

Nonlinear Analysis in Accordance with ASCE 7-16 (proposed) and ASCE 41-13: Compatibilities, Incompatibilities, and Needed Future Work

Presented by: Curt B. Haselton, PhD, PE
Chair, Civil Engineering @ CSU, Chico



Tenth U.S. National Conference on
Earthquake Engineering

July 21-25, 2014; Anchorage, Alaska



Building Seismic Safety Council
Issue Team 4 on Response History Analysis



The Issue Team Membership

Practitioner

- CB Crouse, URS Corp.
- Chung-Soo Doo, SOM
- Andy Fry, MKA
- Mahmoud Hachem, Degenkolb
- Ron Hamburger, SGH
- John Hooper, MKA
- Afshar Jalalian, R&C
- Charles Kircher, Kircher & Assoc.
- Silvia Mazzoni, Degenkolb
- Bob Pekelnicky, Degenkolb
- Mark Sinclair, Degenkolb
- Rafael Sabelli, Walter P Moore
- Reid Zimmerman, R&C

Academic

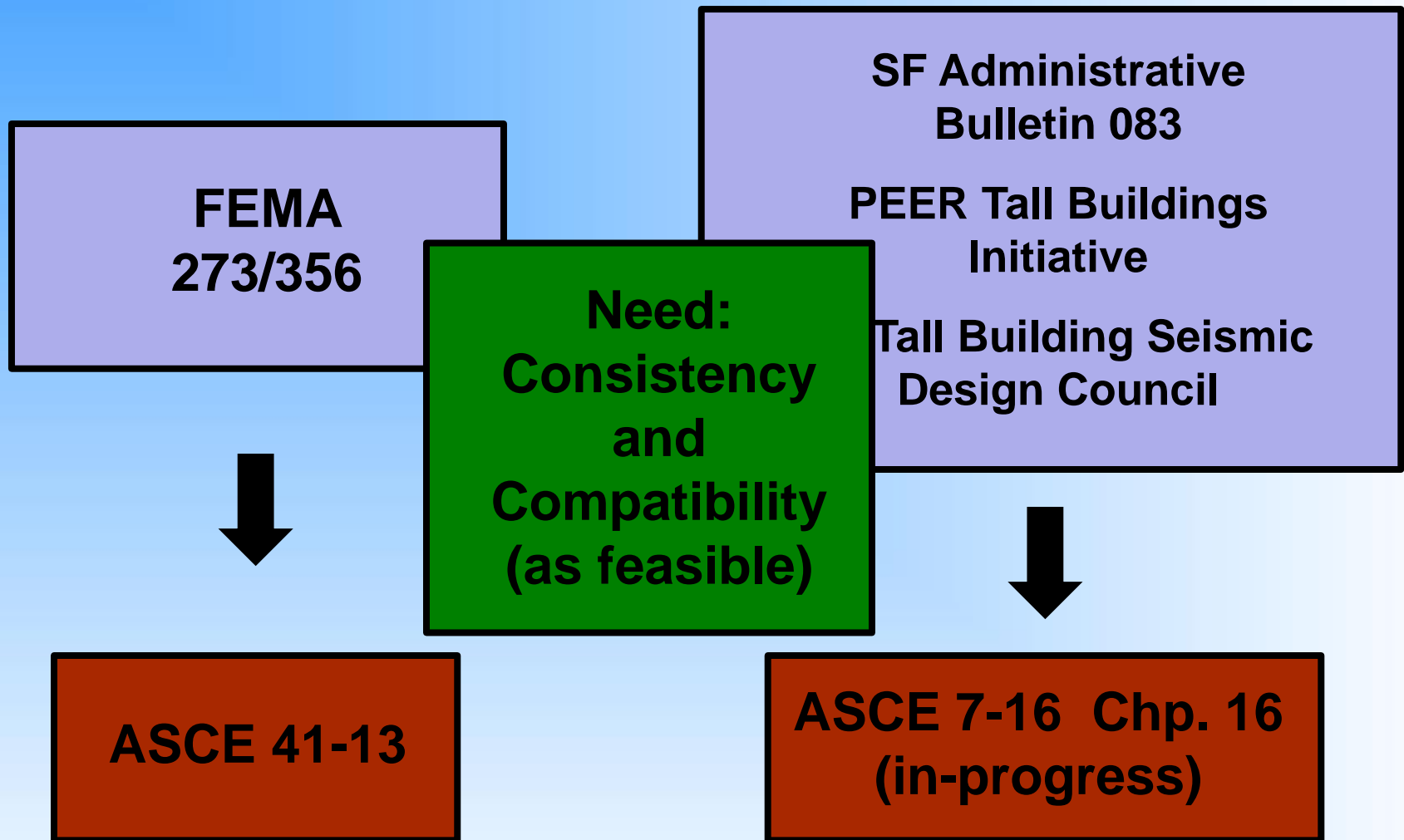
- Curt Haselton, CSUC, Team Chair
- Jack Baker, Stanford University
- Finley Charney, Virginia Tech
- Greg Deierlein, Stanford Univ.
- Ken Elwood, Univ. of British Col.
- Steve Mahin, UC Berkeley
- Graham Powell, UC Berkeley Em.
- Jon Stewart, UCLA
- Andrew Whittaker, SUNY Buffalo

