

# ASCE 41-13

## ***Seismic Evaluation and Retrofit of Existing Buildings***

Overview & General Provisions

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Robert Pekelnicky, PE, SE



- Vice-Chair & Secretariat for the 2013 edition of ASCE 41 and currently the Committee chair
- Regularly performs seismic evaluations and retrofits of buildings for federal, healthcare, educational, and corporate clients

## Objectives

Understand organization of the new standard.

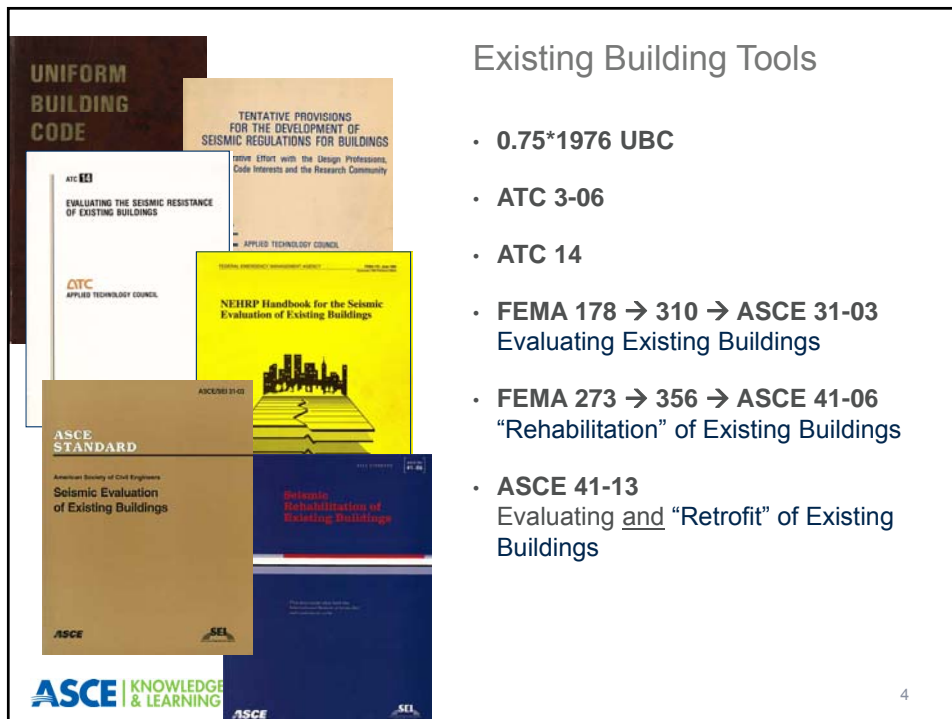
Properly select an evaluation procedure using the three tiered procedure for evaluation

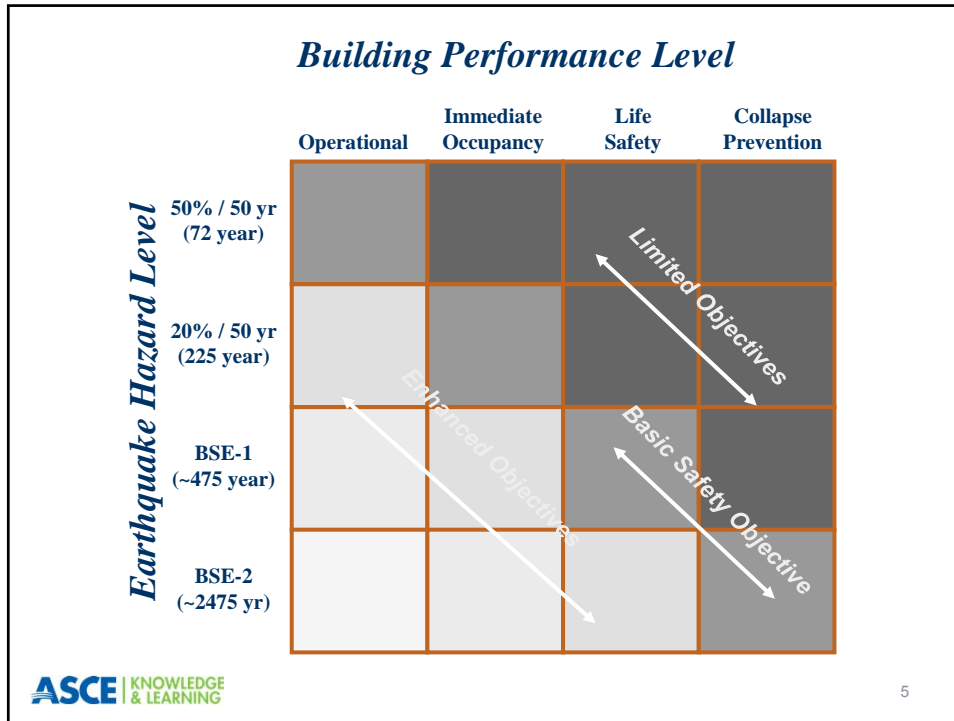
Understand Performance Objectives and Building Performance Levels as part of developing a retrofit feasibility study

