

# WASAFE

## BUILDING SAFETY EVALUATOR TRAINING (ATC 20/45 PLUS)

WABO ANNUAL EDUCATION INSTITUTE  
MARCH 28, 2024


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WASAFE BSE Module 1

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### PROGRAM FOCUS



Reoccupy safe buildings

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# Postearthquake Safety Evaluation of Buildings

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**Original ATC-20 Document Developed by:**  
APPLIED TECHNOLOGY COUNCIL


**With Funding From:**  
FEDERAL EMERGENCY MANAGEMENT AGENCY  
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**This PowerPoint® Presentation Is Based on Original  
ATC-20 Training Materials Developed by:**

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**Original ATC-20 Presentation Modified by:**  
WAsafe Steering Committee

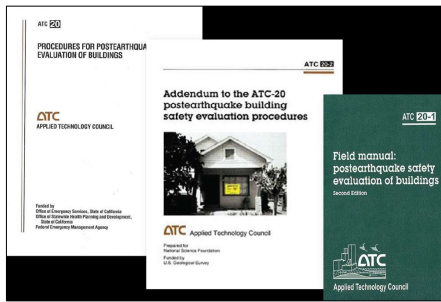
California Governor's Office of  
Emergency Services (CalOES)

With thanks to Reid Middleton (Everett, WA) for many of the  
updated graphics

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## MORE RESOURCE DOCUMENTS



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## LOGISTICS

Restrooms  
Breaks and Lunch  
Tech devices to silent mode  
Registration, forms, photos  
(don't leave early)

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## WASAFE BSE TRAINING OUTLINE

Seismic Hazard Overview  
Field Safety  
Posting System & Evaluation Procedures  
Politics of Response  
WAsafe Program & Procedures

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## OUTLINE (CONT.)

Structural Basics  
Wood-Frame Structures  
Masonry Structures  
Concrete Structures  
Steel-Frame Structures  
Hybrid Structures

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## OUTLINE (CONT.)

Manufactured Housing  
Nonstructural Elements  
Habitability  
Geotechnical Elements  
Non-seismic Hazards  
Politics of Recovery

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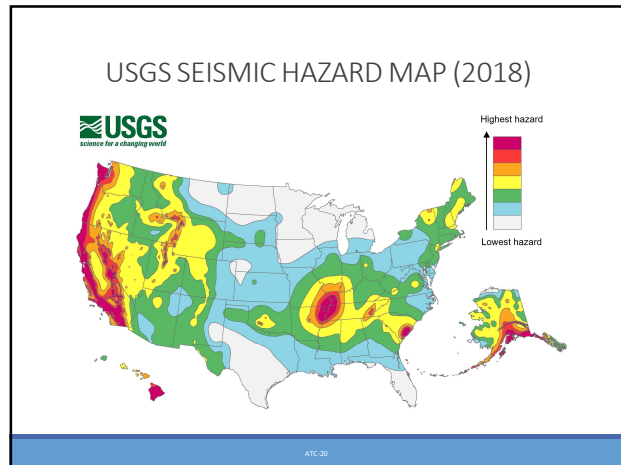
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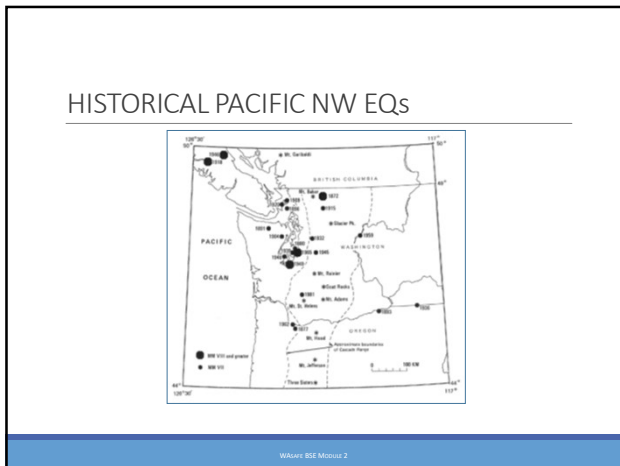
# SEISMIC HAZARD OVERVIEW

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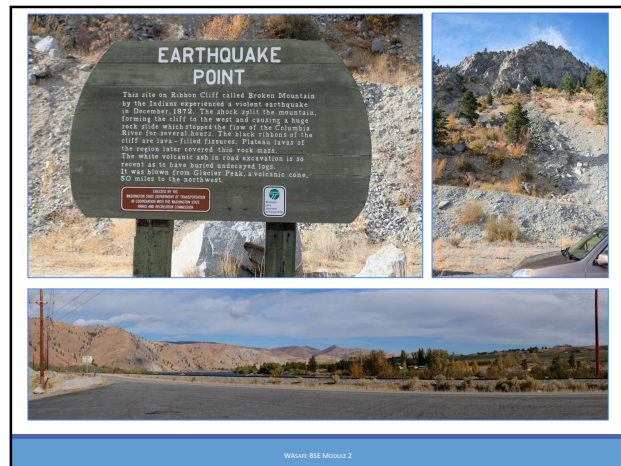
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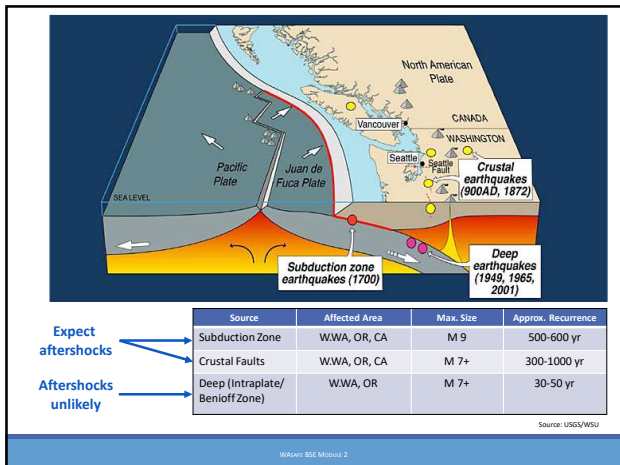
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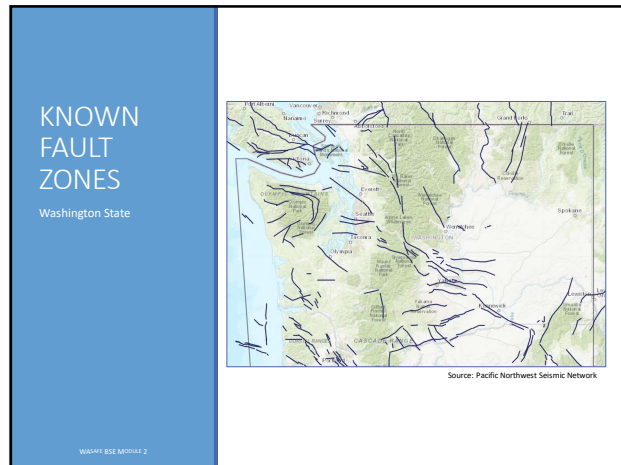
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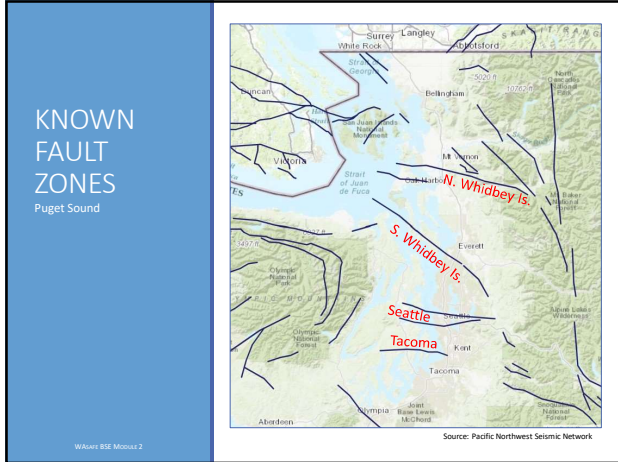
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### RICHTER SCALE

Richter Magnitude ( $M_L$ ) 4 → 6 → 8  
 Energy Increase Ratio 1,000 1,000

**Moment Magnitude ( $M_W$ ) more commonly used today**

### MODIFIED MERCALLI INTENSITY SCALE

**MMI VI** Windows broken. Books off shelves. Weak plaster cracked.

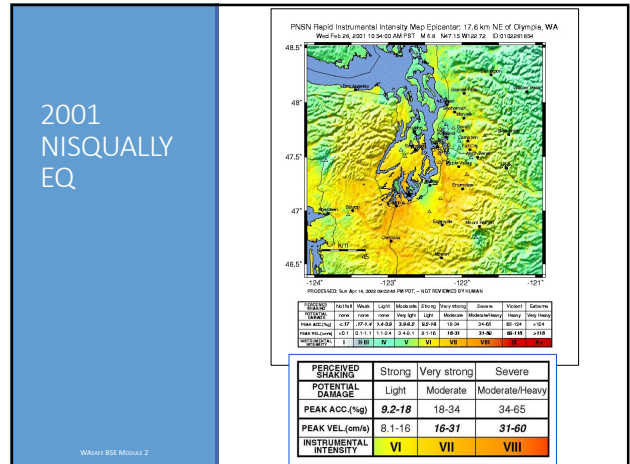
**MMI VII** Damage to weakest masonry. Weak chimneys broken. Fall of plaster, loose bricks, tiles, unbraced parapets.

**MMI VIII** Damage to weak masonry, partial collapse. Frame houses moved on foundations.

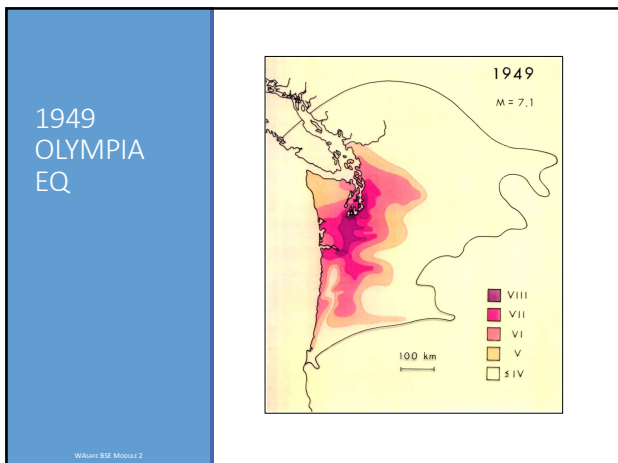
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MMI Intensity	People's Reaction	Furnishings	Built Environment	Natural Environment
I	Not felt			Changes in level and clarity of well water are occasionally associated with great earthquakes at distances beyond which the earthquakes felt by people.
II	Felt by a few.	Delicately suspended objects may swing.		
III	Felt by several; vibration like passing of truck.	Hanging objects may swing appreciably.		
IV	Felt by many; sensation like heavy body striking building.	Dishes rattle.	Walls creak; window rattle.	
V	Felt by nearly all; frightens a few.	Pictures swing out of place; small objects move; a few objects fall from shelves within the community.	A few instances of cracked plaster and cracked windows with the community.	Trees and bushes shaken noticeably.
VI	Frightens many; people move uneasily.	Many objects fall from shelves.	A few instances of fallen plaster, broken windows, and damaged chimneys within the community.	Some fall of tree limbs and tops, isolated rockfalls and landslides, and isolated liquefaction.
VII	Frightens most; some lose balance.	Heavy furniture overturned.	Damage negligible in buildings of good design and construction, but considerable in some poorly built or badly designed structures; weak chimneys broken at roof line, fall of unbraced parapets.	Tree damage, rockfalls, landslides, and liquefaction are more severe and widespread with increasing intensity.
VIII	Many find it difficult to stand.	Very heavy furniture moves conspicuously.	Damage slight in buildings designed to be earthquake resistant; buildings shift off foundations. Widespread fall of chimneys and monuments.	
IX	Some forcibly thrown to the ground.		Damage considerable in some buildings designed to be earthquake resistant; buildings shift off foundations if not built to them.	
X			Most ordinary masonry structures collapse; damage negligible to severe in many buildings designed to be earthquake resistant.	

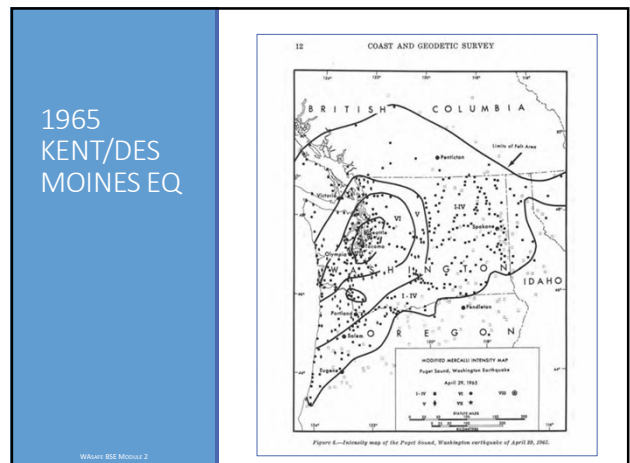
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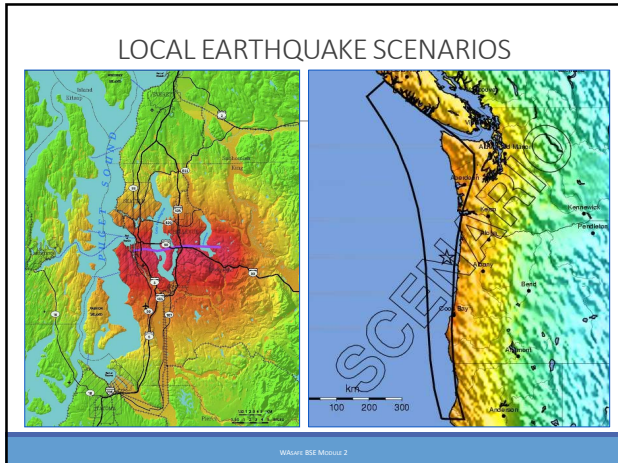
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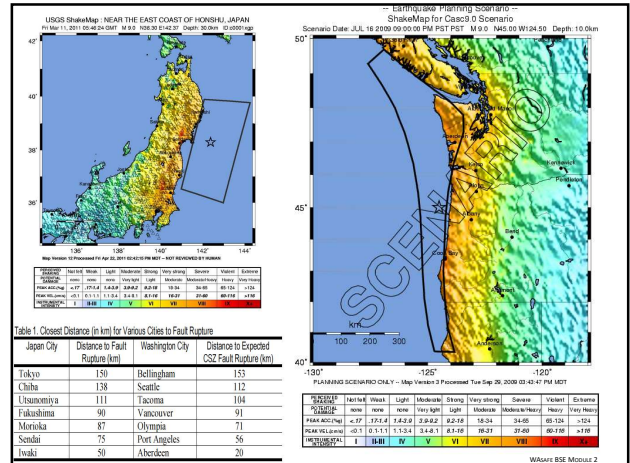
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### TSUNAMIS

Southern Puget Sound – shallow crustal events e.g., Tacoma or [Seattle Fault event](#)

Major issue on coast, northern Puget Sound, Hood Canal, in [Cascadia subduction event](#)

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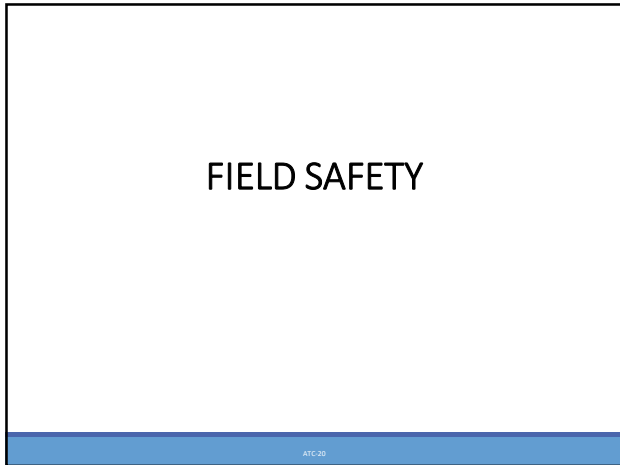
### TSUNAMIS

Tsunami-resistant design provisions in ASCE 7-16 (2018 WSBC), ASCE 7-22 (2021 WSBC)

- Mandatory for RC III & IV
- Optional for RC II
- <https://www.dnr.wa.gov/wa-tdz>

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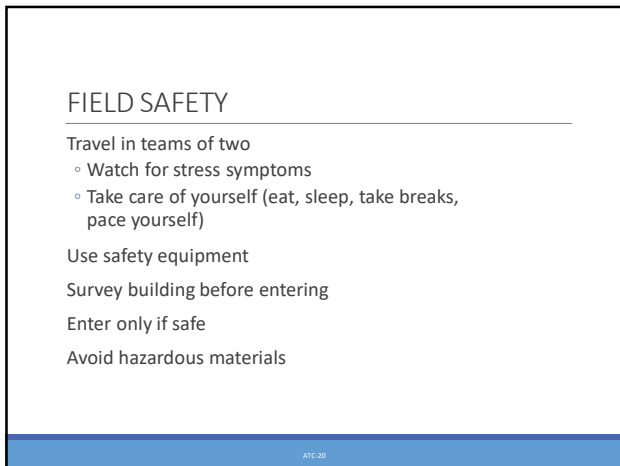
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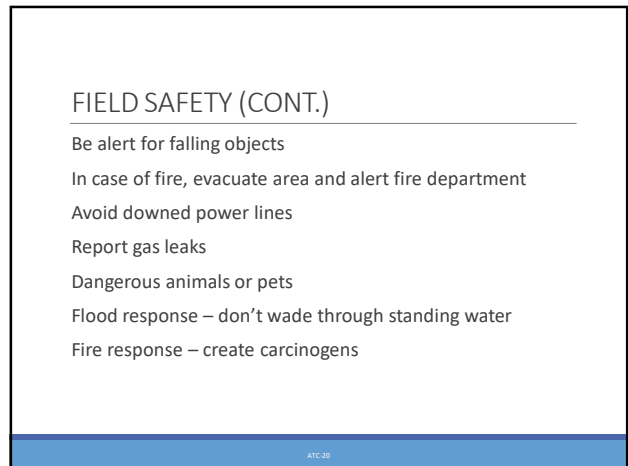
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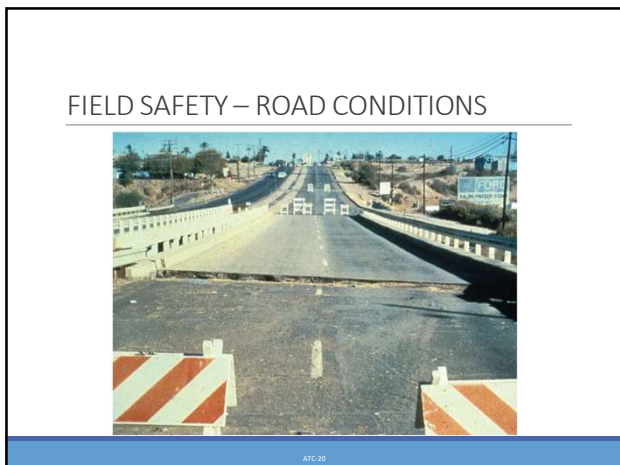
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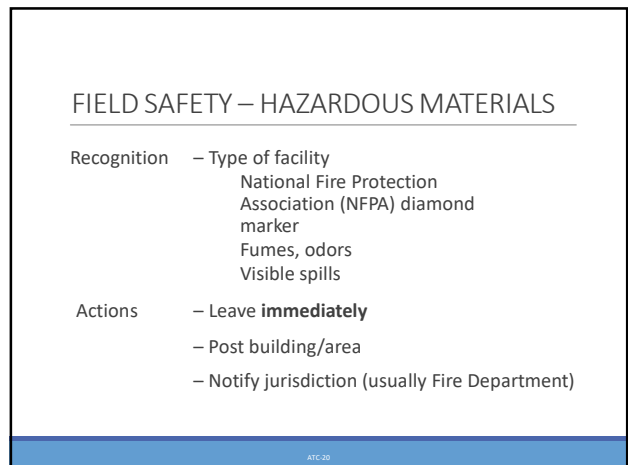
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### COMMON FAILURES CAUSING HAZMAT RELEASES

- Building structural failures
- Dislodged asbestos
- Underground pipeline breaks
- Short connector pipe breaks
- Elephant's foot buckling of vertical cylindrical tanks
- Overturning of elevated tanks
- Sloshing from open-topped tanks
- Falling containers
- Equipment sliding or overturning

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### USDOT HAZMAT LABELS

#### Nine Classes of Hazardous Materials

<b>Class 1: Explosives</b> Divisions 1.1, 1.2, 1.3, 1.4, 1.5, 1.6 	<b>Class 2: Gases</b> Divisions 2.1, 2.2, 2.3 	<b>Class 3: Flammable Liquid and Combustible Liquid</b> 	<b>Class 4: Flammable Solid, Spontaneously Combustible, and Dangerous When Wet</b> Divisions 4.1, 4.2, 4.3 	<b>Class 5: Oxidizer and Organic Peroxide</b> Divisions 5.1, 5.2 
<b>Class 6: Poison (Toxic) and Poison Inhalation Hazard</b> 	<b>Class 7: Radioactive</b> 	<b>Class 8: Corrosive</b> 	<b>Class 9: Miscellaneous</b> 	<b>Dangerous</b> 

Federal Motor Carrier Safety Administration | U.S. Department of Transportation | www.ftcsa.dot.gov | Revised 08/05

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### NFPA DIAMOND (CHEMICALS)

<b>HEALTH HAZARD</b> 4 - Deadly 3 - Extreme Danger 2 - Hazardous 1 - Slightly Hazardous 0 - Normal Material	<b>2</b>	<b>FIRE HAZARD - Flash Point</b> 4 - Below 73F 3 - Below 100F 2 - Below 200F 1 - Above 200F 0 - Will Not Burn
<b>3</b>	<b>1</b>	<b>REACTIVITY</b> 4 - May Detonate 3 - Shock and Heat May Detonate 2 - Violent Chemical Change 1 - Unstable If Heated 0 - Stable
<b>SPECIFIC HAZARD</b> OXY - Oxidizer ACID - Acid ALK - Alkali COR - Corrosive W - Use NO WATER R - Radiation Hazard	<b>W</b>	

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### HMIS/OSHA LABELS

Sodium Aluminum Tetrafluoride	
<b>HEALTH</b>	2
<b>FLAMMABILITY</b>	0
<b>PHYSICAL HAZARD</b>	0
<b>PERSONAL PROTECTION</b>	F



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### US&R MARKING SYSTEM

US&R/USAR teams generally on site before BSA teams  
 Building Safety Evaluators (BSEs) may encounter markings on buildings  
 Understanding the markings  
 BSEs are not to mark the buildings

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### STRUCTURE/HAZARDS MARKS

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### FEMA SEARCH ASSESSMENT MARKING

	<ul style="list-style-type: none"> <li>Single slash upon entry into structure</li> <li>TF ID, date &amp; entry time noted</li> <li>Indicates ongoing search</li> </ul>
	<ul style="list-style-type: none"> <li>Crossing slash upon exit</li> <li>Upon exit, date and time noted in top field</li> <li>Additional information placed in open areas of "X"</li> </ul>
	<ul style="list-style-type: none"> <li>Right - hazards</li> <li>Bottom - # of victims</li> </ul>
	<ul style="list-style-type: none"> <li>When new search completed, cross out previous, and complete new search assessment marking</li> </ul>

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### FIELD SAFETY

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# POSTING SYSTEM & EVALUATION PROCEDURES

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## PRINCIPAL SAFETY CONCERNS

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- Collapse
- Falling hazards
- Other hazards

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## BASIC APPROACH

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- Right to evaluate
- Observe expected damage
- Quickly assess unexpected damage
- Methodically evaluate structure
  - Assume that significant aftershocks will occur, depending on EQ mechanism (if known)
- 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 jurisdiction

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## JUDGMENT IN ASSESSING RISK FROM OBSERVED DAMAGE

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- Amount of risk is not always proportional to amount of damage
- Structural aspects of assessing risk from damage
  - Redundancy
  - Brittleness and Ductility
- Over-conservatism

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## GOOD POSTING PRACTICES

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- Be timely
- Be consistent
- Be visible
- Be clear

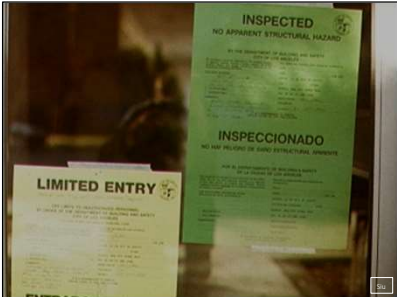
Who's the audience?

