The Horizon For Next-Generation Performance Assessment Of Buildings Is Here: FEMA P-58

Jon A. Heintz Director of Projects Applied Technology Council





Contents

- Background Context
- Next-generation concepts
- Example results
- Products/handouts





Project Context

- Present-generation procedures
 - FEMA 273 NEHRP Guidelines for Seismic Rehabilitation of Buildings (1997)
 - ASCE 41-06 Seismic Rehabilitation of Existing Buildings (2007)





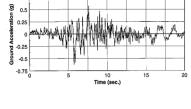


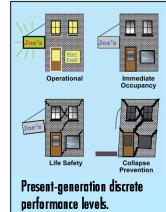
Present-Generation Assessment

- LSP, LDP, NSP, NDP
- Max of 3 or average of 7 records[→]
- Using plastic hinge rotation limits to judge performance
 - Clear mechanism Collapse
 - Isolated hinge locations ??
 - What if one record causes collapse?
- Report to building owner
 - Collapse Prevention ??

ATC







Project Context

- Present-generation procedures
 - FEMA 273 (1997)
 - ASCE 41-06 (2007)
- FEMA began planning program for enhanced procedures (1998)
- FEMA 349 Action Plan (EERI, 2000)

- <text><text><image><text><text><text><text>
- ATC-58 Project initiated in 2001





Need for Next-Generation

- ATC-58 Project Purpose
 - Develop a framework to account for variability and uncertainty
 - Assess performance on a global rather than local level
 - Expand procedures to explicitly assess nonstructural performance
 - Revise discrete performance levels into measures that are more meaningful for decision-making





Project Team

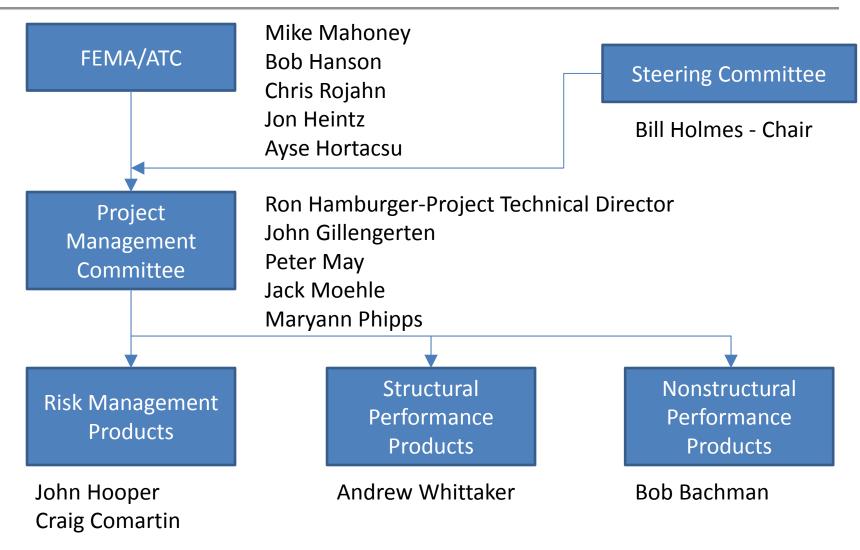
- More than 130 consultants across 16 teams
 - Project Management Committee
 - Project Steering Committee
 - Risk Management Products
 - Structural Performance Products^L
 - Nonstructural Performance
 Products