Understand the seismic hazard as it relates to existing buildings

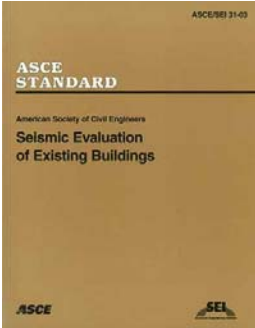
## Existing Building Tools

- 0.75\*1976 UBC
- ATC 3-06
- ATC 14
- FEMA 178 → 310 → ASCE 31-03  
Evaluating Existing Buildings
- FEMA 273 → 356 → ASCE 41-06  
“Rehabilitation” of Existing Buildings
- ASCE 41-13  
Evaluating and “Retrofit” of Existing Buildings





### ASCE 31 Evaluation Process - *Deficiency-Based*



Tier 1 – Screen for ID Potential Deficiencies


- **Select performance level, determine seismicity and model building type**
- **Check for Benchmark Building**
- **Complete Checklists - Geologic, Structural, Non-Structural**

Tier 2 – Evaluate Deficiencies

- **Perform Calculations on Identified Deficiencies**
- **Calculations Similar to ASCE 41**

Tier 3 – Detailed Evaluation

- **Follow Provisions for Seismic Rehabilitation Design or New Building Design using .75 factor**
- **Typically follow ASCE 41 Nonlinear Procedures**



## ASCE 41 Rehabilitation Process *Systematic Analysis Based*



Review Initial Considerations

Select Rehabilitation Objective

- Seismic Hazard – 50/50, 10/50, or 2/50
- Structural Performance – CP, LS, or IO
- Nonstructural Performance – LS, IO, or Operational

Obtain As-Built Information (Drawings & Matl' testing)

Select a Rehabilitation Method

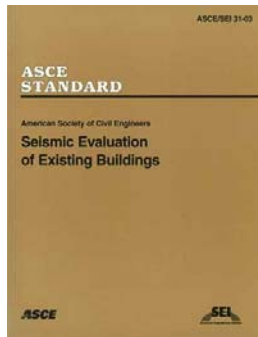
- Simplified Rehabilitation – Deficiency-Based, but Limited
- Systematic Rehabilitation
- Analysis Method – LSP, LDP, NSP, or NDP

Perform Rehabilitation Design

Verify Rehabilitation Design



## Overview of the New Standard



# Why Combine?

## “Consistency”



## Overarching Philosophy

Experientially Based

Same as New

It's too Conservative!

Keep the "Break"

Systematic & Analytical

## Overarching Philosophy

Experientially Based Tier 1 & Tier 2

BPON

Reduce the "false positives"

BPOE

Systematic & Analytical Tier 3

# Overarching Philosophy

## “Consistency”

## ASCE 7 vs. ASCE 41 Inconsistencies



Level of Seismicity does not match  
Seismic Design Categories

Nonstructural Provisions  
inconsistent

Seismic Hazard Parameters  
different due to Risk Targeting and  
new USGS data in ASCE 7-10

Scaling of response spectra and  
time histories different



# Overview of the New Standard



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## Overall Philosophy

Distinguish between prescriptive (experience-based) and systematic evaluation/retrofit

Maintain 31-03 Tier 1 as a self-contained, complete chapter

“Tier 2” as deficiency-only / prescriptive procedure (31-03 outline, 41-06 provisions)

“Tier 3” as systematic / performance procedure (41-06)

Remove distinction between “evaluation” and “retrofit” within the Standard

Do not introduce any additional “hazard reduction” prescriptive methods at this time

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## Difficulties

Potentially more complicated for typical ASCE 31 Tier 1 only users

Larger book, potentially harder to navigate

Learning curve for new uses

## Benefits of Combined ASCE 41-13

Consistent Evaluation and Retrofit Provisions

Explicit direction for existing buildings of different risk categories

Explicit “New Design Code” equivalent performance objectives

Greater consistency with ASCE 7

Less conservative Tier 1 Life Safety provisions

Updated technical provisions

## Specific Criteria for Combining

Use 41-06 as a basis and insert 31-03 into that document with outline revisions as necessary

Provide a “road map” in the first chapter to enable all types of users to effectively navigate the document

Keep performance objectives and seismic hazards one location (used for all Tiers)

Maintain the 3-tiered format but adjust concept away from a linear flow—now it’s more of a “Y”