Government

- Robert Hanson, FEMA
- Jay Harris, NIST
- Nico Luco, USGS
- Mike Tong, FEMA



Existing Versus New Buildings



Chapter 16: Overall Structure

Title: Seismic Response-History Procedure

- **Section 16.1:** General Requirements
- **Section 16.2:** Ground Motions
- **Section 16.3:** Modeling and Analysis
- **Section 16.4:** Analysis Results and Accept. Criteria
- **Section 16.5:** Design Review

Status: In ASCE 7 process.



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- **Section 16.1: General Requirements**
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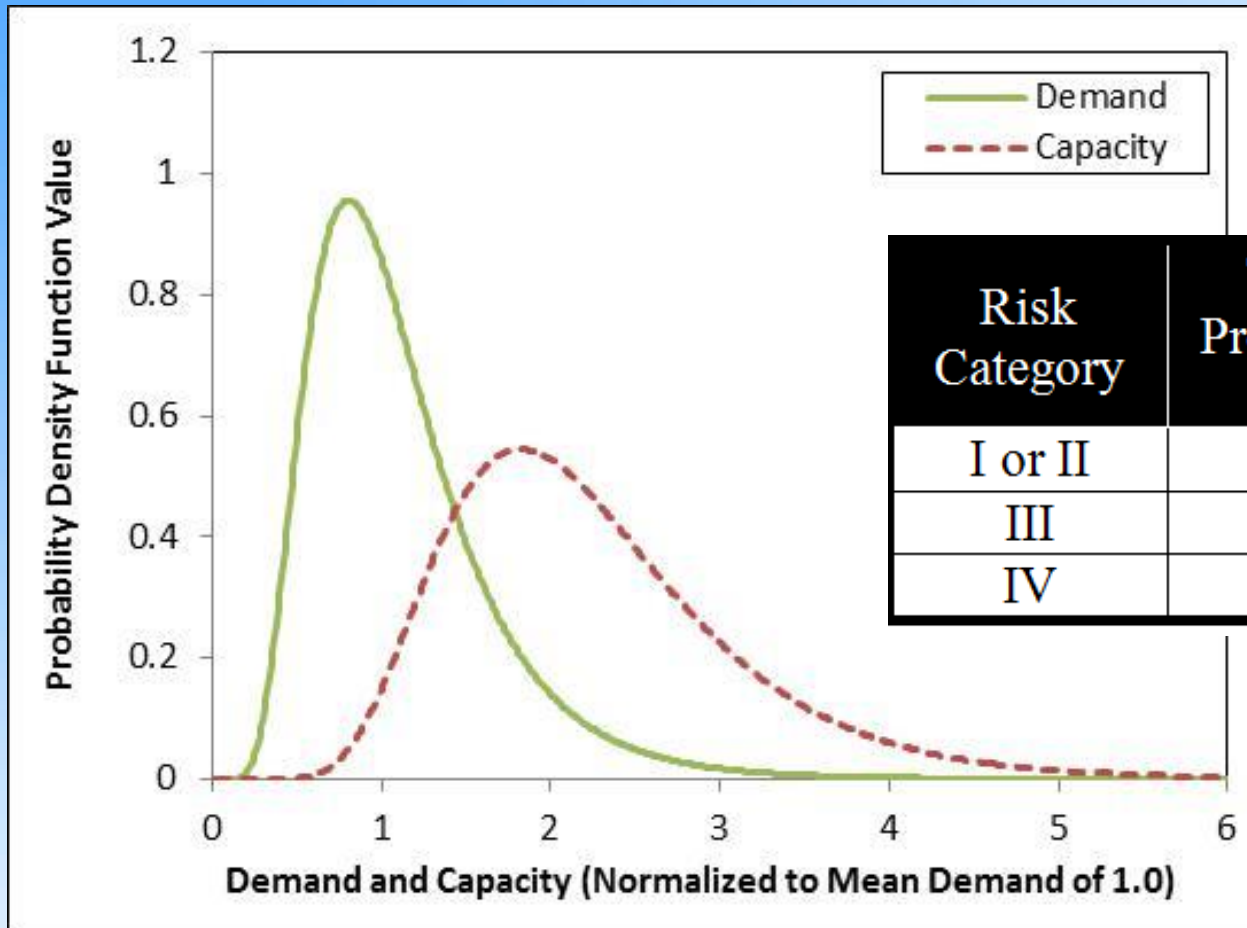


