ATC-20-1:

A Rough Guide to Using Your Trusty Field Manual for Safety Assessment and Reconnaissance

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EERI Annual Meeting

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Outline

- Reconnaissance vs. Safety Assessment
- Overview of ATC-20 Concepts
- Review of ATC-20-1 Resources
- Guidelines for Inspection
- Case Study!
Reconnaissance vs. Safety Assessment

- Similar Methodologies, Different Judgment, Different Timelines

- Reconnaissance: Subjectively document building performance for future action or academic research.
  - Identify both damaged and undamaged structures and components to verify successful practices and identify areas for future improvement (research, codes, optimization)

- Safety Assessment: Identify damage that renders a building unsafe for immediate, continued use.
  - Get people back into safe buildings and out of unsafe buildings as soon as possible.
Seismic Performance Assessment

- Common task for both recon and safety assessment

- Steps:
  1. Look for damaged components.
     - Look for structural and nonstructural vulnerabilities.
     - Track load paths from roof to foundation (or foundation to roof)
  2. Assess severity of damage.
     - Compare to published data/studies/research.
     - Use judgment.
     - Both? (See ATC-20-1, Page 11)
  3. Determine next steps.
     - Code change? Tag? More research?
ATC-20

- A tool for rapid seismic performance assessment.
- The purpose of safety assessment, or “tagging” is built into the methodology.
  - Judgements (bias?) are built into the methodology.
- Can be used as a resource for generic reconnaissance with care.
  - Advises whether or not building is safe for occupancy, not cause, failure mechanism, design intent, code compliance, etc.
ATC-20 Purpose and Scope

- **GOAL**: Disaster Recovery. Get people back into safe structures and out of unsafe ones.
- **Evaluate BUILDING safety, not just structural safety.**
  - Geotechnical Hazards
  - Nonstructural/Falling Hazards
  - Hazardous Materials/Utilities Hazards
- **Needs to be usable by both engineers (of varying abilities) and non-engineers.**
  - Simple, conservative directions for non-technical users.
  - Allows engineers to utilize their “better” judgment.
Conservatism...

- Don’t be overconservative, but when in doubt, follow the manual.
- Still in doubt? Yellow Tag and request a Detailed or Engineering Evaluation.

Conservative vs. Unconservative Safety Evaluations

It is important that posting decisions be carefully considered, particularly those that will displace individuals and businesses. Unnecessarily conservative postings must be avoided. On the other hand, individuals must not be exposed to unnecessary risk. When in doubt, request a Detailed Evaluation.

Evaluation Process

Structure identified for evaluation

Rapid Evaluation

- Post INSPECTED
  - Apparently OK
  - Only building exterior may have been inspected

Post LIMITED ENTRY RESTRICTED USE

- Questionable

Post UNSAFE

- Obviously unsafe

Detailed Evaluation

At the discretion of the Building Department

Post INSPECTED

- Safe but may need repairs

Post LIMITED ENTRY RESTRICTED USE

- Questionable

Engineering Evaluation

Post INSPECTED

Post UNSAFE

- Unsafe, must be repaired or removed

At the discretion of the Building Department

Chapter 3: Rapid Evaluation

- 10-30 Minutes
- Typically Exterior Only
- Often the only evaluation each building will get.
- Six key points of inspection.

### 6 Points of Inspection for Rapid Evaluation

<table>
<thead>
<tr>
<th>Condition</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Building has collapsed, partially collapsed, or moved off its foundation.</td>
<td>Post Unsafe.</td>
</tr>
<tr>
<td>2. Building or any story is significantly out of plumb (i.e., leaning).</td>
<td>Post Unsafe.</td>
</tr>
<tr>
<td>3. Obvious severe damage to primary structural members, severe racking of walls, or other signs of severe damage and distress present.</td>
<td>Post Unsafe.</td>
</tr>
<tr>
<td>4. Obvious parapet, chimney, or other falling hazard present.</td>
<td>Post Restricted Use and barricade the unsafe area.</td>
</tr>
<tr>
<td>5. Large fissures in ground, massive ground movement, or slope displacement is present.</td>
<td>Post Unsafe.</td>
</tr>
<tr>
<td>6. Other hazard present (e.g., toxic spill, asbestos contamination, broken gas line, fallen power line).</td>
<td>Post Unsafe and/or barricade unsafe area.</td>
</tr>
</tbody>
</table>

Chapter 4: Detailed Evaluation

- 1-4 Hours
- Should be performed by a structural engineer with knowledge of the specific structure type.
- Typically interior and exterior.
- Generally must be requested by rapid evaluators via placement of a yellow tag.
Detailed Evaluation: Placard Definitions

Inspected. To post a structure Inspected, which indicates that there are no restrictions on use or occupancy, all of the following conditions must be satisfied:

1. The structural system has not been significantly damaged (i.e., both vertical- and lateral-load systems are intact and without significant damage).
2. No falling or other hazards are present.
3. No evidence of significant foundation damage or ground displacement is present.
4. Main exits are operable and accessible.
5. No other apparent unsafe condition exists.

