Earthquake Mitigation for Hospitals: Workshop

Part 5 – Earthquake Damage Expectations

Earthquake Performance Expectations for the Midwest

Post-Earthquake Expectations for a Major Event Affecting Missouri

Regional Post-Earthquake Expectations

- Historically:
  - MMI Intensities of VII – VIII following an IBC level earthquake event
  - Extensive damage to masonry buildings, old building stock, and nonstructural components & systems
  - Electric Power outages from 1 – 7 days

Regional Post-Earthquake Expectations (Cont.)

- Historically:
  - Natural gas may be shutoff for several days to a few weeks
  - Telephone service will be unreliable for 24 hours, poor service for several days, cellular phones perform better, local exchanges out until power restored
  - Localized water and sewer disruptions from several days to weeks for repairs

Regional Post-Earthquake Expectations (Cont.)

- Historically:
  - Major roadways and bridges generally open, but expect detours and major delays due to inspections

Regional Post-Earthquake Expectations (Cont.)

- Inspection of Buildings for Re-occupancy:
  - Owners calling for building inspections from local building jurisdictions ASAP!
  - Building safety assessments for reoccupation
  - Buildings are tagged (rated) Red, Yellow, or Green
  - Missouri SAVE Coalition trains volunteer inspectors
  - Hospitals should consider hiring an engineering firm to inspect facility

Regional Post-Earthquake Expectations (Cont.)

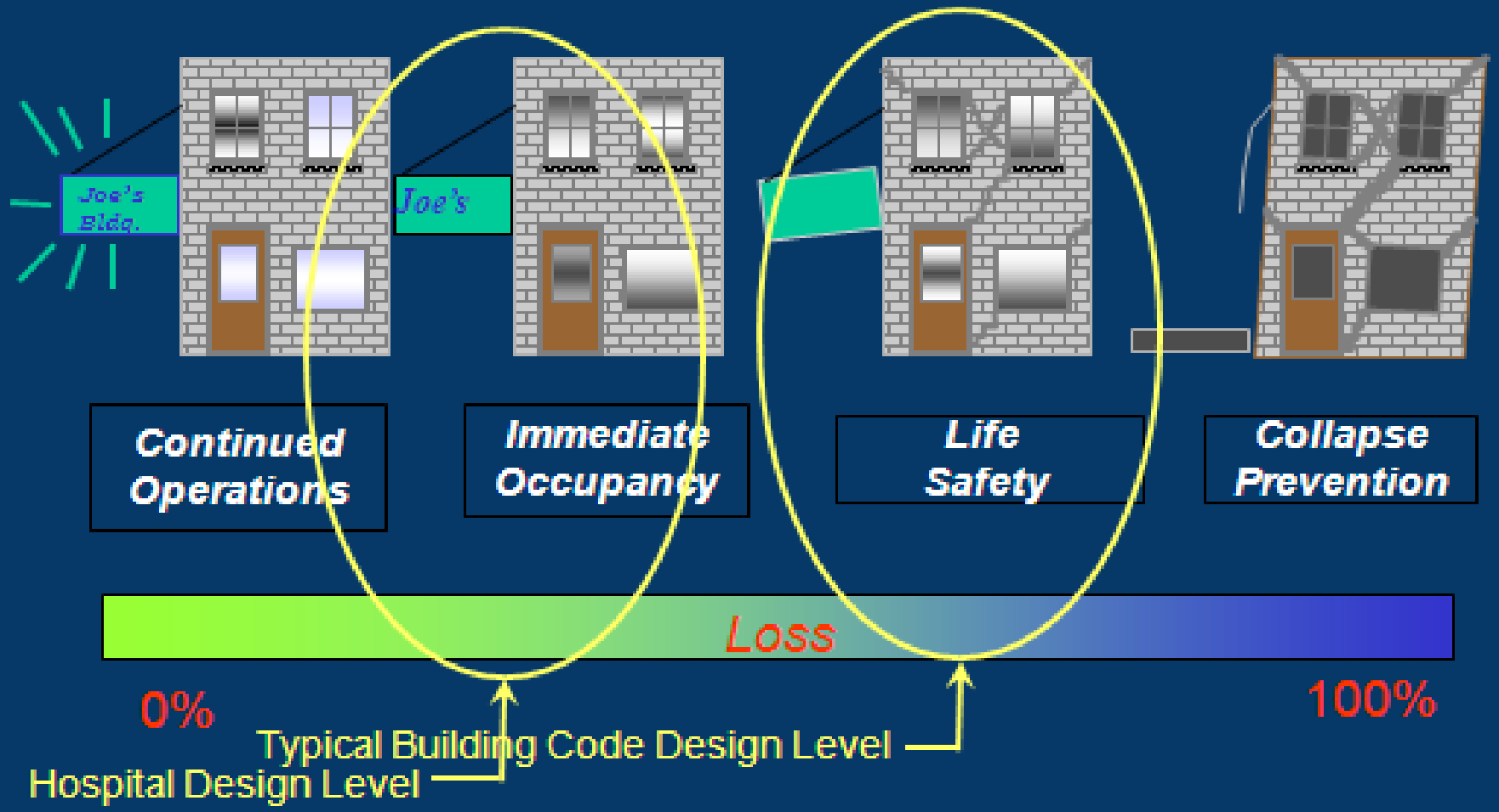
- Potential Consequences:
  - Options for repair/mitigation of life safety hazards will be limited – mitigation may likely be mandated
  - Reactionary public and political demands
  - Area contracting and repair companies stretched to the limit
  - Financial considerations for clean-up, repair, and mitigation
  - Chaotic environment