Acceptance Criteria

- **Big Focus:** Develop acceptance criteria more clearly tied to the ASCE7 safety goals.

Risk Category	Tolerable Probability of Collapse	Ground Motion Level
I or II	10%	MCE_R
III	6%	MCE_R
IV	3%	MCE_R

Acceptance Criteria: Components



Risk Category	Tolerable Probability of Collapse	Ground Motion Level
I or II	10%	MCE_R
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IV	3%	MCE_R



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Acceptance Criteria: Components

- Component Categories:
 - ✓ Force-controlled (brittle)
 - ✓ Deformation-controlled
- Component Sub-Categories:
 - ✓ Critical = failure causes immediate global collapse
 - ✓ Ordinary = failure causes local collapse (one bay)
 - ✓ Non-critical = failure does not cause collapse

Acceptance Criteria: Force-Controlled Example

- Force-controlled (brittle) components:

$2.0 I_e F_u \leq F_e$ for “critical” (same as PEER-TBI)

$1.5 I_e F_u \leq F_e$ for “ordinary”

$1.0 I_e F_u \leq F_e$ for “non-critical” (judgment)

F_u = mean demand (from 11 motions)

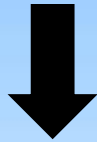
F_e = expected strength

Acceptance Criteria: Collapses

- **Current Treatment in ASCE7-10:** Nothing but silence....
- **Philosophical Camp #1:**
 - ✓ Outliers are statistically meaningless.
 - ✓ Acceptance criteria should be based only on mean/median.
- **Philosophical Camp #2:**
 - ✓ Outliers are statistically meaningless, but are still a concern.
 - ✓ Acceptance criteria should consider “collapses”.
- **Proposed Criterion (based on lots of statistics):**
 - ✓ Basic Case: Allow up to 1/11 “collapses” but not 2/11.