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Armon Der Kiureghia	8	Greg Hards		
Scott Hagie Curt Haselton		Christopher Higgins Gayle Johnson		
Rewell Larson Juan Marcia-Delso		Paul Kremer Dava McCormick		
Scott Shell		Ali M. Memari		
P. Dennon Shing Farrin Zarrian		William O'Drive John Oxforans		
STRUCTURAL PERI	FORMANCE	Elizabeth Pahl		
PRODUCTS AND	FRAGILITY	John Stevenson Xin Xu		
DEVELOPMENT O Jack Baker	CONSULTANTS	FRAGILITY REVIEW P/	ANEL.	
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Charles Ekiert		Stephen Mahin		
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Down Lehman Jingiwa Li		David Bonneville		
Eric Lumpkin Juan Murcia-Delso		Hope Seligion SPECIAL REVIEWERS		
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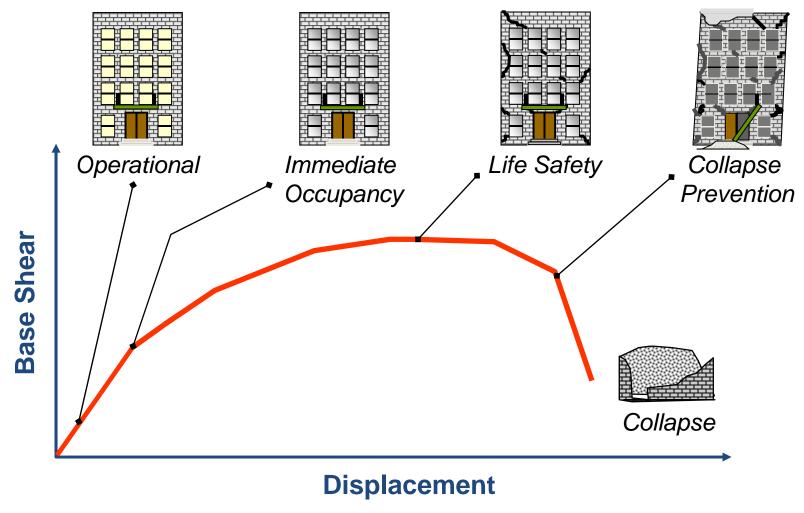
Project Team







Next Generation Performance Continuum







Next Generation Performance Metrics

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













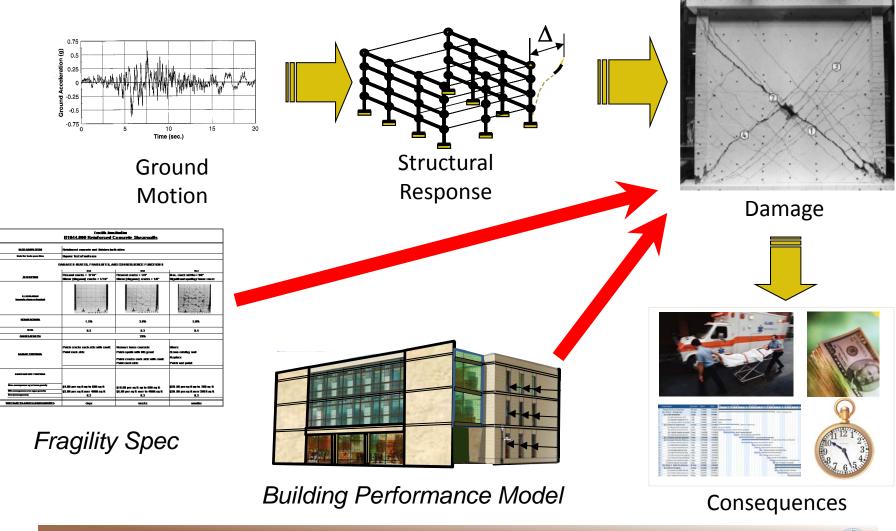
Assessment Types

- Intensity-based
 - Performance given a specific acceleration response spectrum
- Scenario-based
 - Performance given a specific earthquake scenario,
 e.g. repeat of 1906 San Andreas event
- Time-based
 - Performance over a period of time, considering all possible earthquakes, and their individual probabilities of occurrence