## Specific Criteria for Combining

Treat the technical requirements for “evaluation” and “retrofit” as the same

Provide separate, consecutive chapters for Tier 1, Tier 2, and Tier 3 for consistency and flow

Place Tier 1 checklists and Tier 2 commentary statements at the end of the document

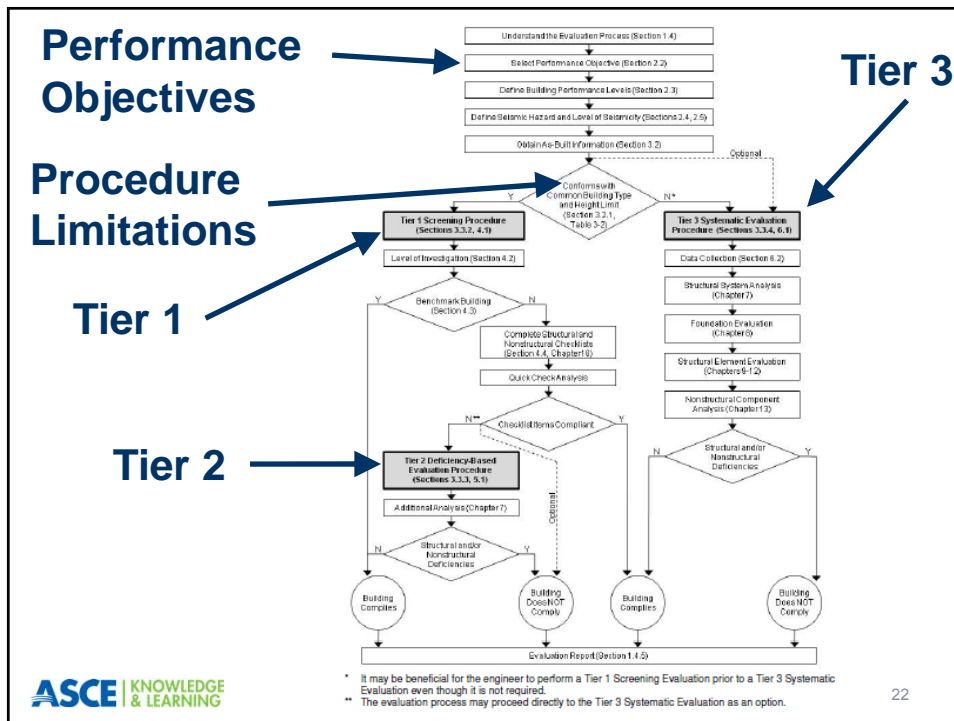
Distinguish between prescriptive (experience-based) and systematic (analytical) evaluation/rehabilitation

Maintain ASCE 31 Tier 1 as a (mostly) self-contained, complete chapter

No outline changes within 41-06 Chapters 4-9 & 11

# ASCE 41-13

- Chapter 1 General Requirements
- Chapter 2 Seismic Performance Objectives and Ground Motions
- Chapter 3 Evaluation and Retrofit Requirements
- Chapter 4 Tier 1 Screening
- Chapter 5 Tier 2 Deficiency-Based Evaluation and Retrofit
- Chapter 6 Tier 3 Systematic Evaluation and Retrofit
- Chapter 7 Analysis Procedures and Acceptance Criteria
- Chapter 8 Foundations and Geologic Site Hazards
- Chapter 9 Steel
- Chapter 10 Concrete
- Chapter 11 Masonry
- Chapter 12 Wood and Cold-Formed Steel
- Chapter 13 Architectural, Mechanical, and Electrical Components
- Chapter 14 Seismic Isolation and Energy Dissipation
- Chapter 15 System-Specific Performance Procedures
- Chapter 16 Tier 1 Checklists
- Appendix A Guidelines for Deficiency-Based Procedures
- Appendix B Use of ASCE 41-13 within Mitigation Programs



## General Provisions

### Chapter 1: General Requirements

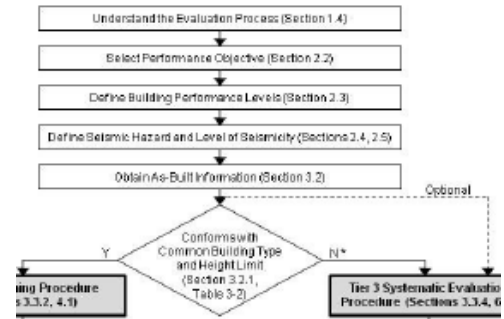
(31-03 Ch1 + 41-06 Ch1)

### Chapter 2: Seismic Performance Objectives and Ground Motions

(31-03 Ch1 + 41-06 Ch1)

### Chapter 3: Evaluation and Retrofit Requirements

(31-03 Ch 1 & 3  
+ 41-06 Ch 2 & 10  
+ new material)