Compatibility Issues

**FEMA
273/356**



ASCE 41-13

**SF Administrative
Bulletin 083**

**PEER Tall Buildings
Initiative**

**LA Tall Building Seismic
Design Council**

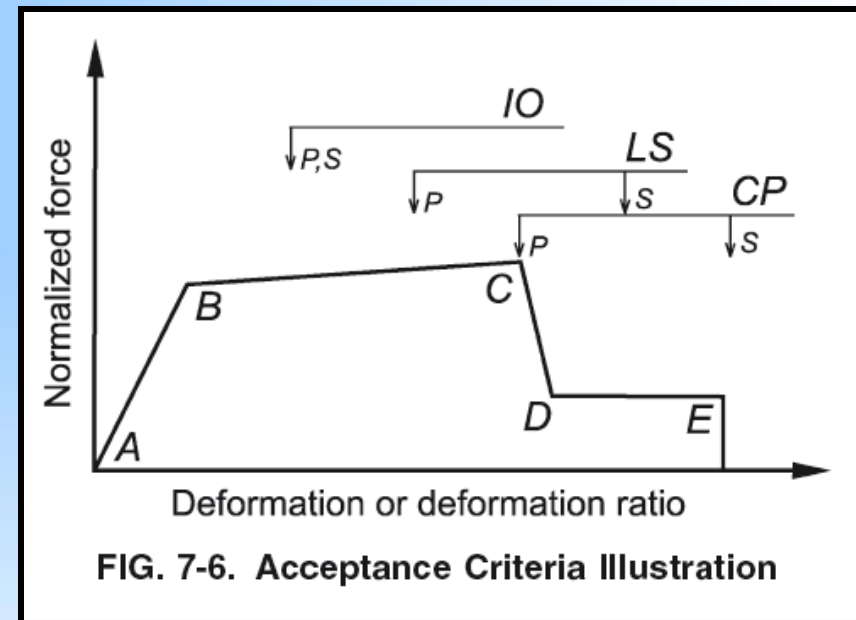


**ASCE 7-16 Chp. 16
(in-progress)**

Compatibility Issues

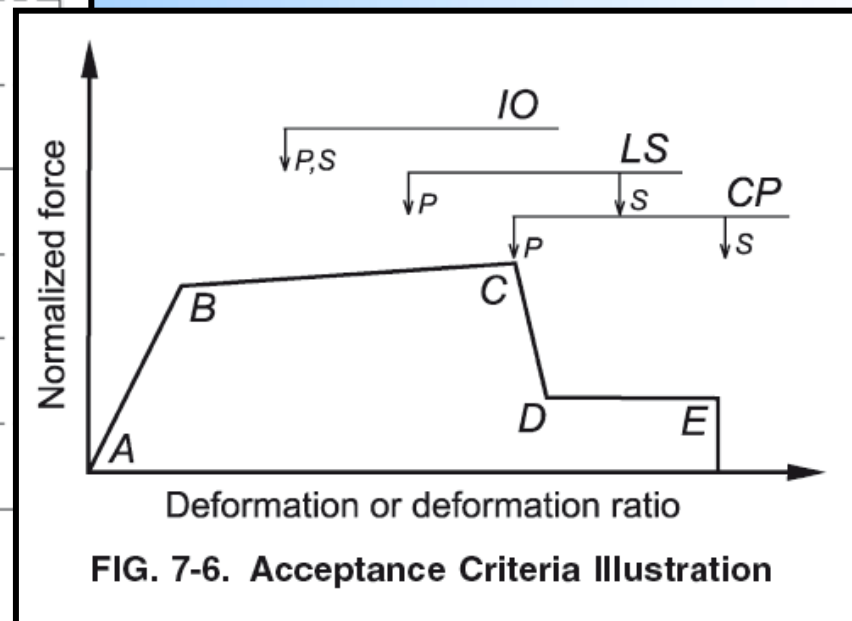
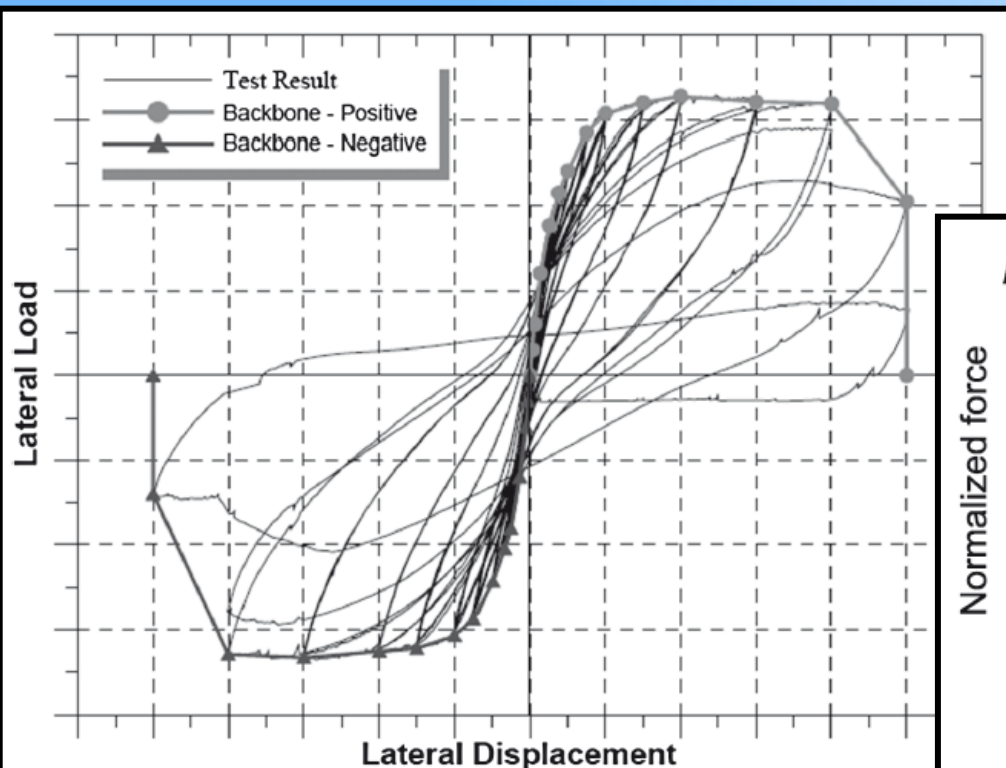
- **Issue #1:** Structure of component types and acceptance criteria.
 - Component Categories:
 - ✓ Force-controlled (brittle)
 - ✓ Deformation-controlled
 - Component Sub-Categories:
 - ✓ Critical = failure causes immediate global collapse
 - ✓ Ordinary = failure causes local collapse (one bay)
 - ✓ Non-critical = failure does not cause collapse

