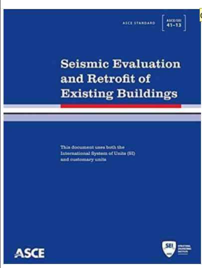
ASCE 41-17



GH1

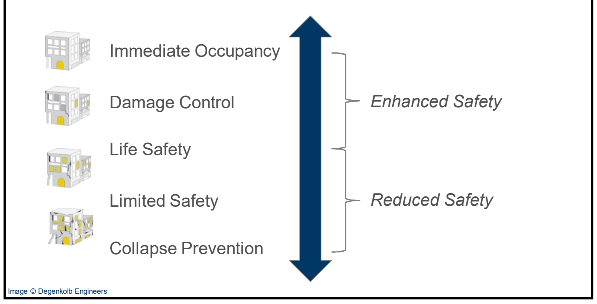
- 3 year update cycle
- 30 voting members & 70 associate members
- Publication December 2017
- Referenced in the 2018 IEBC

2

ASCE 41-17

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
Chapter 15 Supplemental Energy Dissipation
Chapter 16 System-Specific Performance Procedures
Chapter 17 Tier 1 Checklists
Chapter 18 References
Appendix A Guidelines for Deficiency-Based Procedures
Appendix B Use of ASCE 41-13 within Mitigation Programs

ASCE 41 Structural Performance Levels

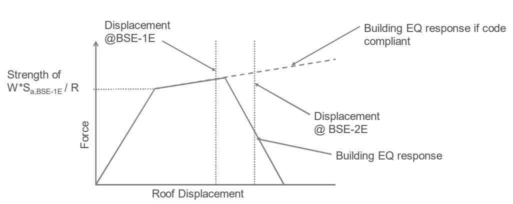


Basic Performance Objective for Existing Buildings (BPOE)

Risk Category	BPOE BSE-1E	BPOE BSE-2E
I & II *(Typical buildings)*	**Life Safety** Structural Performance **Life Safety** Nonstructural Performance	**Collapse Prevention** Structural Performance Nonstructural Performance Not Considered
III *(Schools, Assembly)*	**Damage Control** Structural Performance **Position Retention** Nonstructural Performance	**Limited Safety** Structural Performance Nonstructural Performance Not Considered
IV *(Essential facilities, i.e. hospitals & EOCs)*	**Immediate Occupancy** Structural Performance **Position Retention** Nonstructural Performance	**Life Safety** Structural Performance Nonstructural Performance Not Considered

BPOE Risk Category II

Why check both BSE-1E and BSE-2E when ASCE 7 only requires one?



ASCE 41-13 Basic Performance Objective for Existing Buildings (BPOE)

Tier 1 & 2

Risk Category	BPOE BSE-1E	BPOE BSE-2E
I & II (*Typical buildings*)	**Life Safety** Structural Performance **Life Safety** Nonstructural Performance	**Deemed to Comply per Commentary**
III (*Schools, Assembly*)	**Damage Control** Structural Performance **Position Retention** Nonstructural Performance	**Deemed to Comply per Commentary**
IV (*Essential facilities, i.e. hospitals & EOCs*)	**Immediate Occupancy** Structural Performance **Position Retention** Nonstructural Performance	**Deemed to Comply per Commentary**

BPOE ≈ ASCE 31-03 Life Safety & Immediate Occupancy

BPOE represent a lesser performance objective that has historically been accepted for existing buildings.

- "E" hazards used instead of "N" hazards, as opposed to ¾ "code" or higher "m"
- Same structural performance levels
- Nonstructural is Life Safety instead of Position Retention for RC I & II
- Nonstructural is Position Retention instead of Operational for RC IV
- ASCE 41-13 Tier 1 & Tier 2, only need to check performance in the BSE-1E

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 DE)

BSE-2E/BSE-1E = 1.5

41-13 to 31-03 – 33% increase in demand due to BSE-1E and BSE-1N the same.

Los Angeles Example

New Design Equivalent Hazards – No "Break"

BSE-2N is 2.40

BSE-1N is 1.60

Existing Building Hazards – the "Break"

BSE-2E is 1.76 (73% of MCE_R)

BSE-1E is 0.84 (53% of DE)

BSE-2E/BSE-1E = 2.0

41-13 to 31-03 – ASCE 31 2/3MCE = 1.44 is 77% of ASCE 31 demand.

Salt Lake City Example

New Design Equivalent Hazards – No "Break"

BSE-2N is 1.54

BSE-1N is 1.03

Existing Building Hazards – the "Break"

BSE-2E is 1.07 (69% of MCE_R)

BSE-1E is 0.29 (28% of DE)

BSE-2E/BSE-1E = 3.7

41-13 to 31-03: 2/3MCE = 1.15, 41-13 is 34% of ASCE 31 demand.

