Session SS032.S:
Mini-Workshop on Next-Generation Performance Objectives

Los Angeles

June 28, 2018
Mini-Workshop

- Theme: Use of recent ATC Project information in future code performance objectives

- Plan:
  - Present a little…Talk a little…Present a little…Talk a little…and so on.
Agenda

- Moderator: Jon A. Heintz
- Speakers:
  - **Maryann Phipps**, Improved Seismic Design of Nonstructural Components and Systems
  - **Charlie Kircher**, Solutions to the Short-Period Building Performance Paradox
  - **Kelly Cobeen**, Vulnerability-Based Assessment and Retrofit of One- and Two-Family Dwellings
Food for thought (#1)

- How would the information you hear this afternoon affect your day-to-day design practice?
Session SS032.S:

**FEMA P-58 Expected Seismic Performance of Code-Conforming Buildings**

Jon A. Heintz
ATC Executive Director

*June 25, 2018*
Outline

- Performance expectations expressed in the code
- ATC-58-2 Project efforts to assess performance
- FEMA P-58 performance of code-conforming buildings
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:**
  - 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

- BSSC Provisions Update Committee
  - Issue Team 1, Seismic Performance
  - Currently looking to define performance criteria for:
    - Function of Risk Category IV structures
    - Reliability of nonstructural components
  - Extending structural reliability criteria in ASCE 7-16
    - Aspirational for future reference, even though we can’t really calculate right now
ATC-58-2 Project Context

- Performance needs are evolving beyond life safety
- Performance statements are becoming more explicit
- FEMA P-58 performance metrics:
  - Casualties
  - Repair costs
  - Repair time
  - Unsafe placarding
  - Environmental Impacts
ATC-58 Project Series

- Over 200 consultants across more than 20 teams

  - Project Management Committee
  - Project Steering Committee
  - Performance Products Team
  - Products Update Team
  - Stakeholder Products Team
  - Performance Working Group
  - Structural Performance Products
  - Nonstructural Performance Products
  - Risk Management Products
  - Validation/Verification Team
  - Fragility Review Panel
  - Fragility Development Consultants
  - Environmental Products Working Group
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
Approach

- Identify what controls performance
- Define what is code-conforming
- Parametrically vary important parameters
- Design and assess as many buildings as possible
- Sort through the results
Approach

- Strength and stiffness are key
- The parametric range of code-conforming structures is infinite
Approach

- Design space concept
  - Defines parametric limits based on practical designs
  - Workshop input
  - Generic design space and representative designs
Archetype Design Space

- 5 systems
- 2 occupancies
- 2 risk categories
- Low-, mid-, and high-rise variants
- 3 hazard levels
- 1,755 total
ATC-58-2 Project Results

- Expected Performance of Code-Conforming Buildings
  - 5 performance metrics
  - 5 intensity levels (% MCE)
  - Viewed by system, occupancy, hazard, and height

- Needed a tool to visualize data
  - Performance Estimation Tool (PET)
Summary Findings

- Performance is NOT uniform across systems
- You CAN control performance with design
- Strength and stiffness are absolutely key
- Risk Category IV design criteria improves performance
FEMA P-58 Performance Results

- Repair Costs (% rep.)
FEMA P-58 Performance Results

- Repair Times (days)
FEMA P-58 Performance Results

- Repairability (%)

Risk Category II, office

Risk Category II, healthcare

Risk Category IV, office

Risk Category IV, healthcare
FEMA P-58 Performance Results

- Unsafe Placard (%)
- RC II
- Office
- 67% MCE

Steel SMRF

RC SMRF

Special RCSW

Steel SCBF
FEMA P-58 Performance Results

- Unsafe Placard (%)
- Steel SMRF
- Office
- 67% MCE
- Variation with Risk Category
  - RC II
  - RC IV
So what is code performance?