Why does so much Damage Occur?

- Building Code Design Philosophy
- Seismic Design Process for Nonstructural Components
- Construction Process
- Quality of Construction
- Increased Cost for Enhanced Seismic Anchorage Impedes Implementation

What the building code says!

Model Building Code Earthquake Performance



Model Building Code Design Philosophy

- Model Building Codes for typical buildings (BOCA, SBC, UBC, IBC):
  - Provide a *Minimum* set of design requirements for the protection of public safety, health, and general welfare. A LIFE SAFETY code
  - Do not protect against PROPERTY DAMAGE or LOSSES
  - International Building Code (IBC) should be more effective
- Hospitals are required to have a higher level of design over typical buildings

Model Building Code Design Philosophy (Cont.)

- Acceptable building performance under the Model Building Codes (UBC, BOCA, SBC, & IBC) for Life Safety means:
  - Significant structural damage
  - Extensive nonstructural damage
  - Building may not be safe to reoccupy until repaired
  - Building function may be severely impacted

Model Building Code Nonstructural Design Requirements

- Design Philosophy:
  - Predominantly life safety performance
    - Cladding and wall systems
    - MEP equipment & systems carrying flammable, combustible or highly toxic contents
    - HVAC ductwork transporting hazardous materials
    - Emergency or standby power systems – life safety systems
  - Is not intended to protect against property damage
- ***Minimum*** set of design requirements

Nonstructural Components - Earthquake Design Process

- Who is the most knowledgeable and responsible party to perform the seismic design for Nonstructural Components?
  - Structural/seismic engineer
  - Architect
  - Electrical engineer
  - Mechanical engineer
  - IT/Communications engineer
  - Fire Protection engineer
  - Construction contractors

Earthquake Design Process

- Dependent upon the delivery system used:

OWNER/ DEVELOPER

ARCHITECT

Program Manager

DESIGN TEAM

Civil

Structural

Architectural

MEP Systems

Fire Protection

Communications

IT Systems

Earthquake Design Process (Cont.)

- Subject to the individual Project Architect
- Varies project to project
- Local jurisdiction dependent and enforcement
- Typically addressed by the individual MEP or Architectural discipline
- Seismic Performance Requirements written into the MEP design specifications for Contractor implementation.
- This typical process:

ABDICATES RESPONSIBILITY FOR THE SEISMIC DESIGN OF ARCH/MEP COMPONENTS TO THE RESPECTIVE DISCIPLINE CONSTRUCTION CONTRACTORS

Earthquake Design Process (Cont.)

