Performance Objectives

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2015 NEHRP Provisions

This chapter on the Intent of the 2015 Provisions describes the expected seismic performance that is judged to be inherent in the seismic requirements in Parts 1 and 2.

1.1 INTENT

The NEHRP Recommended Seismic Provisions for New Buildings and Other Structures presents the minimum recommended requirements necessary for the design and construction of new buildings and other structures to resist earthquake ground motions throughout the United States. The objectives of these provisions are to provide reasonable assurance of seismic performance that will:

1. Avoid serious injury and life loss due to
   a. Structure collapse
   b. Failure of nonstructural components or systems
   c. Release of hazardous materials

2. Preserve means of egress
3. Avoid loss of function in critical facilities, and
4. Reduce structural and nonstructural repair costs where practicable.

These performance objectives do not all have the same likelihood of being achieved. Additional detail on the objectives is provided in section 1.1.1 through 1.1.6.

The degree to which these objectives can be achieved depends on a number of factors including structural framing type, building configuration, structural and nonstructural materials and details, and overall quality of design and construction. In addition, large uncertainties as to the intensity and duration of shaking and the possibility of unfavorable response of a small subset of buildings or other structures may prevent full realization of these objectives.
This chapter on the intent of the 2015 Provisions describes the expected seismic performance that is judged to be inherent in the seismic requirements in Parts 1 and 2.
2015 NEHRP Provisions (ASCE 7-16)
What We’re Expecting (Qualitatively)

1.1 Intent

1. Avoid serious injury and life loss due to
   a. Structure collapse
   b. Failure of nonstructural components and systems
   c. Release of hazardous materials
2. Preserve means of egress
3. Avoid loss of function in critical facilities, and
4. Reduce structural and nonstructural repair costs where practicable
2020 NEHRP Provisions Performance Objectives (Qualitative/Quantitative)

• What performance (structural and nonstructural) are we expecting?
• What performance are we getting?
• What performance are we aspiring to?
2020 NEHRP Provisions Performance Objectives

- Coordinate with Project 17 (Basis for Design Maps)
  - Retain the current risk basis - risk-targeted 1% collapse in 50 years, with deterministic cap

- Evaluate the adequacy of the Section 1.1 Performance Objectives (qualitatively/perhaps quantitatively)
  - Consider function and damage level – in RC IV, at least (qualitatively/perhaps quantitatively)

- Reconsider Seismic Design Categories (SDC’s)
  Simplification/Consolidation
Proposal

- Define what constitutes “loss of function”
- Propose an aspirational target reliability of Risk Category IV buildings and nonbuilding structures as having at most a 10% probability of losing function in the Design Earthquake ground motion.
Avoid Loss of *Essential* Function in Critical Facilities

• Explicitly delineate preserving “essential function” as opposed to “function.”

• Essential function intended to mean that minor clean-up and repair may be required and that 100% of pre-earthquake functionality is not preserved.

• Example, hospital may not be able to do every medical procedure, but can provide emergency services and life support services.
Supporting Data

• Use the FEMA P-58 studies on probability of an unsafe placard and 90th percentile repair time
• Look at code minimum design as well as enhancements in system stiffness and strength
• Use buildings designed to Risk Category IV requirements
Performance Varies by Risk Category (RC IV Outperforms II)

FEMA P-58 Predicted Performance - Probability of Unsafe Placard

Intensity

Midrise Office (RC IV)
Medium SDC D Site

Steel BRBF
Steel SCBF
Steel SMRF
Special RCSMRF
Special RCSW

Probability of Unsafe placard

20% MCE  40% MCE  67% MCE  80% MCE  100% MCE

0%  10%  20%  30%  40%  50%  60%  70%  80%  90%  100%
Performance for a Given System Varies Across the Design Space

FEMA P-58 Predicted Performance - 90% CL Repair Time

- Midrise Office (RC IV)
- Steel SMRF
- Medium SDC D Site

Repair Time - Days

Intensity - %MCE

Upper Bound (Code Min Design)

Lower Bound (Enhanced Design) (Stiffer/Stronger)
Should Nonstructural Performance also be Quantified?

