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# ***ATC's Role in Functional Recovery***

ICC/CALBO Seismic Roundtable  
Sacramento, California  
April 30, 2019

Jon A. Heintz  
Executive Director  
Applied Technology Council

# Outline

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- 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

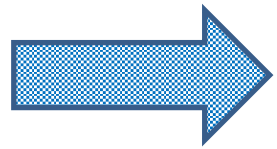
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- Created by engineers for engineers
- 501(c)(3) Non-profit Corporation
- Board of Directors – develops policy
  - SEAOC, SEAoNY, NCSEA, ASCE, WCSEA, Others – appointed
- Mission

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

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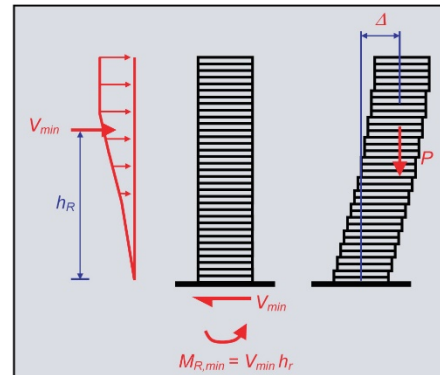
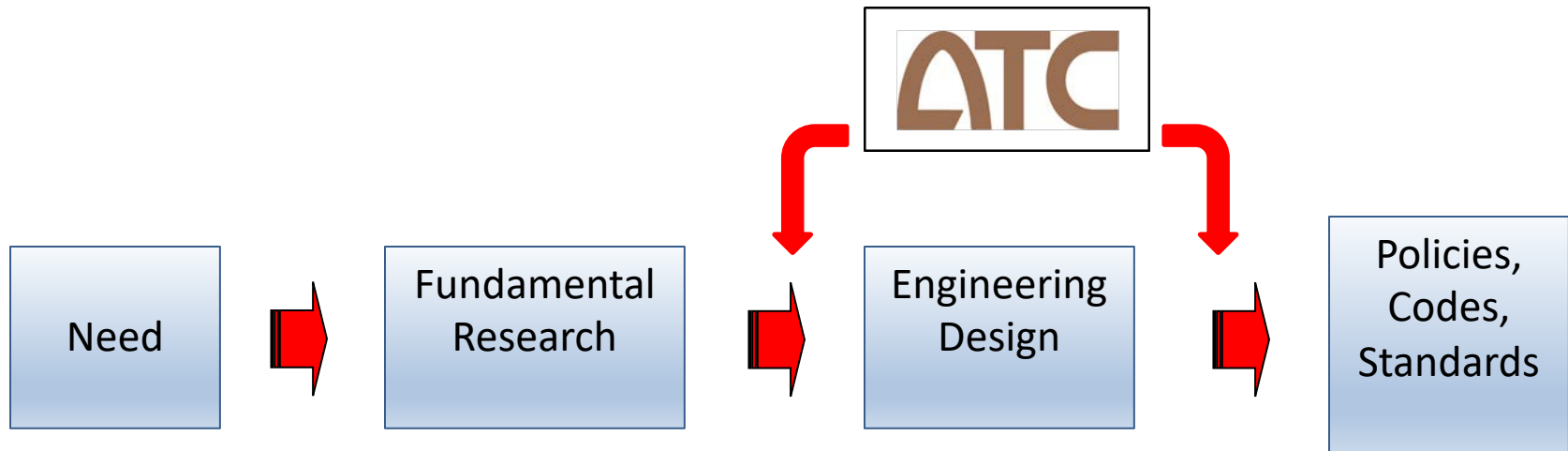
***Save the world one book at a time...***

