ATC's Role in Functional Recovery

ICC/CALBO Seismic Roundtable
Sacramento, California
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Outline

- Applied Technology Council overview and organization
- Past projects of significance
- New release relevant to functional recovery
- Take-aways and a call to action

Overview and Organization

- Created by engineers for engineers
- 501(c)(3) Non-profit Corporation
- Board of Directors – develops policy
  - SEAOC, SEAoNY, NCSEA, ASCE, WCSEA, Others – appointed
- Mission

To develop and promote state-of-the-art, user-friendly engineering resources and applications for use in mitigating the effects of natural and other hazards on the built environment

Mission

Save the world one book at a time…

Project Delivery Model

- Technical Staff – direct projects, prepare reports
- Technical Consultants – conduct project work
  - Structural engineers from diverse firms, researchers from various institutions
- Products – non-proprietary, objective, reflect a broad spectrum of engineering opinion

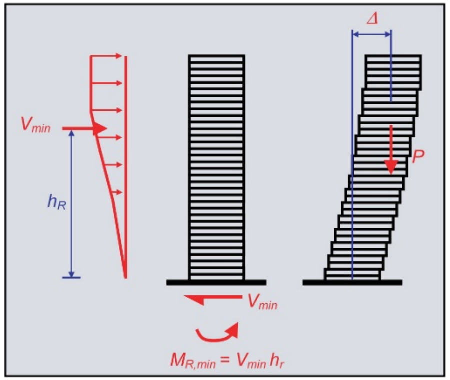
Technology Development Continuum

ATC

Need → Fundamental Research → Engineering Design → Policies, Codes, Standards

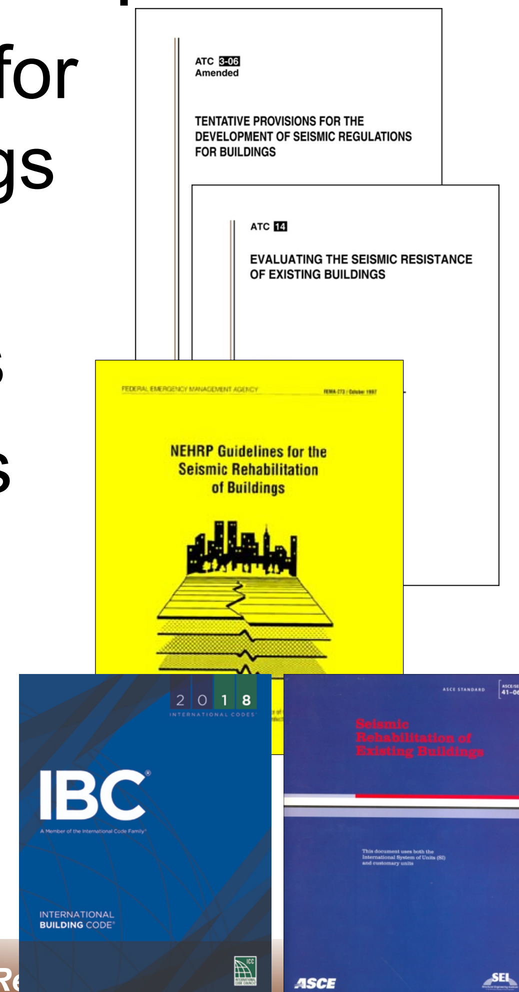
Functional Recovery

Cal, Stanford, Ucla, W, USC, OS, I, CSU, CU, Cal Poly



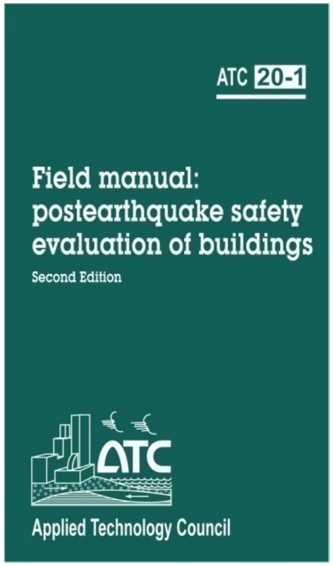
Past Projects of Significance

- 45-year history, more than 300 reports
  - ATC-3-06: Tentative Provisions for Seismic Regulations for Buildings
  - ATC-14: Evaluating the Seismic Resistance of Existing Buildings
  - ATC-33 (FEMA 273): Guidelines for Seismic Rehabilitation
  - Basis for seismic design in the building code and ASCE reference standards