- **Issue #2:** Statistical basis for component-level acceptance criteria.



Compatibility Issues

- **Issue #2:** Statistical basis for component-level acceptance criteria (Sec. 7.6).



Compatibility Issues

- **Issue #2:** Statistical basis for component-level acceptance criteria (tables and Elwood et al. 2007).

Table 10-8. Modeling Parameters and Numerical Acceptance Criteria for Nonlinear Procedures—Reinforced Concrete Columns

Conditions			Modeling Parameters ^a			Acceptance Criteria ^a		
			Plastic Rotations Angle (radians)	Residual Strength Ratio	Plastic Rotations Angle (radians)			
					Performance Level			
					IO	LS	CP	
Condition i. ^b								
$\frac{P}{A_g f'_c}$	$\rho = \frac{A_v}{b_w s}$							
≤0.1	≥0.006	0.035	0.060	0.2	0.005	0.045	0.060	
≥0.6	≥0.006	0.010	0.010	0.0	0.003	0.009	0.010	
≤0.1	=0.002	0.027	0.034	0.2	0.005	0.027	0.034	
≥0.6	=0.002	0.005	0.005	0.0	0.002	0.004	0.005	
Condition ii. ^b								
$\frac{P}{A_g f'_c}$	$\rho = \frac{A_v}{b_w s}$	$\frac{V}{b_w d \sqrt{f'_c}}$						
≤0.1	≥0.006	≤3 (0.25)	0.032	0.060	0.2	0.005	0.045	0.060
≤0.1	≥0.006	≥6 (0.5)	0.025	0.060	0.2	0.005	0.045	0.060
≥0.6	≥0.006	≤3 (0.25)	0.010	0.010	0.0	0.003	0.009	0.010
≥0.6	≥0.006	≥6 (0.5)	0.008	0.008	0.0	0.003	0.007	0.008
≤0.1	≤0.0005	≤3 (0.25)	0.012	0.012	0.2	0.005	0.010	0.012
≤0.1	≤0.0005	≥6 (0.5)	0.006	0.006	0.2	0.004	0.005	0.006
≥0.6	≤0.0005	≤3 (0.25)	0.004	0.004	0.0	0.002	0.003	0.004
≥0.6	≤0.0005	≥6 (0.5)	0.0	0.0	0.0	0.0	0.0	0.0



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Compatibility Issues

- **Issue #3:** Treatment of “collapse” cases (of secondary importance compared with the others).
- Next steps:
 - Decide which compatibility issues are most important (suggest that statistical basis of acceptance criteria is the top priority).
 - Work on it!

Questions/Comments?

- Thanks you for your time.
- Please contact me if you would like more information/background because 11 minutes is not enough!
- Contact:
 - E-mail: chaselton@csuchico.edu
 - Phone: (530) 898-5457