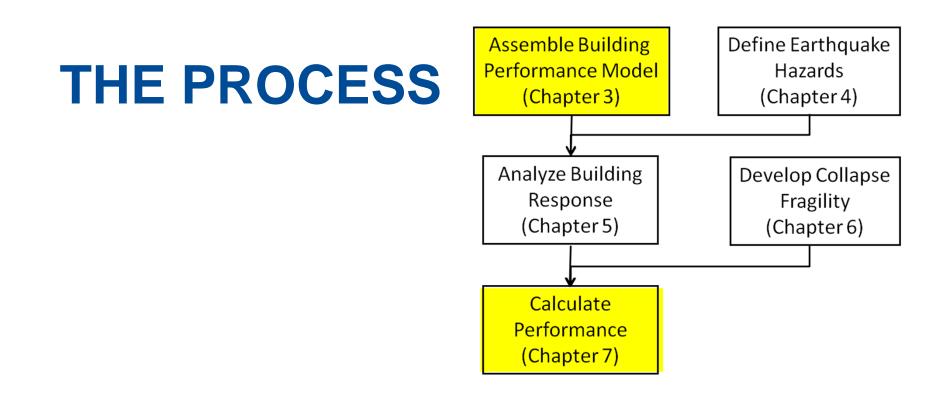


Next Generation Assessment Process





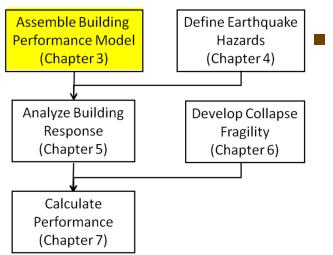








Assemble Building Performance Model



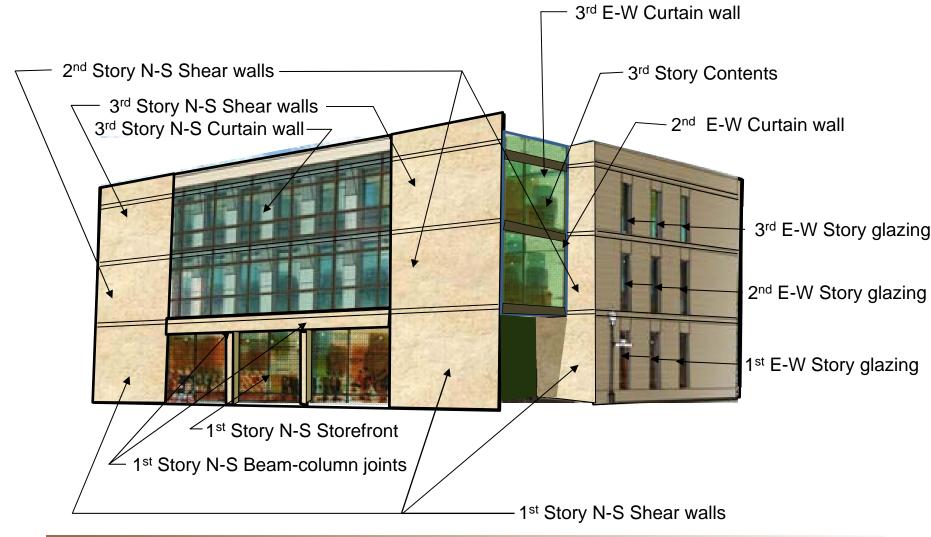
Methodical Building Description

- Structural & Nonstructural Components
 - Type
 - Location
 - Quantity
 - Damage states
 - Fragility relationships
 - Damage conseugences
- Occupancy
 - People at risk
 - Locations
 - Time of day