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## THIS IS NOT CLEAR

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POSTING SYSTEM

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**INSPECTED/NO APPARENT HAZARD** (Green):  
Appears safe for occupancy, unrestricted use or entry allowed

**RESTRICTED USE/LIMITED ENTRY** (Yellow): Some restriction/limitation on use or entry

**UNSAFE** (Red): Entry not allowed

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STANDARD EVALUATION PROCEDURE

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EVALUATION LEVELS

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Windshield	– Overall scope of damage
<b>Rapid</b>	– <b>Assessment sufficient for most buildings</b>
Detailed	– Closer assessment of difficult and essential buildings
Engineering	– Consultant engaged by owner

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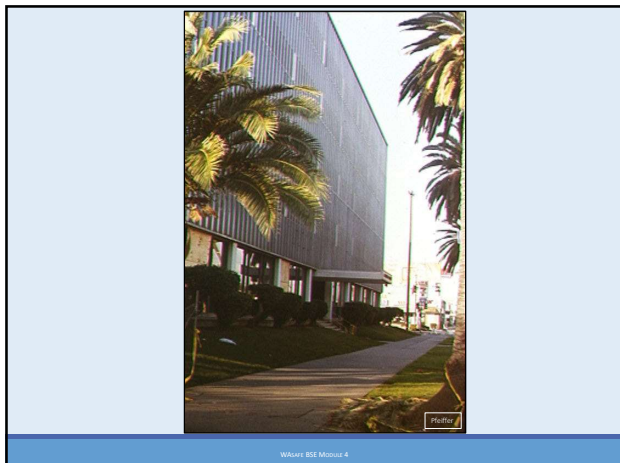
EVALUATION STEPS

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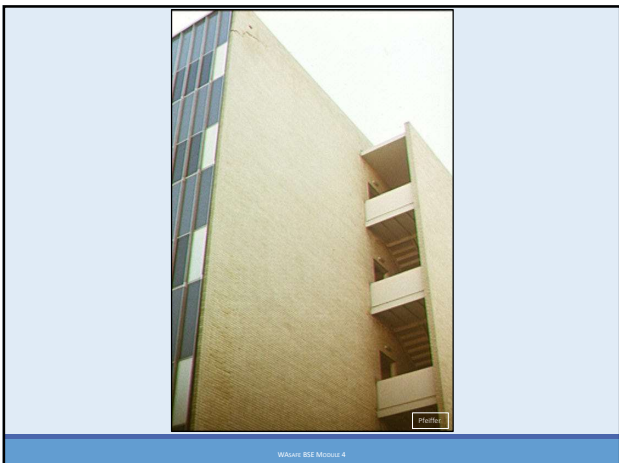
1. Examine entire exterior of building
2. Examine ground for distress or other geotech hazards
3. Enter if safe and continue evaluation
4. Discuss observations; evaluate by criteria
5. Tape off hazardous areas
6. Complete forms and post building at all entrances
7. Inform occupants and management of hazards

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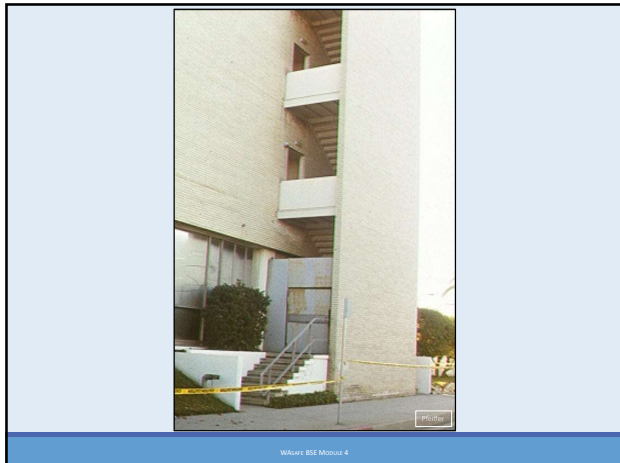


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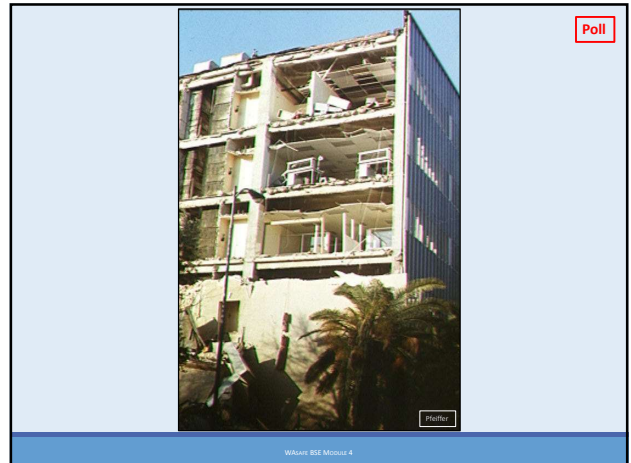


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**RAPID EVALUATION**

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Cursory evaluation (~20-30 minutes), focus on big-picture structural damage  
 Sufficient to evaluate and post most buildings  
 Recommend detailed evaluation for questionable buildings

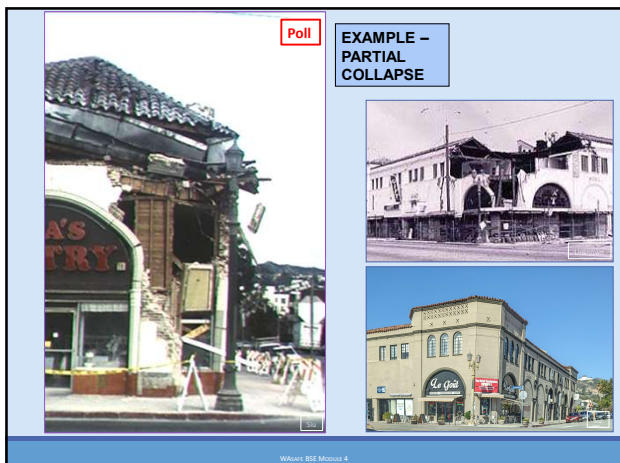
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**RAPID EVALUATION CRITERIA**

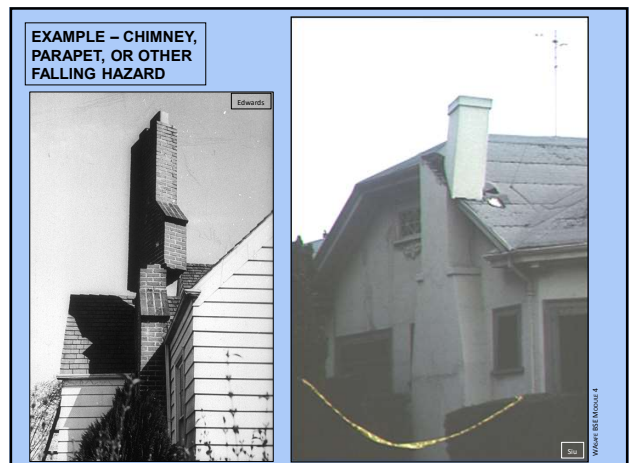
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- Collapse, partial collapse
- Building/foundation displacement
- Building or story noticeably leaning
- Severe racking of walls, obvious severe damage
- Chimney, parapet, or other falling hazard
- Severe ground displacement or foundation damage
- Other hazard present

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**EXAMPLE – SEVERE GROUND DISPLACEMENT OR FOUNDATION DAMAGE**

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### INSPECTED/NO APPARENT HAZARD

Observed damage, if any, does not appear to pose a safety risk

Unlimited entry, occupancy, and use permitted

**INSPECTED**  
LAWFUL OCCUPANCY PERMITTED

This structure has been inspected (as indicated below) and no apparent structural hazard has been found.

Inspected Exterior Only  
 Inspected Exterior and Interior

Report any unsafe condition to local authorities; reinspection may be required.

Inspector comments: \_\_\_\_\_

Facility Name and Address: \_\_\_\_\_

Date: \_\_\_\_\_  
Time: \_\_\_\_\_  
Inspector ID / Agency: \_\_\_\_\_

**Caution:** Aftershocks since inspection may increase damage and risk.

This facility was inspected under emergency conditions for: \_\_\_\_\_

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### INSPECTED/NO APPARENT HAZARD

Original vertical-load or lateral-load carrying capacity not significantly decreased, no potential instabilities

No falling or other life-safety risks

No evidence of significant foundation damage, uplifting, erosion, or ground displacement

Main exits operable and accessible

No other apparent unsafe condition

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### INSPECTED

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**INSPECTED**  
LAWFUL OCCUPANCY PERMITTED

This structure has been inspected (as indicated below) and no apparent structural hazard has been found.

Inspected Exterior Only  
 Inspected Exterior and Interior

Report any unsafe condition to local authorities; reinspection may be required.

Inspector comments: \_\_\_\_\_

Facility Name and Address: \_\_\_\_\_

Date: \_\_\_\_\_  
Time: \_\_\_\_\_

**Caution:** Aftershocks since inspection may increase damage and risk.

This facility was inspected under emergency conditions for: \_\_\_\_\_

(Jurisdiction) \_\_\_\_\_  
Inspector ID / Agency: \_\_\_\_\_

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### 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 owner / manager

**RESTRICTED USE**

**Caution:** This structure has been inspected and found to be damaged or in need of repair.

**Caution:** Aftershocks since inspection may increase damage and risk.

Entry, occupancy and limited use are restricted as indicated below:

Date: \_\_\_\_\_  
Time: \_\_\_\_\_  
Inspector ID / Agency: \_\_\_\_\_

This facility was inspected under emergency conditions for: \_\_\_\_\_

Facility Name and Address: \_\_\_\_\_

Do Not Remove, Alter or Destroy this Report until Authorized by Issuing Authority

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LIMITED ENTRY/RESTRICTED USE

Safety issues can only be resolved by removal of architectural elements or by an Engineering Evaluation

Cladding damage may result in further damage

Interior finishes or ceilings...may lead to falling hazards or air quality issues

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LIMITED ENTRY/RESTRICTED USE

Possibility of further damage due to foundation conditions & occupant load

Possible presence of other risks (toxic materials release, etc.)

Portion of the building cannot be safely occupied

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LIMITED ENTRY/RESTRICTED USE



Photo: ATC-20

Photo: Source Unknown

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RESTRICTED USE

Caution: This structure has been inspected and found to be damaged as described below:

Date \_\_\_\_\_  
Time \_\_\_\_\_

(Caution: Aftershocks since inspection may increase damage and risk.)

Entry, occupancy, and lawful use are restricted as indicated below:

- Do not enter the following areas: \_\_\_\_\_
- Brief entry allowed for access to contents: \_\_\_\_\_
- Other restrictions: \_\_\_\_\_

This facility was inspected under emergency conditions for:

\_\_\_\_\_  
(Jurisdiction)

Inspector ID / Agency \_\_\_\_\_

Facility name and address: \_\_\_\_\_

Do Not Remove, Alter, or Cover this Placard until Authorized by Governing Authority

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LIMITED ENTRY/RESTRICTED USE

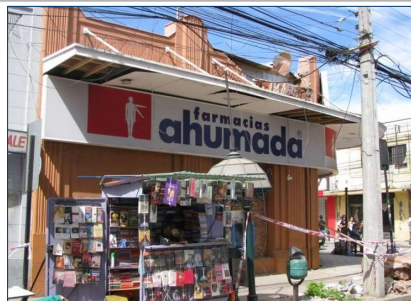


Photo: Fred Halderson

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UNSAFE

Falling, collapse, or other hazard

Does not necessarily indicate that demolition is required

Owner must mitigate hazards to satisfaction of jurisdiction to gain entry



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**UNSAFE**

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Obvious safety risks are present

Structure is believed to be in danger of collapse from static conditions, subsequent events, or addition of occupant loads

Another unsafe condition is present

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**UNSAFE**

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**UNSAFE**

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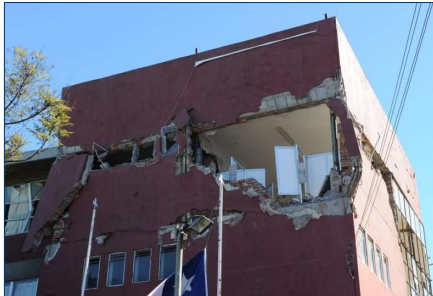


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**UNSAFE**

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**UNSAFE**

**DO NOT ENTER OR OCCUPY**  
(THIS PLACARD IS NOT A DEMOLITION ORDER)

This structure has been inspected, found to be seriously damaged and is unsafe to occupy, as described below.

Date \_\_\_\_\_  
Time \_\_\_\_\_

This facility was inspected under emergency conditions for: \_\_\_\_\_  
(Jurisdiction)

Do not enter, except as specifically authorized in writing by jurisdiction. Entry may result in death or injury.

Inspector ID / Agency \_\_\_\_\_

Facility Name and Address: \_\_\_\_\_

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### NOTES ON POSTING

- Consider earthquake mechanism
  - Large aftershocks very unlikely in deep event (e.g., Nisqually)
  - Aftershocks likely in subduction or shallow fault events (i.e. Cascadia & Seattle Fault)
- Consider if other hazards or political issues are greater

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### JUDGMENT IN ASSESSING RISK – OVER-CONSERVATISM

“There is a benefit to the community if a building can safely be posted Restricted Use instead of Unsafe.”

“It is important that posting decisions be carefully considered, particularly those that will displace individuals and businesses.”

“Unnecessarily conservative postings must be avoided”

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### CHANGING A POSTING

- Correct oversight or mistake in judgment
- Removal of hazard
- Significant aftershock
- Engineered reevaluation and repair

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

**Inspection**  
 Inspector ID: \_\_\_\_\_ Inspection date and time: \_\_\_\_\_  AM  PM  
 Affiliation: \_\_\_\_\_ Areas inspected:  Exterior only  Exterior and interior

**Building Description**  
 Building name: \_\_\_\_\_ Type of Construction  
 Address: \_\_\_\_\_  Wood frame  Concrete shear wall  
 Steel frame  Unreinforced masonry  
 Tilt-up concrete  Reinforced masonry  
 Concrete frame  Other: \_\_\_\_\_  
 Building contact/phone: \_\_\_\_\_  
 Number of stories above ground: \_\_\_\_\_ Number of stories below ground: \_\_\_\_\_  
 Primary Occupancy  
 Approx. "Footprint area" (square feet): \_\_\_\_\_  Dwelling  Commercial  Government  
 Number of residential units: \_\_\_\_\_  Other residential  Offices  Historic  
 Public assembly  Industrial  School  
 Number of residential units not habitable: \_\_\_\_\_  Other: \_\_\_\_\_  
 Emergency services

**Evaluation**  
 Investigate the building for the conditions below and check the appropriate column.  
 Observed Conditions:  None/None  Moderate  Severe  None (excluding contents)  
 Collapse, partial collapse, or building off foundation     0-1%  
 Building or story leaning     1-10%  
 Racking damage to walls, other structural damage     10-30%  
 Chimney, parapet, or other falling hazard     30-60%  
 Ground slope movement or cracking     80-100%  
 Other (specify) \_\_\_\_\_     100%  
 Comments: \_\_\_\_\_

Download forms: [www.atccouncil.org/placards-and-evaluation-forms](http://www.atccouncil.org/placards-and-evaluation-forms)

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**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: \_\_\_\_\_

**Further Actions** Check the boxes below only if further actions are needed.  
 Barricades needed in the following areas: \_\_\_\_\_  
 Detailed Evaluation recommended:  Structural  Geotechnical  Other: \_\_\_\_\_  
 Other recommendations: \_\_\_\_\_  
 Comments: \_\_\_\_\_

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### DETAILED EVALUATION

Careful exterior and interior visual examination by more qualified team

Follows rapid evaluation when required

Important for essential facilities

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### DETAILED EVALUATION OF ESSENTIAL FACILITIES

- Health care facilities
- Police and fire stations
- Jails and detention centers
- Emergency operations centers
- High-occupancy shelters (schools, community centers)

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### DETAILED EVALUATION CRITERIA

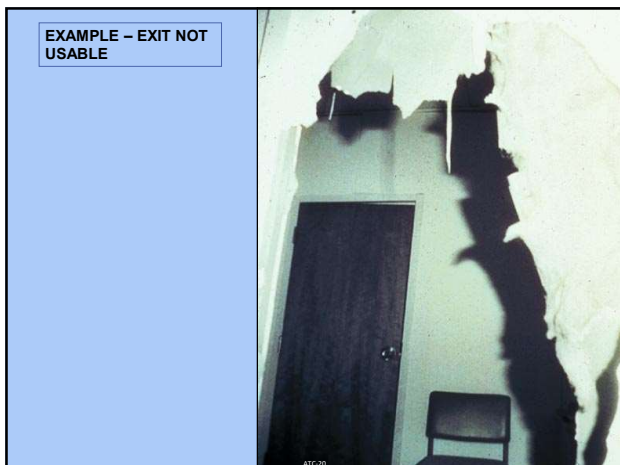
- Vertical load capacity not significantly decreased
- Lateral load capacity not significantly decreased
- No falling or other hazards present
- No evidence of foundation damage or ground displacement
- Main exits are usable
- No other unsafe condition

ATC-20

45



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BEO

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

<b>Inspection</b> Inspector ID: _____ Affiliation: _____ Inspection date and time: _____ <input type="checkbox"/> AM <input type="checkbox"/> PM		<b>Final Posting</b> from page 2 <input type="checkbox"/> Inspected <input type="checkbox"/> Restricted Use <input type="checkbox"/> Unsafe
<b>Building Description</b> Building name: _____ Address: _____ Building contact/phone: _____ Number of stories above ground: _____ below ground: _____ Approx. "Footprint area" (square feet): _____ Number of residential units: _____ Number of residential units not habitable: _____		<b>Type of Construction</b> <input type="checkbox"/> Wood frame <input type="checkbox"/> Steel frame <input type="checkbox"/> Tilt-up concrete <input type="checkbox"/> Concrete frame <input type="checkbox"/> Concrete shear wall <input type="checkbox"/> Unreinforced masonry <input type="checkbox"/> Reinforced masonry <input type="checkbox"/> Other: _____
<b>Primary Occupancy</b> <input type="checkbox"/> Dwelling <input type="checkbox"/> Other residential <input type="checkbox"/> Public assembly <input type="checkbox"/> Emergency services		<input type="checkbox"/> Commercial <input type="checkbox"/> Offices <input type="checkbox"/> Industrial <input type="checkbox"/> Other: _____ <input type="checkbox"/> Government <input type="checkbox"/> Historic <input type="checkbox"/> School

ATC-20

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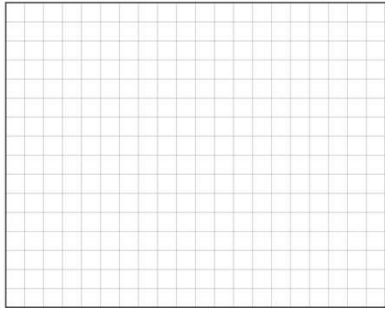
**Evaluation**  
Investigate the building for the conditions below and check the appropriate column. There is room on the second page for a sketch.

	Minor/None	Moderate	Severe	Comments
<b>Overall hazards:</b>				
Collapse or partial collapse	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Building or story leaning	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Other	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<b>Structural hazards:</b>				
Foundations	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Roofs, floors (vertical loads)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Columns, pilasters, corbels	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Diaphragms, horizontal bracing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Walls, vertical bracing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Precast connections	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Other	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<b>Nonstructural hazards:</b>				
Parapets, ornamentation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Cladding, glazing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Ceilings, light fixtures	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Interior walls, partitions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Elevators	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Stairs, exits	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Electric, gas	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Other	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<b>Geotechnical hazards:</b>				
Slope failure, debris	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Ground movement, fissures	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Other	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<b>General Comments:</b>				

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Building name: \_\_\_\_\_ Inspector ID: \_\_\_\_\_

**Sketch (optional)**  
Provide a sketch of the building or damaged portions. Indicate damage points.



**Estimated Building Damage**  
If requested by the jurisdiction, estimate building damage (repair cost → replacement cost, excluding contents).

None  
 0-1%  
 1-10%  
 10-30%  
 30-60%  
 60-100%  
 100%

50

**Posting**  
If there is an existing posting from a previous evaluation, check the appropriate box.

Previous posting:  INSPECTED  RESTRICTED USE  UNSAFE Inspector ID: \_\_\_\_\_ Date: \_\_\_\_\_

If necessary, revise the posting based on the new evaluation and team judgment. Severe conditions endangering the overall building are grounds for an Unsafe posting. Local Severe and overall Moderate conditions may allow a Restricted Use posting. Indicate the current posting below and at the top of page one.

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

Record any use and entry restrictions exactly as written on placard: \_\_\_\_\_

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

Barricades needed in the following areas: \_\_\_\_\_

Engineering Evaluation recommended:  Structural  Geotechnical  Other: \_\_\_\_\_

Other recommendations: \_\_\_\_\_


Comments: \_\_\_\_\_

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### ESTABLISHING CORDON AREAS

FEMA P-2055-2

- Guidance on how far to cordon from failed buildings ("collapse/fall shadow," "debris shadow"), how to manage cordon areas
- Based on research on how buildings and components fail and lessons from multiple-year closure of Christchurch central business district



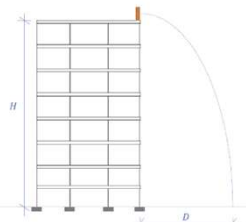
Recommendations for Cordoning Earthquake-Damaged Buildings  
FEMA P-2055-2 / September 2023

FEMA  

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### INITIAL CORDON DISTANCE (RAPID EVAL)

"Immediately after the damaging event, armed only with the knowledge of obvious serious damage or visible lean of a building, an initial emergency cordon distance, D, equal to the height of the building above the significant damage or hinge point is prudent."


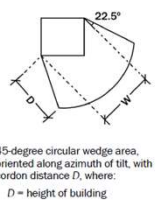


Source: FEMA P-2055-2

WAsafe BSE Module 4

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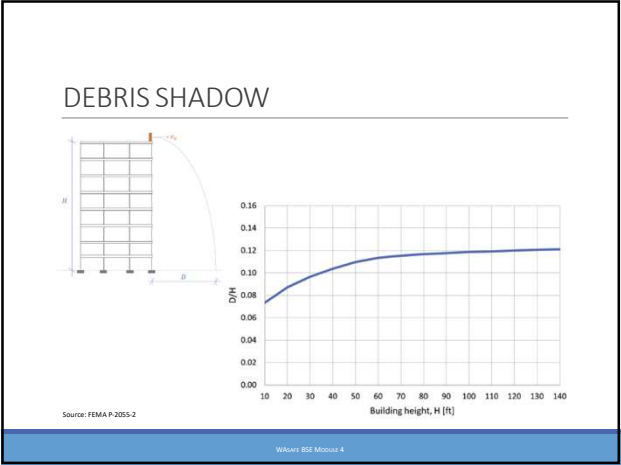
### REFINED CORDON DISTANCE (ENGINEERING EVAL)

Structure Type	Visible Damage and Potential Collapse Mode	Collapse Shadow Cordon Area
Frame (steel, concrete, wood)	 Sidesway mechanism: Progressive collapse mechanism likely per engineering evaluation See Section 3.2.2: Story Mechanism	 45-degree circular wedge area, oriented along azimuth of tilt, with cordon distance D, where: D = height of building

Source: FEMA P-2055-2

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**POLITICS OF RESPONSE**

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1

**“THE LOMA PRIETA QUAKE:  
WHAT ONE CITY LEARNED”**

---

Richard C. Wilson  
City Manager  
Santa Cruz,  
California

Published by  
International City/County Management Association

ATC-20

2

**“THE LOMA PRIETA QUAKE:  
WHAT ONE CITY LEARNED”**

---

“The city was ... under enormous pressure to provide access to damaged buildings.”