## Evaluation and Retrofit Procedures

### Chapter 3: Evaluation and Retrofit Requirements

(31-03 Ch 1 & 3 + 41-06 Ch 2 & 10 + new material)

### Chapter 4: Tier 1 Screening

(31-03 Ch 3)

### Chapter 5: Tier 2 Deficiency-Based Evaluation and Retrofit

(31-03 Ch 2 & 4 + 41-06 Ch 10)

### Chapter 6: Tier 3 Systematic Evaluation and Retrofit

(41-06 Ch 2)



## Tier 1

### Chapter 4: Tier 1 Screening

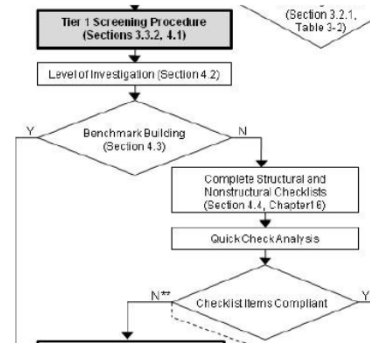
(31-03 Ch 3)

### Chapter 16: Tier 1 Checklists – Will be PDF's

(31-03 Ch 3)

### Appendix A: Guidelines for Deficiency-Based Procedures

(31-03 Ch 4 + 41-06 Ch 10)  
Commentary



## Tier 2

### Chapter 5: Tier 2 Deficiency-Based Evaluation and Retrofit

(31-03 Ch 4 + 41-06 Ch 10)

### Appendix A: Guidelines for Deficiency-Based Procedures

(31-03 Ch 4 + 41-06 Ch 10) ← Commentary

### Chapter 7: Analysis Procedures and Acceptance Criteria

(41-06 Ch 2 & 3)

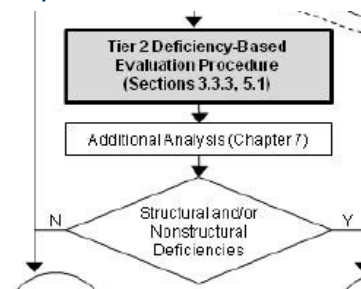
### Chapter 8: Foundations and Geologic

(41-06 Ch 4)

### Chapters 9-12: Steel, Concrete, Masonry, Wood

(41-06 Ch 5-8)

### Chapter 13: Architectural, Mechanical, and Electrical Components (41-06 Ch 11)



## Tier 3

### Chapter 6: Tier 3 Systematic Evaluation and Retrofit

(41-06 Ch 2)

### Chapter 7: Analysis Procedures and Acceptance Criteria

(41-06 Ch 2 & 3)

### Chapter 8: Foundations and Geologic Site Hazards (41-06 Ch 4)

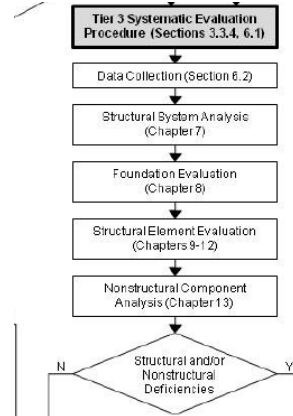
### Chapters 9-12: Steel, Concrete, Masonry, Wood

(41-06 Ch 5-8)

### Chapter 13: Architectural, Mechanical, and Electrical Components

(41-06 Ch 11)

### Chapter 14: Seismic Isolation and Energy Dissipation (41-06 Ch 9)



## The Rest...

### Chapter 15: System-Specific Performance Procedures

Special Procedure for URM (31-03 Ch 4)

Potentially others in future editions

### Appendix B: Use of ASCE 41-13 within Mitigation Programs

Guidelines for the use of the Standard for mandatory, voluntary, or triggered evaluation or retrofit (41-06 App A)

## Substantive Changes Due to Combining

Revised limitations on the applicability of T1/T2

Revised height limits and limitations on mixed systems for T1/T2

31-03 elemental T2 analysis, strengths, and acceptance criteria replaced with 41-06

31-03 full-building T2 replaced with Tier 3 (41-06)

31-03 T2 nonstructural prov. replaced with 41-06

Eliminate 0.75 factor for 31-03 T3 evaluation  
(partially offset by General Provisions updates)

Simplified retrofit (41-06 Ch10) permitted for IO

General Provisions

## The Old

### ASCE 31-03

Two Performance Levels – Life Safety & Immediate Occupancy

One Seismic Hazard –  $(2/3)*MCE$

Buried within the acceptance criteria is a factor of 0.75, which is intended to give existing buildings a “break”

### ASCE 41-06

Three Performance Levels – Collapse Prevention, Life Safety & Immediate Occupancy