Restricted Use. To post a structure Restricted Use, which indicates that entry and use have been restricted, one of the following conditions must be present:

1. A structural or other hazard requires that a part or parts of the structure not be entered or used.
2. Uncertainty about the building's safety that can only be resolved by further evaluation (e.g., an Engineering Evaluation).

Unsafe. To post a structure Unsafe, which indicates that it is unsafe for occupancy or entry\(^1\), one of the following conditions must be present:

1. Obvious safety hazards (e.g., leaning building, partially collapsed building) require that the entire building not be entered or occupied.
2. Degree of damage is such that it is unsafe to enter or occupy the entire building.
3. Another unsafe condition (e.g., known toxic material release, landslide threat) requires that the entire building not be entered or occupied.

Vertical and Plan Irregularities

Chapter 5: Wood-Frame Structures

Figure 5-1  Inspection points for older wood-frame dwellings.

* Also check gas water heater, furnace, and service entry for ruptured gas lines.

Chapter 6: Masonry Structures

Figure 6-2 Inspection points for low-rise unreinforced masonry bearing-wall buildings.

Chapter 7: Tilt-Up Concrete

Figure 7-2 Inspection points for tilt-up buildings.

Chapter 8: Concrete Shear Walls

Figure 8-1 Inspection points for reinforced concrete shear wall buildings.

Chapter 8: Concrete Frame

Figure 8-2 Inspection points for reinforced concrete frame buildings.

Chapter 9: Light/Pre-Engineered Steel

Figure 9-1 Inspection points for light braced steel-frame buildings.

Chapter 9: Steel Frame Buildings

Figure 9-2 Inspection points for older steel-frame buildings. New steel-frame buildings often have cladding instead of solid masonry or concrete walls as shown above.

Chapter 9:
Concealed Damage/Pre-Northridge MF Clause

When an Engineering Evaluation is Required

Structural engineers performing Detailed Evaluations of steel-frame buildings must be concerned about the possibility of serious damage that cannot be seen because it is covered by architectural finishes and fireproofing. When ground motions are sufficiently high, an Engineering Evaluation needs to be done, and finishes and fireproofing removed.

Can’t Determine the Structural System?

When the Structural System is not Viewable

Architectural finishes such as walls and ceilings conceal the structural system of most buildings. When serious damage is suspected and not enough of the structural system is viewable to permit a reliable evaluation, **post the building Restricted Use or Unsafe** and advise the occupants of the significance of the posting. Table 2-3 provides examples of typical restrictions for buildings posted Restricted Use. If possible, **inform the owner that he or she must either arrange for demolition or removal of walls, plaster ceilings, and other architectural finishes to permit completion of the Detailed Evaluation, or alternately arrange for an Engineering Evaluation.**
Other Resources

- Chapter 10: Mobile Homes
- Chapter 11: Geotechnical Hazards
- Chapter 12: Non-Structural Hazards
- Appendices:
  - Dealing with people
  - Safety tips/Hazmat
  - Building Entry
  - Examples/Case Studies
- Lots and lots of full-grayscale photos!
10 Steps to A Successful (and Safe) Inspection…

1. Prepare, if possible:
   - Review your field manual
   - Look at pre-earthquake photos (download Google Earth to your smartphone, if you haven’t already)
   - Determine PGA and intensities (USGS)

2. Look around you prior to approaching your subject:
   - Evidence of geotechnical hazards
   - Damage to/from surrounding buildings
   - Environmental hazards
   - Don’t die, it's too early…
10 Steps to A Successful (and Safe) Inspection…

3. **Look/listen/smell for non-structural hazards:**
   - Gas meters, power lines, storage sheds, strange liquids
   - Look up for possible falling hazards
   - Look for NFPA markings (commercial and industrial)
   - Again, still to early to die…

4. **Identify building occupancy:**
   - Layout of interior walls.
   - Hazardous content.
   - Benefits of bringing this building back into service.
10 Steps to A Successful (and Safe) Inspection…

5. **Identify Structural System:**
   - Find appropriate chapter in Field Manual for points of inspection.
   - Check Figures 4-1 and 4-2 for vertical and plan irregularities.

6. **Identify obvious damage/movement.**

7. **If in doubt, track load path:**
   - Diaphragm to vertical elements (connections too!)
   - Vertical elements to foundation (connections too!)