“Residents wanted to remove ... valued personal belongings ... cash and essential documents.”

“Business owners wanted to remove inventory ... computers ... files.”

“At each afternoon’s city council meeting they pleaded for access.”

“We had to decide whether to err on the side of access or safety. The needs for access were urgent and compelling, but the dangers were real and manifest.”

ATC-20

3

**“THE LOMA PRIETA QUAKE:  
WHAT ONE CITY LEARNED”**

---

“Many of the occupants of even the three most seriously damaged buildings were **more than prepared to risk their lives** to remove contents.”

“Final decisions about access of course fell to me.”

ATC-20

4

**MANAGE EXPECTATIONS**

---

- Expect chaos in the beginning
- Police/Fire/Emergency Management call the shots
- 1st priority – to establish \$ value of damage for Presidential declaration (limited timeframe)
- Tagging is not a first response
- Pre-plan priority buildings
- Plan before doing
- Manage upwards (don’t let politicians make promises w/o checking with you)
- Manage public expectations (esp. in moderate event)

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5

**COSTS & FEMA**

---

- Begin tracking costs immediately
- FEMA will reimburse for consultant contracts, and supplies/equipment
- Includes inspection kits, supplies for volunteers, etc.
- FEMA will not reimburse for regular staff time – only overtime


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### DEALING WITH OUTSIDE HELP

Options for deploying:

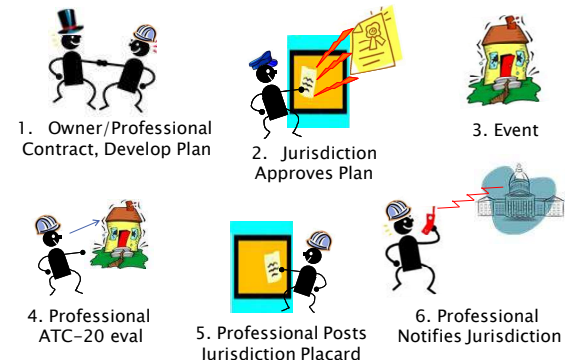
- Deputize mutual aid & volunteers *ad hoc*
  - WAsafe
- Accelerated Building Reoccupancy (ABR) Programs
  - FEMA P-2055-1 (January 2023)
  - Authorized Evaluator Program
  - Pre-deputize private sector professional
- Advisory Evaluator Program
- Owner/private sector professional agreement
- WABO/SEAW White Paper 5-2021



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### AUTHORIZED EVALUATOR PROGRAM

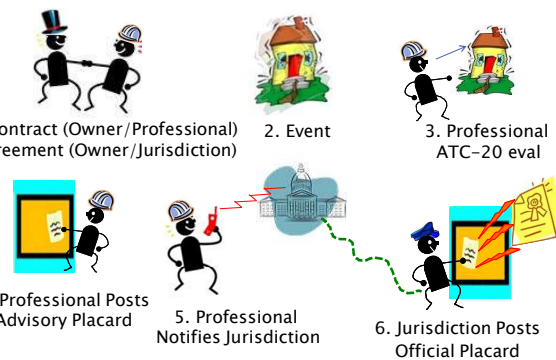


1. Owner/Professional Contract, Develop Plan
2. Jurisdiction Approves Plan
3. Event
4. Professional ATC-20 eval
5. Professional Posts Jurisdiction Placard
6. Professional Notifies Jurisdiction

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### ADVISORY EVALUATOR PROGRAM



1. Contract (Owner/Professional) /agreement (Owner/Jurisdiction)
2. Event
3. Professional ATC-20 eval
4. Professional Posts Advisory Placard
5. Professional Notifies Jurisdiction
6. Jurisdiction Posts Official Placard

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### WABO/SEAW WHITE PAPER 5-2021

<p><b>WABO/SEAW Liaison Committee</b> Washington Consortium of Building Officials and Safety Engineers of Washington</p>	<p><b>WHITE PAPER 5-2021</b></p>
<p><b>Title:</b> Guidelines – Post-Disaster Current Safety Evaluations</p>	<p><b>Issue:</b> March 18, 2021 <b>Replaces:</b> March 18, 2021</p>
<p><b>Abstract:</b> In the event of a natural disaster, this white paper is intended to establish standard processes by which engineering firms and private building safety evaluation under contract to a building owner and would provide references to the local building official of the results.</p>	<p><b>Committee Members:</b> Alan Bond (SEAW Co-chair), Lee Patten (WBO Co-chair), Michael Peterson (WBO), Steve Jensen (WBO), Lane Franklin (SEAW), Alan Lee (SEAW), Alan Lee (SEAW), Cheryl Barrett (WBO), Chris Roberts (WBO), Steve Arnold (WBO), Travis Collier (SEAW)</p>
<p><b>Committee Mission Statement:</b></p> <ul style="list-style-type: none"> <li>• Improve the design and construction of public structures that address building code and the engineering design community that supports construction demands.</li> <li>• Improve consistency and quality of engineering submittal and program review.</li> <li>• Build consensus between engineering design community and building officials with regard to code interpretation and submittal requirements.</li> </ul>	<p>Available at <a href="http://www.wabo.org">www.wabo.org</a> or <a href="http://www.seaw.org">www.seaw.org</a></p>

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### CORDONING IS POLITICAL

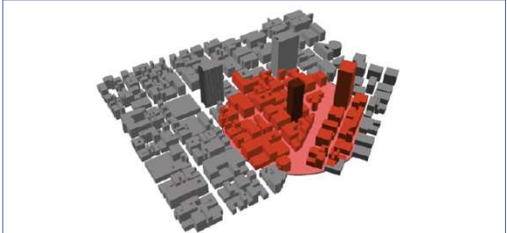


**Figure 2-2 Evolution of the CBD cordon in Christchurch (Image from (Shrestha et al. 2022)).**  
Source: FEMA P-2055-2

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### CORDONING IS POLITICAL



**Figure 2-1 Illustration of cordon around a 520 ft tall building at radius equal to 1.5 times the building height impacting downtown San Francisco following a simulated earthquake event (ATC, 2018).**  
Source: FEMA P-2055-2

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# WASAFE AND VOLUNTEER DEPLOYMENT

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1

## WASAFE AND VOLUNTEER DEPLOYMENT

WAsafe Overview

- Concept of Operations in WA
  - Incident Command System (ICS)
  - Activation and Deployment of WAsafe Responders
  - Roles of WAsafe Responders and Local Government (AHJ)

Washington Law – Emergency Management Worker Program, Good Samaritan Law, Workman’s Comp

Enrolling in WAsafe (WAserv)

Interstate Operations - EMAC

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# OVERVIEW: WHAT IS WASAFE?

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Washington State Safety Assessment Facility Evaluators








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## WHO IS WASAFE?

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Coalition formed in 2015

- Washington Chapter, American Institute of Architects (AIA Washington)
- Structural Engineers Association of Washington (SEAW)
- Washington Association of Building Officials (WABO)
- American Society of Civil Engineers (ASCE) Seattle Section (2019)

With key assistance from the Washington State Department of Health (DOH) – providing the WAserv registry


MOU with WA EMD => WAsafe recognized as a resource

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## WASAFE OBJECTIVES

- Assist building officials with building safety assessments following a disaster (earthquake, flood, storm, etc.)
- Develop a group of qualified volunteers
  - Provide WAsafe BSE training
  - Include information on authority, liability & field safety
  - Maintain registry of volunteers
- Assist WA State EMD in calling up and dispatching WAsafe responders to where they are needed in large events
  - Share resources



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### BUILDING SAFETY EVALUATORS (BSEs)



California Office of Emergency Services Safety Assessment Program (Cal OES SAP)

Missouri Safety and Visual Evaluation Coalition (Missouri SAVE)

Missouri SAVE Coalition  
Ensuring Building Safety In a Disaster



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### WASAFE PROGRAM FOCUS

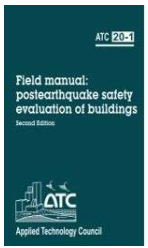




Reoccupy safe buildings

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### GUIDANCE DOCUMENTS

ATC-20-1 (2005): Earthquakes

ATC-45 (2004): Floods, Windstorms

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### WASAFE CAPABILITIES

Volunteer enrollment managed by WAsafe member orgs



Response/deployment managed by WA State Emergency Management Division (EMD)



Multi-Hazard



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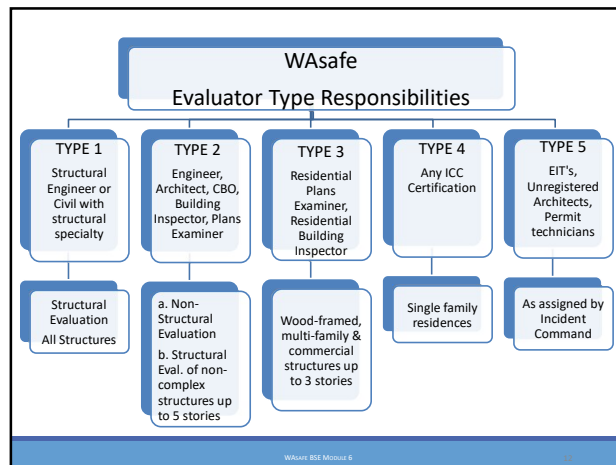
10

### WASAFE BSEs – DESIRED QUALIFICATIONS

- General knowledge of construction
- Professional experience
- Broad building review capability
- Good judgment
  - Balance

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### WASAFE RESOURCES – TYPES AND QUAL'S

Type	Duties/Limitations	Minimum Qualifications
<b>1</b>	<ul style="list-style-type: none"> <li>Structural evaluation only: all buildings, including multi-family and commercial structures over 5 stories and buildings w/complex structural systems</li> </ul>	<ul style="list-style-type: none"> <li>Registered structural engineer or civil engineer with structural specialty</li> <li>*WAsafe BSE training</li> </ul>
<b>2</b>	<ul style="list-style-type: none"> <li>a. Non-structural evaluation: all single family residential, multi-family and commercial buildings</li> <li>b. Structural evaluation: single family residential, multi-family and commercial buildings up to 5 stories with non-complex structural systems</li> </ul>	<ul style="list-style-type: none"> <li>Certified Building Plans Examiner, Commercial Building Inspector, Building Inspector, Certified Building Official; or Registered Architect or Engineer</li> <li>*WAsafe BSE training</li> </ul>

\* For first-time enrollees in WAsafe: ATC-20 (or combo ATC-20/45) plus this WAsafe-specific module (online) will be accepted in place of WAsafe BSE training

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### WASAFE RESOURCES – TYPES AND QUAL'S (cont.)

Type	Duties/Limitations	Minimum Qualifications
<b>3</b>	<ul style="list-style-type: none"> <li>Wood-framed single family residential, multi-family and commercial structures up to 3 stories</li> </ul>	<ul style="list-style-type: none"> <li>Certified Residential Building Plans Examiner or Residential Building Inspector</li> <li>*WAsafe BSE training</li> </ul>
<b>4</b>	<ul style="list-style-type: none"> <li>Single family residences and associated accessory structures</li> </ul>	<ul style="list-style-type: none"> <li>Any ICC Certification</li> <li>*WAsafe BSE training</li> </ul>
<b>5</b>	<ul style="list-style-type: none"> <li>As assigned by Incident Command (or building official or other AHJ)</li> </ul>	<ul style="list-style-type: none"> <li>EITs, Unregistered Architects, Permit Technicians</li> <li>Relevant Experience</li> <li>*WAsafe BSE training</li> </ul>

\* For first-time enrollees in WAsafe: ATC-20 (or combo ATC-20/45) plus this WAsafe-specific module (online) will be accepted in place of WAsafe BSE training

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### FEMA IS TRAININGS

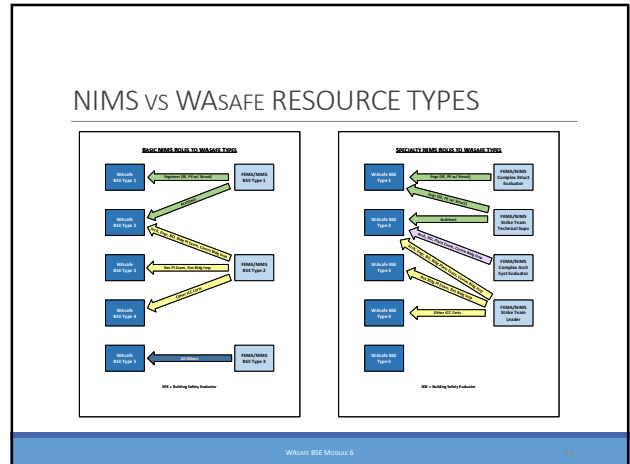
Independent Study (IS), Online, Free <https://training.fema.gov/is/>

*Recommended for WAsafe BSEs (Boots-on-the-Ground);  
Required for NIMS "Post-Disaster Building Safety Evaluator"*

X	X	IS-100	Introduction to the Incident Command System (2 hours)
X		IS-200	ICS for Single Resources and Initial Action Incidents (3 hours)
	X	IS-230	Fundamentals of Emergency Management (6 hours)
X	X	IS-700	An Introduction to the National Incident Management System (NIMS) (3.5 hours)
X		IS-800	National Response Framework, An Introduction (3 hours)

*Required for WAsafe Coordinators*

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## CONCEPT OF OPERATIONS

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### EMERGENCY RESPONSE HIERARCHY

Local Government is always in charge in emergency response.

- Upper levels supply aid to local level
- Hierarchy established by the **Incident Command System (ICS)**, a standardized, all-hazards incident management concept.

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### WASAFE – PART OF A LARGER SYSTEM

#### What Is ICS?

**ICS:**

- Is a standardized, on-scene, all-hazards incident management concept.
- Enables a coordinated response among various jurisdictions and agencies.
- Establishes common processes for planning and management of resources.
- Allows for integration within a common organizational structure.

Visual 2.4  
ICS Overview

FEMA

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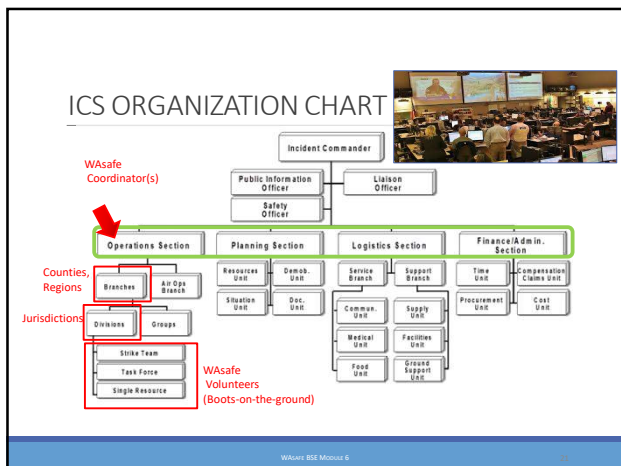
### WASAFE – PART OF A LARGER SYSTEM

Other responders:

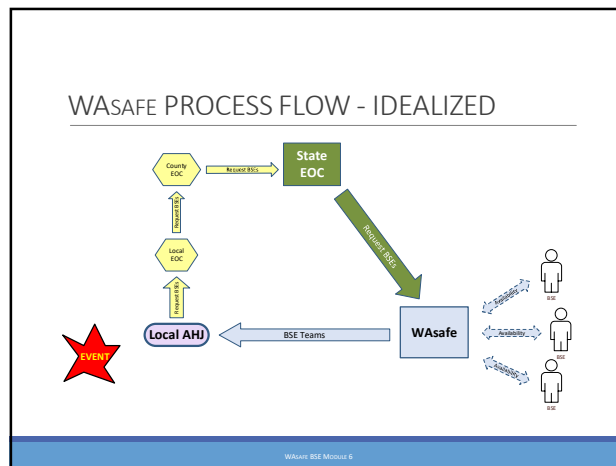
Red Cross	Fire Fighters
Insurance companies	Medical personnel
Media	Haz Mat teams
FEMA	Law Enforcement
Small Business Administration	Utility workers

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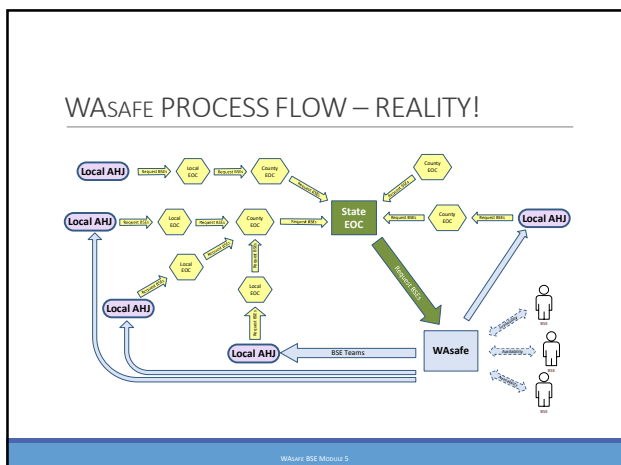
20



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### WASAFE ACTIVATION

- Event triggers local response
  - Includes mutual aid agreements
- Local building official requests additional resources through local EOC
- Local EOC sends request to County
- County cannot fulfill request => forward request to State
- State initiates contact with WAsafe Coordinators

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### WASAFE RESPONDER EXPECTATIONS

WAsafe Coordinator dispatches BSEs to staging area

On first day:

- Report to staging area (local EOC or building department)
- Register as Temporary Emergency Worker
- Receive briefing instructions and refresher
- Deputized by building official




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### WASAFE RESPONDER EXPECTATIONS

Each day (until assignment is done):


- Report to staging area (local EOC or building department)
- Sign in
- Receive assignments
- Follow guidance of jurisdiction while in field
- At the end of the day
  - Report to staging area to review assessment forms with jurisdiction
  - Sign out



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### WASAFE – DEPUTIZING



- Non-jurisdiction personnel cannot post official jurisdiction placards unless deputized

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### WASAFE BSE'S ROLE

Provide rapid evaluation of buildings

Provide detailed evaluations as directed by the local jurisdiction

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### WASAFE BSE'S ROLE (CONT.)

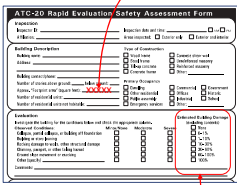
Do NOT provide COST estimates

- DO provide % DAMAGE estimates, if required by jurisdiction

Do NOT evaluate compliance of grandfathered conditions to current code

Do NOT provide escort or property retrieval services

Do NOT leave business cards



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### LOCAL GOVERNMENT ROLE

Provide jurisdictional contact

Issue local placards

Deputize WAsafe Responders

Coordinate WAsafe Responder activities

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## LOCAL GOVERNMENT ROLE (CONT.)

### Briefing information

- Key contact information for Building Official, law enforcement, fire, haz mat, utilities, and animal control
- Relevant local policies

### Lodging & Meals information

Ensure necessary authorization exists to allow WAsafe work

Provide EMD with Disaster Data if requested

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## WASHINGTON STATE LAW

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## WA EMERGENCY WORKER PROGRAM

Program established/regulated by state law

### Legal Foundation

- RCW 38.52 – Emergency Management Act (Authority)
  - WAC 118-04 – Emergency Worker Program (Rules)
- <http://www.leg.wa.gov/CodeReviser>

The WA Emergency Management Division (EMD) developed and runs the Emergency Worker Program

WAsafe is set up to comply

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## WA EMERGENCY WORKER PROGRAM

### State coverage:

- Immunity from liability (“Good Samaritan”), and
- Injury/Damage to Individual (Workers’ Comp)

### Must be a **registered** Emergency Worker

- Typically this is “temporary registration” under a State-issued Mission Number
- The jurisdiction gets the Mission Number from EMD
- WAsafe Volunteers register when reporting to jurisdiction!

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## ARCHITECT AND ENGINEER LIABILITY

Liability Protection under RCW 38.52.180

### RCW 38.52.1951:

For purposes of the liability of an architect or engineer serving as a **volunteer emergency worker**, the exemption from liability provided under RCW 38.52.195 extends to all damages, so long as the conditions specified in RCW 38.52.195 (1) through (5) occur.

### RCW 38.52.195 conditions:

- (1) Where, at the time of the incident the worker is **performing services as an emergency worker**, and is acting within the course of his or her duties as an emergency worker;
- (2) Where, at the time of the injury, loss, or damage, the **organization for emergency management which the worker is assisting** is an approved organization for emergency management;
- (3) Where the injury, loss, or damage is **proximately caused by his or her service** either with or without negligence as an emergency worker;
- (4) Where the injury, loss, or damage is not caused by the **intoxication** of the worker; and
- (5) Where the injury, loss, or damage is not due to **willful misconduct or gross negligence** on the part of a worker.