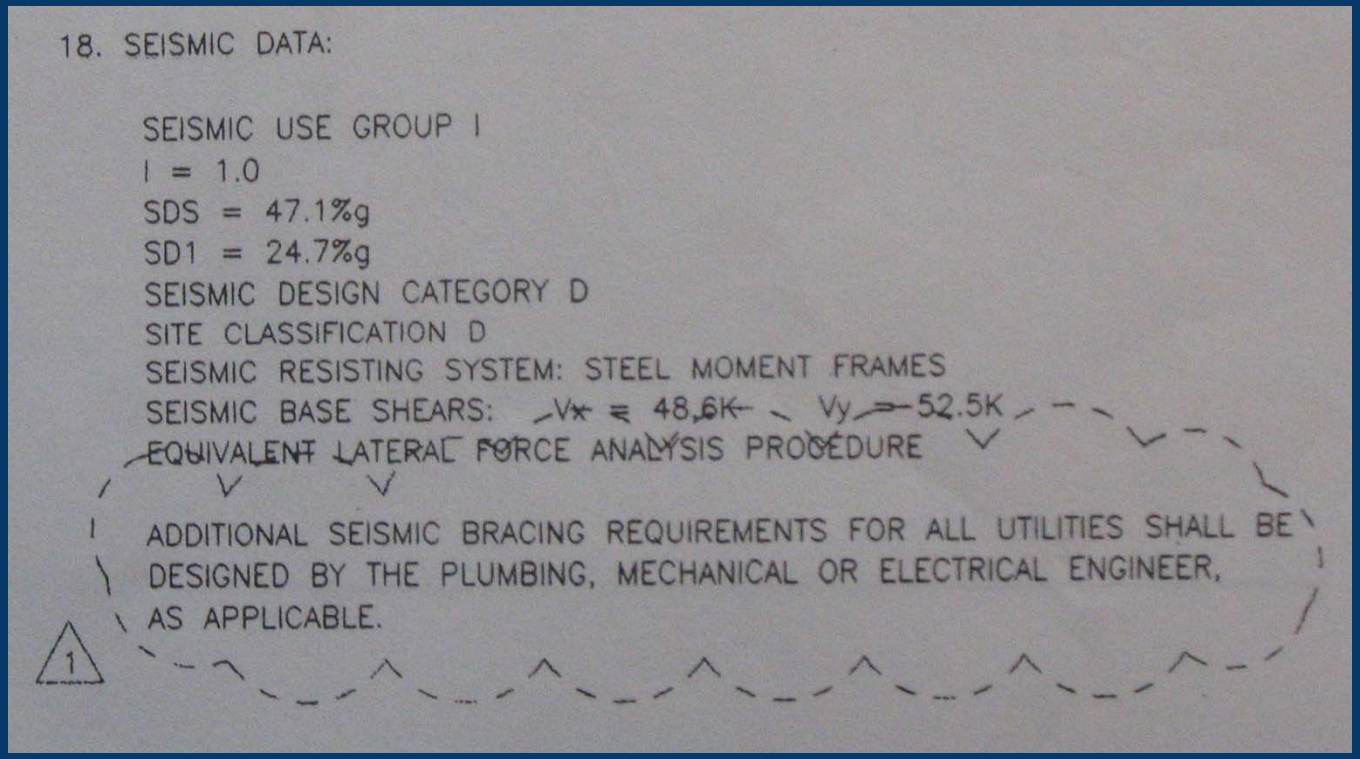
- Structural/Seismic design requirements:
  - *International Building Code*
  - *ASCE 7-05*
- MEP design requirements:
  - *International Mechanical Code*
  - *International Electrical Code*
  - *International Plumbing Code*
  - *International Fire Code*

$$F_p = \frac{0.4 a_p S_{DS} W_p}{\left[\frac{R_p}{I_p}\right]}\left[1 + 2\frac{z}{h}\right]$$

$$D_p = \delta_{xA} - \delta_{yA}$$

Earthquake Design Process (Cont.)

- Structural approach to NS Component design?



18. SEISMIC DATA:

SEISMIC USE GROUP I
I = 1.0
SDS = 47.1%g
SD1 = 24.7%g
SEISMIC DESIGN CATEGORY D
SITE CLASSIFICATION D
SEISMIC RESISTING SYSTEM: STEEL MOMENT FRAMES
SEISMIC BASE SHEARS: Vx = 48.6K Vy = 52.5K
EQUIVALENT LATERAL FORCE ANALYSIS PROCEDURE

ADDITIONAL SEISMIC BRACING REQUIREMENTS FOR ALL UTILITIES SHALL BE DESIGNED BY THE PLUMBING, MECHANICAL OR ELECTRICAL ENGINEER, AS APPLICABLE.