# Project Delivery Model

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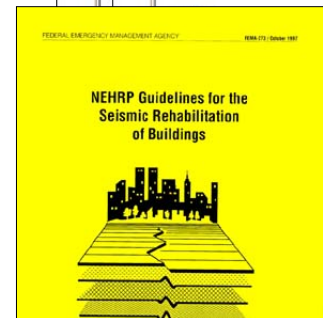
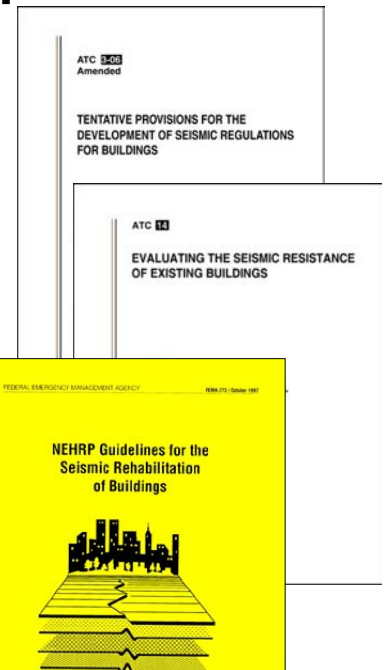
- Technical Staff – direct projects, prepare reports
- Technical Consultants – conduct project work
  - Structural engineers from diverse firms, researchers from various institutions
- Products – non-proprietary, objective, reflect a broad spectrum of engineering opinion

# Technology Development Continuum



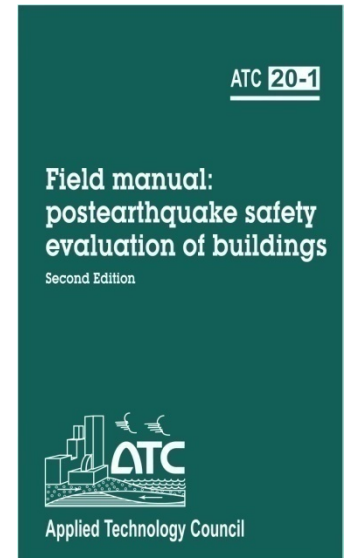
# Past Projects of Significance

- 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





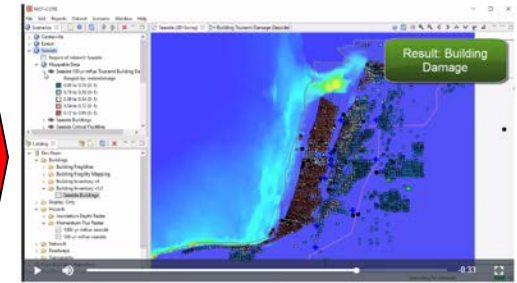
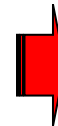
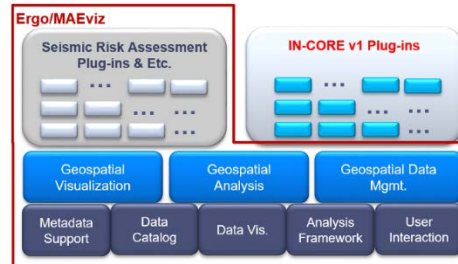
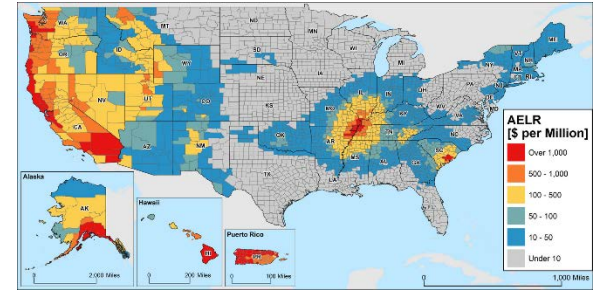
# New Release

- 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

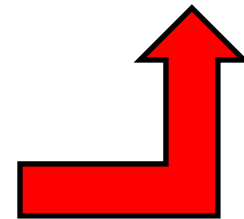
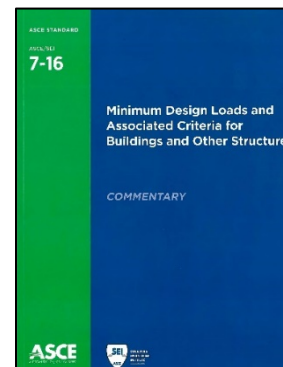
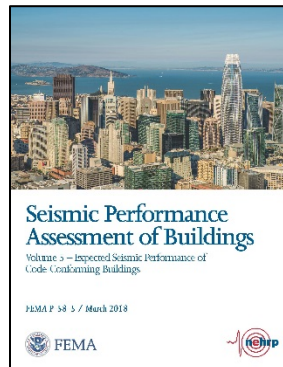
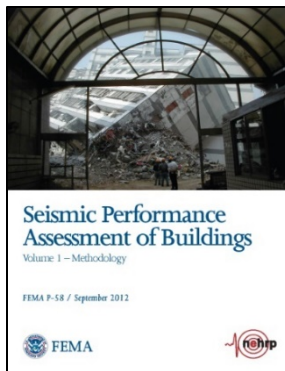