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## WA EMERGENCY WORKER REGISTRATION (WAC 118-04-080)

### **Government employees – Covered!**

Considered as registered with local emergency management agency if within own jurisdiction;

### Outside their jurisdiction:

- Acting under a Mutual Aid agreement; or
- Deployed by State EMD (through WAsafe)

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### WA GOOD SAMARITAN IMMUNITY FROM LIABILITY FOR NON-MEDICAL ASSISTANCE

**RCW 4.24.311 Immunity from liability for certain care or assistance at scene of emergency or disaster**

Immunity from liability outside of the Emergency Worker Program

Good Samaritan Law for **volunteers**:

- Members of a Community Emergency Response Team (CERT)
- Neighbors helping neighbors

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### WASAFE – REIMBURSEMENTS

Housing, meals, travel, and other necessary expenses may or may not be reimbursed by requesting agency

Volunteers must be on their own time (e.g., vacation)

Public employees may be reimbursed by the requesting jurisdictions

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## ENROLLING IN WASAFE

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### WASAFE – ENROLLMENT

Associated with a professional organization (WABO, SEAW, AIA, ASCE) or “Other”

Meet minimum qualifications, including WAsafe BSE class taught by approved trainer

Digital picture & documentation

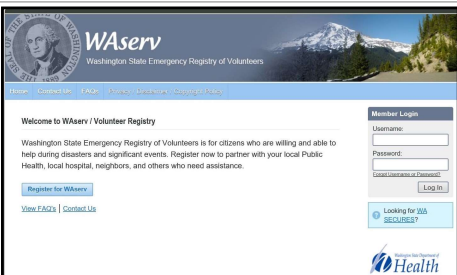
Enroll through WAserv

Refresher training (online) every 5 years



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JOIN WASAFE AT <https://www.waserv.org/>



See <https://wasafecoalition.org/volunteer/how-to-enroll> for “How-To” guide

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## INTERSTATE EMERGENCY MANAGEMENT (EMAC)

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## EMERGENCY MANAGEMENT ASSISTANCE COMPACT (EMAC)



- State-to-state mutual aid agreement through which states can assist one another directly
- All 50 States are signatories to EMAC and can provide or receive aid
- Workers' comp and immunity coverage is carried forward through EMAC, along with licenses

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## EMAC – HURRICANE KATRINA (2005)



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## RECAP - WASAFE AND VOLUNTEER DEPLOYMENT

### WAsafe Overview

#### Concept of Operations in WA

- Incident Command System (ICS)
- Activation and Deployment of WAsafe Volunteers
- Roles of WAsafe Volunteers and Local Government

Washington Law – Emergency Management Worker Program, Good Samaritan Law, Workman's Comp

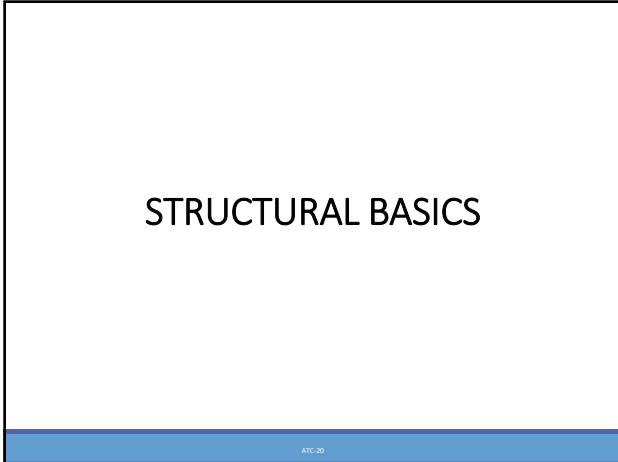
Enrolling in WAsafe (WAserv)

Interstate Operations - EMAC

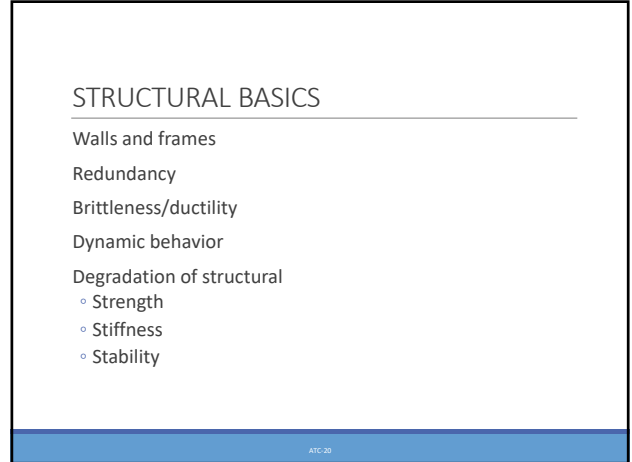
See [www.wasafecoalition.org](http://www.wasafecoalition.org) for more information

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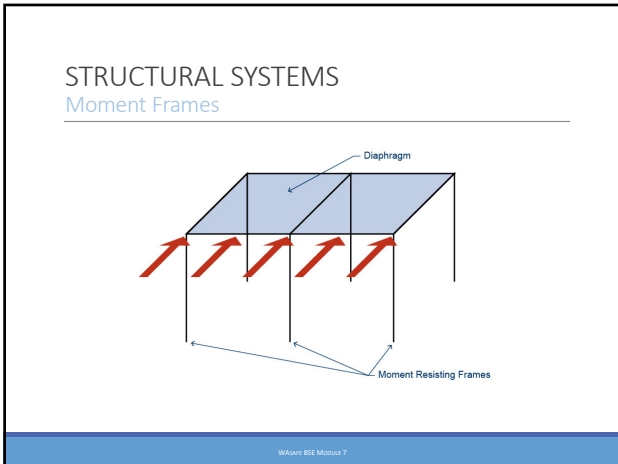
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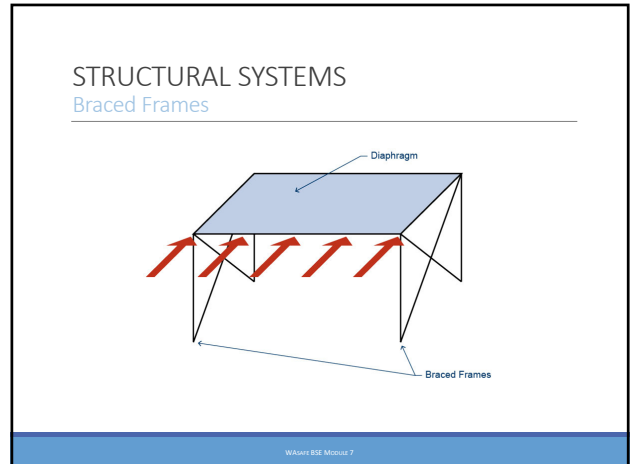
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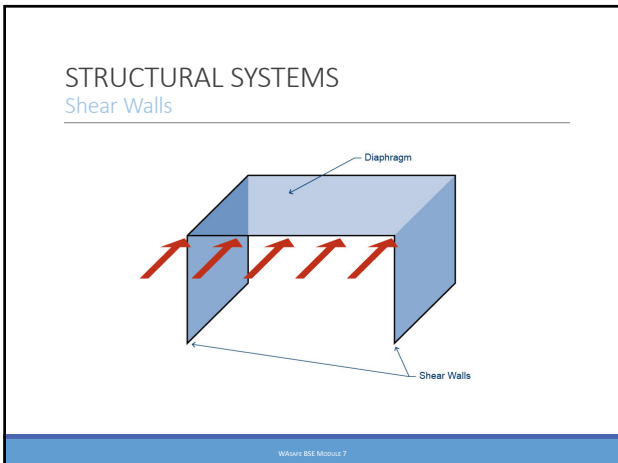
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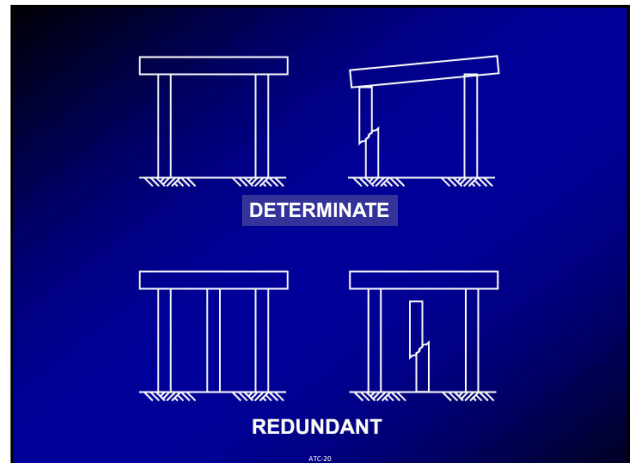
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### REDUNDANCY



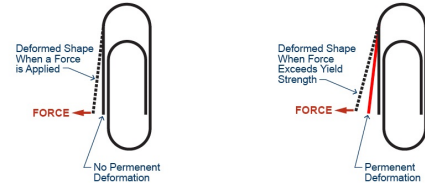
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### DUCTILE BEHAVIOR

FORCE < YIELD STRENGTH

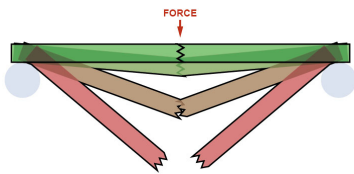
FORCE > YIELD STRENGTH



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### BRITTLE BEHAVIOR



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### BRITTLE VS DUCTILE BEHAVIOR

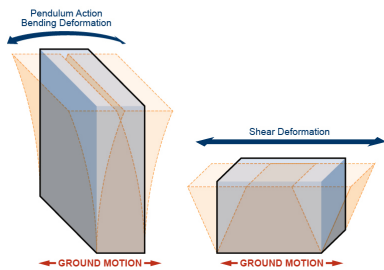


Photos: Y. Siu

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### BUILDING DYNAMIC BEHAVIOR



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### RESONANCE



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### RESONANCE

Tacoma Narrows Bridge (Galloping Gertie)

<https://www.youtube.com/watch?v=qbOixPCfaFk>



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### BUILDING RESPONSE

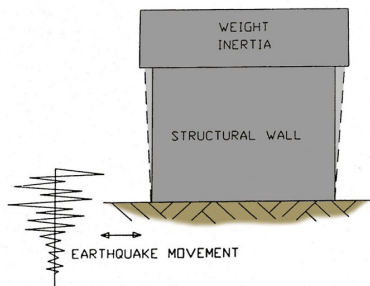
[https://youtu.be/LV\\_UuzEznHs](https://youtu.be/LV_UuzEznHs)



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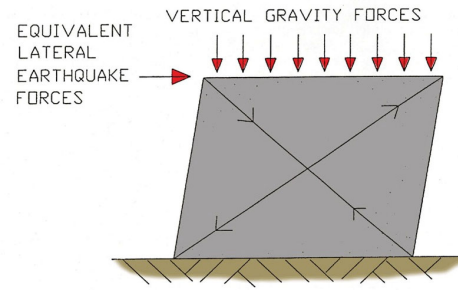
### EARTHQUAKE FORCES



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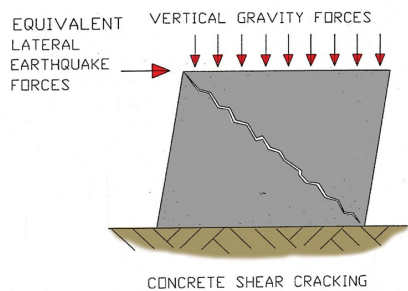
### EARTHQUAKE FORCES - WALL



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### EARTHQUAKE FORCES - WALL



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### X-CRACKING IN BRITTLE MATERIAL



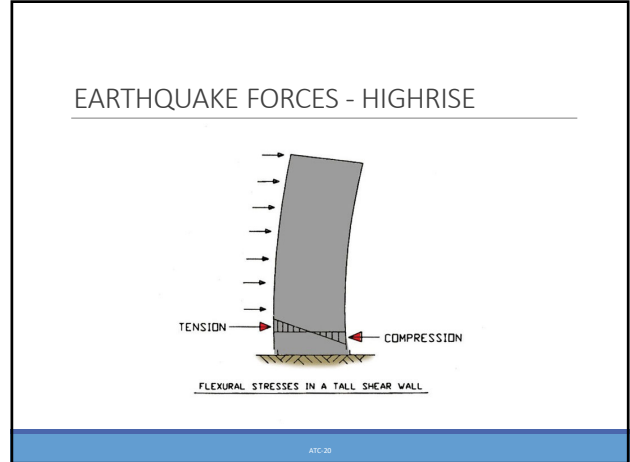
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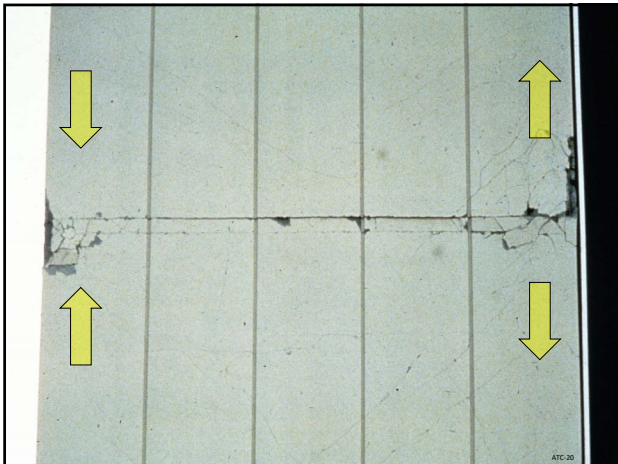




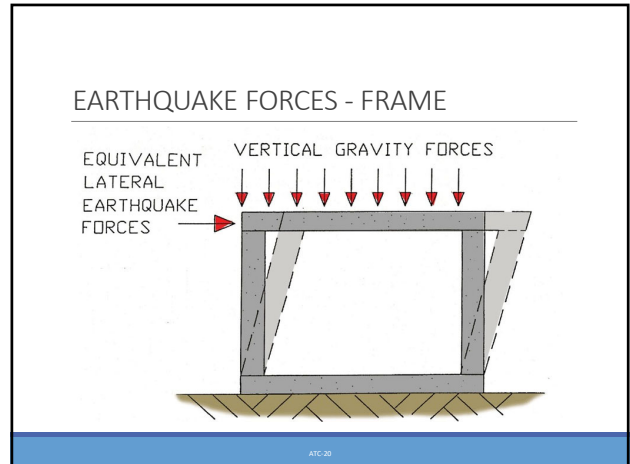
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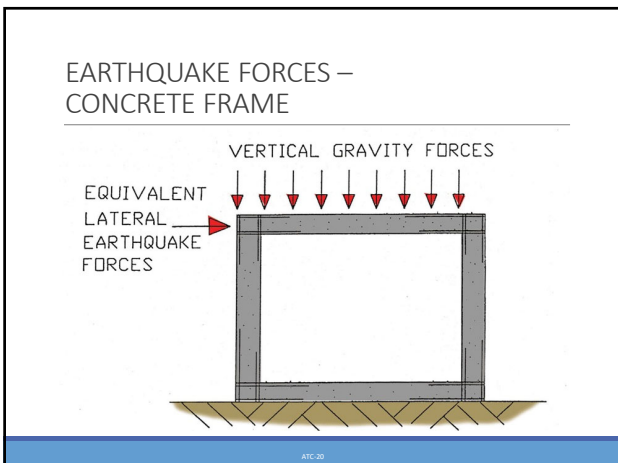
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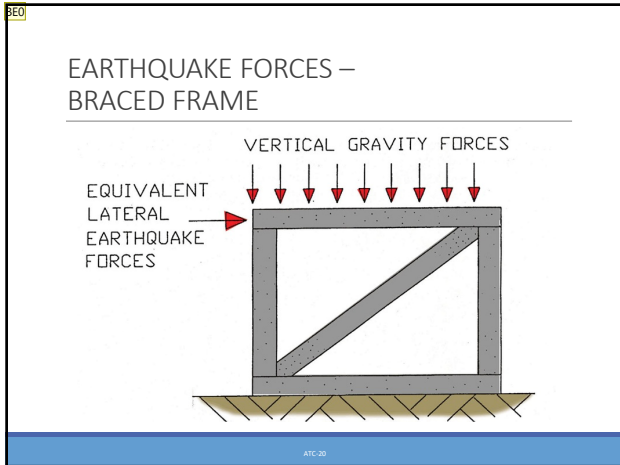
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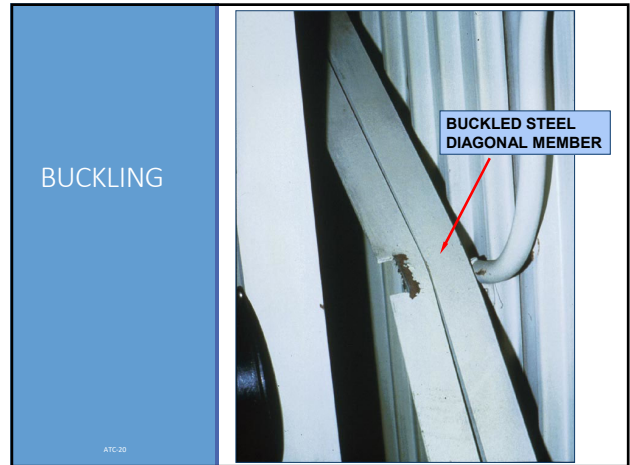
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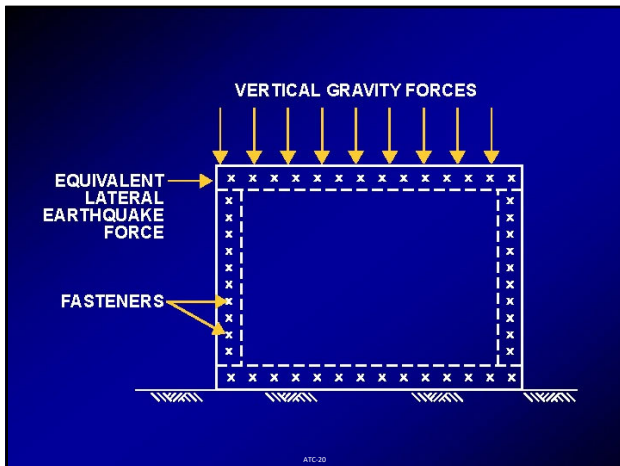
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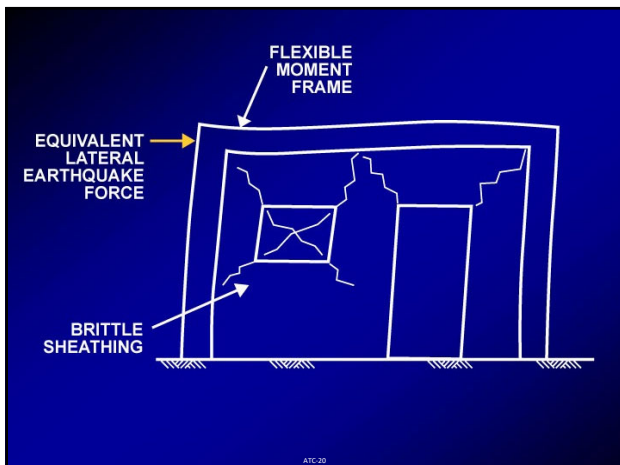
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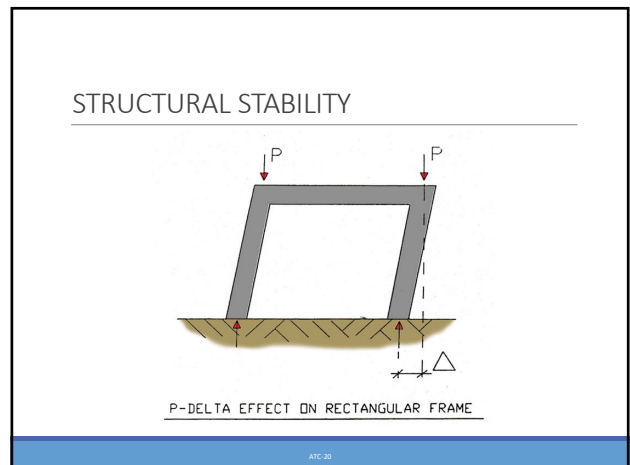
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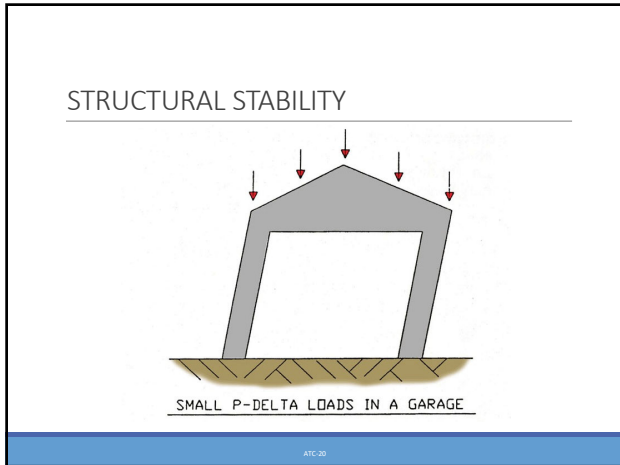
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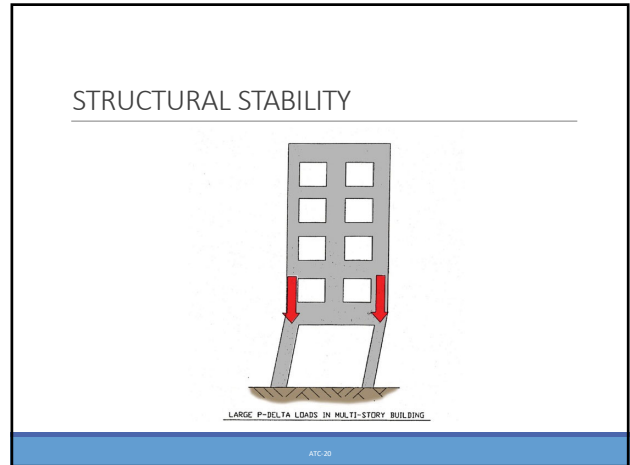
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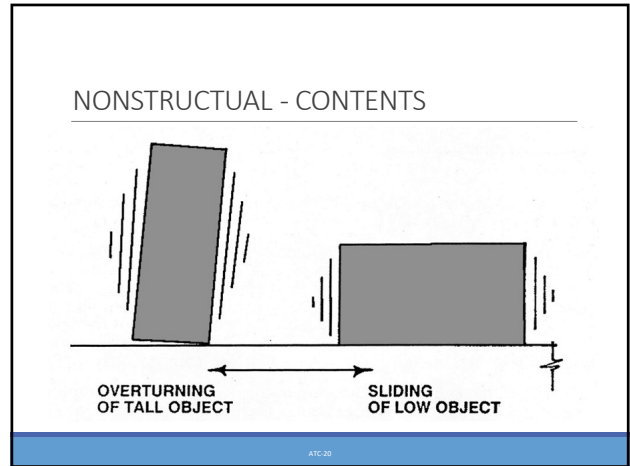
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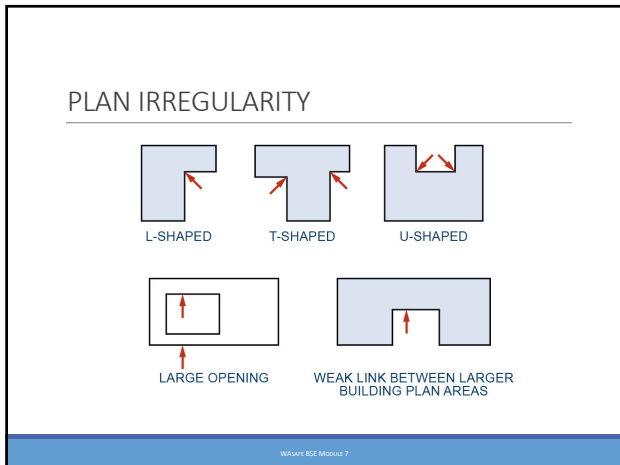
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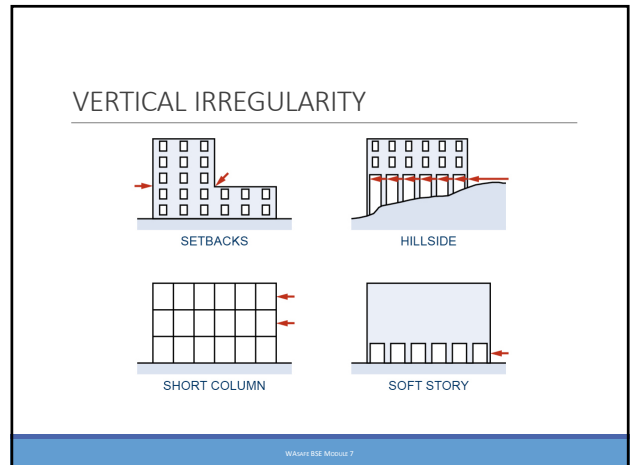
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VERTICAL IRREGULARITY – SOFT STORY



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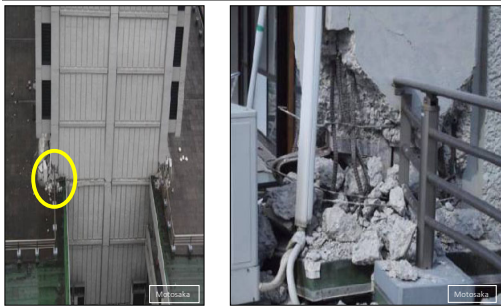
VERTICAL IRREGULARITY – SOFT STORY



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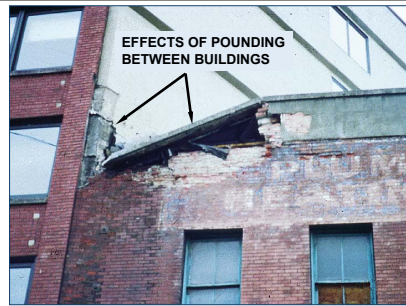
VERTICAL IRREGULARITY - SETBACK



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OTHER STRUCTURAL ISSUES - POUNDING



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OTHER STRUCTURAL ISSUES - COUPLED SHEAR WALL



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# WOOD-FRAME CONSTRUCTION

ATC-20

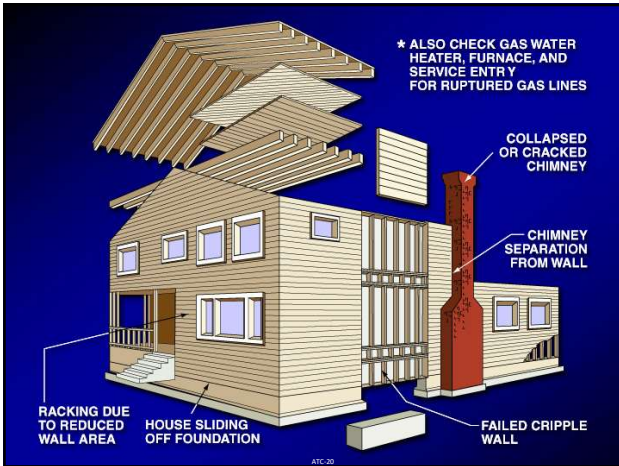
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## WOOD-FRAME CONSTRUCTION

Single-family residential  
Multi-unit residential and commercial

ATC-20

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## COMMON WOOD FRAME FAILURES