Building Performance Model



FEMA P-58 Seminar on Seismic Performance Assessment of Buildings

ΔΤC



Fragility Specifications

Fragility Specification

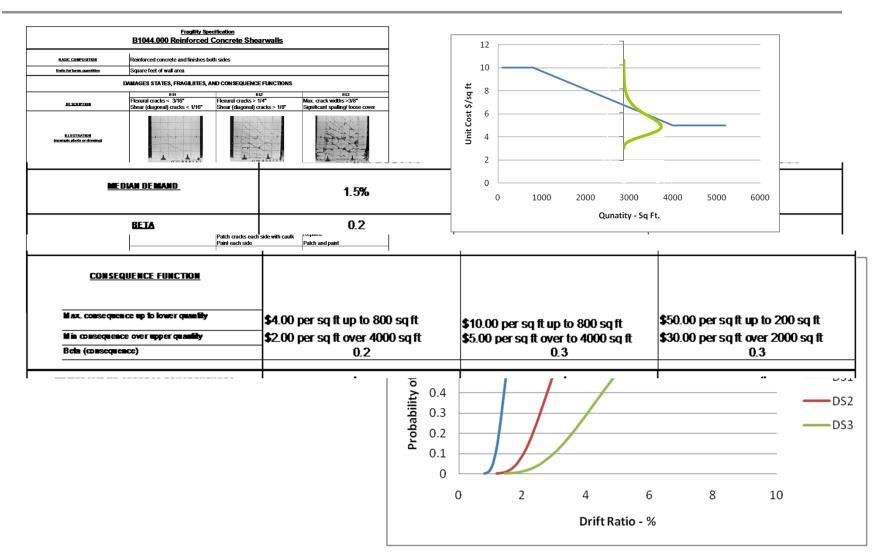
B1044.000 Reinforced Concrete Shearwalls Reinforced concrete and finishes both sides BASIC COMPOSITION Units for basic quantities Square feet of wall area DAMAGES STATES, FRAGILIITES, AND CONSEQUENCE FUNCTIONS D\$1 DS2 DS3 Flexural cracks < 3/16" Flexural cracks > 1/4" Max. crack widths >3/8" DESCRIPTION Shear (diagonal) cracks < 1/16" Significant spalling/ loose cover Shear (diagonal) cracks > 1/8" LLUSTRATION (example photo or drawing) MEDIAN DEMAND 1.5% 3.0% 5.0% **BETA** 0.2 0.3 0.4 70% CORRELATION (%) Patch cracks each side with caulk Remove loose concrete Shore Paint each side Demo existing wall Patch spalls with NS grout DAMAGE FUNCTIONS Replace Patch cracks each side with caulk Paint each side Patch and paint

CONSEQUENCE FUNCTION Max. consequence up to lower quantity \$4.00 per sq ft up to 800 sq ft \$50.00 per sq ft up to 200 sq ft \$10.00 per sq ft up to 800 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 Specification







Provided Fragility Specifications

More than 700 building elements

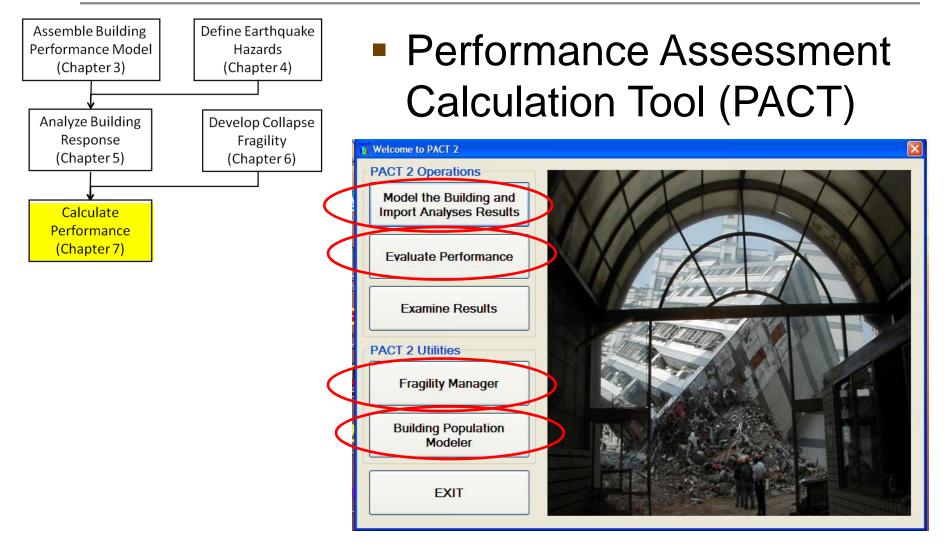
- Steel
 - Moment frame
 - Braced frame
- Concrete
 - Moment frame
 - Slender walls
 - Squat walls
 - Coupling beams
- Masonry walls
 - Shear controlled
 - Flexural Controlled
- Light Framed
 - Wood
 - CFS

- Cladding
- Partitions
- Roofing
- Plumbing
- Mechanical/HVAC
- Elevators
- Electrical Equipment
- Lighting
- Contents





