Earthquake Mitigation for Hospitals: Workshop

Part 10 – Integration Opportunities

Integration Opportunities for Structural and Nonstructural Mitigation

Categories of Hospital Maintenance and Capital Improvement Projects

1. Patient Care Improvements
2. New Technology Accommodation
3. Fire and Life Safety Improvements
4. Roofing Maintenance and Repair
5. Exterior Wall and Window Maintenance/Facade Modernization

Integration Opportunities for Structural and Nonstructural Mitigation

Categories of Hospital Maintenance and Capital Improvement Projects

6. Underfloor and Basement Maintenance & Repair
7. HVAC Improvements
8. Energy Conservation / Weatherization
9. Hazardous Materials Abatement
10. Building Additions

Integration Opportunities for Structural and Nonstructural Mitigation

Examples From FEMA 396

Table C-1: Patient Care Improvements

Number*	Level of Seismicity L	Level of Seismicity M	Level of Seismicity H	Building Structural Element	Structural Sub-System	Seismic Performance Improvement	Vertical Load Carrying Structure: Wood	Masonry[1]: Unreinforced Masonry	Masonry[1]: Reinforced Masonry	Concrete: Wood Diaphragm	Concrete: Concrete Diaphragm	Steel: Wood Diaphragm	Steel: Concrete Diaphragm
Nonstructural													
3		✓	✓	n/a	n/a	Bracing and Detailing of Sprinkler and Piping	■	■	■	■	■	■	■
4		✓	✓	n/a	n/a	Suspension and Bracing of Lights	■	■	■	■	■	■	■
5		✓	✓	n/a	n/a	Fastening and Bracing of Ceilings	■	■	■	■	■	■	■
6	✓	✓	✓	n/a	n/a	Anchorage and Bracing of Emergency Lighting	■	■	■	■	■	■	■
7		✓	✓	n/a	n/a	Attachment and Bracing of Cabinets and Furnishings	■	■	■	■	■	■	■
8		✓	✓	n/a	n/a	Fastening and Bracing of Equipment (Mechanical and Electrical)	■	■	■	■	■	■	■
9		✓	✓	n/a	n/a	Support and Detailing of Elevators		■	■	■	■	■	■
10	✓	✓	✓	n/a	n/a	Bracing or Reinforcing Masonry Walls at Interior Stairs		■	■	■	■	■	■
11		✓	✓	n/a	n/a	Attachment and Bracing of Large Ductwork	■	■	■	■	■	■	■
13		✓	✓	n/a	n/a	Restraint of Hazardous Materials Containers	■	■	■	■	■	■	■
14		✓	✓	n/a	n/a	Bracing of Interior Partitions (Masonry & Wood)	■	■	■	■	■	■	■
16	✓	✓	✓	n/a	n/a	Glazing Selection and Detailing	■	■	■	■	■	■	■
17		✓	✓	n/a	n/a	Underfloor Bracing of Computer Access Floor	■	■	■	■	■	■	■
20		✓	✓	n/a	n/a	Anchorage of Steel Stud Backup		■	■	■	■	■	■
Structural													
n/a		✓	✓	All		Collector and Drag Element Improvement	□	□	□	□	☒	□	☒
n/a		✓	✓	Foundation		Anchor Bolts	■						
n/a		✓	✓	Foundation		Cripple Stud Bracing	■						
n/a		✓	✓	Foundation		New Foundations	■						
n/a		✓	✓	Horizontal Elements	Diaphragms	Mezzanine Anchorage and Bracing		■	■	■	■	■	■
n/a		✓	✓	Horizontal Elements	Diaphragms	Strengthening at Openings	□	□	□	□		□	
n/a		✓	✓	Horizontal Elements	Diaphragms	Strengthening at Re-entrant Corners	□	□	□	□	☒	□	☒
n/a	✓	✓	✓	Vertical Elements	Load Path	Lateral Resisting System to Diaphragm Connection	■	■	■	■	☒	■	☒
n/a		✓	✓	Vertical Elements	Braced Frames	Capacity/Stiffness				□	☒	□	☒
n/a		✓	✓	Vertical Elements	Braced Frames	Continuity				□	☒	□	☒
n/a		✓	✓	Vertical Elements	Braced Frames	Connections				□	□	□	□
n/a		✓	✓	Vertical Elements	Moment Frames	Beam Column Capacity/Stiffness				□	☒	□	☒
n/a		✓	✓	Vertical Elements	Moment Frames	Beam Column Connection				□	□	□	□
n/a		✓	✓	Vertical Elements	Shear Walls	Capacity	■	□	□	□	☒	□	☒
n/a		✓	✓	Vertical Elements	Shear Walls	Continuity	■	□	□	□	☒	□	☒
n/a		✓	✓	Vertical Elements	Shear Walls	Extension of Wood Interior Walls to Roof	■	■	■				
n/a		✓	✓	Vertical Elements	Shear Walls	Lateral Stability		■	■	□	□	□	□
n/a	✓	✓	✓	Vertical Elements		Out-of-Plane Anchorage of Concrete or Masonry Wall		■	■	■	□	■	□