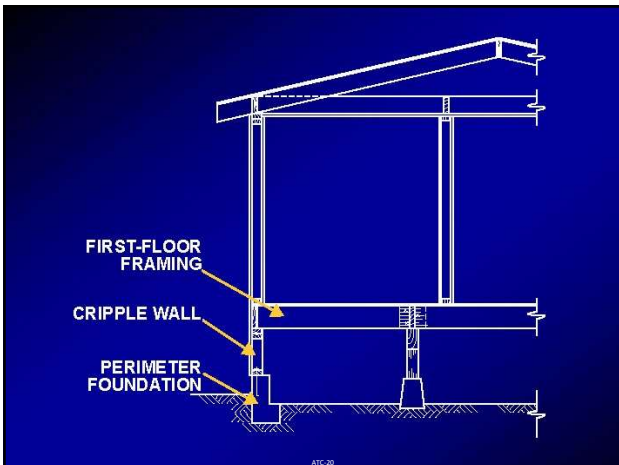
Inadequate bracing => collapse or shifting

- Cripple walls
- Reduced wall area
- Material failure (e.g., GWB)
- Soft stories
- Hillside construction
- Appendages
  - Porch roofs
  - Unanchored/unbraced masonry chimneys
  - Veneer

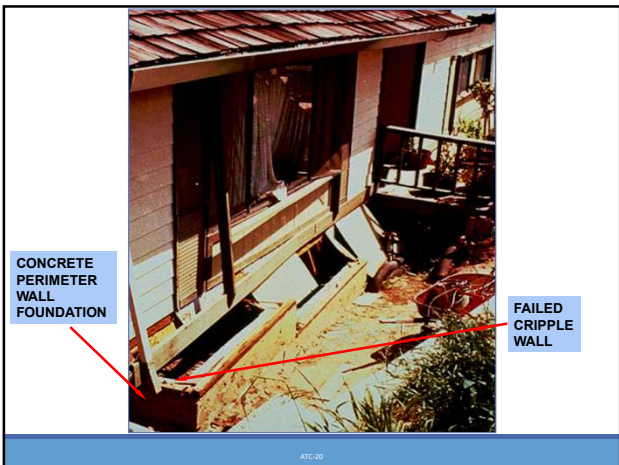
Inadequate foundation anchorage => sliding

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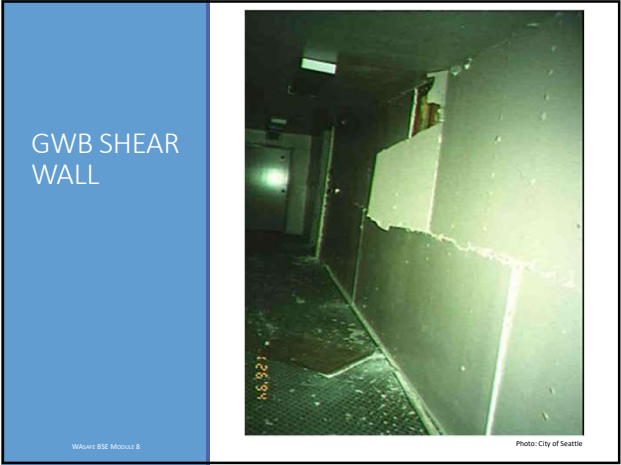


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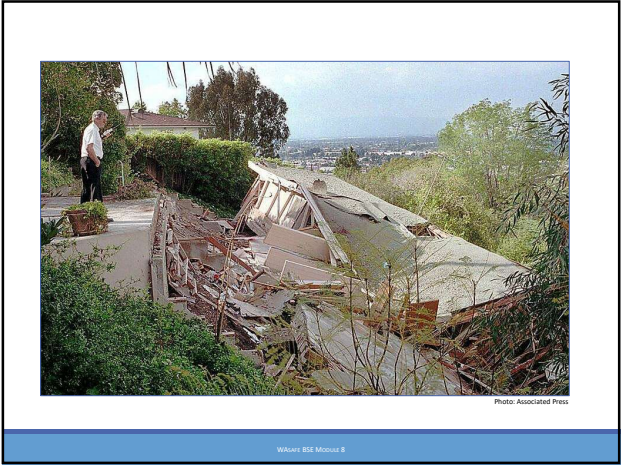


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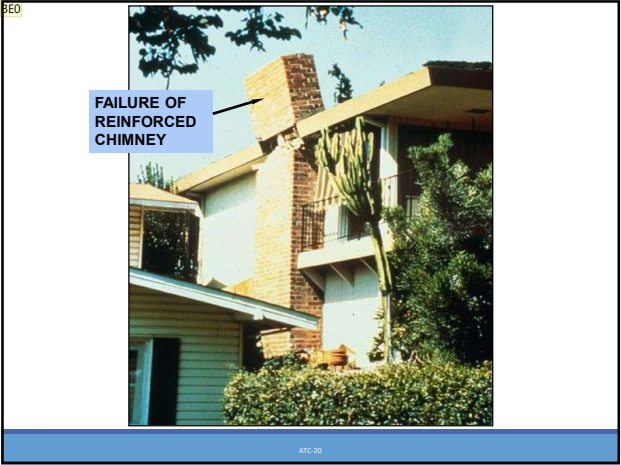
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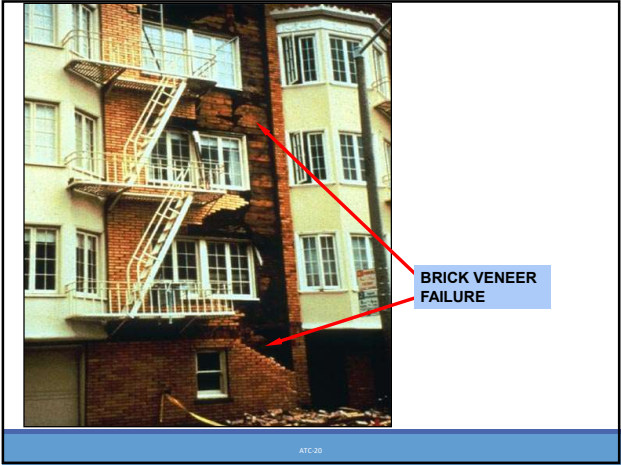
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### MASS TIMBER

Heavy timber/mill construction (old)

- Lateral systems unlikely to be designed for seismic

Engineered wood products

- Glu-lam beams/columns
- Composite laminated timber (CLT)
- Other composite components

Evaluate connections for damage, gaps, displacement

Source: Image, Fire Science Magazine  
Photo: Magnusson Klemencic Associates

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# MASONRY CONSTRUCTION

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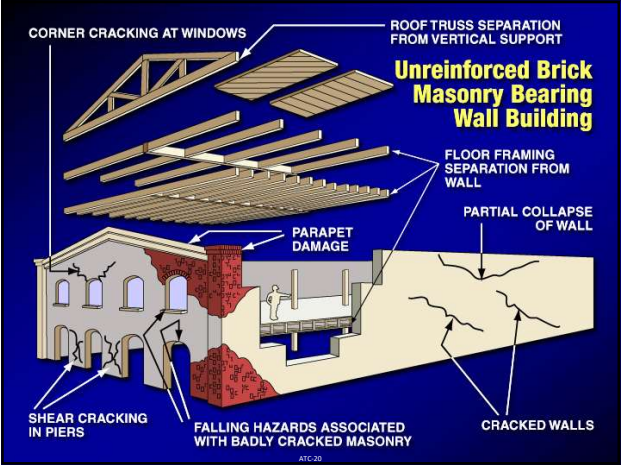
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## MASONRY CONSTRUCTION

- Unreinforced brick masonry bearing wall buildings
- Unreinforced concrete block masonry bearing wall buildings
- Reinforced masonry buildings

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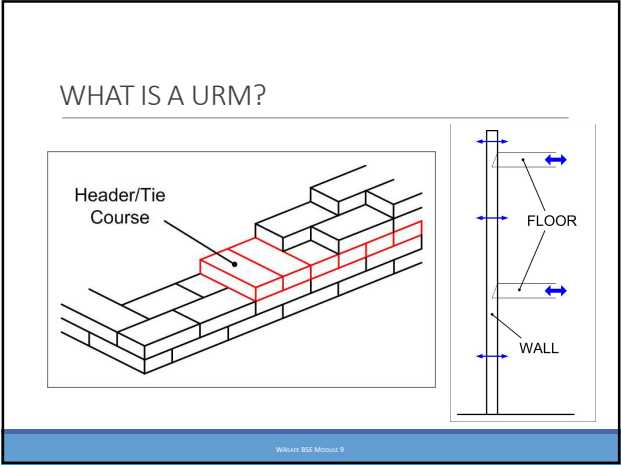
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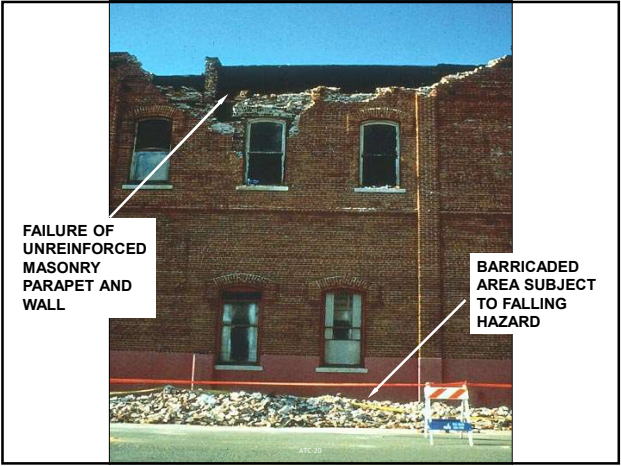


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**EARTHQUAKE (MIS)BEHAVIOR**

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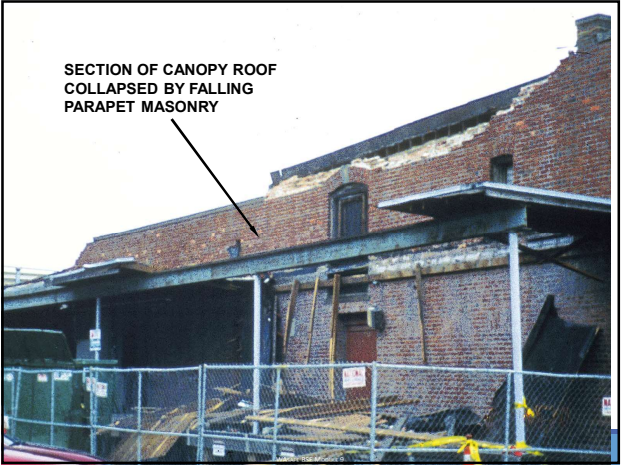


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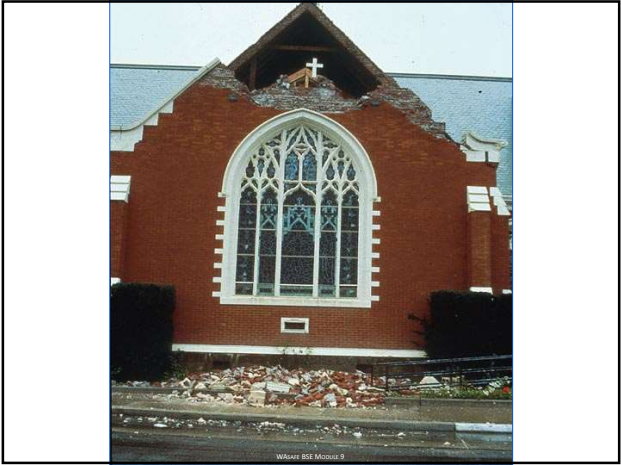


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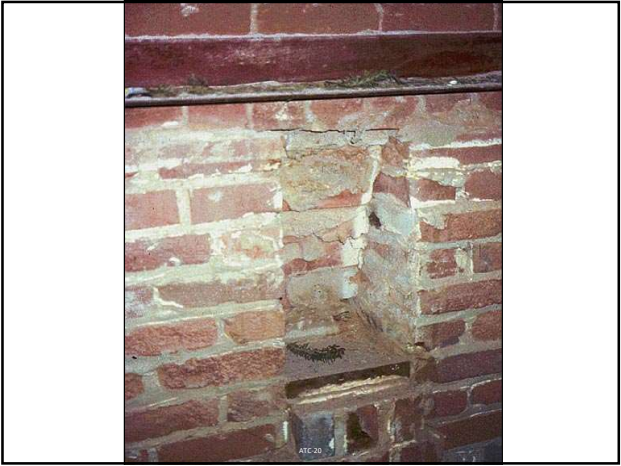




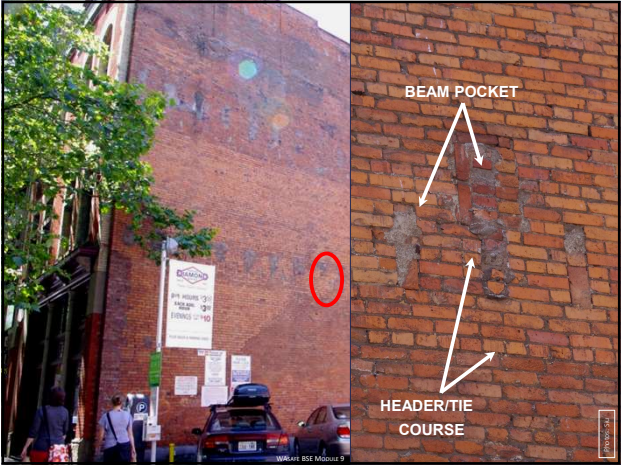
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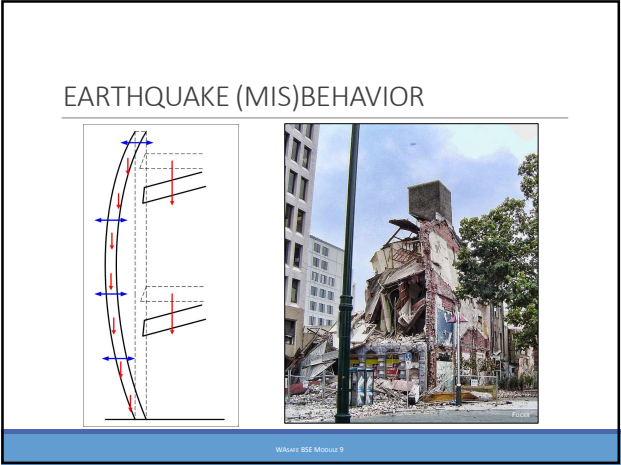
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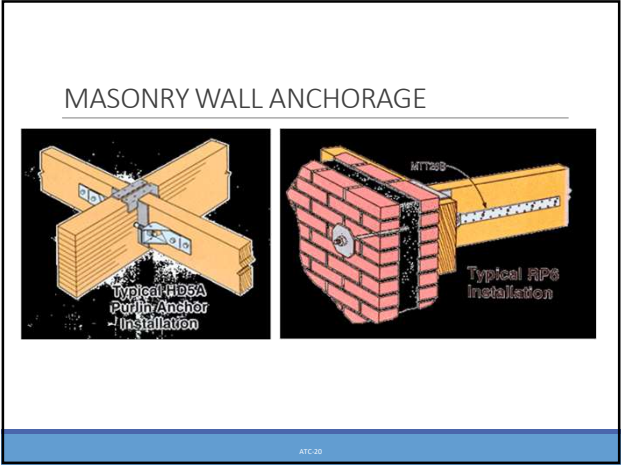
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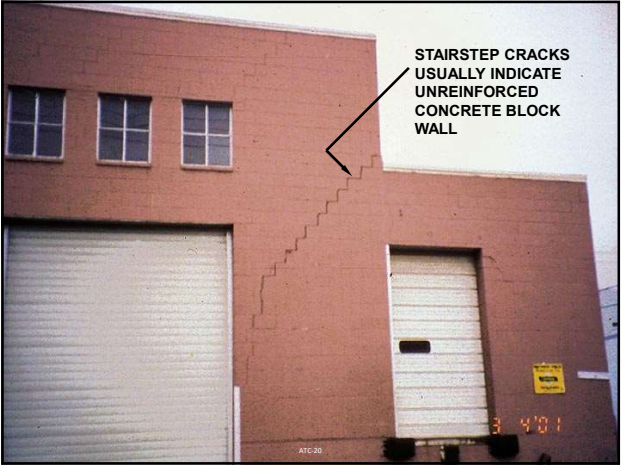




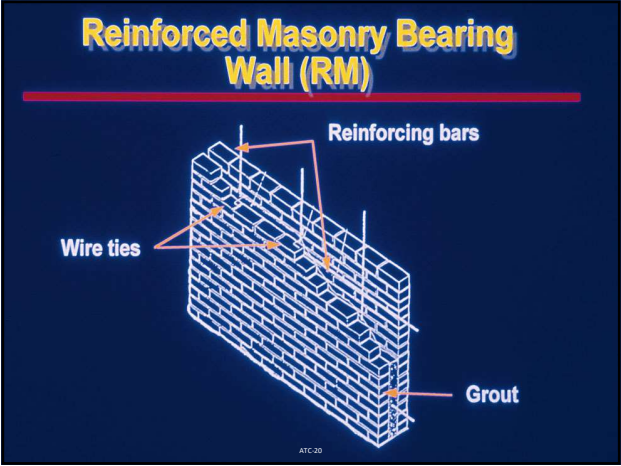
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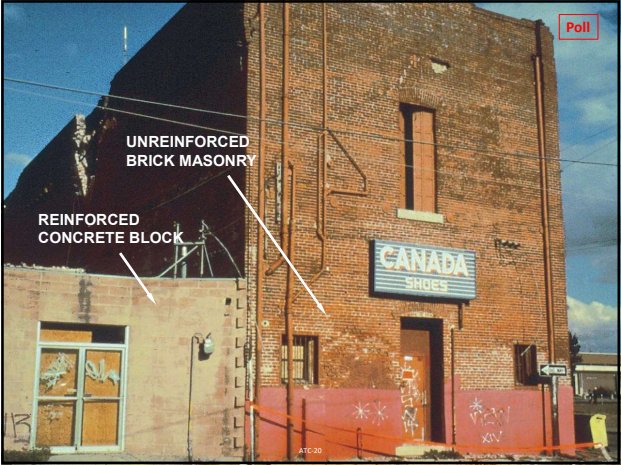
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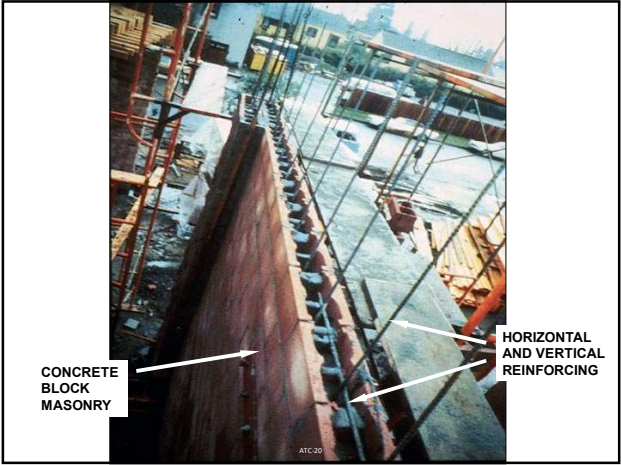
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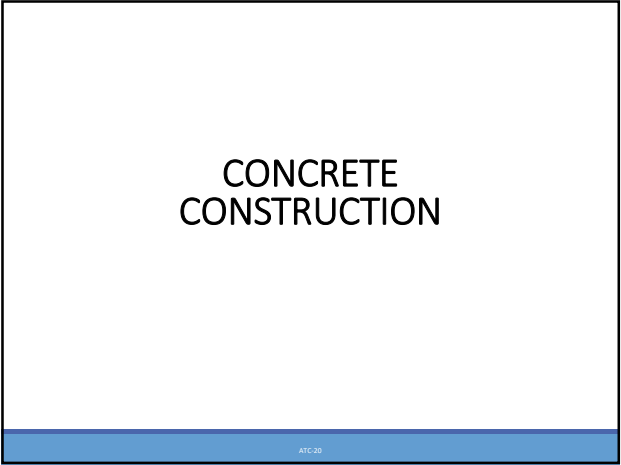


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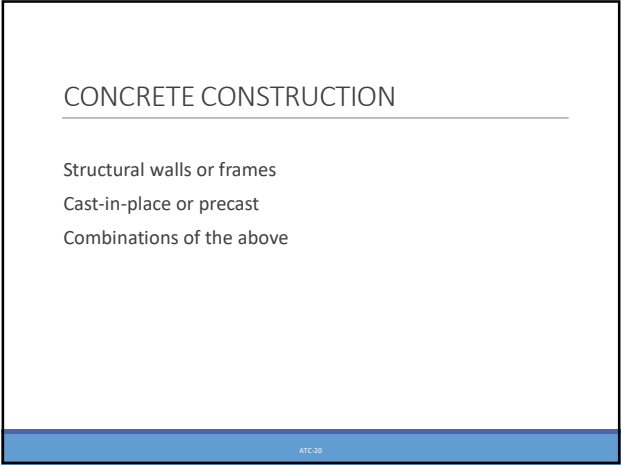


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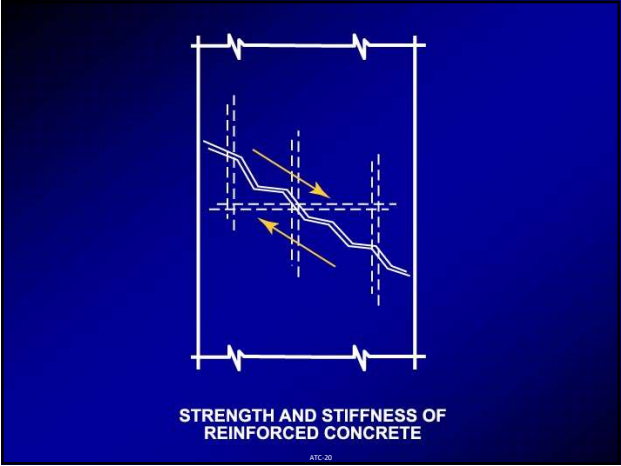




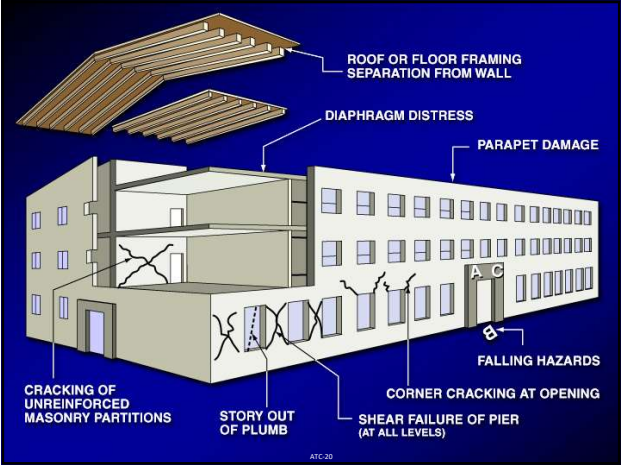
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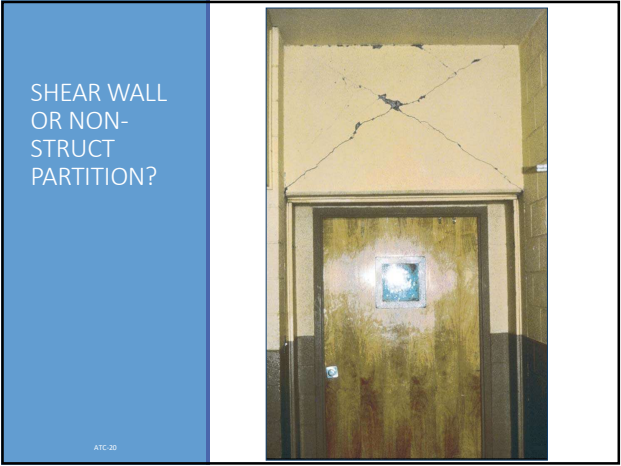
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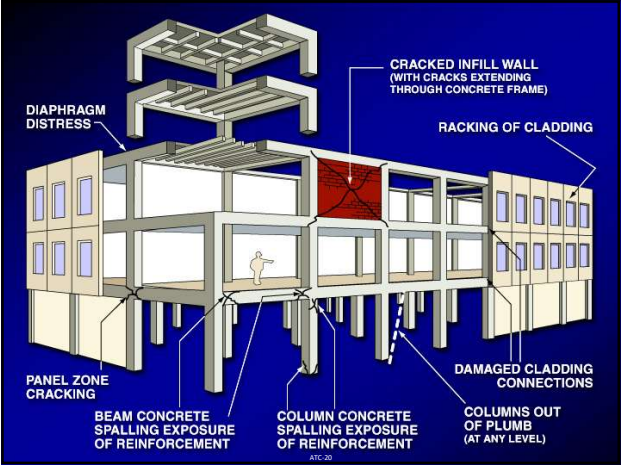