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Earthquake Design Process (Cont.)

- Example – Electrical equipment seismic design:
  - Specification Section 16010 – *General Electrical Provisions with Seismic Design Requirements*
  - Individual Spec. Sections provide electrical performance requirements only
    - Section 16110 - Raceways
    - Section 16425 – Switchboards
    - Section 16460 – Dry Type Transformers
    - Section 16470 – Panelboards
    - Section 16481 – Motor Control Centers

Construction Process

GENERAL CONTRACTOR

Subcontractors

Building Structure →

Steel Erector

Concrete Work

Constructs the Seismic Design (on design drawings)

Nonstructural Components →

Architectural

Mechanical

Electrical

Fire Protection

IT Systems

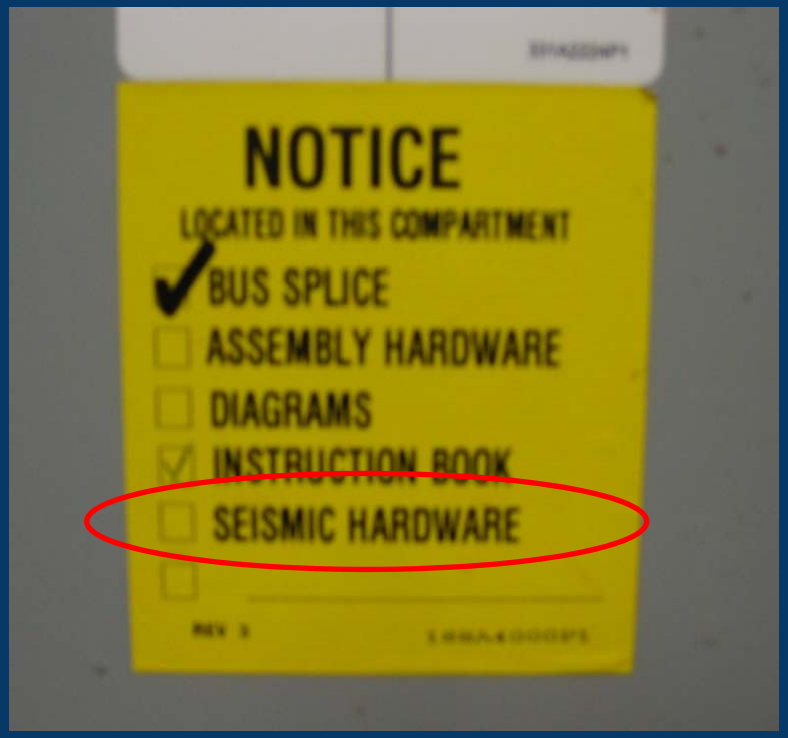
Etc.

Seismic Design? (Must Implement thru Performance Specs)

Construction Process (Cont.)

- Electrical equipment seismic design:
  - General Contractor (GC)
    - Electrical Contractor (EC)

- Example – Switchboards
  - EC Orders Equipment
  - Provides Equipment Supplier with Spec. Section 16425
  - Section 16010 – General Provisions with seismic design requirements are not provided to the Equipment Supplier



Construction Process (Cont.)

Construction Issues for MEP Systems:

- Contractor designed
- Trade sequencing
- Field routed
  - Conduit
  - Piping
  - Cable-tray
  - Ducting

Earthquake Performance Expectations?

Earthquake Performance Expectations?

Natural Gas Line

Quality of Construction

- Why is Proper Construction Important?
  - Assures the expected earthquake performance objectives
  - Assures reduction in risk or damage to the component itself
  - Assures a reduction in risk or damage to adjacent or closely located items – falling, overturning, swinging or impacting
  - Assures reduction in life safety risk to building occupants
  - Assures for critical facilities the needed operability assurances necessary for Immediate Occupancy (e.g., hospitals, fire stations, police stations, other critical facilities, etc.)

Improper construction is more prevalent than you think!

Structural Issues can Happen!

Adequate Anchorage?