Performance ranges between levels

Two Seismic Hazard – 10%/50 or  $(2/3)*MCE$  and MCE

No break for existing buildings

Basic Safety Objective  $\approx$  Performance of Occupancy Category II

## The New

### New Design Equivalent Hazards – No “Break”

BSE-2N is the ASCE 7-10  $MCE_R$

BSE-1N is  $2/3*ASCE 7-10 MCE_R$

### Existing Building Hazards – the “Break”

BSE-2E is the 5% in 50-year (975-year)

BSE-1E is the 20% in 50-year (225-year)

BSE-2E and BSE-1E cannot be greater than the BSE-2N and BSE-1N

- In SF, San Jose, parts of LA, and Oakland this means no force reduction for existing buildings

## New York Example

### New Design Equivalent Hazards – No “Break”

BSE-2N is 0.44

BSE-1N is 0.29

### Existing Building Hazards – the “Break”

BSE-2E is 0.25 (56% of  $MCE_R$ )

BSE-1E is 0.067 (23% of  $2/3 * MCE_R$ )

## San Francisco Example

### New Design Equivalent Hazards – No “Break”

BSE-2N is 1.50

BSE-1N is 1.00

### Existing Building Hazards – the “Break”

BSE-2E is 1.48 (99% of  $MCE_R$ )

BSE-1E is 0.99 (99% of  $2/3 * MCE_R$ )

## New Seismic Hazards

Consistent Seismic Hazard science between ASCE 7-10 and ASCE 41-13

NGA relationships and new USGS maps used

All hazards are Maximum Direction

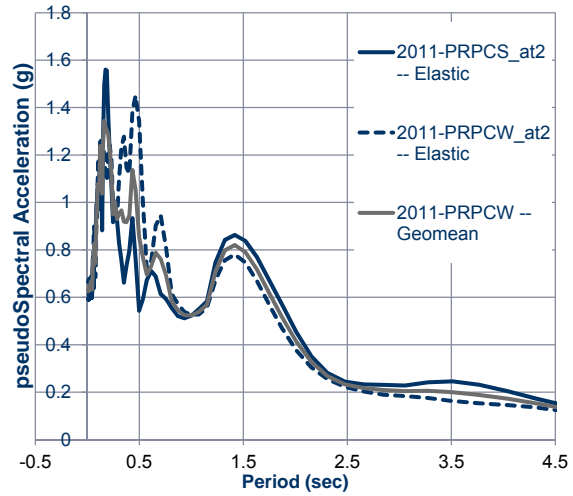
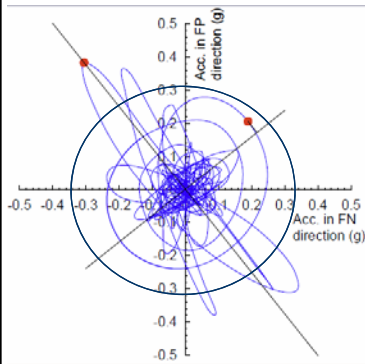
Scaling of site specific hazards matches ASCE 7 provisions

Scaling of response histories now can be done by using spectral matching or other approved methods

## Maximum Direction vs. Geomean

Geomean  

$$S_{a,gm} = \sqrt{(S_{aN}) * (S_{aP})}$$



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## Old Structural Performance Levels & Ranges