# FEMA P-58 Context

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



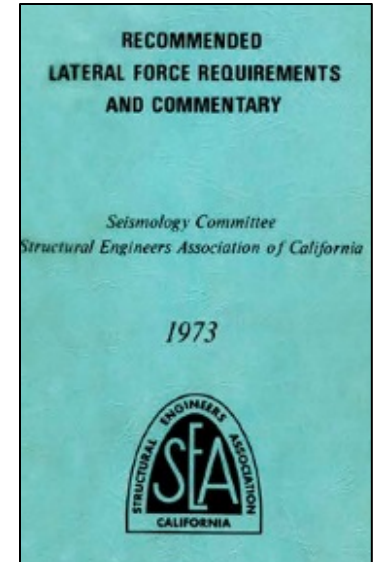
Task Name	Duration	Start	End
1. Develop plan for new business	10 days	1/1/2000	1/10/2000
2. 2B.1 Phase 1 - Strategic Plan	30 days	1/10/2000	2/9/2000
3. 2B.2 Risk Assessment	2 days	1/10/2000	1/12/2000
4. 1.0.1 Determine business plan	1 day	1/10/2000	1/11/2000
5. 1.0.2 Identify market segments	1 day	1/10/2000	1/11/2000
6. 1.0.3 Decide whether to proceed	1 day	1/10/2000	1/11/2000
7. 1.0.4 Define the Opportunity	10 days	1/10/2000	1/20/2000
8. 1.0.5 Research the market and	1 day	1/10/2000	1/11/2000
9. 1.0.6 Interview sources of funds	5 days	1/10/2000	1/15/2000
10. 1.0.7 Identify needed resources	2 days	1/10/2000	1/12/2000
11. 1.0.8 Evaluate Business Opportunity	2 days	1/10/2000	1/12/2000
12. 1.0.9 Evaluate Potential Risks and	2 days	1/10/2000	1/12/2000
13. 1.0.10 Estimate the opportunity	1 day	1/10/2000	1/11/2000
14. 1.0.11 Assess investment requirements	2 days	1/10/2000	1/12/2000
15. 1.0.12 Determine the business plan	1 day	1/10/2000	1/11/2000
16. 1.0.13 Determine financial requirements	2 days	1/10/2000	1/12/2000
17. 1.0.14 Review the opportunity	1 day	1/10/2000	1/11/2000
18. 1.0.15 Confirm the opportunity	1 day	1/10/2000	1/11/2000
19. 1.0.16 Confirm the opportunity	1 day	1/10/2000	1/11/2000
20. 1.0.17 Confirm the opportunity	1 day	1/10/2000	1/11/2000
21. 1.0.18 Confirm the opportunity	1 day	1/10/2000	1/11/2000
22. 1.0.19 Confirm the opportunity	1 day	1/10/2000	1/11/2000
23. 1.0.20 Confirm the opportunity	1 day	1/10/2000	1/11/2000
24. 1.0.21 Confirm the opportunity	1 day	1/10/2000	1/11/2000
25. 1.0.22 Confirm the opportunity	1 day	1/10/2000	1/11/2000
26. 1.0.23 Confirm the opportunity	1 day	1/10/2000	1/11/2000
27. 1.0.24 Confirm the opportunity	1 day	1/10/2000	1/11/2000
28. 1.0.25 Confirm the opportunity	1 day	1/10/2000	1/11/2000
29. 1.0.26 Confirm the opportunity	1 day	1/10/2000	1/11/2000
30. 1.0.27 Confirm the opportunity	1 day	1/10/2000	1/11/2000