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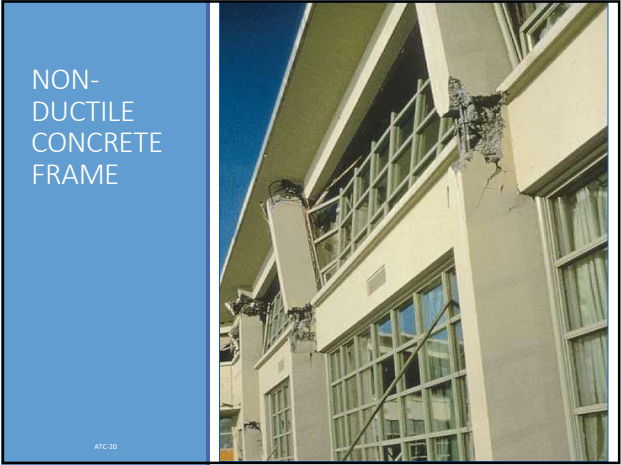


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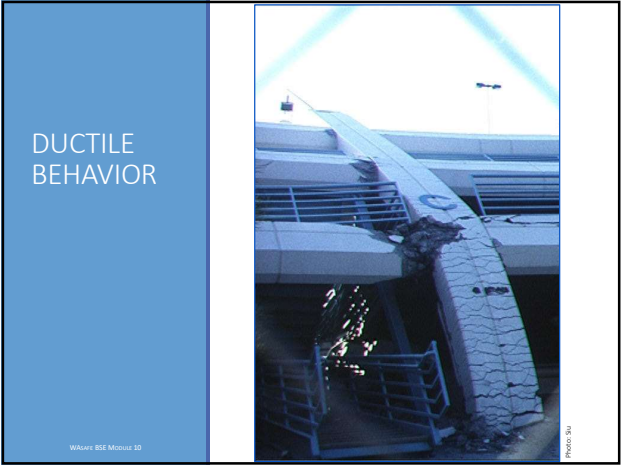
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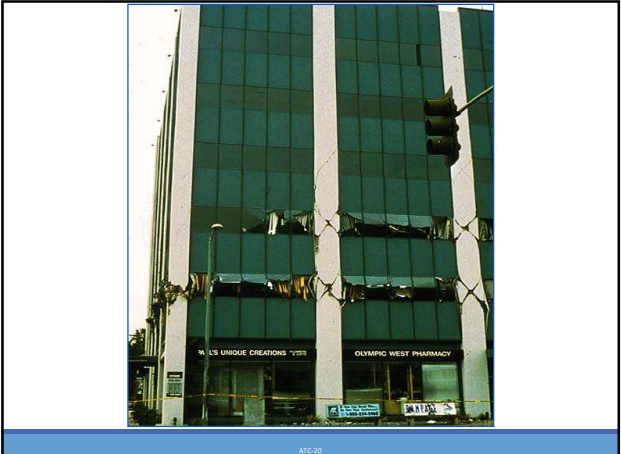
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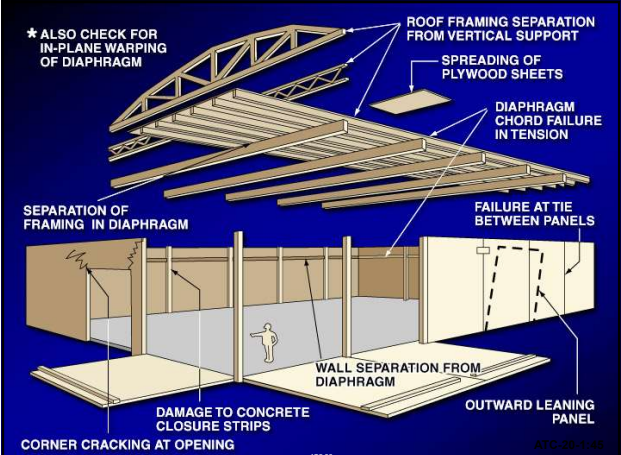
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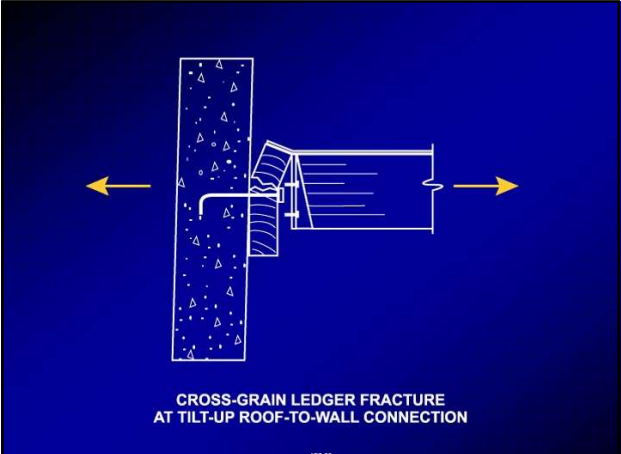
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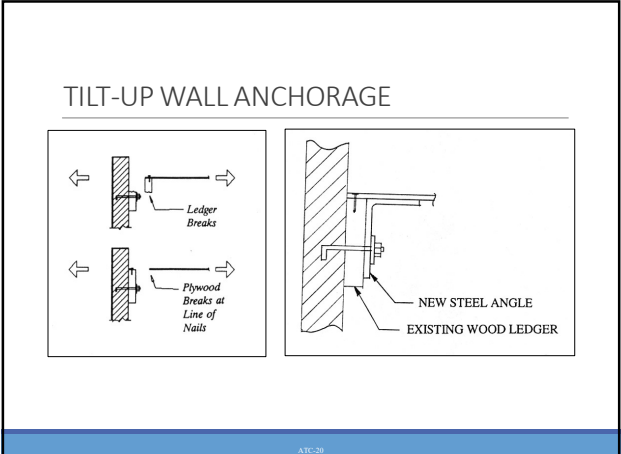
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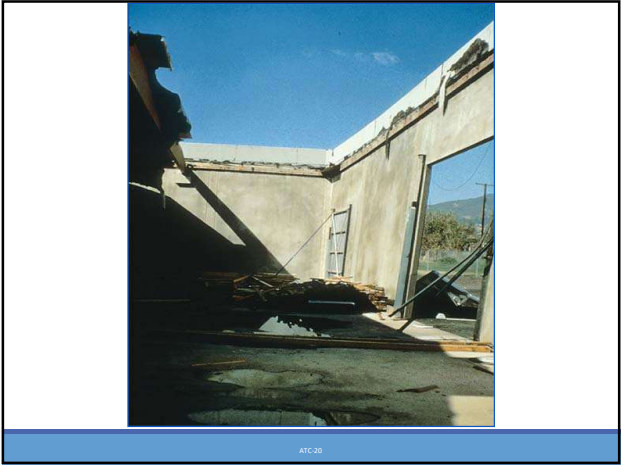


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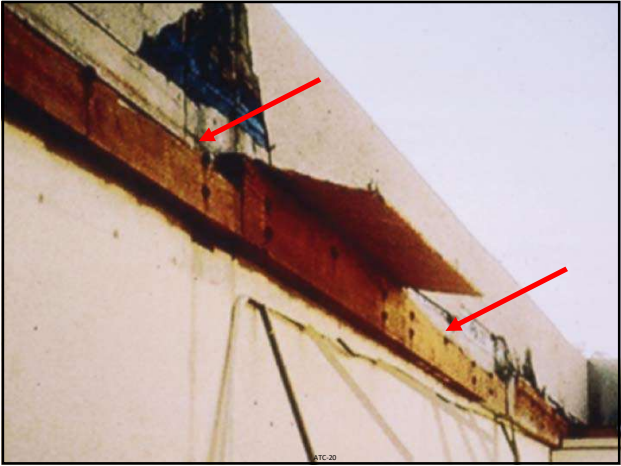
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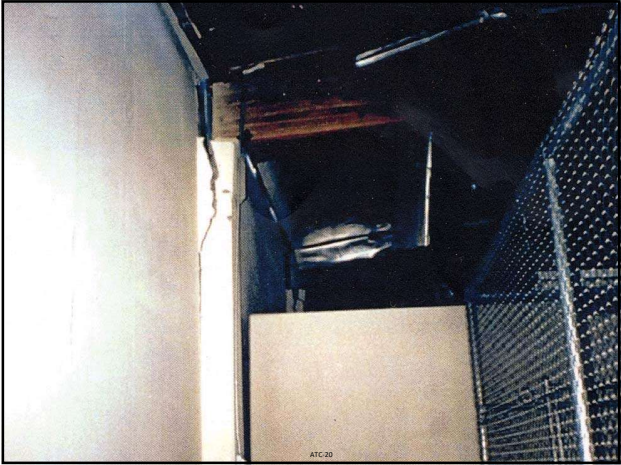
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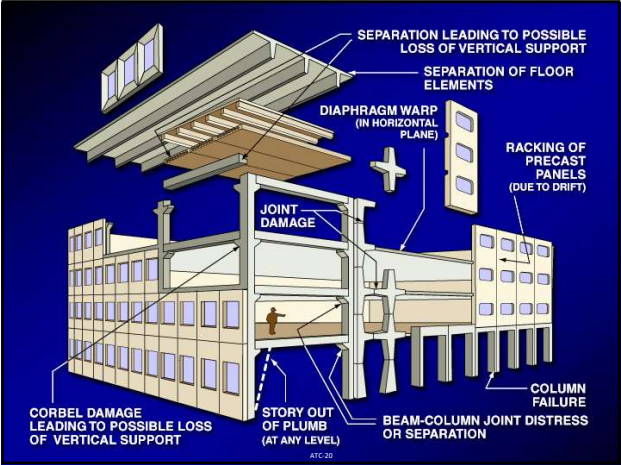


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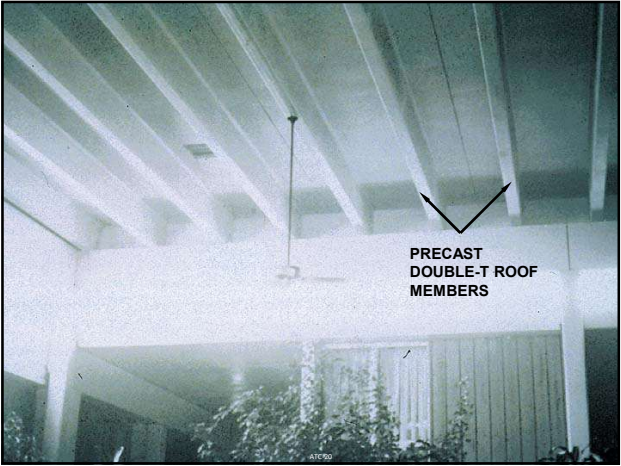




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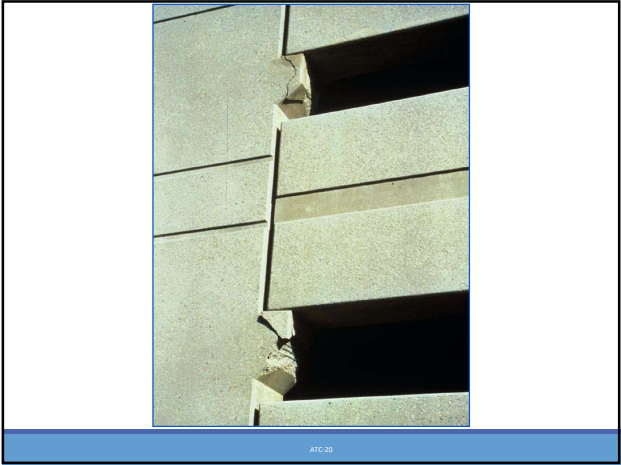
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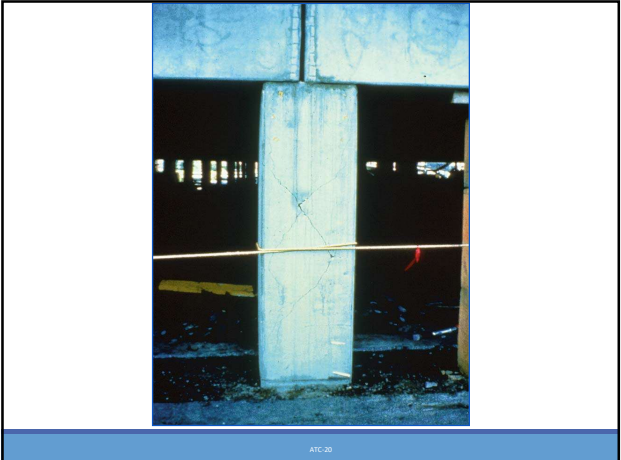
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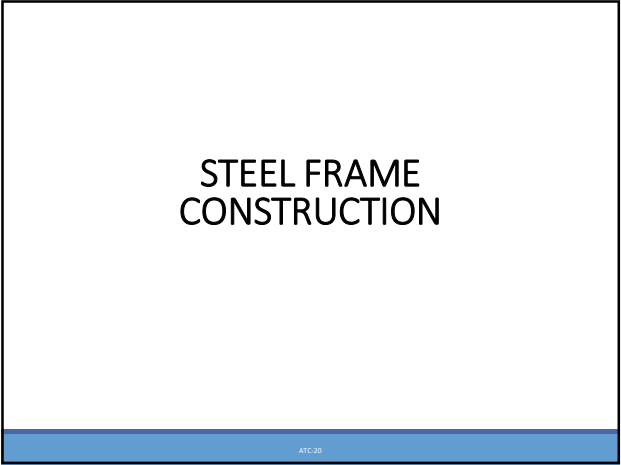


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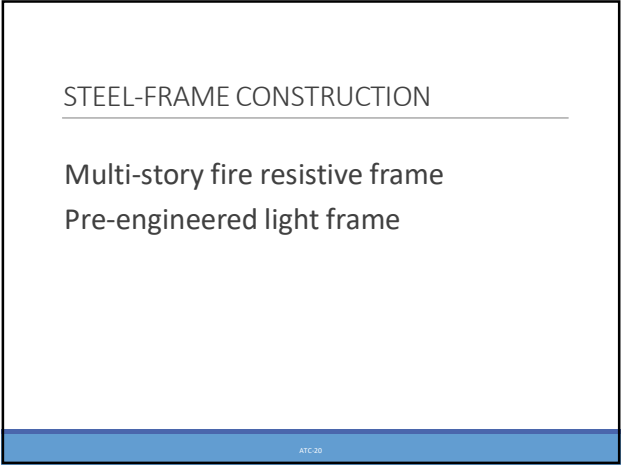


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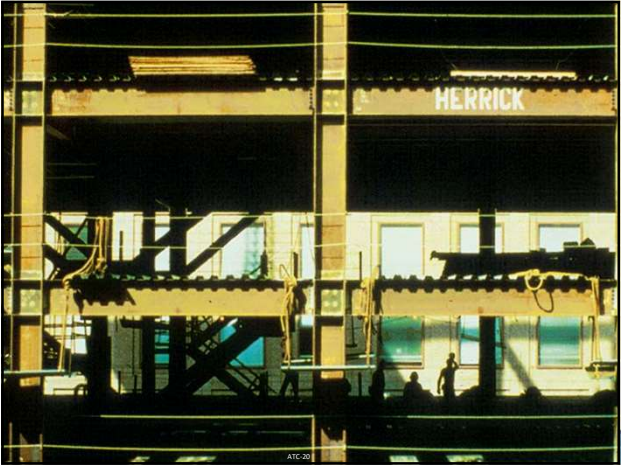




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### STEEL MOMENT FRAMES

**FEMA Building Type S1 STEEL MOMENT FRAMES**

Vertical shafts of nonstructural materials

Steel beams and columns

Nonstructural exterior cladding often window wall or paneled construction

Selected bays in each direction constructed as moment frames. See chapter 3.

Floors must often concrete over metal deck

These buildings consist of an essentially complete frame assembly of steel beams and columns. Lateral forces are resisted by moment frames that develop stiffness through rigid connections of the beams and columns created by angles, plates and bolts, or by welding. Moment frames may be developed on all framing lines or only in selected bays. It is significant that no structural walls are required. Floors are cast-in-place concrete slabs or metal deck and concrete. This building is used for a wide variety of occupancies such as offices, hospitals, laboratories, and academic and government buildings.

The S1A building type is similar but has floors and roof that are on flexible diaphragms, such as wood or spigotted metal deck. One family of these buildings are older warehouses or industrial buildings, while another more recent use is for small office or commercial buildings in which the live loading of concrete floors is not needed.

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### STEEL MOMENT FRAME

Column Slab

Welded or Bolted Shear Connection

Girder or Beam

WELDED MOMENT CONNECTION

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### BRITTLE STEEL??

#### Quake Cracks Steel Buildings

In past earthquakes, unreinforced brick and stiffly designed concrete buildings were considered too vulnerable to collapse. Buildings made of steel were deemed safer because they tend to bend but not break. The Northridge earthquake shattered those assumptions. Engineers have identified a dozen more steel buildings as high as 10 stories with badly cracked welds and supporting steel columns. Although they did not collapse, they were seriously weakened.

**Two types of cracks**

Moment-resisting frame

A steel-moment resisting frame is a rectangular assembly of beams and columns. The beams are welded and bolted to the columns.

Fracture near interface of weld and column flange

Fracture through column

ATC-20

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### MOMENT FRAME CONNECTION

ATC-20

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### STEEL BRACED FRAMES

**FEMA Building Type S2 STEEL-BRACED FRAMES**

Braced frames often placed within shaft walls

Steel beams and columns

Nonstructural exterior cladding often window wall or paneled construction

Selected frames in each direction constructed as braced frames. See chapter 3.

These buildings consist of a frame assembly of steel columns and beams. Lateral forces are resisted by diagonal steel members placed in selected bays. Floors are cast-in-place concrete slabs or metal deck and concrete. These buildings are typically used for buildings similar to steel moment frames, although one more often low rise.

The S2A building type is similar but has floors and roof that rest on flexible diaphragms such as wood or spigotted metal deck. This is a relatively uncommon building type and is used mostly for smaller office or commercial buildings in which the live loading of concrete floors is not needed.

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11

### STEEL BRACED FRAME

SINGLE DIAGONAL

DOUBLE DIAGONAL

CHEVRON

ECCENTRIC BRACED FRAME

Beam Specially Strengthened at Eccentric Joints

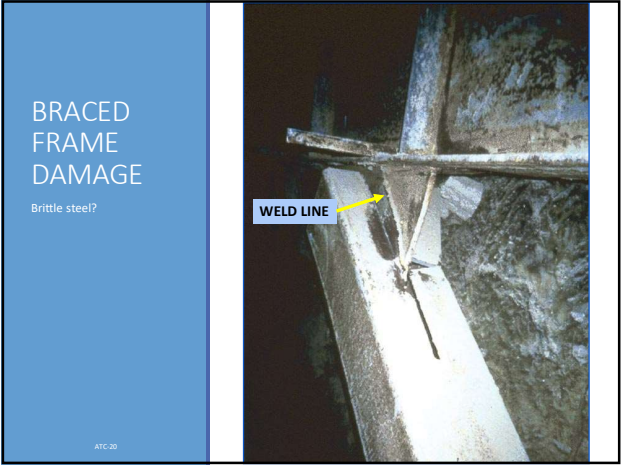
WABO BSE Module 11

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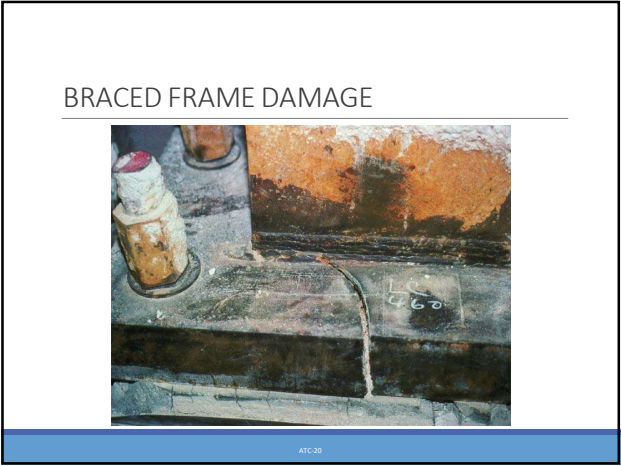