Incorrect Routing – Fire Protection Piping

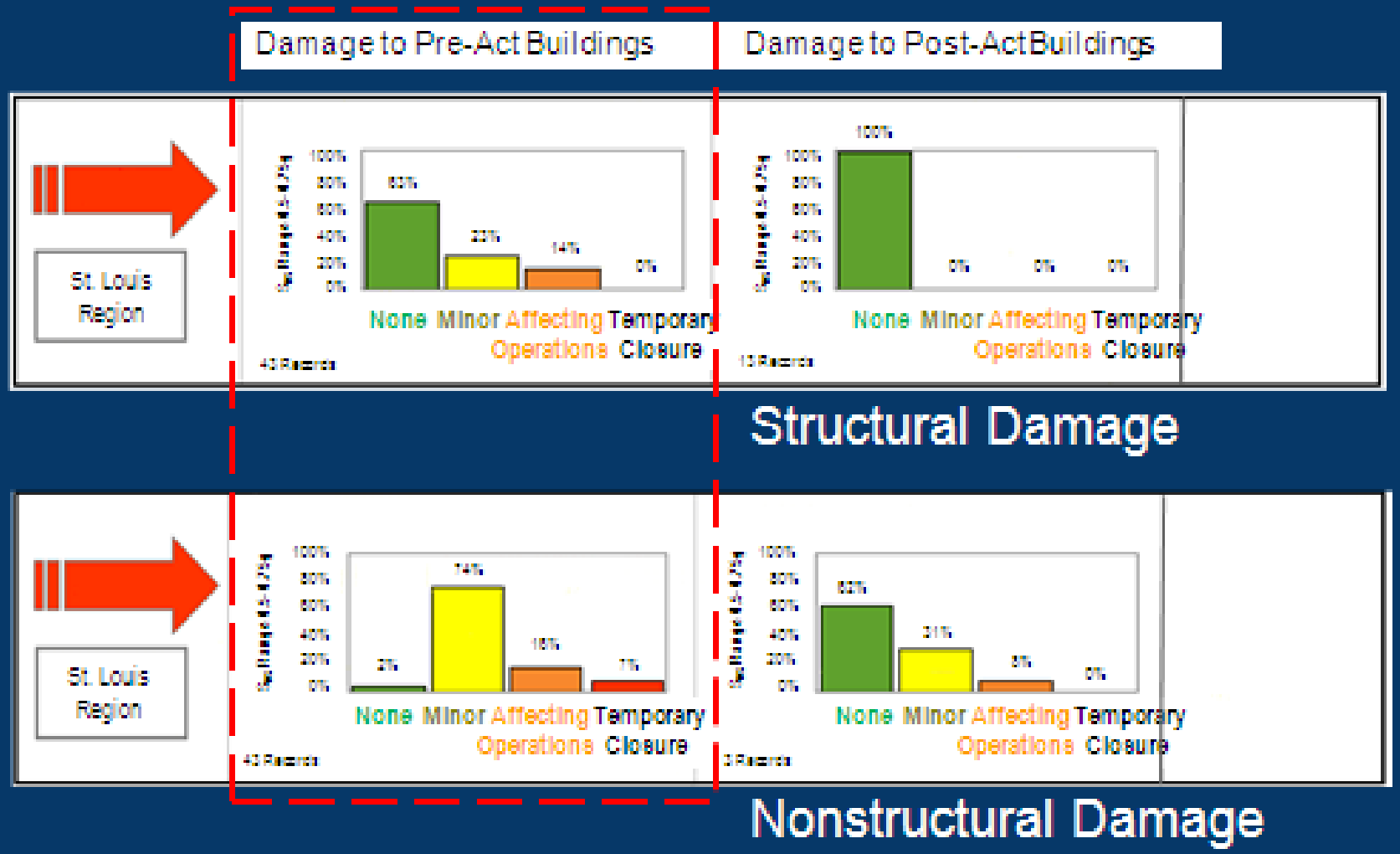
Communication Cable Support?

Emergency Generator Adequate?

Expectations for Hospitals

- Study by Holmes & Burkett, EERI 8th NCEE – California Hospital Earthquake Performance
- Primary purpose - identify levels of ground motion affecting operational performance of hospitals
- 218 Hospitals or data points that experienced earthquake ground shaking
- Pre-1973 Hospitals considered representative of hospitals outside of California to assess performance

Expectations for Hospitals (Cont.)



Questions?