# Early Performance Statements

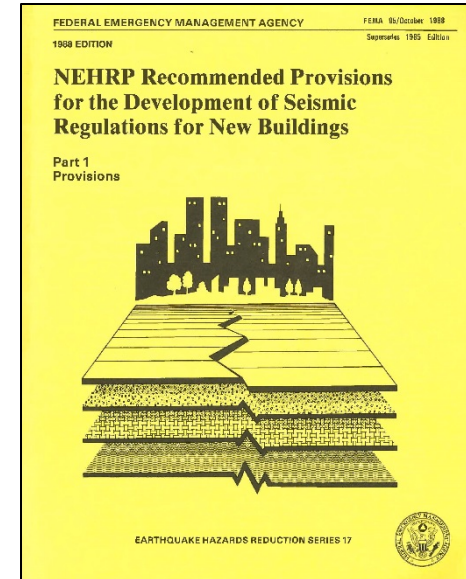
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- SEAOC Blue Book:
  - Resist minor earthquakes without damage
  - Resist moderate earthquakes with some nonstructural damage
  - Resists major earthquakes with structural/nonstructural damage
  - Resist the most severe earthquakes without collapse



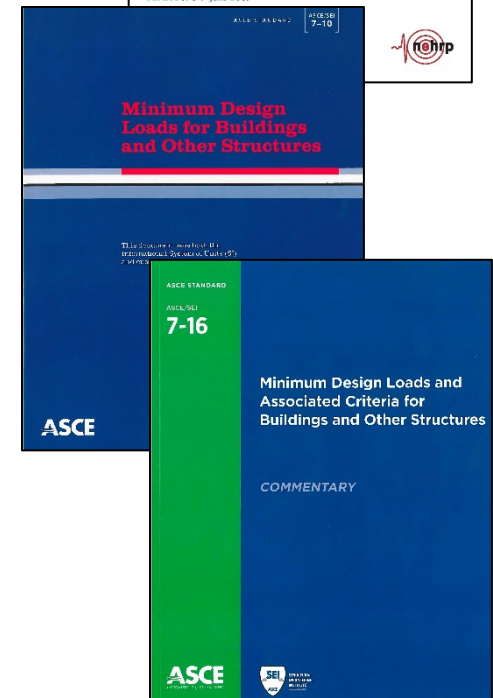
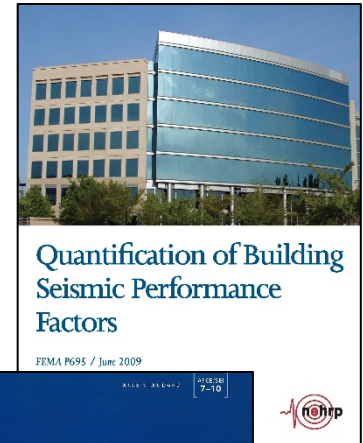
# Early Performance Statements