Immediate Occupancy

Life Safety

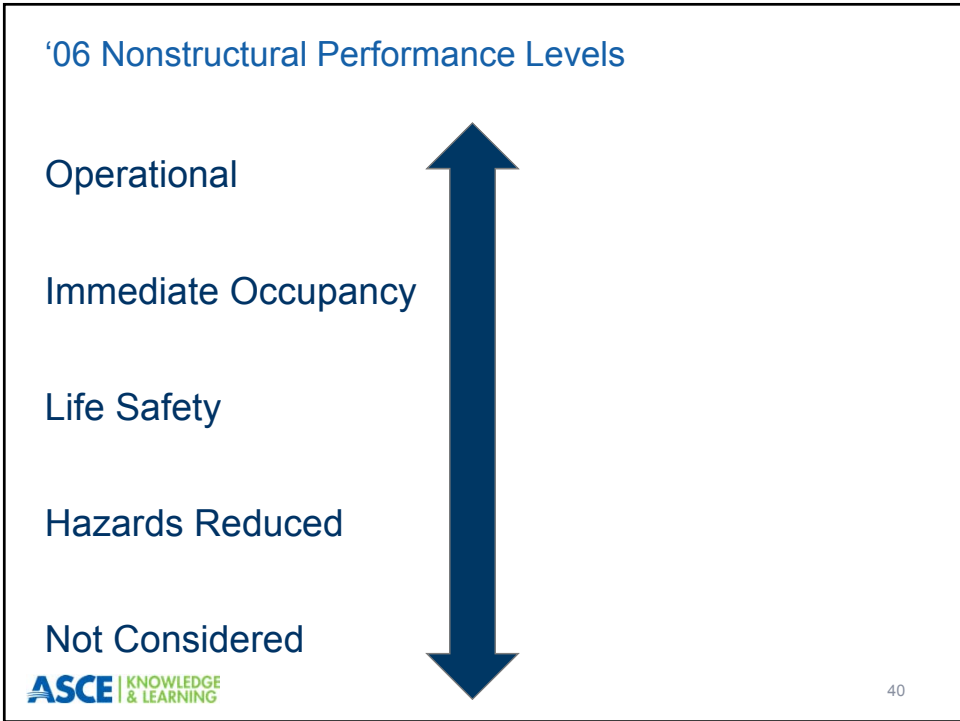
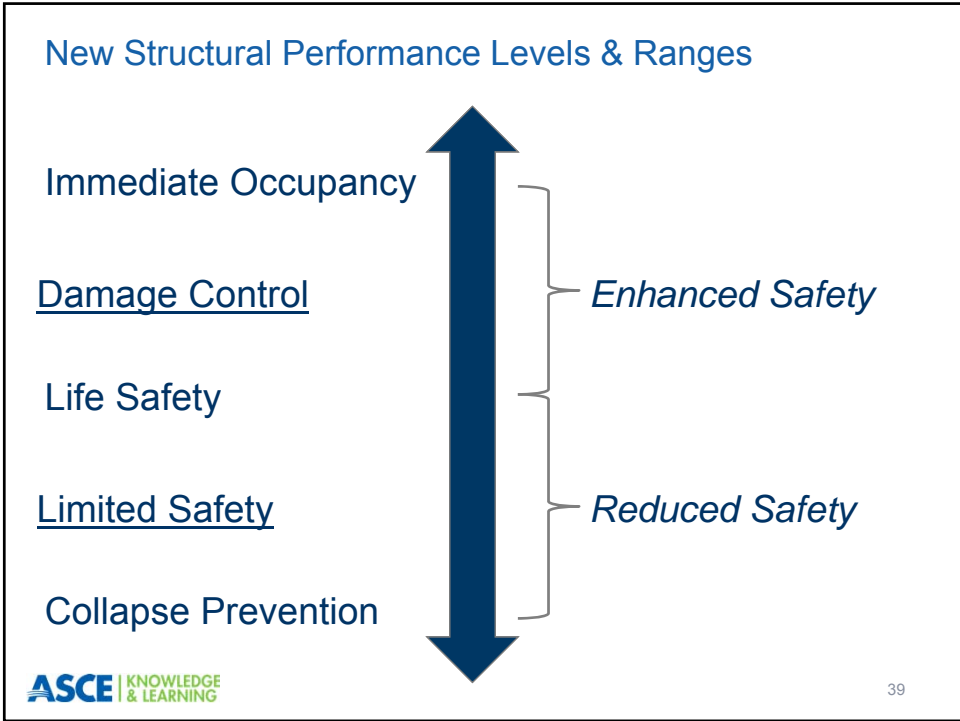
Collapse Prevention

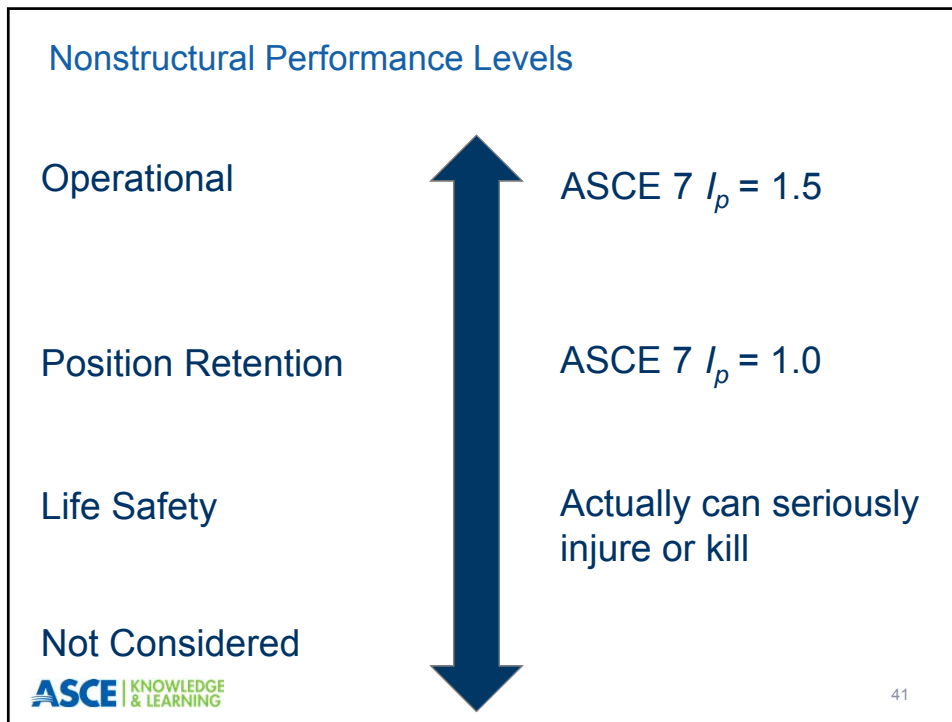


Damage Control

Limited Safety

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### Basic Performance Objective for Existing Buildings - BPOE