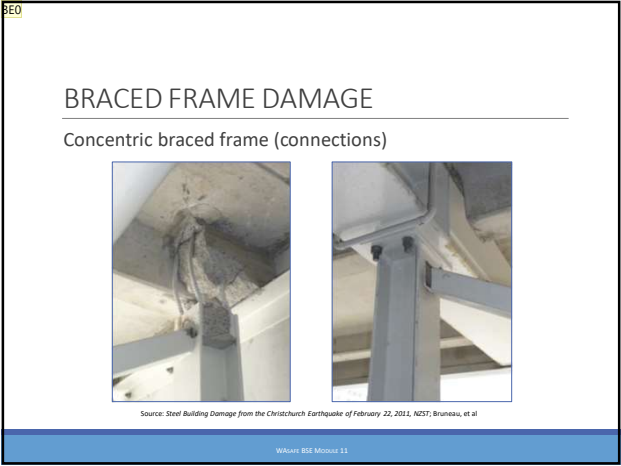
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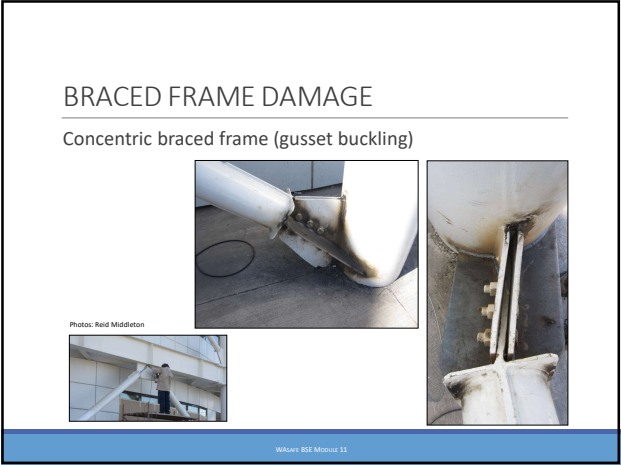
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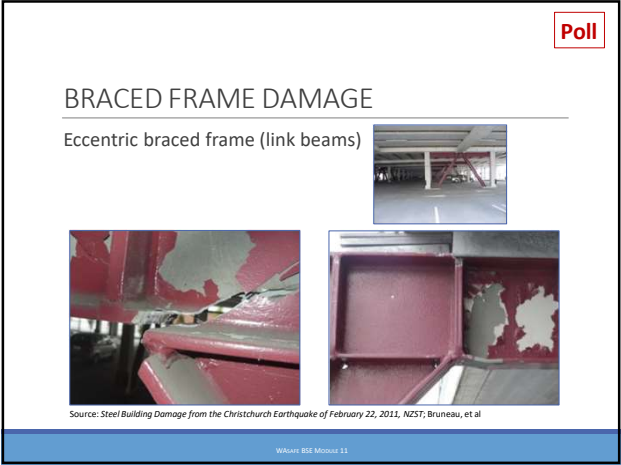
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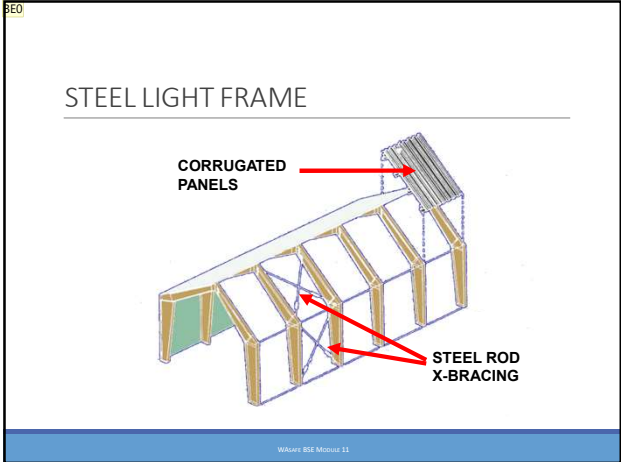
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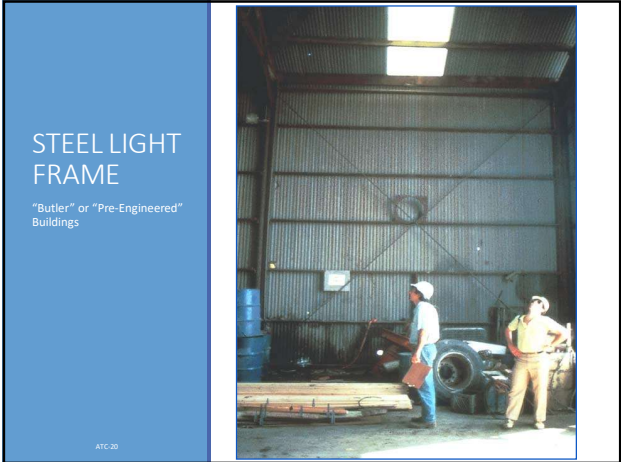
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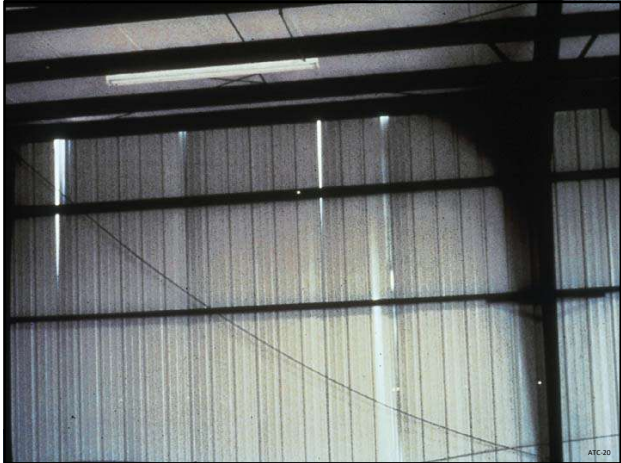
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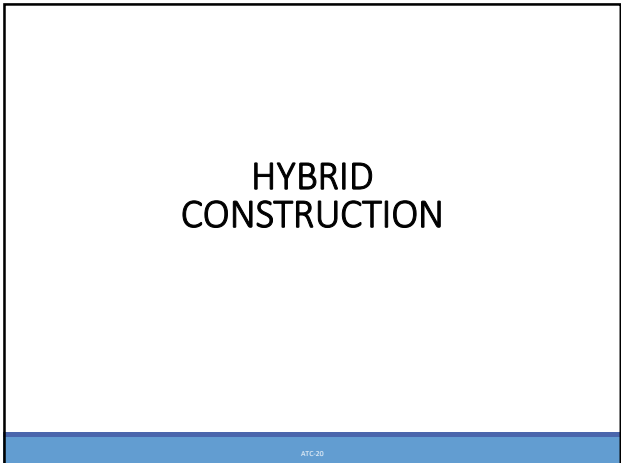
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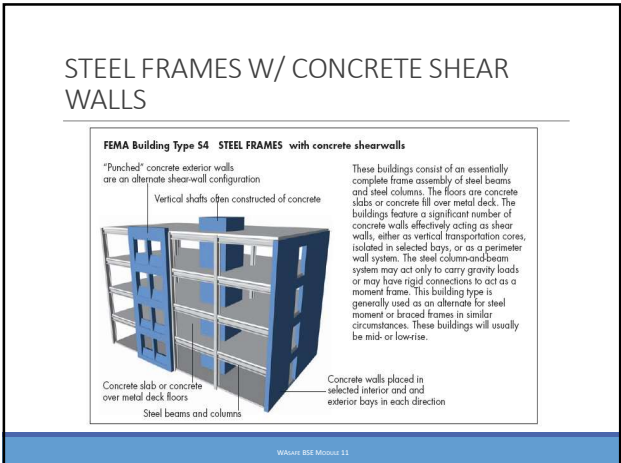
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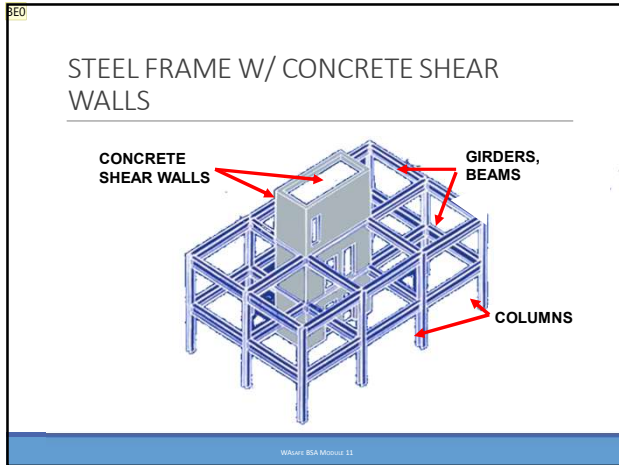
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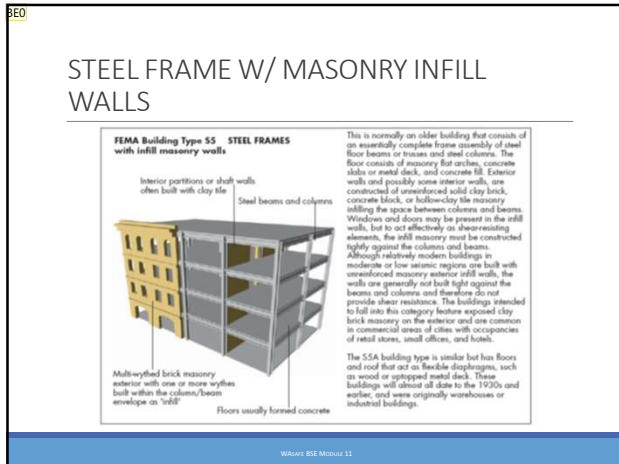
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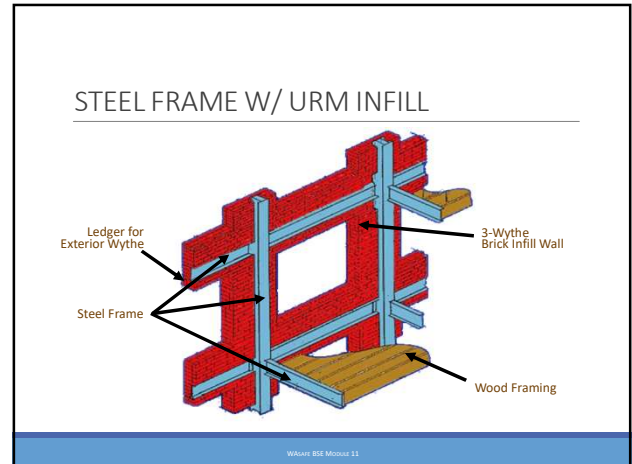
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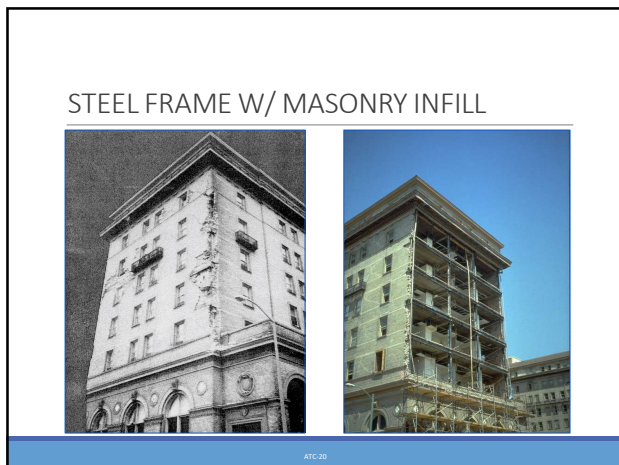
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CONCRETE FRAME W/ MASONRY INFILL



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Photo: Bralier

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MASS TIMBER W/ CONCRETE CORE



Source: Architects Magazine

32

# MANUFACTURED HOMES

ATC-20

1

## DAMAGE TO MANUFACTURED HOMES

---

- Off their piers, blocks, or jack stands either partially or totally
- Piers penetrating the interior floor decking
- Fully or partially burned
- Energizing of metal skin in older units
- Utilities damaged and turned off
- Water heater movement effecting venting and/or gas supply
- Displaced sewer connections

ATC-20

2

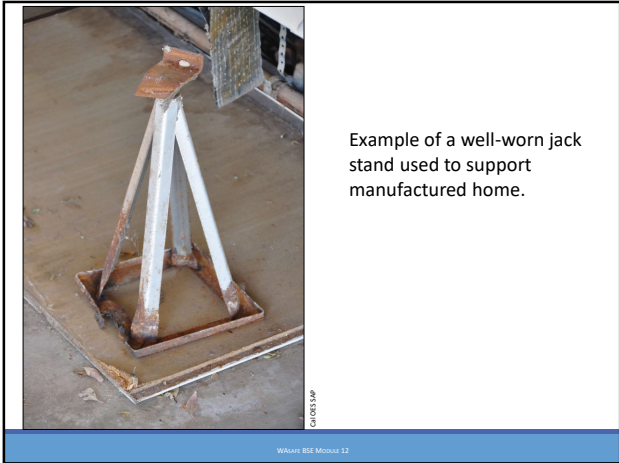
## MANUFACTURED HOME EVALUATION PROCEDURES

---

- Stability of the jack stands
- Safety of accessories, awnings, etc.
- Condition of utilities
- Home ingress and egress
- Geotechnical

ATC-20

3



4



5

# NONSTRUCTURAL ELEMENTS

ATC-20

6

### NONSTRUCTURAL ELEMENTS

- Parapets, chimneys, ornamentation
- Cladding and glazing
- Partitions
- Suspended ceilings, raised floors
- Tanks, piping, and ductwork
- Equipment
- Furnishings and contents

ATC-20

7



DISLODGED CLAY ROOF TILES CREATE A FALLING HAZARD

ATC-20

8



ATC-20

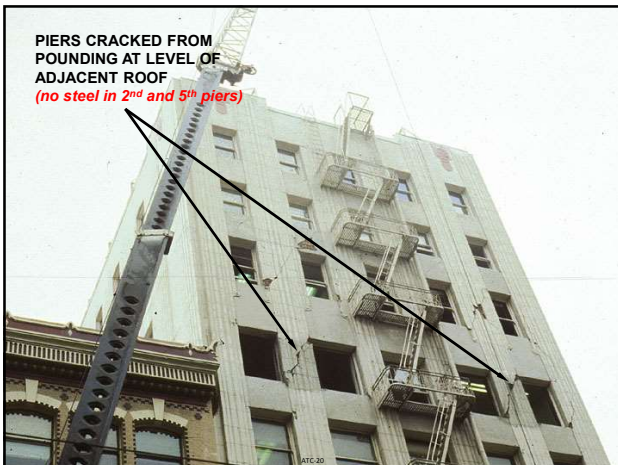
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Photo: Sika

10



ATC-20

11



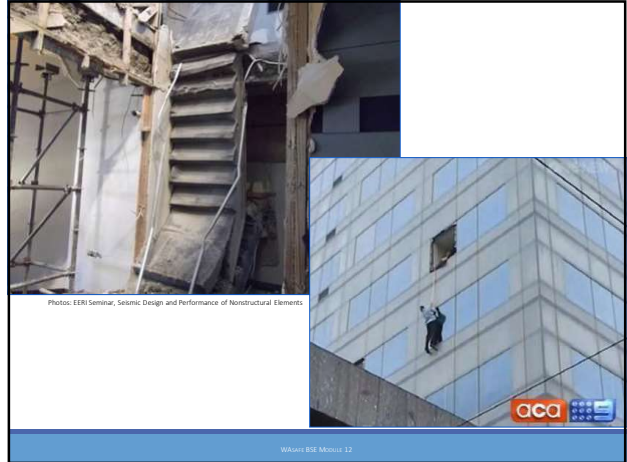
ATC-20

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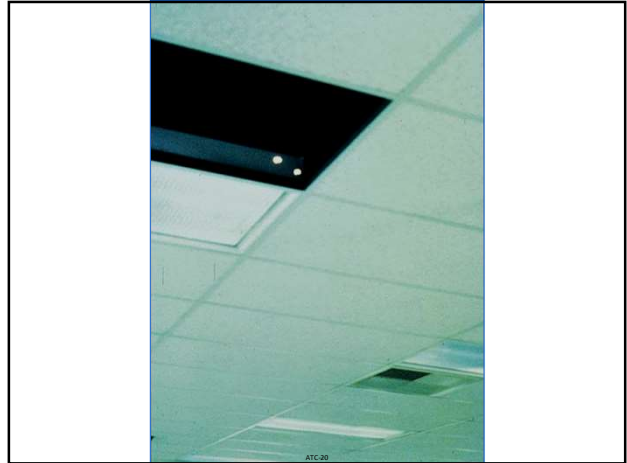
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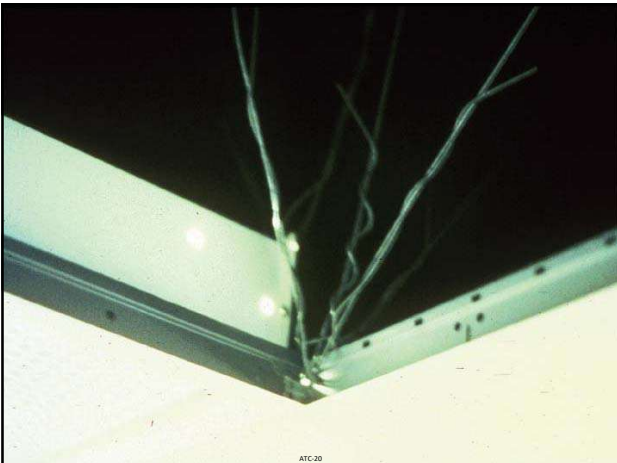
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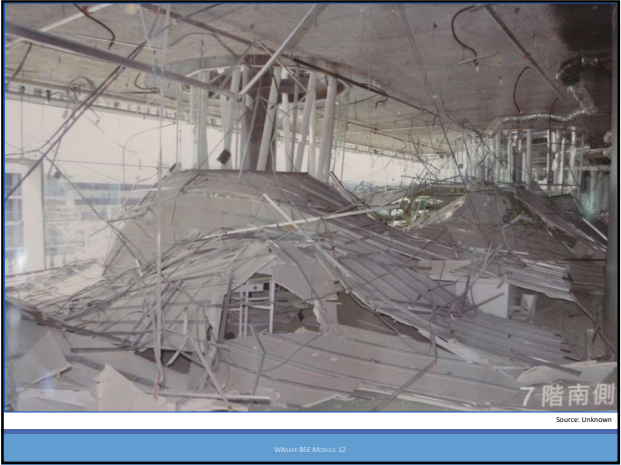


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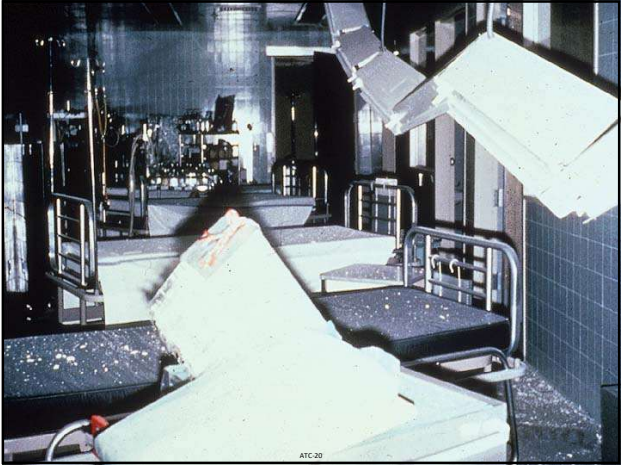


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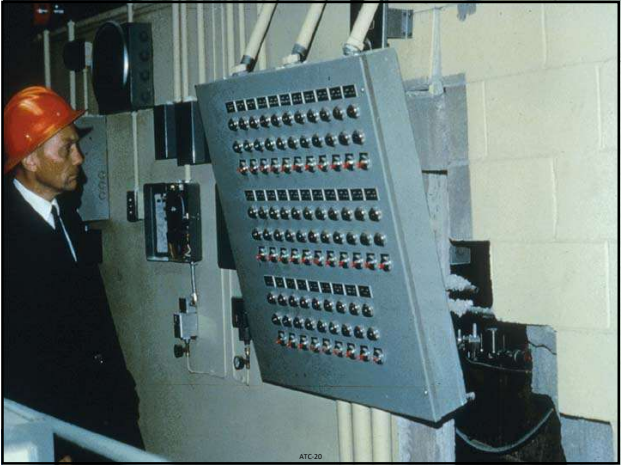




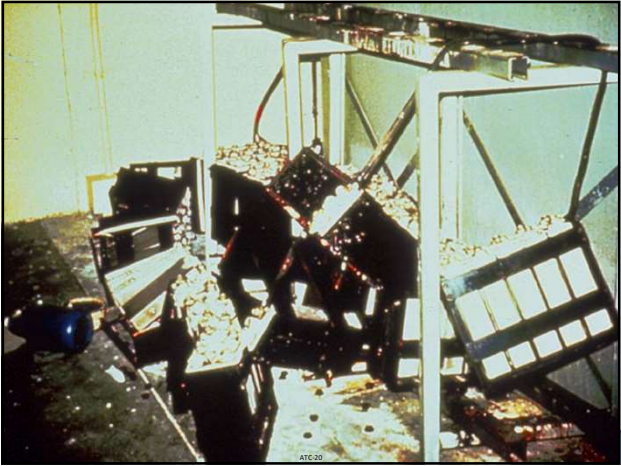
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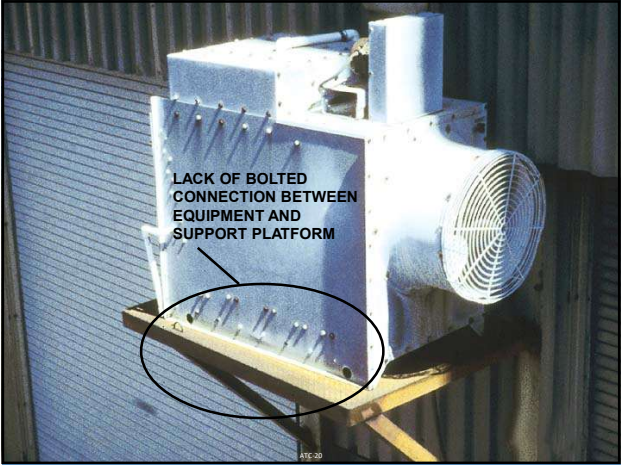
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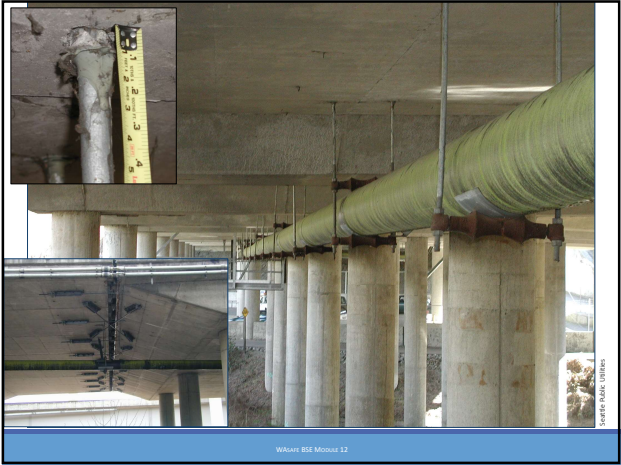


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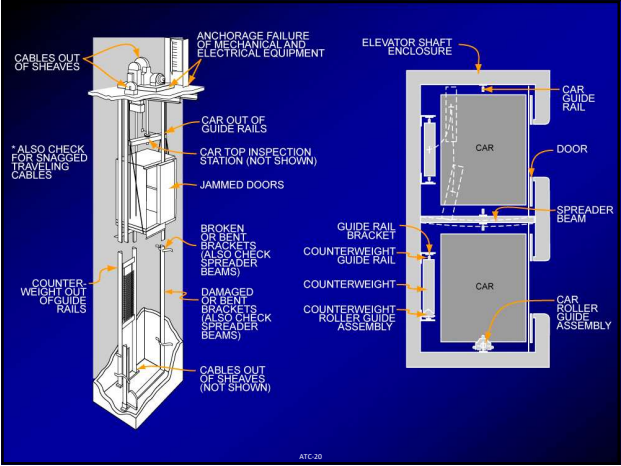




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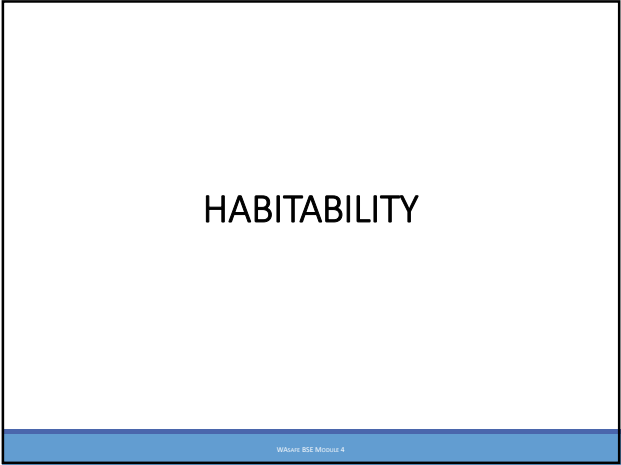
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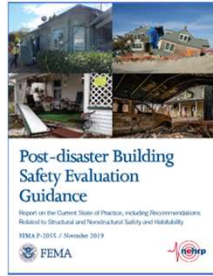


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### HABITABILITY – WHAT IS IT?

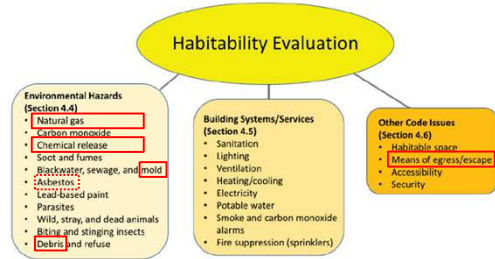
- Used in FEMA P-2055
- Equated with “occupiability”
- Not limited to residential
- Evaluation based on factors other than structural



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### HABITABILITY EVALUATION



Source: FEMA P-2055-1

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### HABITABILITY POLICIES

- Building Official needs to decide:
- Add habitability as a criterion for placards?
  - Which issues must be evaluated?
  - What is unsafe?
  - Flexibility in larger events?

Develop and communicate standards to BSEs



Source: FEMA P-2055-1

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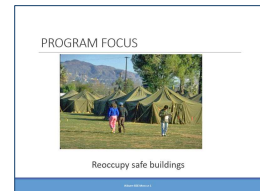
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### HABITABILITY POLICIES (POLITICS!)

- Building Official needs to decide:
- Add habitability as a criterion for placards?
  - Which issues must be evaluated?
  - What is unsafe?
  - Flexibility in larger events?