- 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



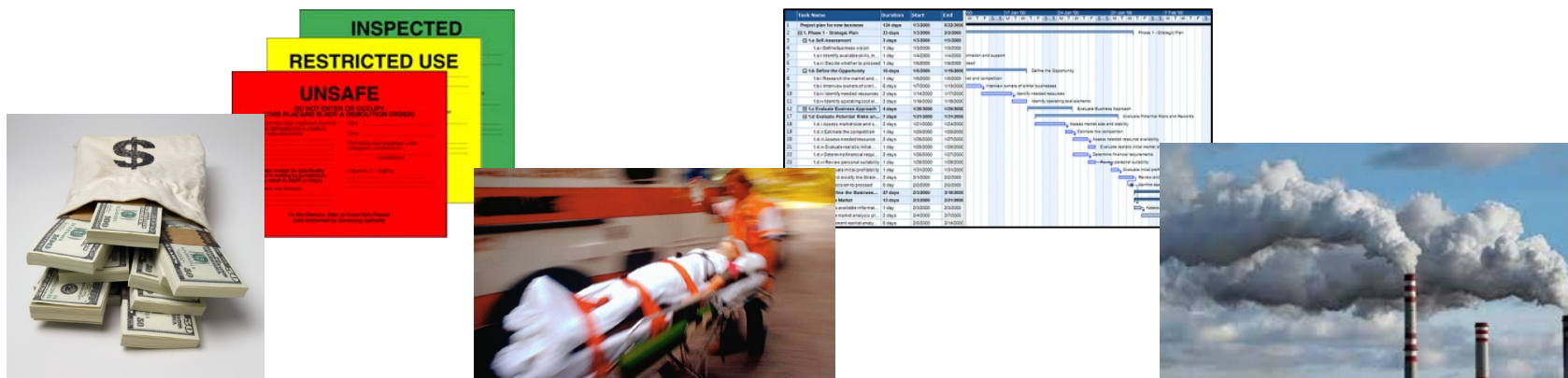
# Recent Performance Statements

- 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

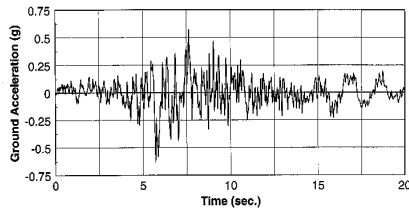


# Future Performance Statements

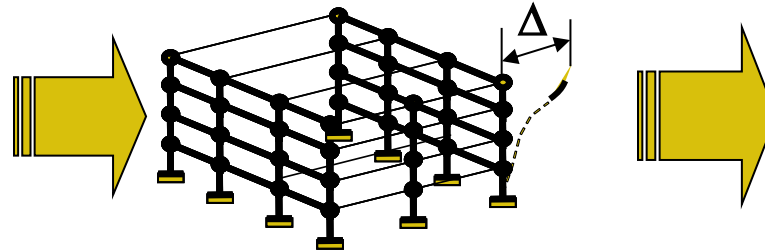
- Performance needs have been evolving beyond life safety
- Some performance statements in building codes have been intentionally aspirational (inserted before we knew how to calculate)
- FEMA P-58 performance metrics provide a quantitative link to the future



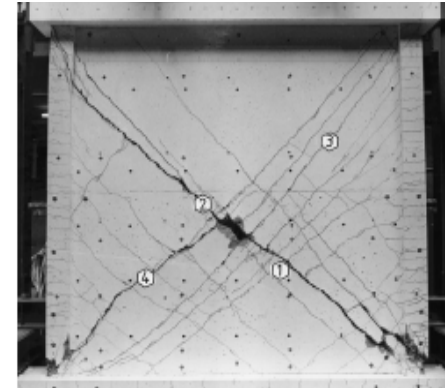
# Next-Generation Assessment Process



Ground Motion



Structural Response



Damage

Fragility Specification			
B1044.000 Reinforced Concrete Shearwalls			
<b>BASE CONDITION</b>	Reinforced concrete and finishes both sides		
<b>UNIT OF MEASURE</b>	Square feet of wall area		
<b>DAMAGES STATES, FRAGILITIES, AND CONSEQUENCE FUNCTIONS</b>			
<b>DAMAGE STATE</b>	<b>DS1</b>	<b>DS2</b>	<b>DS3</b>
<b>DESCRIPTION</b>	Vertical cracks < 1/16" Shear (diagonal) cracks < 1/16"	Vertical cracks < 1/8" Shear (diagonal) cracks < 1/8"	Max. crack width > 1/8" Significant spalling/ loose cover
<b>REPAIR METHOD</b>			
<b>REPAIR COST</b>	1.5%	3.0%	5.0%
<b>RISK</b>	0.2	0.3	0.4
<b>REPAIRABILITY</b>	70%		
<b>REPAIR CONTRACT</b>	Patch cracks each side with caulk Patch each side	Remove loose concrete Patch spalls with NS grout Patch cracks each side with caulk Paint each side	Shore Demo existing wall Reinforce Patch and paint
<b>CONSEQUENCE FUNCTION</b>			
<b>Max. interruption of function (months)</b>	\$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
<b>Intermediate repair quality</b>	\$2.00 per sq ft over 4000 sq ft	\$5.00 per sq ft over 4000 sq ft	\$30.00 per sq ft over 2000 sq ft
<b>Repairability</b>	0.2	0.3	0.3
<b>CONSEQUENCE CLASSIFICATION</b>	Short	Weeks	Months