Risk Category	Tier 1	Tier 2	Tier 3	
	BSE-1E	BSE-1E	BSE-1E	BSE-2E
I & II	<b>Life Safety</b> Structural Performance  <b>Life Safety</b> Nonstructural Performance (3-C)	<b>Life Safety</b> Structural Performance  <b>Life Safety</b> Nonstructural Performance (3-C)	<b>Life Safety</b> Structural Performance  <b>Life Safety</b> Nonstructural Performance (3-C)	<b>Collapse Prevention</b> Structural Performance  Nonstructural Performance Not Considered (5-D)
III	<b>Damage Control</b> Structural Performance  <b>Position Retention</b> Nonstructural Performance (2-B)	<b>Damage Control</b> Structural Performance  <b>Position Retention</b> Nonstructural Performance (2-B)	<b>Damage Control</b> Structural Performance  <b>Position Retention</b> Nonstructural Performance (2-B)	<b>Limited Safety</b> Structural Performance  Nonstructural Performance Not Considered (4-D)
IV	<b>Immediate Occupancy</b> Structural Performance  <b>Position Retention</b> Nonstructural Performance (1-B)	<b>Immediate Occupancy</b> Structural Performance  <b>Position Retention</b> Nonstructural Performance (1-B)	<b>Immediate Occupancy</b> Structural Performance  <b>Position Retention</b> Nonstructural Performance (1-B)	<b>Life Safety</b> Structural Performance  Nonstructural Performance Not Considered (3-D) <sup>42</sup>

## Basic Performance Objective- Equivalent to New Building Standards - BPON

Risk Category	Tier 3	
	BSE-1N	BSE-2N
I & II	<b>Life Safety</b> Structural Performance <b>Position Retention</b> Nonstructural Performance (3-C)	<b>Collapse Prevention</b> Structural Performance Nonstructural Performance Not Considered (5-D)
III	<b>Damage Control</b> Structural Performance <b>Position Retention</b> Nonstructural Performance (2-B)	<b>Limited Safety</b> Structural Performance Nonstructural Performance Not Considered (4-D)
IV	<b>Immediate Occupancy</b> Structural Performance <b>Operational</b> Nonstructural Performance (1-A)	<b>Life Safety</b> Structural Performance Nonstructural Performance Not Considered (3-D)

## Levels of Seismicity

<u>ASCE 41-13 Checklists</u>		<u>ASCE 7 Seismic Design Categories</u>
Very Low Seismicity	—————>	SDC A
Low Seismicity	—————>	SDC B
Moderate Seismicity	—————>	SDC C
High Seismicity	—————>	SDC D, E and F