Integration Opportunities for Structural and Nonstructural Mitigation

Examples From FEMA 396

Table C-1: Patient Care Improvements

Number*	Level of Seismicity L	M	H	Building Structural Element	Structural Sub-System	Seismic Performance Improvement	Vertical Load Carrying Structure: Wood	Masonry[1]: Unreinforced Masonry	Masonry[1]: Reinforced Masonry	Concrete: Wood Diaphragm	Concrete: Concrete Diaphragm	Steel: Wood Diaphragm	Steel: Concrete Diaphragm
Nonstructural													
3		✓	✓	n/a	n/a	Bracing and Detailing of Sprinkler and Piping	■	■	■	■	■	■	■
4		✓	✓	n/a	n/a	Suspension and Bracing of Lights	■	■	■	■	■	■	■
5		✓	✓	n/a	n/a	Fastening and Bracing of Ceilings	■	■	■	■	■	■	■
6	✓	✓	✓	n/a	n/a	Anchorage and Bracing of Emergency Lighting	■	■	■	■	■	■	■
7		✓	✓	n/a	n/a	Attachment and Bracing of Cabinets and Furnishings	■	■	■	■	■	■	■
8		✓	✓	n/a	n/a	Fastening and Bracing of Equipment (Mechanical and Electrical)	■	■	■	■	■	■	■
9		✓	✓	n/a	n/a	Support and Detailing of Elevators		■	■	■	■	■	■
10	✓	✓	✓	n/a	n/a	Bracing or Reinforcing Masonry Walls at Interior Stairs		■	■	■	■	■	■
11		✓	✓	n/a	n/a	Attachment and Bracing of Large Ductwork	■	■	■	■	■	■	■
13		✓	✓	n/a	n/a	Restraint of Hazardous Materials Containers	■	■	■	■	■	■	■
14		✓	✓	n/a	n/a	Bracing of Interior Partitions (Masonry & Wood)	■	■	■	■	■	■	■
16	✓	✓	✓	n/a	n/a	Glazing Selection and Detailing	■	■	■	■	■	■	■
17		✓	✓	n/a	n/a	Underfloor Bracing of Computer Access Floor	■	■	■	■	■	■	■
20		✓	✓	n/a	n/a	Anchorage of Steel Stud Backup		■	■	■	■	■	■
Structural													
n/a		✓	✓	All		Collector and Drag Element Improvement	□	□	□	□	☒	□	☒
n/a		✓	✓	Foundation		Anchor Bolts	■						
n/a		✓	✓	Foundation		Cripple Stud Bracing	■						
n/a		✓	✓	Foundation		New Foundations	■						
n/a		✓	✓	Horizontal Elements	Diaphragms	Mezzanine Anchorage and Bracing		■	■	■	■	■	■
n/a		✓	✓	Horizontal Elements	Diaphragms	Strengthening at Openings	□	□	□	□		□	
n/a		✓	✓	Horizontal Elements	Diaphragms	Strengthening at Re-entrant Corners	□	□	□	□	☒	□	☒
n/a	✓	✓	✓	Vertical Elements	Load Path	Lateral Resisting System to Diaphragm Connection	■	■	■	■	☒	■	☒
n/a		✓	✓	Vertical Elements	Braced Frames	Capacity/Stiffness				□	☒	□	☒
n/a		✓	✓	Vertical Elements	Braced Frames	Continuity				□	☒	□	☒
n/a		✓	✓	Vertical Elements	Braced Frames	Connections				□	□	□	□
n/a		✓	✓	Vertical Elements	Moment Frames	Beam Column Capacity/Stiffness				□	☒	□	☒
n/a		✓	✓	Vertical Elements	Moment Frames	Beam Column Connection				□	□	□	□
n/a		✓	✓	Vertical Elements	Shear Walls	Capacity	■	□	□	□	☒	□	☒
n/a		✓	✓	Vertical Elements	Shear Walls	Continuity	■	□	□	□	☒	□	☒
n/a		✓	✓	Vertical Elements	Shear Walls	Extension of Wood Interior Walls to Roof	■	■	■				
n/a		✓	✓	Vertical Elements	Shear Walls	Lateral Stability		■	■	□	□	□	□
n/a	✓	✓	✓	Vertical Elements		Out-of-Plane Anchorage of Concrete or Masonry Wall		■	■	■	□	■	□