Fragility Spec



Building Performance Model

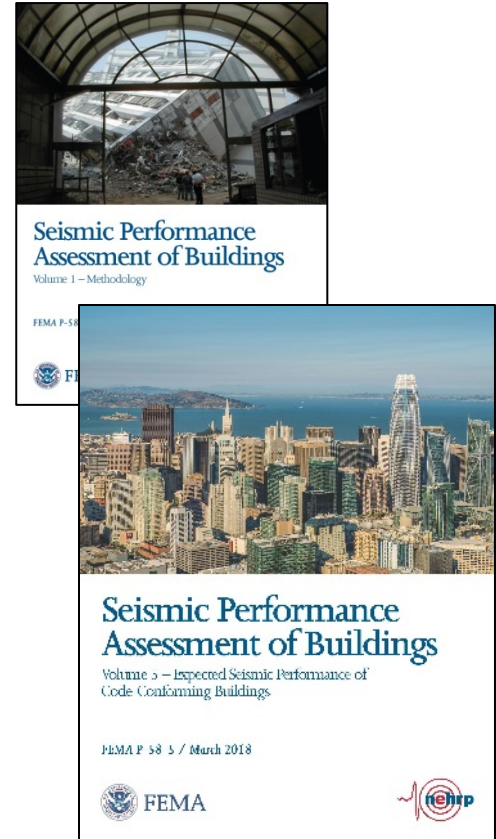
A collage of three images representing the consequences of damage. On the left, an ambulance with a stretcher being loaded. In the middle, a stack of US dollar bills. On the right, a pocket watch showing the time.

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

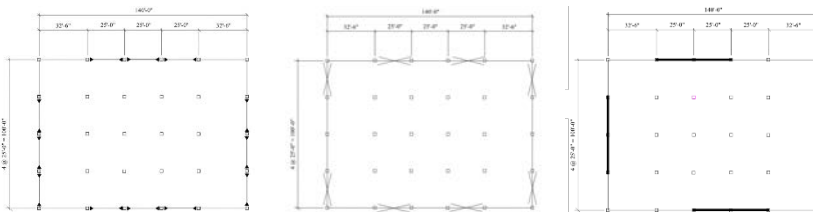
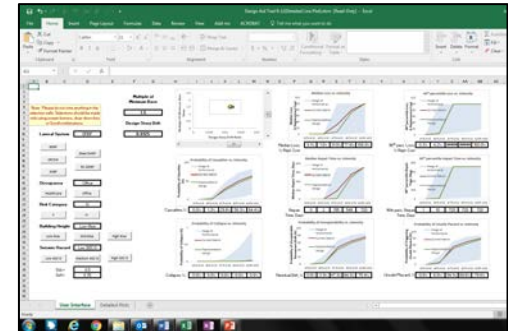
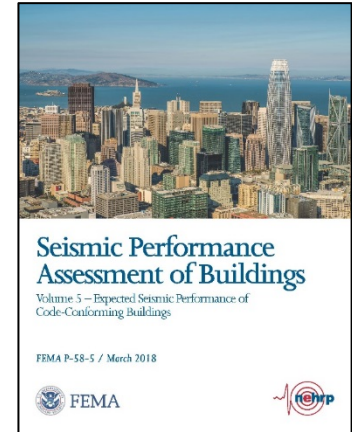


Table 2-9 Summary of Archetypes by Occupancy, System, Risk Category, and Building Height

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
<b>Risk Category II – Healthcare (Medical Office Building or Laboratory)</b>		
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%
<b>Risk Category IV – Healthcare (Hospital)</b>		
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%

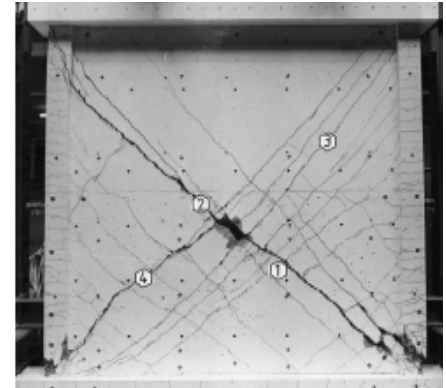
# Use in Future Code Performance Objectives

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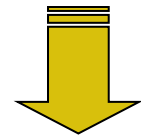
- FEMA P-58-5 now provides quantitative information for conversations to:
  - Determine acceptable performance
  - Determine appropriate performance targets
  - Consider necessary levels of confidence
  - Consider relative system performance
  - Define functional performance
  - Design buildings to achieve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

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- 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

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***Thank you!***