 schools destroyed

California’s Response

- 1933 Long Beach Earthquake
- 1 month later California adopted the Field Act
- All school design, plans and construction authorized and supervised by the California State Department of Works Division of Architecture
- 6 years later Garrison Act enacted to regulate all school construction in the state
Sichuan, China Earthquake 2008

Magnitude Mw 7.9
6,900 school rooms collapsed
9,000 students & teachers perished
More than 1,000 students along perished at the Beichuan Middle School in Mianyang

Mineral, VA Earthquake M5.8

Small magnitude event
Infrequent activity regionally for moderate and large events
No fatalities
Estimated losses $200-$300 million
Nonstructural damage to Louisa County High School
Primary Contributors to Nonstructural Damage

1. Code Design Philosophy
   Life safety performance

   Nonstructural Design Importance Factor:
   - Life safety system
   - Contains or transports hazardous materials
   - Required to operate/function following an earthquake event
Primary Contributors to Nonstructural Damage

1. Code Design Philosophy
2. Not all components governed by code
   - Bookcases
   - Screen
   - Projector
   - Desks
3. Design Professional Knowledge
   of seismic design & responsibility
## Knowledge & Responsibility?

- Engineers
  - Structural
  - Mechanical
  - Plumbing
  - Fire protection
  - Electrical
  - Telecom
- Architects
- Building Officials
- Owners
- General Contractor
- Subcontractors
  - Fire Protection
  - Cladding
  - Mechanical
  - Plumbing
  - Electrical
  - Drywall
  - Ceiling
  - Telecom
- Installers
- Equipment vendors
- Inspectors
- Tenants
- Facility Managers
- Office Manager

## Responsibility?
## Primary Contributors to Nonstructural Damage

1. Code Design Philosophy
2. Not all components governed by code
3. Design Professional Knowledge of seismic design & responsibility
4. Construction quality & enforcement

## Benefits of Mitigation
Benefits of Nonstructural Mitigation

1. Life-safety risks significantly reduced and controlled
   - Students
   - Staff
   - Visitors

2. Repair & recovery costs significantly reduced

3. Availability as a community shelter in time of need

4. Greatest cost-benefits achieved
   - FEMA – National Average: $4 Benefit for every $1 spent

5. Many nonstructural mitigation measures are easily implemented by staff
Mitigation Measures

- Implement good housekeeping measures
- Relocate contents to lower risk
  - Egress routes
- Restrain contents
- Install proper equipment anchorage

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6. Largest financial investment in your school
Nonstructural Costs

Majority of facility cost
- Contents
- Nonstructural
- Structural

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AND

7. Life-safety risks are significantly reduced and controlled
Nonstructural Mitigation Resources

- FEMA E-74
- FEMA 412 – Installing Seismic Restraints for Mechanical Equipment
- FEMA 413 – Installing Seismic Restraints for Electrical Equipment
- FEMA 414 – Installing Seismic Restraints for Duct & Pipe
- FEMA 395: Incremental Seismic Rehabilitation of School Buildings (K-12)
- ASCE – Earthquake Protection of Building Equipment and Systems, by Gatscher, McGavin & Caldwell

Final Thoughts

- Ensure Design Professionals incorporate seismic design provisions for ANYTHING going forward.
- Perform construction inspection to verify seismic provisions have been installed correctly – anchorage, bracing, etc.
- Incorporate and implement a housekeeping policy to reduce the life-safety risks – reduce clutter.
- Review and properly anchor existing equipment when the opportunity is available – maintenance activities, equipment replacements, relocated equipment and furnishings, etc.
Questions?

IF YOU HAVE ADDITIONAL QUESTIONS PLEASE CONTACT ME AT:

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