FEMA P-58 Predicted Performance - Median Loss

Midrise Office (RC IV)
Steel SMRF
Medium SDC D Site
Impacts / Changes

• Would require further study of hazardous materials containment systems to validate reliabilities.
• Review nonstructural performance and certification to confirm that current procedures produce 90% reliability.
• Drift limits for some systems (e.g. BRBF) may need to be tightened.
• Some systems (e.g. SCBF) may not meet these targets without significant changes in design rules.
• May need to validate other structural systems or prohibit in RC IV in SDC D and higher without additional validation.
Seismic Design Category Consolidation

• Simplify the standard, by consolidating 6 SDCs to 3
  – Low (A), Moderate (B/C), High (D/E/F)
• Combining several categories eliminates some of the instability in SDC determination as ground motion values change.
SDC Background

- Seismic Design Categories as presently used in ASCE 7 were developed under the 1997 NEHRP Provisions. SDC’s calibrated to spectral values tied to MMI

<table>
<thead>
<tr>
<th>SDC</th>
<th>( S_{ds} )</th>
<th>( S_{ms} )</th>
<th>MCE MMI</th>
<th>( S_{d1} )</th>
<th>( S_{m1} )</th>
<th>MCE MMI</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>&lt;.167</td>
<td>&lt;.25</td>
<td>VI</td>
<td>&lt;.067</td>
<td>&lt;.1</td>
<td>VI</td>
<td>Structural Integrity</td>
</tr>
<tr>
<td>B</td>
<td>&lt;.33</td>
<td>&lt;.5</td>
<td>VII</td>
<td>&lt;.133</td>
<td>&lt;.2</td>
<td>VII</td>
<td>Structure design, parapets, few system limits</td>
</tr>
<tr>
<td>C</td>
<td>&lt;.5</td>
<td>&lt;.75</td>
<td>VIII</td>
<td>&lt;.2</td>
<td>&lt;.3</td>
<td>VII</td>
<td>Structure design, multi-direction, nonstructural, few more</td>
</tr>
<tr>
<td>D</td>
<td>.5( \leq )</td>
<td>.75( \leq )</td>
<td>VIII+</td>
<td>.2( \leq )</td>
<td>.3( &lt; )</td>
<td>VIII</td>
<td>Restrictions on analysis method and systems</td>
</tr>
<tr>
<td>E</td>
<td>IX</td>
<td>.75( &lt; )</td>
<td>1.1( \leq )</td>
<td>IX</td>
<td>Irregularity restrictions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>IX</td>
<td>IX</td>
<td>IX</td>
<td>IX</td>
<td>Irregularity restrictions and height limits</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

16th percentile MMI to Sa conversion
EQ Damage Study Conclusions

• Current SDC boundaries map reasonably well to high confidence of having:
  – SDC A – MMI V - maximum
  – SDC B – MMI VI - maximum
  – SDC C – MMI VII - Maximum
  – SDC D – having MMI VIII or higher

• Recent observations suggest that MMI VI and lower, there is no need to provide seismic protection

• For MMI VII – probably need to protect against the worst performing structural systems, cantilevered parapets, chimneys and nonstructural falling hazards

• MMI VIII and above design for earthquake like you mean it!
Proposed SDC’s

- Based on mapping $S_{MS}$ & $S_{M1}$ to Mean MMI

<table>
<thead>
<tr>
<th>SDC</th>
<th>MCE MMI</th>
<th>$S_{MS}$</th>
<th>$S_{M1}$</th>
<th>DE MMI</th>
<th>Old (Current) SDC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>VI</td>
<td>&lt;0.25</td>
<td>&lt;0.10</td>
<td>V</td>
<td>A – lower half of B</td>
</tr>
<tr>
<td>Moderate</td>
<td>VII</td>
<td>0.25 to 0.75</td>
<td>0.10 to 0.30</td>
<td>VI</td>
<td>Upper half of B to lower part of D</td>
</tr>
<tr>
<td>High</td>
<td>VIII</td>
<td>&gt;0.75</td>
<td>&gt;0.30</td>
<td>VII</td>
<td>Most of D through F</td>
</tr>
</tbody>
</table>
LOW

- Current SDC A requirements only
- Index force of 0.01W
- No seismic design
- All systems permitted for all heights
- No consideration of nonstructural components.
Moderate

- Current SDC C requirements
- Design for seismic but with minimal rules
- Most systems permitted for all heights
- Not permitted systems
  - AAC
  - Ordinary Concrete Moment Frames
  - Plain Concrete & Masonry Wall
  - Concrete Shear Wall / Frame Interactive System
- **Nonstructural: Architectural systems & MEP when Ip = 1.5**
  - May be decoupled from structural SDCs
High

• Current SDC D requirements
• Design for seismic but with rules
• Mostly special systems
• Keeps SDC D permissions on Intermediate systems and on height limits
• Nonstructural: All Architectural & MEP systems braced
Questions?