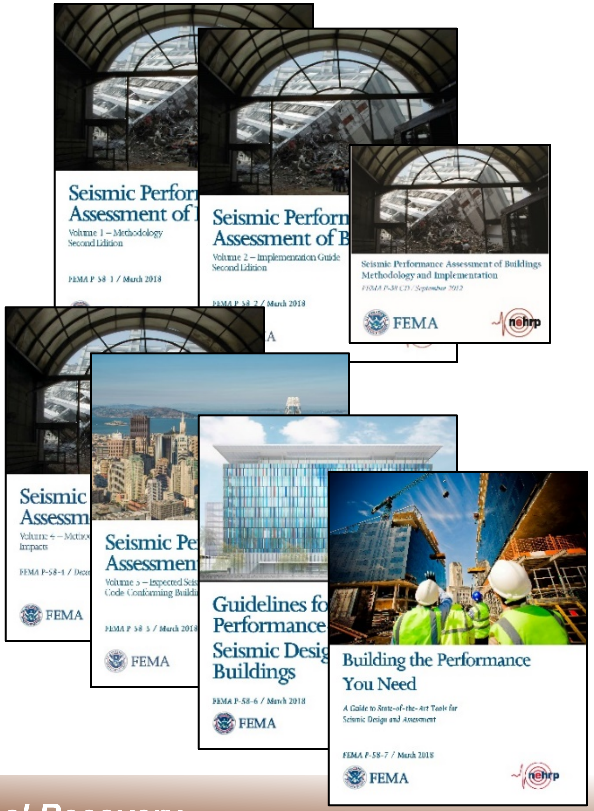
ATC "Scotch Tape"

- Even if you don't know who ATC is or what ATC stands for…
  - ATC-20: Postearthquake Safety Evaluation of Buildings
  - Basis for inspection and posting of buildings after damaging events



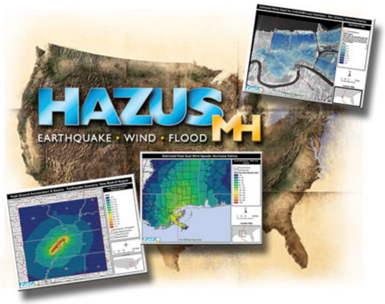
New Release

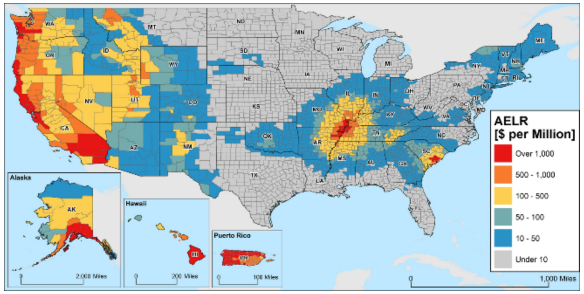
- ATC-58 Project on Next-Generation Performance-Based Seismic Design
  - FEMA P-58 *Seismic Performance Assessment of Buildings, Methodology and Implementation* (2018)
  - New technology that creates an opportunity for moving resilience concepts forward

