Post-Disaster Safety Evaluations Using ATC-20/45

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Post-Disaster Safety Evaluation of Buildings (ATC-20/45)

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Presentation Overview
- Introduction
- Seismology/Faults/Loads
- ATC-20/45 Posting System
- Structural Basics/Load Path
- Evaluation Procedures
- Rapid Evaluation and Assessment Program (REAP)
- Disaster Damage Exercises
  - Wood, Masonry, Concrete, Steel
How We Measure Earthquakes

Richter Scale (Mr)

<table>
<thead>
<tr>
<th>Richter Magnitude</th>
<th>4</th>
<th>6</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Increase</td>
<td>1000</td>
<td>1000</td>
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</table>

Modified Mercalli Intensity Scale (MMI)

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>MMI VII</td>
<td>Damage to weakest masonry. Weak chimneys broken. Fall of plaster, loose bricks, tiles, un-braced parapets.</td>
</tr>
<tr>
<td>MMI VIII</td>
<td>Damage to weak masonry, partial collapse. Frame houses moved on foundations.</td>
</tr>
</tbody>
</table>

Source: USGS

USGS U.S. Seismic Hazard Map

X Phoenix, AZ
Plate Boundaries

Basic Fault Types – Normal Fault

Basic Fault Types – Reverse Fault
Basic Fault Types – Strike-Slip Fault

M6.8 Earthquake on a Blind Thrust Fault
Deformation on Vertical Slice

M6.8 Earthquake on a Blind Thrust Fault
Deformation on Ground Surface

Brad Aagaard
U.S. Geological Survey
Why ATC-20/45 Post Disaster

- 1989 Loma Prieta Earthquake, San Francisco:
  - Over 150,000 buildings impacted
  - 30 Building inspectors and 15 Civil or Structural Engineers
  - Over 3,000 buildings per inspector
  - 10 buildings per day per inspector = 1 year!

- 2005 Hurricane Katrina, Gulf states:
  - 1.3 million housing inspections over 1 year
  - 108,333 inspections per month
  - 3561 inspections per day!
  - 99 million cubic yards of debris clean up
  - 1 square mile x 90 feet tall!

- 2012 Hurricane Sandy, NYC
  - 80,000 hurricane damaged buildings inspected in 30 days
  - 2700 inspections per day!

Posting System
Principal Safety Concerns
- Collapse
- Falling hazards
- Other hazards

Basic Approach
- Right to inspect
- Observe expected damage
- Quickly assess unexpected damage
- Methodically evaluate structure
- Utilize checklists and safety criteria
- Exercise judgment in assessing risks from damage
- Communicate risks to public with posting system
- Collect and report damage data to jurisdictions

Inspection Procedures
1. Survey of the building exterior.
2. Examine the site for geotechnical hazards.
3. Inspect structural system from inside building.
4. Inspect for nonstructural hazards.
5. Inspect for other hazards.
6. Complete forms and post building.
Posting System

- **INSPECTED** (Green):
  - Appears safe for lawful occupancy
  - No control on use or occupancy

- **LIMITED ENTRY/RESTRICTED USE** (Yellow):
  - Some restriction on use, can be area, use, time, or function
  - Control of restrictions are by tenant/owner

- **UNSAFE** (Red):
  - No access or use of structure
  - Entry controlled by jurisdiction

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Inspected

- Observed damage, if any, does not appear to pose a safety risk
- Unrestricted lawful entry, occupancy, and use is permitted
Limited Entry/Restricted Use

- Some risk from damage in all or part of building
- Restricted
  - duration of occupancy
  - areas of occupancy
  - usage
- Restrictions enforced by property tenant, owner, or manager
Limited Entry/Restricted Use

Unsafe
- Falling, collapse, or other hazards
- Does not necessarily indicate demolition
- Owner must mitigate hazards to satisfaction of jurisdiction to gain entry
- Jurisdiction controls and enforces entry
Changing a Posting
- Correct mistake or oversight
- Significant aftershock
- Significant weather (wind and flood)
- Hired re-evaluation and repair

Posting Should
- Be timely
- Be consistent
- Be visible
- Carry authority of jurisdiction
Structural Basics

- Walls and frames
- Redundancy
- Ductility/Brittleness
- Degradation of structural
  - Strength
  - Stiffness
  - Stability
- Dynamic Affects
Post-Disaster Safety Evaluation of Buildings (ATC-20/45)

Structural Basics

[Diagram showing forces and cracking]

- Equivalent Lateral Earthquake Forces
- Vertical Gravity Forces
- Masonry Shear Cracking

- Tension
- Compression

- Flexural Stresses in a Tall Shear Wall
Structural Basics

- Vertical Gravity Forces
- Equivalent Lateral Earthquake Forces

Cracking at Girder-Column Connection
Structural Basics

- Equations and diagrams related to structural forces and members, such as buckled steel and diagonal members, are discussed.
- Vertical and lateral earthquake forces are illustrated.