Develop and communicate standards to BSEs

WAsafe encourages erring on side of allowing safe buildings to be reoccupied



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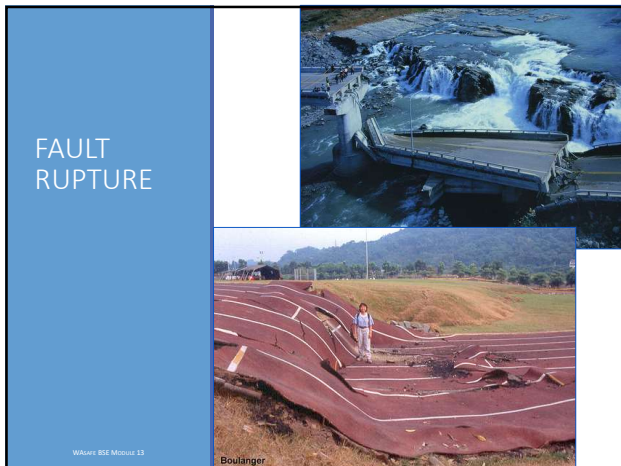
# GEOTECHNICAL HAZARDS

ATC-20

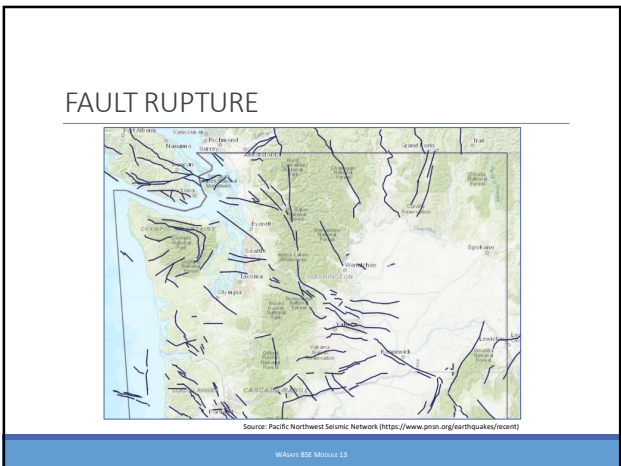
1

- ## GEOTECHNICAL HAZARDS
- Fault rupture
  - Basin amplification
  - Soft Soil Effects
    - Increased shaking
    - Liquefaction/Lateral spreading
  - Landslides
- WAsafe BSE Module 13

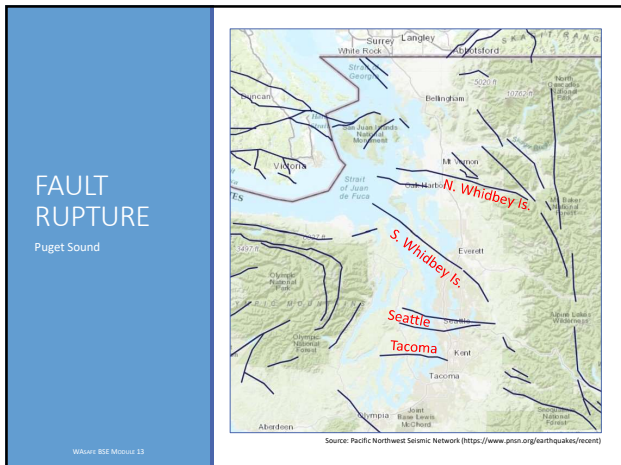
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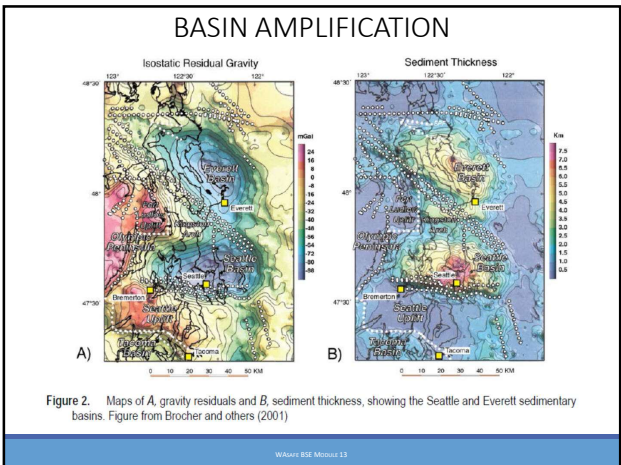
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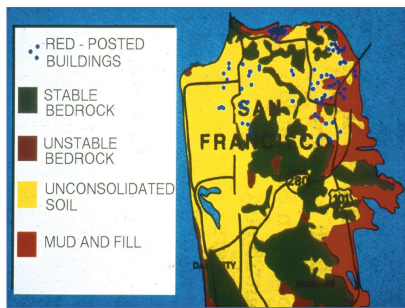


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### SOFT SOIL EFFECTS – INCREASED SHAKING



ATC-20

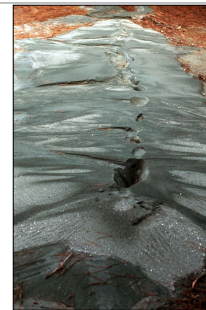
7

### SOFT SOIL EFFECTS - LIQUEFACTION

Phenomenon in which soil strength and stiffness are significantly reduced by earthquake shaking

Strength loss in soil due to build-up of water pressure

Occurs in loose, saturated, sandy and silty soils



Source: <https://www.flickr.com/photos/vepostcard/>

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### LIQUEFACTION EFFECTS

Settlement and differential settlement (bearing capacity failure)

Loss of deep foundation capacity (settlement or breakage of piles)

Lateral spreading

Slope failure

Effect on ground motions

Flooding and uplift of utilities

Damage over very large areas



SEAW Tohoku Reconnaissance Team

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BUILDING FOUNDATION SETTLEMENT DUE TO SOIL LIQUEFACTION



11

PILE SUPPORTED, NO SETTLEMENT

SHALLOW (RAFT) FOUNDATION, 27" SETTLEMENT



GROUND, 15" SETTLEMENT

Photo: SEAW Tohoku Reconnaissance Team

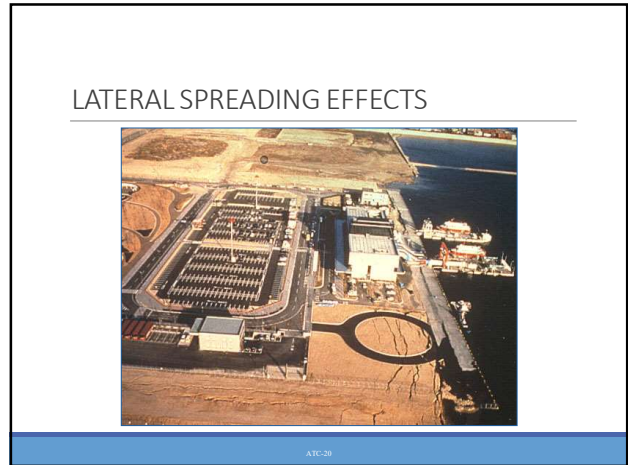
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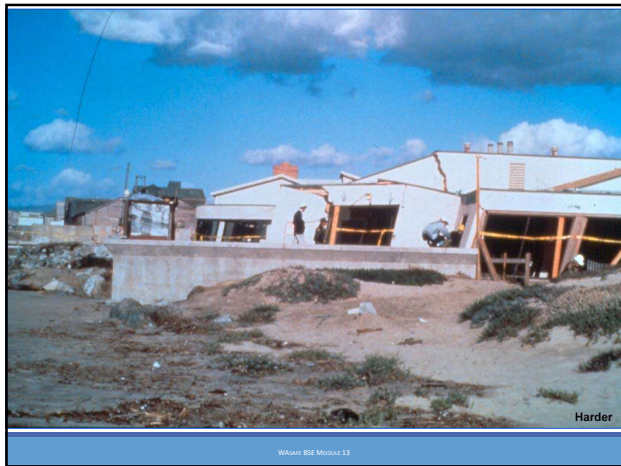




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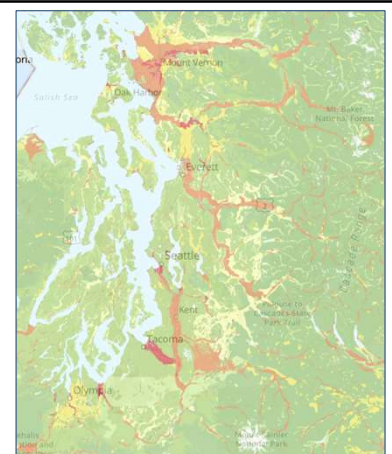


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**LIQUEFACTION/  
LATERAL  
SPREADING**


Puget Sound  
<http://geologyportal.dnr.wa.gov/>

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**LIQEFACTION/LATERAL SPREADING  
(LYNNWOOD)**



<http://geologyportal.dnr.wa.gov/>

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**LANDSLIDES**

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Photo: Los Angeles County


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**LANDSLIDES**

---

**Considerations for tagging:**

- Risk to life-safety - potential for near-term sliding
- Cause of slide
- Geology, groundwater, typical slide types in area
- Cracks, leaning trees, running groundwater, bulges at toe of slope



USGS

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**LANDSLIDES**

---

**Considerations for tagging (cont.):**

- Likelihood of aftershocks
- Foundation system of structure
- May be able to be conservative because of limited effect of tagging
- May need help from geotechnical consultant
- Likelihood of damage to buildings above/below

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**LANDSLIDES**

---

**Considerations for tagging (cont.):**

- Undamaged but threatened=> Yellow tag (Restricted Use) for recovery of belongings
- Evaluate damaged buildings using standard structural criteria
- Heavy damage, loss of foundation support => Red tag (Unsafe)

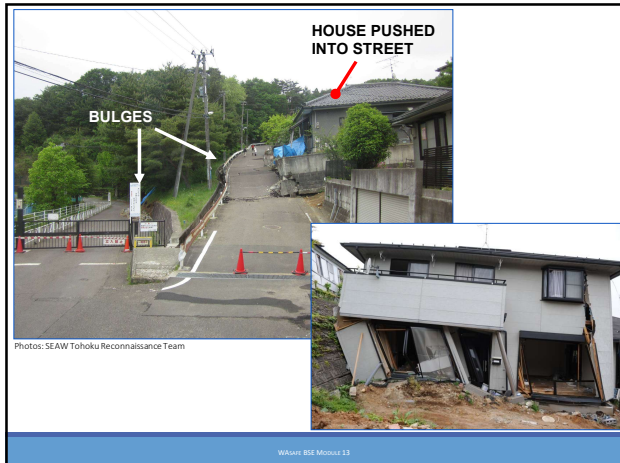


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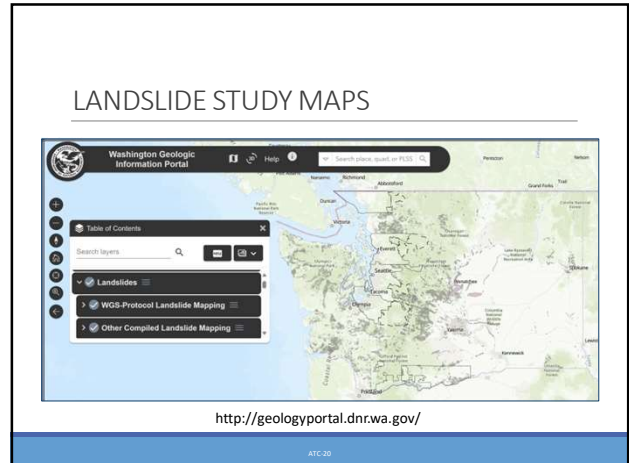
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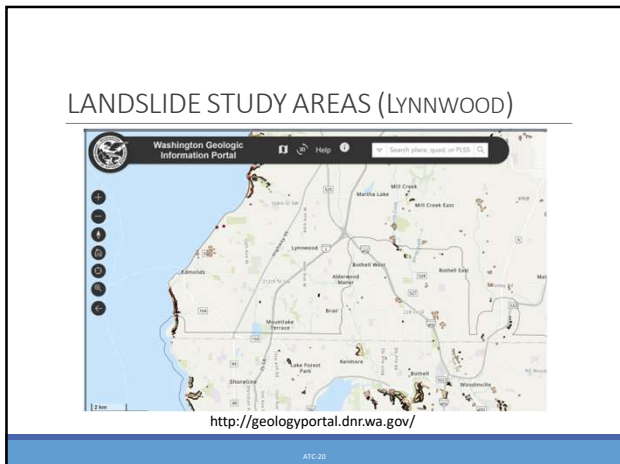




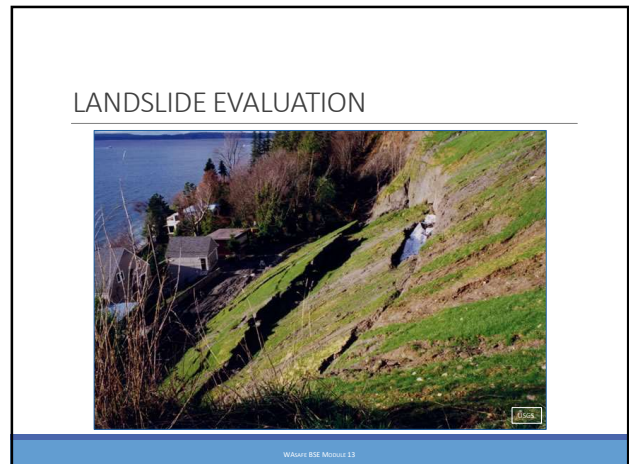
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LANDSLIDE DOCUMENTATION

Site damage (cracks in slope)

Structural vs minor/cosmetic damage to structure

- Collapse/partial collapse of structure
- Severe racking of walls or other obvious damage/signs of distress
- Foundation damage or loss of support

Ongoing slope movement under current conditions

Debris stacked up against structure

Obvious drainage/seepage issues

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# OTHER NON-SEISMIC HAZARDS

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## NON-SEISMIC HAZARDS

- Wind Events (ATC-45)
  - Hurricanes
  - Tornadoes
  - Other Wind Storms
- Floods (ATC-45)
- Blast (explosions)
- Fires



CHAPMAN, KS TORNADO 2008  
DAMAGED NEIGHBORHOOD  
Photo: CALDES SAP

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## GENERAL PRINCIPLES

Structural safety principles are same as seismic

- Focus on immediate stability/imminent hazard
- Assume no immediate following event

Follow instructions/policies of local jurisdiction

- Placards required, even if no structure remaining?
- Do we know the structure belongs on the site?


Be aware of, protect self from additional hazards

- Mold, chemicals (floods)
- Hazardous dust (blast)
- Airborne carcinogens (fire)

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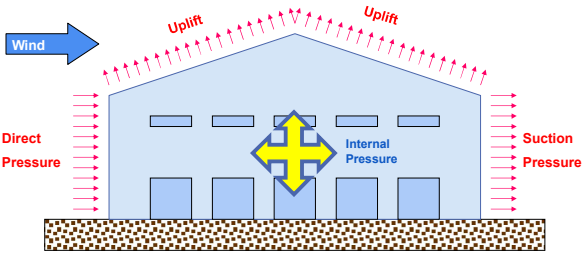
## RESOURCE DOCUMENT (WIND & FLOOD)



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## WIND EFFECTS ON BUILDINGS



Source: Missouri S&VE

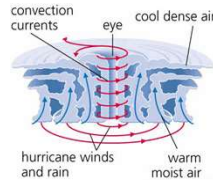

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## ATC-45 HURRICANES

≥ 74 mph winds

Building damage:  
External & internal pressures (wind force)  
Storm surge/flooding  
Debris impact

CALDES SAP

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**ATC-45  
TORNADOS**

Smaller area,  
greater intensity  
vs hurricanes

**Building damage:**  
Strong winds near  
center ( $\geq 200$  mph)  
Pressure drop at  
center

Clipart.com

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ENHANCED FUJITA TORNADO SCALE		
Scale	Speed (mph)	Typical Damage
EF0	65 - 85	<b>Minor or no damage</b> Peels surface off some roofs, some damage to gutters or siding.
EF1	86-110	<b>Moderate damage</b> Roofs severely stripped, Mobile homes overturned or badly damaged; Severe damage to large buildings; Loss of exterior doors, windows and other glass broken.
EF2	111-135	<b>Considerable damage</b> Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes destroyed; light-object missiles generated.
EF3	136- 165	<b>Severe damage</b> Entire stories of well-constructed houses destroyed; Severe damage to large buildings; Structures with weak foundations are badly damaged.
EF4	166-200	<b>Extreme damage</b> Well-constructed and whole frame houses completely leveled; Cars and other large objects thrown Small missiles generated.
EF5	Over 200	<b>Total destruction of buildings</b> Well-built houses leveled off foundations; Reinforced concrete structures critically damaged; Many tall buildings collapse.

Source: Missouri S&T

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### TORNADO DESTRUCTION

Photo: CA/DES SAP      Photo: Preuss

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### TORNADO DAMAGE

Missile

Roof Uplift

PHOTO: PREUSS

Rooftop Units

Moved off Foundation

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### ATC-45 WIND STORMS

Linear wind storms (West Coast)

Building damage:  
High wind  
Wind-driven waves

CHLOES SAP

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### LINEAR WIND STORM DAMAGE

PHOTO: PREUSS

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### WIND SPEED-UP EFFECT

Expect increased damage behind tops of escarpments, ridges, and hills

ESCARPMENT

3-D RIDGE OR 3-D ASYMMETRICAL HILL

ASCE 7-22, Figure 26.8-1. Topographic factor,  $K_{zt}$

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### WIND SPEED-UP EFFECT - SEATTLE MAPS

<https://seattle.gov/hdc/resources/wind-load-factors>

Wind Tunnel 10  
Zone  
Page 1 of 8

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### ATC-45 FLOODS

Flash floods/other swift water

Inundation (slow-moving water)

Building damage:  
Water force on lateral force resisting system  
Foundation scour  
Unanchored buildings  
Mold, contaminated water

CHLOES SAP

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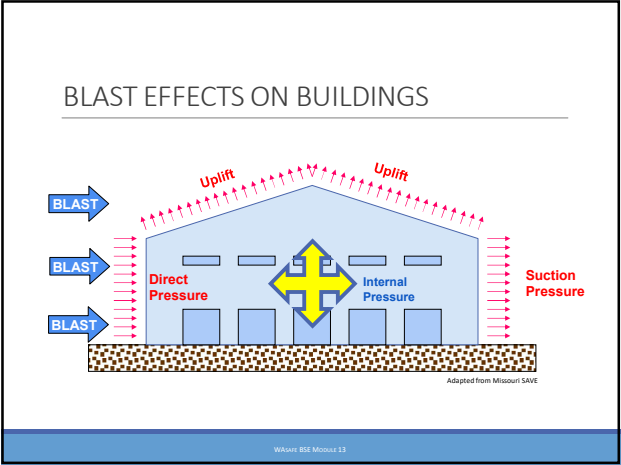
**BLAST/  
EXPLOSIONS**

Building damage  
Overpressure on/in  
structures

Evaluate nearby  
buildings

Photo: www.osm2.com

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**FIRE**

Large-scale (wildfire)  
Individual buildings

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### FIRE – LARGE-SCALE (WILDFIRE)

- May still require placarding
  - See AHJ
- Free-standing masonry/concrete walls & chimneys



Photo: C/OES SAF

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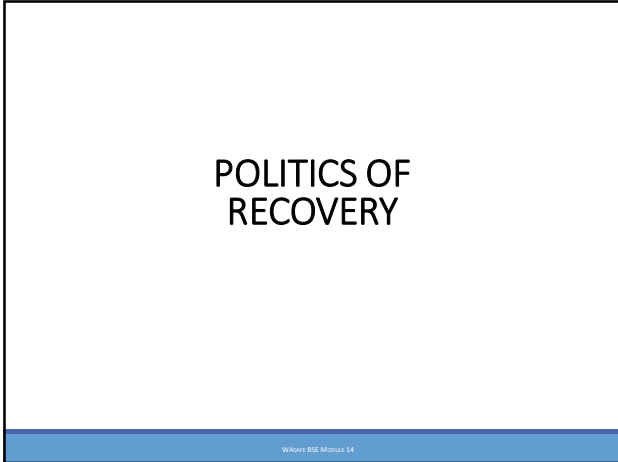
### FIRE – INDIVIDUAL BUILDINGS

- Assess effect on structural stability
  - Sagging floors
  - Spalled concrete
  - Burned wood beams/bearing walls
  - Out of plane wall stability



Source: USFA

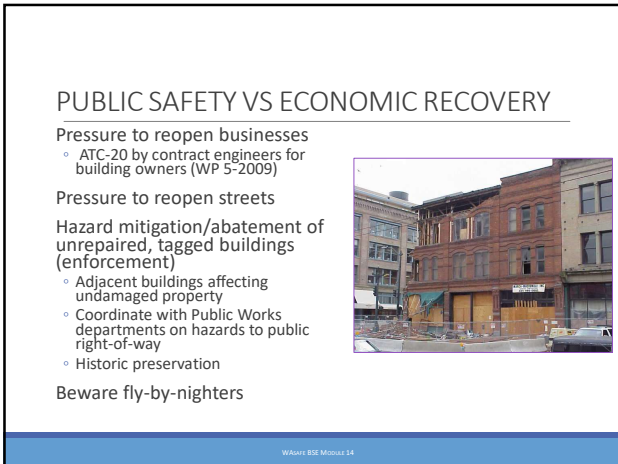
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# NEXT STEPS

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## NEXT STEPS (Individuals)

Personal preparation (work and home)

Decide if want to volunteer

- In-state – WAsafe
  - See WAsafe Coalition website (<https://wasafecoalition.org/volunteer>)
  - Apply through member organization (AIA, ASCE, SEAW, WABO) via WAserv database ([www.waserv.org](http://www.waserv.org))
  - Unaffiliated => apply through WABO
- Out of state (private sector)
  - California Office of Emergency Services Structural Assessment Program (Cal OES SAP) ([www.caloes.ca.gov](http://www.caloes.ca.gov))
    - Search for Safety Assessment.
  - Disaster Response Alliance (ICC/NCSEA) ([www.disasterresponse.org](http://www.disasterresponse.org))

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## NEXT STEPS (Building Officials)

Personal preparation (work and home)

Prepare before the event happens

- Gather supplies (or plan how to procure them quickly)
  - ATC-20 placards, forms
    - Electronic or paper forms (or both)
  - Other supplies (e.g., barrier tape, clipboards, volunteer ID cards, waterproof markers & tape)
- Prepare policies/procedures for onboarding volunteers
- Engage with local/regional Emergency Managers
  - Preparation to request, register/deputize, and care for WAsafe BSEs
- See WAsafe Coalition website for more information (<https://wasafecoalition.org/requesting-help>)

Explore mutual aid agreements with neighboring jurisdictions

Engage with local building owners and design professionals to explore establishing Accelerated Building Reoccupancy programs

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## NEXT STEPS (Emergency Managers)

~~Personal preparation (work and home)~~

Engage with/support local/regional building official(s)

- Preparation to request, register/deputize, and care for WAsafe BSEs
  - See WAsafe Coalition website for more information (<https://wasafecoalition.org/requesting-help>)
- Prepare for post-event supply procurement/resupply
- Explore mutual aid agreements with neighboring jurisdictions
- Engage with local building owners and design professionals to explore establishing ABR programs

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10

## SLIDE CREDITS

---

ASCE/SEI Chilean Earthquake Assessment Teams  
 Christopher Arnold  
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 California Office of Emergency Services  
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 H. J. Degenkolb Associates  
 Jon Egan  
 Ronald P. Gallagher  
 Geotechnical Extreme Events Reconnaissance (GEER) Teams  
 GeoEngineers (J. Gordon)  
 Dr. Les Harder  
 Doug Lindquist  
 Los Angeles Department of Building and Safety  
 Los Angeles County Department of Building and Safety  
 John Meehan  
 National Fire Protection Association  
 National Oceanic and Atmospheric Administration  
 National Paint and Coatings Association  
 National Research Council

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## SLIDE CREDITS (CONT.)

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Pacific Northwest Seismic Network  
 San Francisco Bureau of Building Inspection  
 Seattle Department of Construction and Inspections  
 Shannon & Wilson, Inc.  
 Stephen D. Pfeiffer  
 RDD Consultants, Inc.  
 Reid Middleton, Inc.  
 Robert Reitherman  
 Jonathan C. Siu  
 Yet M. Siu  
 SEAW Tohoku Reconnaissance Team  
 Steinbrugge Slide Collection, EERC  
 James Stratta  
 U.S. Geological Survey (Art Frankel)  
 Tom Wangerin  
 Washington Department of Labor & Industries  
 Wiss, Janney, Elstner Associates  
 Kit Wong

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**WASAFE**  
**BUILDING SAFETY EVALUATIONS**  
**(ATC 20/45 PLUS)**

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THANK YOU FOR ATTENDING!

WASAFE BSE Module 14

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