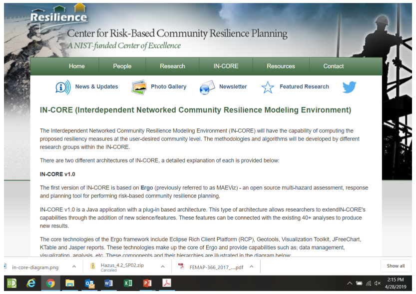


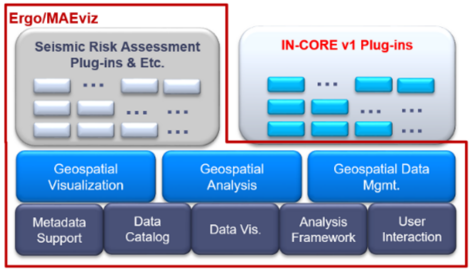
FEMA P-58 Context

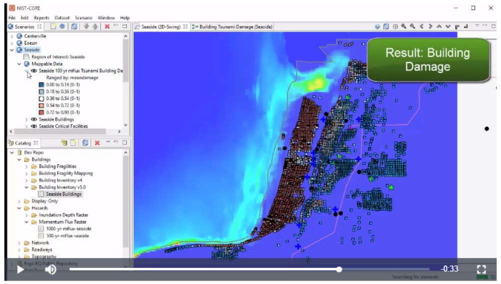
Regional/Community Scale



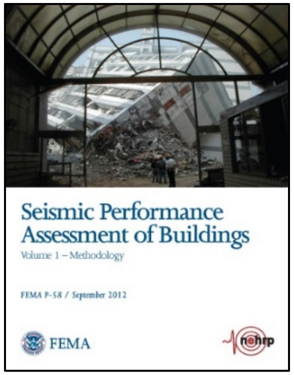


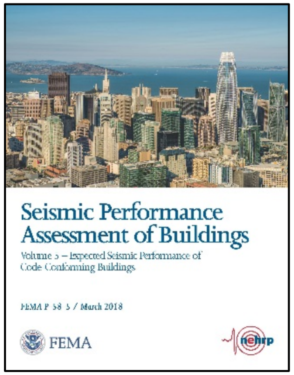


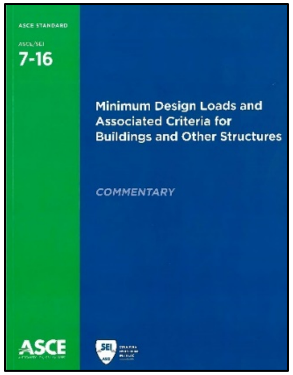




Building/Asset Scale



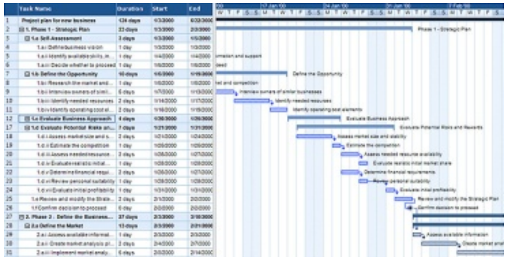




What we design today is the resilience we will provide tomorrow

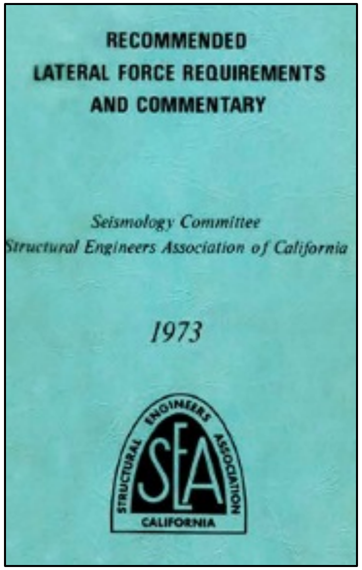
Next-Generation Performance Metrics

- Probable consequences and explicit consideration of uncertainty
  - Casualties
  - Repair costs
  - Repair time
  - Unsafe placarding
  - Environmental Impacts



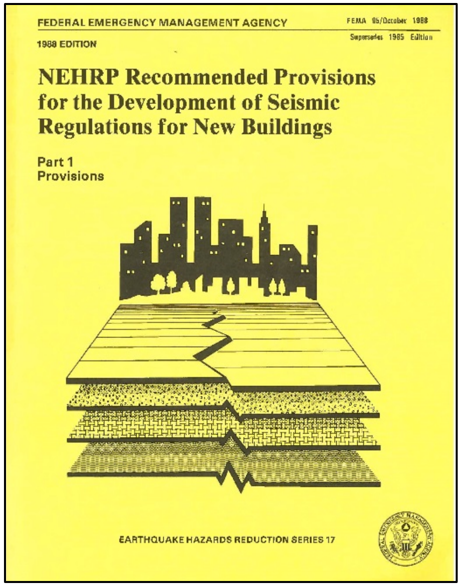
Early Performance Statements

- SEAOC Blue Book:
  - Resist minor earthquakes without damage
  - Resist moderate earthquakes with some nonstructural damage
  - Resists major earthquakes with structural/nonstructural damage
  - Resist the most severe earthquakes without collapse