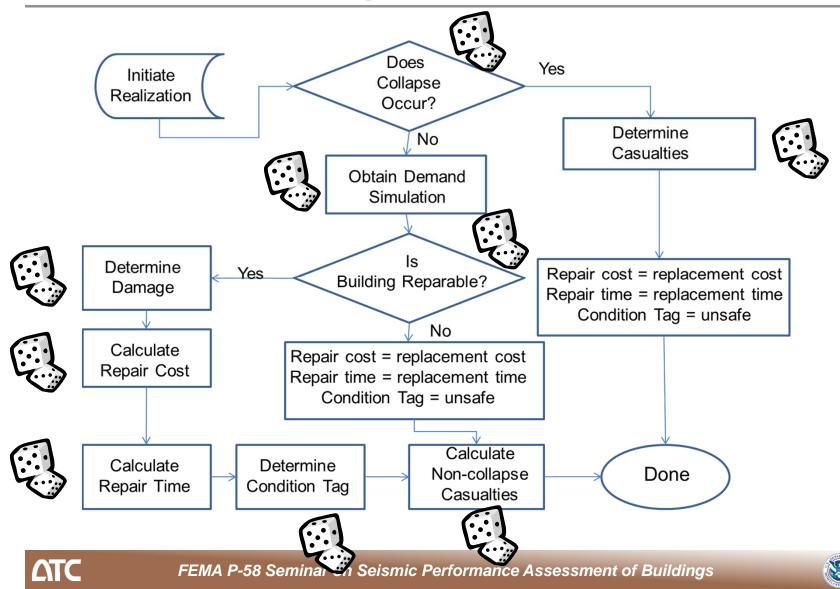
Calculate Performance





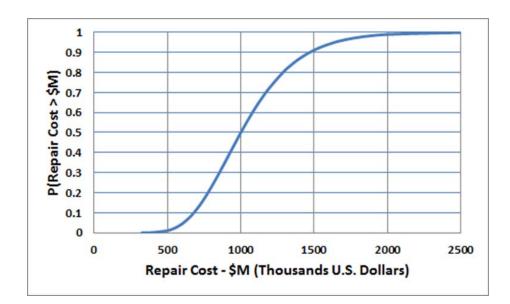


For Each Realization We Compute Building Performance



Intensity- and Scenario-Based Assessment Results

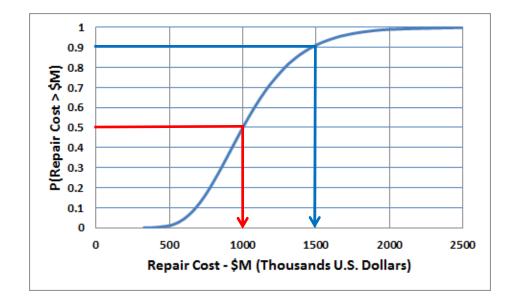
- Losses computed for 100s to 1000s of realizations
- For each performance measure, realizations are assembled into performance functions







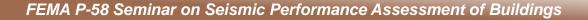
Scenario or Intensity Assessments



- 50% probability that repair cost will not exceed \$1M
 - Expected repair cost is \$1.0M

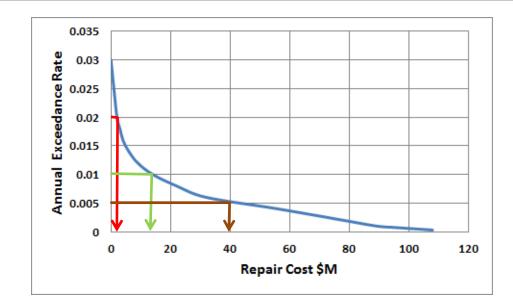
ΔΤ

- 90% probability repair costs will not exceed \$1.5M
 - Probable Maximum Loss (PML) is \$1.5M