Vertical Load Carrying Structure:

- Wood
- Unreinforced Masonry
- Reinforced Masonry
- Concrete
- Steel

Generalized Building Structure Earthquake Performance

Decreasing Vulnerability

Stiff Structures	Flexible Structures
Unreinforced Masonry (Brick)	Concrete Precast Frame (Parking Garages)
Concrete Frame with URM Infill	Concrete Moment Resisting Frames
Concrete Tilt-Up	
Steel Frame w/URM Infill Shear Walls	
Reinforced Masonry	Steel Moment Resisting Frames
Concrete Shear Wall	Light Metal Frame Buildings
Steel Braced Frames	Wood Frame Buildings

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Nonstructural													
3		✓	✓	n/a	n/a	Bracing and Detailing of Sprinkler and Piping	■	■	■	■	■	■	■
4		✓	✓	n/a	n/a	Suspension and Bracing of Lights	■	■	■	■	■	■	■
5		✓	✓	n/a	n/a	Fastening and Bracing of Ceilings	■	■	■	■	■	■	■
6	✓	✓	✓	n/a	n/a	Anchorage and Bracing of Emergency Lighting	■	■	■	■	■	■	■
7		✓	✓	n/a	n/a	Attachment and Bracing of Cabinets and Furnishings	■	■	■	■	■	■	■
8		✓	✓	n/a	n/a	Fastening and Bracing of Equipment (Mechanical and Electrical)	■	■	■	■	■	■	■
9		✓	✓	n/a	n/a	Support and Detailing of Elevators		■	■	■	■	■	■
10	✓	✓	✓	n/a	n/a	Bracing or Reinforcing Masonry Walls at Interior Stairs		■	■	■	■	■	■
11		✓	✓	n/a	n/a	Attachment and Bracing of Large Ductwork	■	■	■	■	■	■	■
13		✓	✓	n/a	n/a	Restraint of Hazardous Materials Containers	■	■	■	■	■	■	■
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16	✓	✓	✓	n/a	n/a	Glazing Selection and Detailing	■	■	■	■	■	■	■
17		✓	✓	n/a	n/a	Underfloor Bracing of Computer Access Floor	■	■	■	■	■	■	■
20		✓	✓	n/a	n/a	Anchorage of Steel Stud Backup		■	■	■	■	■	■
Structural													
n/a		✓		All		Collector and Drag Element Improvement	□	□	□	□	☒	□	☒
n/a		✓	✓	Foundation		Anchor Bolts	■						
n/a		✓	✓	Foundation		Cripple Stud Bracing	■						
n/a		✓	✓	Foundation		New Foundations	■						
n/a		✓	✓	Horizontal Elements	Diaphragms	Mezzanine Anchorage and Bracing		■	■	■	■	■	■
n/a		✓	✓	Horizontal Elements	Diaphragms	Strengthening at Openings	□	□	□	□		□	
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n/a	✓	✓	✓	Vertical Elements	Load Path	Lateral Resisting System to Diaphragm Connection	■	■	■	■	☒	■	☒
n/a		✓	✓	Vertical Elements	Braced Frames	Capacity/Stiffness				□	☒	□	☒
n/a		✓	✓	Vertical Elements	Braced Frames	Continuity				□	☒	□	☒
n/a		✓	✓	Vertical Elements	Braced Frames	Connections				□	□	□	□
n/a		✓	✓	Vertical Elements	Moment Frames	Beam Column Capacity/Stiffness				□	☒	□	☒
n/a		✓	✓	Vertical Elements	Moment Frames	Beam Column Connection				□	□	□	□
n/a		✓	✓	Vertical Elements	Shear Walls	Capacity	■	□	□	□	☒	□	☒
n/a		✓	✓	Vertical Elements	Shear Walls	Continuity	■	□	□	□	☒	□	☒
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n/a	✓	✓	✓	Vertical Elements		Out-of-Plane Anchorage of Concrete or Masonry Wall		■	■	■	□	■	□

Structural Improvements

- Foundations
- Horizontal Elements
- Vertical Elements

Structural Mitigation

- Member strengthening
- Connection strengthening
- Addition of new Lateral Force-Resisting Systems
- Foundation strengthening