- Varies by:
  - system
  - occupancy
  - height
  - hazard level

- Depends on:
  - Risk Category
  - Shaking intensity (e.g., design or other level)
Expected Code Performance

- Generalized performance
  - Judgmentally selected/rounded values
  - FEMA P-58 results averaged across
    - multiple structural systems,
    - building heights, and
    - hazard levels
# Expected Code Performance

## Table 6-1 Generalized Performance of Code-Conforming Buildings, Risk Category II and IV, Office and Healthcare Occupancies

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>Frequent</th>
<th>Design</th>
<th>MCE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Risk Category II - Office</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repair Cost</td>
<td></td>
<td>10%</td>
<td>30%</td>
</tr>
<tr>
<td>Repair Time</td>
<td></td>
<td>45 days</td>
<td>150 days</td>
</tr>
<tr>
<td>Casualty Rate</td>
<td></td>
<td>1.0%</td>
<td>2.0%</td>
</tr>
<tr>
<td>Probability of Unsafe Placard</td>
<td></td>
<td>20%</td>
<td>40%</td>
</tr>
<tr>
<td>Repairability</td>
<td></td>
<td>95%</td>
<td>80%</td>
</tr>
<tr>
<td><strong>Risk Category II – Healthcare (Medical Office Building or Laboratory)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repair Cost</td>
<td></td>
<td>20%</td>
<td>40%</td>
</tr>
<tr>
<td>Repair Time</td>
<td></td>
<td>60 days</td>
<td>180 days</td>
</tr>
<tr>
<td>Casualty Rate</td>
<td></td>
<td>1.0%</td>
<td>2.0%</td>
</tr>
<tr>
<td>Probability of Unsafe Placard</td>
<td></td>
<td>20%</td>
<td>40%</td>
</tr>
<tr>
<td>Repairability</td>
<td></td>
<td>85%</td>
<td>65%</td>
</tr>
</tbody>
</table>
# Expected Code Performance

## Table 6-1 Generalized Performance of Code-Conforming Buildings, Risk Category II and IV, Office and Healthcare Occupancies

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>Earthquake Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequent</td>
</tr>
<tr>
<td>Risk Category IV – Office (Emergency Operations Center)</td>
<td></td>
</tr>
<tr>
<td>Repair Cost</td>
<td></td>
</tr>
<tr>
<td>Repair Time</td>
<td></td>
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<tr>
<td>Casualty Rate</td>
<td></td>
</tr>
<tr>
<td>Probability of Unsafe Placard</td>
<td></td>
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<tr>
<td>Repairability</td>
<td></td>
</tr>
<tr>
<td>Risk Category IV – Healthcare (Hospital)</td>
<td></td>
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<tr>
<td>Repair Cost</td>
<td></td>
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<tr>
<td>Repair Time</td>
<td></td>
</tr>
<tr>
<td>Casualty Rate</td>
<td></td>
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<tr>
<td>Probability of Unsafe Placard</td>
<td></td>
</tr>
<tr>
<td>Repairability</td>
<td></td>
</tr>
</tbody>
</table>
### Comparison RC II / RC IV

**Table 6-1: Generalized Performance of Code-Conforming Buildings, Risk Category II and IV, Office and Healthcare Occupancies**

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<tbody>
<tr>
<td><strong>Risk Category II - Office</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repair Cost</td>
<td>10%</td>
<td>30%</td>
<td></td>
</tr>
<tr>
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<td>150 days</td>
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<td>40%</td>
<td></td>
</tr>
<tr>
<td>Repairability</td>
<td>95%</td>
<td>80%</td>
<td></td>
</tr>
<tr>
<td><strong>Risk Category IV – Office (Emergency Operations Center)</strong></td>
<td></td>
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<tr>
<td>Repair Cost</td>
<td>5%</td>
<td>15%</td>
<td></td>
</tr>
<tr>
<td>Repair Time</td>
<td>30 days</td>
<td>75 days</td>
<td></td>
</tr>
<tr>
<td>Casualty Rate</td>
<td>0.5%</td>
<td>1.5%</td>
<td></td>
</tr>
<tr>
<td>Probability of Unsafe Placard</td>
<td>10%</td>
<td>25%</td>
<td></td>
</tr>
<tr>
<td>Repairability</td>
<td>98%</td>
<td>90%</td>
<td></td>
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</tbody>
</table>
FEMA P-58 Wrap up

- Complete final production and quality reviews
- Conduct FEMA External Affairs review
- Prepare final documents for print and electronic distribution
- Final release expected Fall 2018
Thank you!
Food for thought (#2)

- What level of damage do you think is acceptable for nonstructural components... at what earthquake level?
Food for thought (#3)

- Is the ASCE 7 collapse safety objective too liberal... should it be modified to be more conservative?
Food for thought (#4)

- What are the pros and cons in the balance between high performance objectives and constructability?