Time-based Assessment



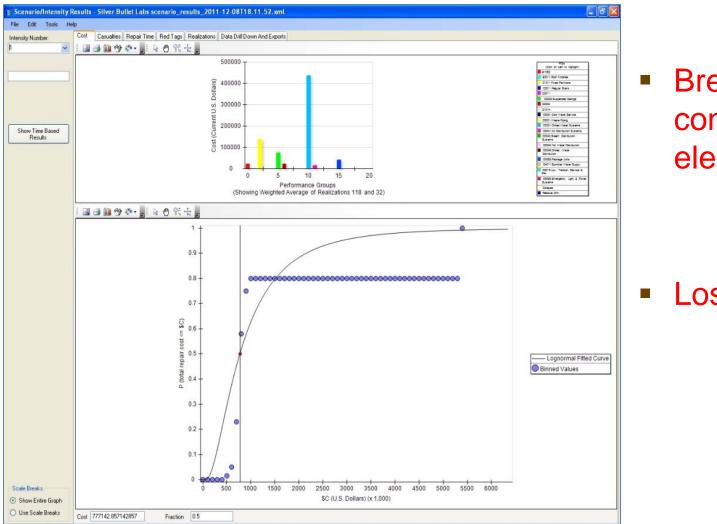
- 50-year loss \$2,000
- 100-year loss \$14,000
- 200-year loss \$40,000

ΔΤ

Average annual loss \$540



Repair Cost



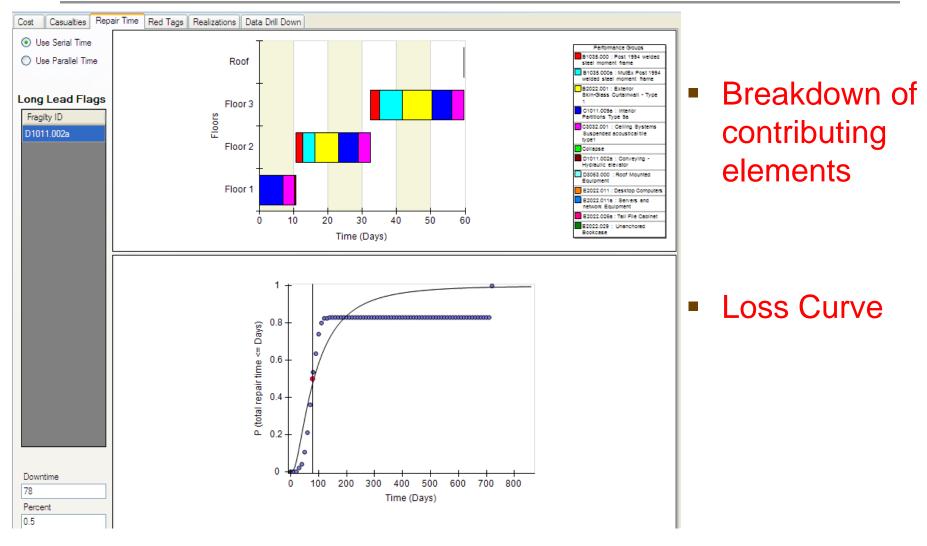
 Breakdown of contributing elements

Loss Curve





Downtime







Use of Next-Generation Performance Assessment

- Demonstrate that performance is not certain
- Perform cost-benefit studies on alternative design and retrofit criteria
- Determine appropriate insurance premiums
- Form the basis for property rating systems
- Benchmark code performance
- Evaluate the adequacy of building practices without the occurrence of earthquakes

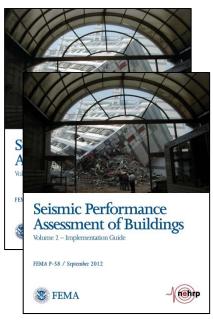




ATC-58 Products

- FEMA P-58 Seismic Performance Assessment of Buildings (2012)
 - Volume 1 Methodology
 - Volume 2 Implementation Guide
 - Volume 3 Electronic Materials
 - Background Documents



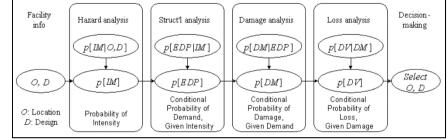






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 Research Center
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 - Tony Yang
 - Craig Comartin
 - Armen Der Kiureghian







Thank you!