Integration Opportunities for Structural and Nonstructural Mitigation

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5		✓	✓	n/a	n/a	Fastening and Bracing of Ceilings	■	■	■	■	■	■	■
6	✓	✓	✓	n/a	n/a	Anchorage and Bracing of Emergency Lighting	■	■	■	■	■	■	■
7		✓	✓	n/a	n/a	Attachment and Bracing of Cabinets and Furnishings	■	■	■	■	■	■	■
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9		✓	✓	n/a	n/a	Support and Detailing of Elevators		■	■	■	■	■	■
10	✓	✓	✓	n/a	n/a	Bracing or Reinforcing Masonry Walls at Interior Stairs		■	■	■	■	■	■
11		✓	✓	n/a	n/a	Attachment and Bracing of Large Ductwork	■	■	■	■	■	■	■
13		✓	✓	n/a	n/a	Restraint of Hazardous Materials Containers	■	■	■	■	■	■	■
14		✓	✓	n/a	n/a	Bracing of Interior Partitions (Masonry & Wood)	■	■	■	■	■	■	■
16	✓	✓	✓	n/a	n/a	Glazing Selection and Detailing	■	■	■	■	■	■	■
17		✓	✓	n/a	n/a	Underfloor Bracing of Computer Access Floor	■	■	■	■	■	■	■
20		✓	✓	[illegible]	n/a	Anchorage of Steel Stud Backup		■	■	■	■	■	■
Structural													
n/a		✓	✓	All		Collector and Drag Element Improvement	□	□	□	□	☒	□	☒
n/a		✓	✓	Foundation		Anchor Bolts	■						
n/a		✓	✓	Foundation		Cripple Stud Bracing	■						
n/a		✓	✓	Foundation		New Foundations	■						
n/a		✓	✓	Horizontal Elements	Diaphragms	Mezzanine Anchorage and Bracing		■	■	■	■	■	■
n/a		✓	✓	Horizontal Elements	Diaphragms	Strengthening at Openings	□	□	□	□		□	
n/a		✓	✓	Horizontal Elements	Diaphragms	Strengthening at Re-entrant Corners	□	□	□	□	☒	□	☒
n/a	✓	✓	✓	Vertical Elements	Load Path	Lateral Resisting System to Diaphragm Connection	■	■	■	■	☒	■	☒
n/a		✓	✓	Vertical Elements	Braced Frames	Capacity/Stiffness				□	☒	□	☒
n/a		✓	✓	Vertical Elements	Braced Frames	Continuity				□	☒	□	☒
n/a		✓	✓	Vertical Elements	Braced Frames	Connections				□	□	□	□
n/a		✓	✓	Vertical Elements	Moment Frames	Beam Column Capacity/Stiffness				□	☒	□	☒
n/a		✓	✓	Vertical Elements	Moment Frames	Beam Column Connection				□	□	□	□
n/a		✓	✓	Vertical Elements	Shear Walls	Capacity	■	□	□	□	☒	□	☒
n/a		✓	✓	Vertical Elements	Shear Walls	Continuity	■	□	□	□	☒	□	☒
n/a		✓	✓	Vertical Elements	Shear Walls	Extension of Wood Interior Walls to Roof	■	■	■				
n/a		✓	✓	Vertical Elements	Shear Walls	Lateral Stability		■	■	□	□	□	□
n/a	✓	✓	✓	Vertical Elements		Out-of-Plane Anchorage of Concrete or Masonry Wall		■	■	■	□	■	□

Nonstructural Improvements

Integration Opportunities for Structural and Nonstructural Mitigation

- Building Utilities
- Architectural Components
- Medical Equipment
- Furniture and Contents
- Communications / IT Systems

Integration Opportunities for Structural and Nonstructural Mitigation

- Building Utilities
  - Patient Care Improvement
  - Lighting/Electrical
  - Fire Extinguishing System
  - Mechanical and Plumbing Systems
  - Boilers

Integration Opportunities for Structural and Nonstructural Mitigation

- Architectural Components
  - Ceilings
  - Partitions
  - Cladding
  - Access Floors
  - Canopies

Integration Opportunities for Structural and Nonstructural Mitigation

- Medical Equipment
  - X-Ray and Scanning Devices
  - Cabinets and Storage
  - Refrigerators
  - Benchtop Equipment

Integration Opportunities for Structural and Nonstructural Mitigation

- Furniture and Contents
  - Storage racks
  - Shelving
  - File Cabinets
  - Bookcases

Integration Opportunities for Structural and Nonstructural Mitigation

RISK = f (HAZARD, VULNERABILITY)

Risk is a function of both the potential hazard (seismic ground motion) and vulnerability (lack of seismic preparedness in structural and nonstructural systems)

Questions?