Early Performance Statements

- 1988 NEHRP Provisions:
  - Minimize hazard to life
  - Increase expected performance of higher occupancy structures
  - Improve functional capability of essential facilities
  - (2009) Minimize repair costs, where practical to do so

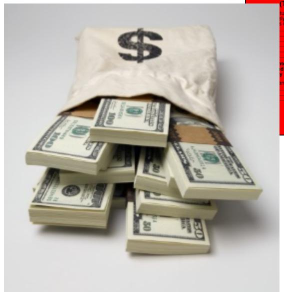


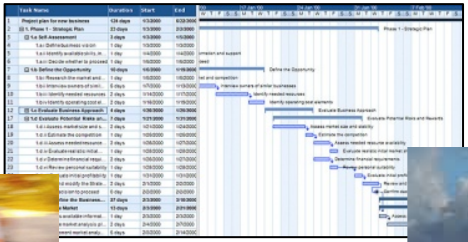
Recent Performance Statements

- FEMA P-695 (2009):
  - 10% Probability of collapse given MCE shaking intensity
- ASCE 7-10 Commentary
  - Quantitative structural reliability criteria based on FEMA P-695
- ASCE 7-16 Provisions
  - PBSD must meet reliability criteria specified in the standard

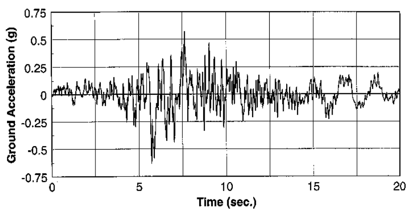
Future Performance Statements

- Performance needs have been evolving beyond life safety
- Some performance statements in building codes have been intentionally aspirational (inserted before we knew how to calculate)
- FEMA P-58 performance metrics provide a quantitative link to the future

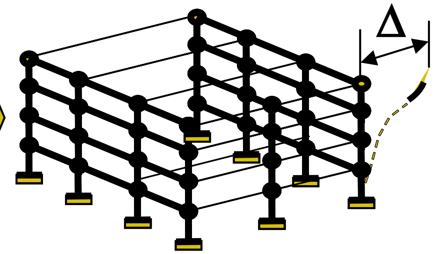




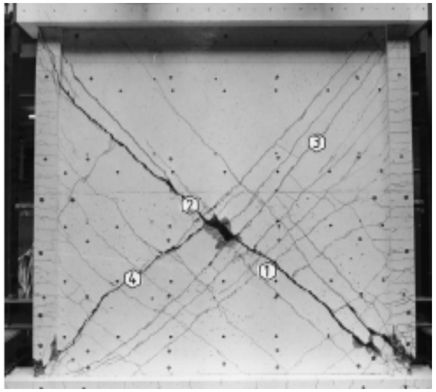
Next-Generation Assessment Process



Ground Motion



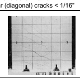
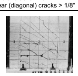
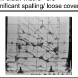
Structural Response