8. **Enter if necessary and safe.**
10 Steps to A Successful (and Safe) Inspection…

9. **Ask yourself:**
   - Am I doing safety assessment or reconnaissance?
   - Is the structure in significantly worse shape than it was before the quake?
   - Will any new damage increase the likelihood of collapse or occupant harm in an aftershock or in service?
   - Are there new dangers from hazmat, neighboring buildings, landslides?
   - Do people need to be in this building?
   - Do I feel comfortable making this assessment?

10. **Tag it, yo.**
Good Luck!
CASE STUDY:

Pool and Recreation Center

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EERI Annual Meeting
3 April 2015
Background

- 3 days after Magnitude 5.8 quake. Minor aftershocks daily, including 4.5 yesterday.
- Main Shock: PGA estimated at 10-15%g, MMI = VI.
- Most homes in area have little to no damage and have green tags, moderate damage to buried utilities.
- Hot and muggy, major hurricane is inbound and heavy wind and flooding rain are expected. Site is not coastal.
- About 200 local residents are seeking shelter, primarily due to lack of electricity, running water, or fear.
Aerial View
North Elevation

Admin/Classroom Wing

Pool

Slopes Down
East Elevation

Pool

Slopes Down
South Elevation
West Elevation
Structure

- Phase 1 built around 1980, Phase 2 in 1983
- Sloped site.
- Phase 1 Admin/Classroom Wing: CMU bearing/shear walls with steel truss floors.
- Phase 2 Pool Area: Pre-engineered steel frame with CMU infill walls.
- Designated as an emergency shelter site by county.
- Owners/users reported “significant movement” of pool area.
- Spa losing water (2 inches/hour) since quake.
North Entrance
Slope to right of north entrance (south face sim.)

Vertical Cracks through EFIS Panel Joints.
Classroom/Admin Areas: Typical Damage

Trophies unharmed. Whew!
Classroom/Admin Areas: Typical Damage
Classroom/Admin Areas: Typical Damage
Classroom/Admin Areas: Typical Damage
Classroom/Admin Areas: Typical Damage
Classroom/Admin Areas: Typical Damage
Pool: Looking West
Pool: Looking East
Pool: Looking South

Bolted Splices, no other stiffeners.
Pool: Looking South
Pool: Typical Damage at Pilaster
Pool: Typical Damage at Pilaster
Pool: Looking North
Pool: Typical Damage at Pilasters
Pool: Spa Area (Southwest Corner)
Pool: Spa Area (Southwest Corner)
Pool: Spa Area (Southwest Corner)
Pool: West Deck
Pool: West Deck
Pool: West Deck
Pool: West Deck
Pool: West Deck
Pool: East Wall
Pool: East Wall
Pool: East Wall
Damage Summary

- Buckling of Bottom Flanges of Girders
- Spa Loosing Water
- Hung Ceiling Disturbance, Minor Cracking of CMU Walls (Bed Joints, Pilasters)
- Damage to Infill Wall Connections
- Stairway with cracked pilaster
“ANSWERS”
Virginia Earthquake

- Low intensity shaking felt over long distances.
- Buildings not explicitly designed for earthquakes.
- Vulnerable, non-ductile building systems (URM, tilt-up, infill walls), often 19th century vintage.
- Incomplete load paths.
- Poor foundation soils, expansive clays.
- Single family homes largely unaffected.
- Seemingly random buildings saw significant damage.
Pre-Engineered Steel Frames

- Many different systems available.
- Typically used for warehouses, industrial facilities.
- Optimized for gravity loads for maximum spans.
- Two Different Lateral Systems:
  - Moment Frame along girder lines
  - Braced Frame or Shear Wall in opposite direction
- Can perform very well in seismic and wind events if designed appropriately.
Example
Example
Critical Differences

- Long span required deeper beams (plate girders).
- Stiffening and bracing requirements were not increased appropriately.
Long, Inclined Span, Flexible Diaphragm

Compression Toward Lower End Under Gravity
Few Stiffeners, No Cross Braces

Bolted Splices, no other stiffeners.
Infill Wall Out of Plane Movement
Tall, Torsionally Flexible
Short, Restrained, Rigid
Flange Local Buckling
Flange Local Buckling
Flange Local Buckling
Global Lateral Torsional Buckling
Lateral Torsional Buckling, Utica, NY
## ATC-20 Field Manual

### Condition

7. **Moment Frames**

   - Broken, leaning, or seriously degraded moment frames .................. Unsafe
   - Significant weld or other connection failure at moment joint .................. Unsafe
   - Flange buckling near moment joints .................. Unsafe
   - Noticeable residual story drift at any level .................. Unsafe

9. **Other**

   - Unreinforced infill masonry walls with large cracks and/or spalling .................. Restricted Use²
   - Falling hazard present (see Chapter 12) ........ Restricted Use²

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1. Refer to FEMA 352 (SAC, 2000) for additional information on conducting a Detailed Evaluation of steel moment-frame structures. (An ATC-20 Detailed Evaluation corresponds to a FEMA 352 Preliminary Postearthquake Assessment.)