Post-Disaster Safety Evaluation of Buildings (ATC-20/45)
Evaluation Procedures

Evaluation Levels
- **Windshield**: Assess scope of damage in jurisdiction
- **Rapid**: Assess more obvious and smaller buildings
- **Detailed**: Closer assessment of difficult buildings
- **Engineering**: Consultant engaged by owner
Evaluation Steps
- Examine entire outside of building
- Examine ground for distress
- Enter if safe and continue inspection
- Discuss observations; evaluate by criteria
- Post building
- Inform occupants of hazards

Rapid Evaluation
- Evaluate and post buildings with most obvious conditions
- Recommend detailed evaluation for questionable buildings

Rapid Evaluation Criteria
- Collapse, partial collapse
- Building or story noticeably leaning
- Severe racking of walls, obvious severe damage
- Chimney, parapet or other falling hazard
- Severe ground displacement or foundation damage
- Other hazard present
Make Notes for Possession Retrieval Access
- Exits
- Corridors
- Stairways

Rapid Evaluation Criteria
Rapid Evaluation Criteria

- Careful exterior and interior visual examination by most qualified team
- Follows rapid evaluation when required
- Important for essential facilities

Detailed Evaluation Criteria

- Vertical load capacity not significantly decreased
- Lateral load capacity not significantly decreased
- No falling or other hazards present
- No evidence of foundation damage or ground displacement
- Main exits are useable
- No other unsafe condition
### Detailed Evaluation Criteria

**ATC-20 Detailed Evaluation Safety Assessment Form**

<table>
<thead>
<tr>
<th>Building Description</th>
<th>Overall Rating</th>
<th>Instructed (Space)</th>
<th>Limited Entry (Space)</th>
<th>Unaltered (Space)</th>
</tr>
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**Building Description**

- [ ] Standard
- [ ] Non-standard

**Structural Systems**

- [ ] Steel Frame
- [ ] Wood Frame
- [ ] Masonry
- [ ] Other

**Loading Categories**

- [ ] Commercial
- [ ] Residential
- [ ] Other

**Loading Category - Other**

- [ ] N/A

**Condition**

- [ ] Good
- [ ] Fair
- [ ] Poor
- [ ] Fail

**Comments**

- [ ] N/A

**Instructor(s)**

- [ ] N/A

**Date**

- [ ] N/A

**Instructions**

- Complete building evaluation checklist on next page and three communities results below.
- Post-Disaster Safety Evaluation of Buildings (ATC-20/45)

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**Detailed Evaluation Criteria**

**Post-Disaster Safety Evaluation of Buildings (ATC-20/45)**

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**Detailed Evaluation Criteria**

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**Detailed Evaluation Criteria**

**Post-Disaster Safety Evaluation of Buildings (ATC-20/45)**
Detailed Evaluation Criteria

Fixed Equipment Checklist

Detailed Evaluation of Essential Facilities
- Health care facilities
- Police and fire stations
- Jails and detention centers
- Emergency operations centers
- High occupancy shelters
- Other facility types?
Pre-Event Actions at Essential Facilities
• Pre-arrangements made with local jurisdictions
• Reference information and drawings on site
• Facility-specific inspection procedures
  - BORP (Building Occupancy Resumption Program)
  - REAP (Rapid Evaluation and Assessment Program)
• REAP with SMS (Seismic Monitoring System)
  - Dubai Burj Khalifa
  - Dubai World Trade Center
  - Naval Hospital Bremerton
  - Naval Medical Center San Diego
  - Delta Pier Support Facility, Bangor
  - Naval Hospital Twentynine Palms
  - SWFPAC Facilities, Bangor

NMCSD Facility Overview
• Largest Navy Healthcare Facility
• 70 Acre Campus
• Construction 1986 (1979 Code)
• 6000 Personnel, 500,000 Population Served
• 8 Stories, Gross area of Buildings 1, 2 & 3 equal 1.2M SF, Welded Steel Moment Resisting Frame
• $500M Facility Valuation
• 23 Buildings on Campus, 2.5M SF
REAP Development Timeline

REAP Field Materials Overview
- REAP Post-Earthquake Evaluation Field Manual (Volume 1)
  - Program Flow Chart & Assessment Plan
  - Post-Earthquake Evaluation & Assessment Forms
  - Building Descriptions
  - NMCSD Campus & Building Layout Maps
  - Building “Pre-Event” Photographs
  - Recommended Emergency Equipment List
  - REAP Background
- ATC 20-1 Field Manual (Included in Volume 1)
- ATC 20-1 Placards

REAP Assessment Plan
Seismic Monitoring System (SMS)

- SMS Provides Real-Time Building Response Data Immediately Following an Event
- Building Response Data is Invaluable in Determining Structural Condition
- Aspects of SMS
  - Real-time monitoring and evaluation of structural response
  - Immediate structural evaluation using pre-defined trigger values
  - Building condition reporting and posting recommendations
  - Time-histories for use in further analysis by structural engineer
  - Works in conjunction w/ REAP
SMS Concept

- Equipment records site and building response
- Estimated Displacement Time-History is computed from the recorded acceleration data

Drift Ratios are computed and compared to predetermined trigger values
- Ties together PBEE and ATC-20 Posting System
- Standard of Care
- Rapid evaluation “initial posting” (Note: Preliminary information; follow REAP Steps)
GUI Building-by-Building Status

GUI Building’s Floor-by-Floor Status

Wood Frame Structures
Wood Frame Structures
- Single-family residential
- Multi-unit residential and commercial

Wood Frame Construction

Wood Frame Full Scale Shake Table
Wood Frame Construction

- Sheathing
- Wood studs
- Flooring over subfloor
- Anchor bolts or Z-V plates (in newer homes)
- Concrete or steel perimeter footing

Wood Frame Construction

- Plaster or gypsumboard
- Floor joists
Masonry Structures

Masonry Construction
- Un-reinforced brick masonry bearing
- Un-reinforced concrete block masonry bearing wall buildings
- Steel frame with masonry in-fill buildings
- Reinforced masonry buildings
Concrete Structures
Concrete Construction

- Structural walls or frames
- Cast-in-place or pre-cast
- Combinations of the above

Structure Discontinuities

Concrete Wall Construction
Steel Structures

Steel Frame Construction
- Multi-story fire resistive frame
- Pre-engineered light frame