## Limits on Deficiency-Based Procedures

Only allowed for Model Bldg type in each direction

Limited use for mixed systems

Tier 2 now allowed for IO retrofit



Table 3-2 Limitations on the Use of the Tier 1 and Tier 2 Procedures<sup>1</sup>

Common Building Type <sup>2</sup>	Number of Stories <sup>3</sup> beyond which the Tier 3 Systematic Procedures are Required							
	Level of Seismicity							
	Very Low		Low		Moderate		High	
	S-3	S-1	S-3	S-1	S-3	S-1	S-3	S-1
<b>Wood Frames</b>								
Light (W1)	NL	NL	NL	4	4	4	4	4
Multi-Story, Multi-Unit Residential (W1A)	NL	NL	NL	6	6	6	6	4
Commercial and Industrial (W2)	NL	NL	NL	6	6	6	6	4
<b>Steel Moment Frames</b>								
Rigid Diaphragm (S1)	NL	NL	NL	12	12	8	8	6
Flexible Diaphragm (S1A)	NL	NL	NL	12	12	8	8	6
<b>Steel Braced Frames</b>								
Rigid Diaphragm (S2)	NL	NL	NL	8	8	8	8	6
Flexible Diaphragm (S2A)	NL	NL	NL	8	8	8	8	6
<b>Steel Light Frames (S3)</b>	NL	1	1	1	1	1	1	1
<b>Dual Systems with Backup Steel Moment Frames (S4)</b>	NL	NL	NL	12	12	8	8	6
<b>Steel Frames with Infill Masonry Shear Walls</b>								
Rigid Diaphragm (S5)	NL	NL	NL	12	12	8	8	4
Flexible Diaphragm (S5A)	NL	NL	NL	12	12	8	8	4
<b>Concrete Moment Frames (C1)</b>	NL	NL	NL	12	12	8	8	6
<b>Concrete Shear Walls</b>								
Rigid Diaphragm (C2)	NL	NL	NL	12	12	8	8	6
Flexible Diaphragm (C2A)	NL	NL	NL	12	12	8	8	6
<b>Concrete Frame with Infill Masonry Shear Walls</b>								
Rigid Diaphragm (C3)	NL	NL	NL	12	12	8	8	4
Flexible Diaphragm (C3A)	NL	NL	NL	12	12	8	8	4
<b>Precast/Tilt-up Concrete Shear Walls</b>								
Flexible Diaphragm (PC1)	NL	NL	3	2	2	2	2	2
Rigid Diaphragm (PC1A)	NL	NL	3	2	2	2	2	2
<b>Precast Concrete Frames</b>								
With Shear Walls (PC2)	NL	NL	NL	6	6	NP	4	NP
Without Shear Walls (PC2A)	NL	NL	NL	6	6	NP	4	NP
<b>Reinforced Masonry Bearing Walls</b>								
Flexible Diaphragm (RM1)	NL	NL	NL	8	8	8	8	6
Rigid Diaphragm (RM2)	NL	NL	NL	8	8	8	8	6
<b>Unreinforced Masonry Bearing Walls</b>								
Flexible Diaphragm (URM)	NL	NL	6	4	6	NP	4	NP
Rigid Diaphragm (URMA)	NL	NL	6	4	6	NP	4	NP

<sup>1</sup>The Tier 3 Systematic procedures are required for buildings with more than the number of stories listed herein.

<sup>2</sup>Common Building Types are defined in Section 3.2.1.

<sup>3</sup>Number of stories shall be considered as the number of stories above lowest adjacent grade.

NL = No Limit (No limit on the number of stories).

NP = Not Permitted (Tier 3 Systematic procedures are required).

# Technical Changes

## Tier 1 Screening Updates

Benchmark buildings revised

Data collection and condition assessment spelled out

Checklist statements reorganized

General Building Checklist

System Specific Checklist

Nonstructural Checklist

Checklist statements removed to reduce false positives

Future webinar on this topic



## Tier 2 Evaluation Updates

All Tier 2 analysis provisions are the same as Tier 3

Chapter 5 contains explicit pointers to analysis, foundation, and material sections for deficiency-based evaluation

All material capacities and acceptance criteria per ASCE 41 provisions

Kappa = 0.75 required unless testing carried out



## Material Testing Provisions Updates

Kappa can be taken as 0.9 when you are evaluating to the BSO-E, have good drawings, but don't do testing

Rebar testing provisions updated

Concrete testing provisions updated



## Analysis Provision Updates

Nonlinear response history (NDP)

Wall out-of-plane forces revised

Force-controlled elements permitted to be modeled and fail in nonlinear analysis

Simplified NSP deleted

Simplified table for  $C_1C_2$



## Geotechnical Provision Updates

Geotechnical hazards are evaluated at the same seismic hazard level the building is being evaluated to

### Liquefaction Analysis Procedure

- Analyze the structure with no Liquefaction
- Analyze the structure with a liquefaction adjusted spectra and foundation properties
- Analyze the structure for the lateral spreads and differential settlements

New provisions for foundation rocking

Updated soil-structure interaction provisions



## Steel Provision Updates

Addition of BRBF Provisions

Updated CBF Provisions

Updated default material properties



## Concrete Provision Updates

Supplement 1 changes completely included in the published document

Updated bi-axial column provisions

Updated anchors in concrete provisions



## Light-Frame Provision Updates

Separate sections for wood and cold-formed steel light frame

Updated wood and CFS reference standards

Updated provisions for shear walls and horizontally sheathed walls



## Masonry Provision Updates

Re-introduction of bed-joint sliding as a deformation controlled action

Updated pier/wall rocking provisions and re-introduction of toe-crushing limit state

Updated provisions for masonry infill

Provision for anchors into masonry

Updates to the Special Provision for URM



## Seismic Isolation/Supplemental Damping Provision Updates

Design can proceed with upper and lower bound properties instead of waiting for isolator testing

Accidental torsion reduced

Vertical force distribution equation updated

Damper testing revised to be more stringent

Peer review requirements reduced



## Status

Referenced in

UFC 03-310-04

2015 IBC and IEBC

Update in Progress with new edition expected in 2017



# **ASCE 41-13** ***Seismic Evaluation and Retrofit of Existing Buildings***

Your Thoughts & Questions?