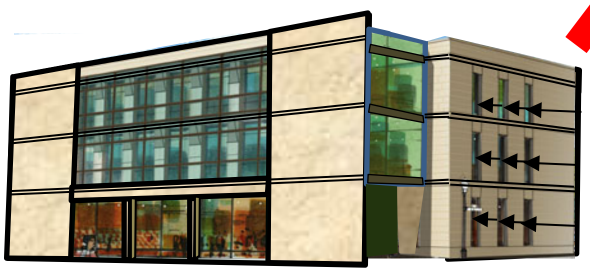
Damage

Fragility Specification

B1044.000 Reinforced Concrete Shearwalls

BASIC COMPOSITION	Reinforced concrete and finishes both sides		
Units for basic quantities	Square feet of wall area		
DAMAGES STATES, FRAGILIITES, AND CONSEQUENCE FUNCTIONS			
	DS1	DS2	DS3
DESCRIPTION	Flexural cracks < 3/16" Shear (diagonal) cracks < 1/16"	Flexural cracks > 1/4" Shear (diagonal) cracks > 1/8"	Max. crack widths >3/8" Significant spalling/ loose cover
ILLUSTRATION (example photo or drawing)			
MEDIAN DEMAND	1.5%	3.0%	5.0%
BETA	0.2	0.3	0.4
CORRELATION (%)	70%		
DAMAGE FUNCTIONS	Patch cracks each side with caulk Paint each side	Remove loose concrete Patch spalls with NS grout Patch cracks each side with caulk Paint each side	Shore Demo existing wall Replace Patch and paint
CONSEQUENCE FUNCTION			
Max. consequence up to lower quantity	$4.00 per sq ft up to 800 sq ft	$10.00 per sq ft up to 800 sq ft	$50.00 per sq ft up to 200 sq ft
Min consequence over upper quantity	$2.00 per sq ft over 4000 sq ft	$5.00 per sq ft over to 4000 sq ft	$30.00 per sq ft over 2000 sq ft
Beta (consequence)	0.2	0.3	0.3
TIMEFRAME TO ADDRESS CONSEQUENCES	days	weeks	months

Fragility Spec

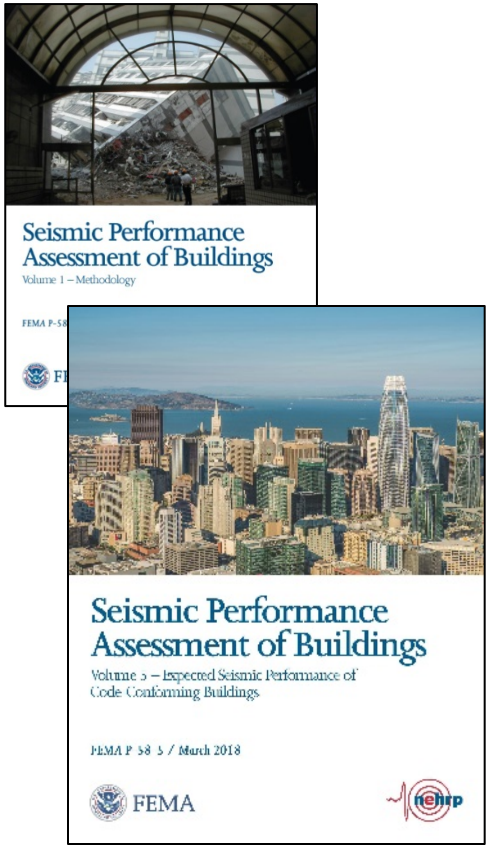


Building Performance Model

Consequences

FEMA P-58-5

- FEMA P-58 assessment of code-conforming buildings was needed to:
  - Benchmark current capability using FEMA P-58 metrics
  - Identify factors that contribute to performance
  - Provide a technical basis for development of performance objectives and design guidance

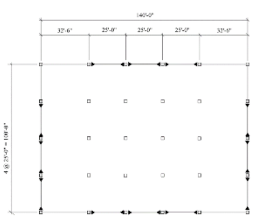


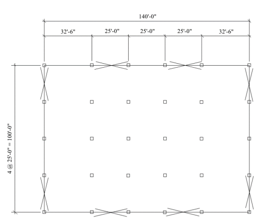
Archetype Design Space

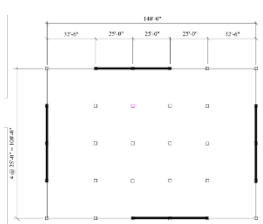
- 5 systems
- 2 occupancies
- 2 risk categories
- Low-, mid-, and high-rise variants
- 3 hazard levels
- 1,755 total

Table 2-9 Summary of Archetypes by Occupancy, System, Risk Category, and Building Height