2. Barricade unsafe area.
Considerations

- Limited access/visibility of all moment frame connections. Full inspection is beyond your means.
- This may be a designated shelter but is not an essential facility; don’t take unnecessary risks, especially if you are unsure of the consequences of the damage you’ve seen.
- Aftershocks are continuing, a hurricane is inbound.
- Pool area appears to be relatively isolated from classroom/administration building to the east, which has little damage.
- Was the buckling actually caused by the earthquake?
### ATC-20 Rapid Evaluation Safety Assessment Form

**Inspection**
- Inspector ID: 24601
- Affiliation: SEAOC
- Inspection date and time: 12 July 2012, 6:00 AM
- Areas inspected: [ ] Exterior only [ ] Exterior and interior

**Building Description**
- Building name: Pool and Recreation Center
- Address: 1060 W. Addison, If I Tell You Where I’ll Get Sued, VA 200102
- Building contact/phone: Cletus Harper, (555) 523-8890
- Number of stories above ground: 2, below ground: 1
- Approx. “Footprint area” (square feet): 30,000
- Number of residential units: 0
- Number of residential units not habitable: N/A

**Type of Construction**
- Wood frame
- Steel frame
- Tilt-up concrete
- Concrete frame
- Concrete shear wall
- Unreinforced masonry
- Reinforced masonry
- Other: Pre-Engineered

**Primary Occupancy**
- [ ] Dwelling
- [ ] Other residential
- [ ] Public assembly
- [ ] Emergency services
- [ ] Commercial
- [ ] Offices
- [ ] Industrial
- [ ] Historic
- [ ] Government
- [ ] School
- [ ] Other:

**Evaluation**
Investigate the building for the conditions below and check the appropriate column.

<table>
<thead>
<tr>
<th>Observed Conditions</th>
<th>Minor/None</th>
<th>Moderate</th>
<th>Severe</th>
<th>Estimated Building Damage (excluding contents)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collapse, partial collapse, or building off foundation</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ] None</td>
</tr>
<tr>
<td>Building or story leaning</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ] 0-1%</td>
</tr>
<tr>
<td>Racking damage to walls, other structural damage</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ] 1-10%</td>
</tr>
<tr>
<td>Chimney, parapet, or other falling hazard</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ] 10-30%</td>
</tr>
<tr>
<td>Ground slope movement or cracking</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ] 30-60%</td>
</tr>
<tr>
<td>Other (specify)</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ] 60-100%</td>
</tr>
<tr>
<td>Buckling of Girder Flanges @ Pool</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ] 100%</td>
</tr>
</tbody>
</table>

**Comments:** Minimal, cosmetic damage to eastern administrative/classroom wing. Western pool wing: spalling and loss of anchorage at north and south CMU infill walls, bottom flange local buckling at west end of three main moment frame girders.
Rapid Assessment Form

Posting
Choose a posting based on the evaluation and team judgment. Severe conditions endangering the overall building are grounds for an Unsafe posting. Localized Severe and overall Moderate conditions may allow a Restricted Use posting. Post INSPECTED placard at main entrance. Post RESTRICTED USE and UNSAFE placards at all entrances.

☐ INSPECTED (Green placard)  ☐ RESTRICTED USE (Yellow placard)  ☐ UNSAFE (Red placard)

Record any use and entry restrictions exactly as written on placard: Continued occupancy limited to east wing. Brief entry into pool wing permitted to retrieve critical items and access mechanical equipment. Continuous occupancy of pool wing not permitted pending detailed evaluation. Avoid occupancy of pool wing exterior. Hazardous materials present.

Further Actions  Check the boxes below only if further actions are needed.

☐ Barricades needed in the following areas: All pool wing entrances.

☐ Detailed Evaluation recommended:  ☐ Structural  ☐ Geotechnical  ☐ Other: 

☐ Other recommendations: Detailed examination of all pool moment frame connections is recommended. Secure Hazardous Materials.

Comments: 

______________________________________________________________

______________________________________________________________
Things to Remember

- Consider occupancy (do people need to be here?)
- Understand the limits of your expertise and call for backup (in the form of a detailed evaluation) if needed.
- Don’t expect that damage will be textbook in nature; not all buildings are designed to California “standards”
- If you identify some damage, trace the implied building movement/load path back to the foundation and look for additional damage.
- You are evaluating BUILDING safety, not just structural safety. Look out for Nonstructural/Falling Hazards, HazMat/Utilities, Geotechnical Hazards.
QUESTIONS?
COMMENTS?