Occupancy	Seismic Force-Resisting System	Risk Category	2-Story	3-Story	5-Story	12-Story
Office (975 archetypes)	Steel SMRF (195 archetypes)	II		■	■	■
		IV		■	■	
	RC SMRF (195 archetypes)	II		■	■	■
		IV		■	■	
	Steel BRBF (195 archetypes)	II	■		■	■
		IV	■		■	
	Steel SCBF (195 archetypes)	II	■		■	■
		IV	■		■	
	Special RCSW (195 archetypes)	II	■		■	■
		IV	■		■	
Healthcare (780 archetypes)	Steel SMRF (156 archetypes)	II		■	■	
		IV		■	■	
	RC SMRF (156 archetypes)	II		■	■	
		IV		■	■	
	Steel BRBF (156 archetypes)	II	■		■	
		IV	■		■	
	Steel SCBF (156 archetypes)	II	■		■	
		IV	■		■	
	Special RCSW (156 archetypes)	II	■		■	
		IV	■		■	

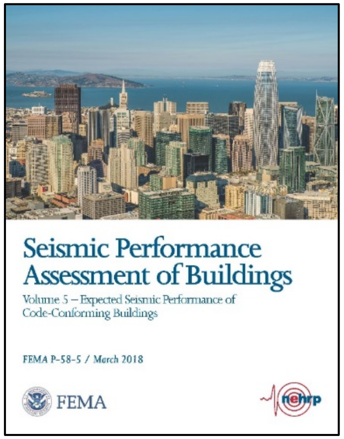


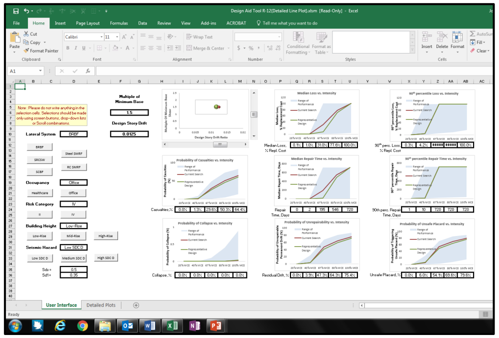




Summary Findings

- Performance is NOT uniform across systems
- You CAN control performance with design
- Strength and stiffness are key
- Risk Category IV design criteria improve performance





Expected Code Performance

Table 6-1 Generalized Performance Expectations for Code-Conforming Buildings

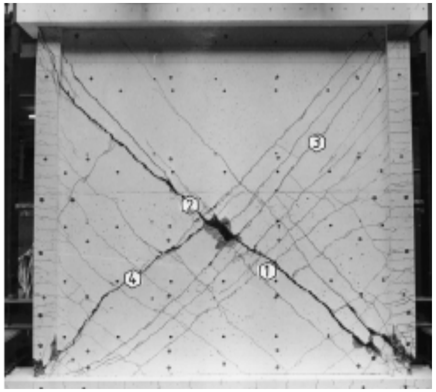
Performance Measure	Performance Expectation	
	Design EQ	MCE
Risk Category II – Healthcare (Medical Office Building or Laboratory)		
Repair Cost	20%	40%
Repair Time	60 days	180 days
Casualty Rate	1.0%	2.0%
Probability of Unsafe Placard	20%	40%
Repairability	85%	65%
Risk Category IV – Healthcare (Hospital)		
Repair Cost	10%	20%
Repair Time	45 days	100 days
Casualty Rate	0.5%	1.5%
Probability of Unsafe Placard	10%	25%
Repairability	95%	85%

Use in Future Code Performance Objectives

- FEMA P-58-5 now provides quantitative information for conversations to:
  - Determine acceptable performance
  - Determine appropriate performance targets
  - Consider necessary levels of confidence
  - Consider relative system performance
  - Define functional performance
  - Design buildings to achieve function

Another Take-Away

- Good seismic design is based on stable, ductile performance
- Ductility is damage
- Code-conforming buildings will experience damage
- There is a disconnect between current seismic design paradigms and resilience concepts



Damage

Consequences

What can we do?

- Before performance-based design, engineers made decisions on behalf of society
  - Codes were made safe because we knew people wanted safety
- It is now obvious that society wants resilience (in some form)
  - We need to create a code that offers a functional performance objective for buildings and infrastructure

Thank you!