Memphis Example

New Design Equivalent Hazards – No "Break"

BSE-2N is 1.01

BSE-1N is 0.67

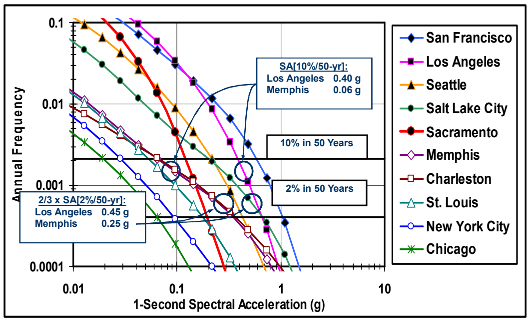
Existing Building Hazards – the "Break"

BSE-2E is 0.71 (67% of MCE_R)

BSE-1E is 0.13 (19% of DE)

BSE-2E/BSE-1E = 5.5

41-13 to 31-03: 2/3MCE = 0.93, 41-13 is 19% of ASCE 31 demand

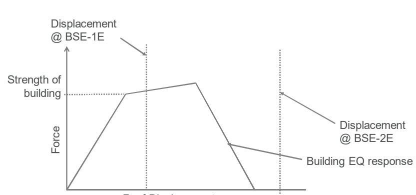


Reasons for ASCE 41-13 decision

- "The hazard is the hazard,"
  - If it is low => lack of probability of a major earthquake
- Better to address the most egregious buildings (i.e. ones that fail at a very low hazard level) than set to high a bar

ASCE 41-17 Issue

- Engineers in Memphis and other west of CA regions concerned that the new hazard is too low and does not provide collapse prevention at the BSE-2E hazard



Why Does BSE-2E Matter?

ASCE 41-17
Tier 1 & Tier 2
Basic Performance Objective for Existing Buildings (BPOE)

- RC I – III: Tier 1 & 2 at BSE-2E
- RC IV: Explicitly check both hazards.

	BPOE	
Risk Category	BSE-1E	BSE-2E
I & II *(Typical buildings)*	*Deemed to Comply* **Life Safety** Nonstructural Performance	**Collapse Prevention** Structural Performance Nonstructural Performance Not Considered
III *(Schools, Assembly)*	*Deemed to Comply* **Position Retention** Nonstructural Performance	**Limited Safety** Structural Performance Nonstructural Performance Not Considered
IV *(Essential facilities, i.e. hospitals & EOCs)*	**Immediate Occupancy** Structural Performance **Position Retention** Nonstructural Performance	**Life Safety** Structural Performance Nonstructural Performance Not Considered

Nonstructural BSE-1E vs. BSE-2E

If BSE-1E is too low in certain parts of the country for structural evaluation, would it not also be too low for nonstructural?

Nonstructural BSE-1E vs. BSE-2E

Since a building is checked for collapse prevention at BSE-2E, is there a corollary nonstructural performance level?

What nonstructural components would be included?

Hazards Reduced Nonstructural Performance

Create a performance level that addresses falling hazard that could serious injure or kill many people.

Different than Life Safety which is based on injuring or killing a person.

ASCE 41 Nonstructural Performance Levels

Operational	ASCE 7 I_p = 1.5
Position Retention	ASCE 7 I_p = 1.0
Life Safety	Actually can seriously injure or kill someone
Hazards Reduced	Actually can seriously injure or kill lots of people

Hazards Reduced Nonstructural Performance

- In ASCE 41-13:
  - Nonstructural components not considered at BSE-2E level and only evaluated at BSE-1E
- Where BSE-1E may be much less than BSE-2E, some nonstructural components may not be adequately evaluated for life safety
- Hazards Reduced represents a subset of nonstructural components to be evaluated at BSE-2E level
  - Some nonstructural hazards can have as great of an effect on life safety as local collapse of the structure
  - If BSE-2E exceeds BSE-1N, force level is capped at BSE-1N
- Table 13-1 updated to include Hazards Reduced
- Nonstructural Checklists updated

Hazards Reduced Examples

- Cladding and parapets over busy sidewalks
- Heavy plaster ceilings over assembly spaces
- URM or hollow clay tile partitions in assembly spaces
- Hazardous materials
- Marquees and architectural appendages over egress and sidewalks
- Storage racks

"If it can be demonstrated that the component does not pose a threat of serious injury to many people due to falling or failing under the seismic hazard level being considered, the component need not be considered in the Hazards Reduced nonstructural performance level."

ASCE 41-17 Basic Performance Objective for Existing Buildings (BPOE)

- Screen for both Life Safety and Hazards Reduced.
- Do calculations for HR NS components at BSE-2E.

	BPOE	
Risk Category	BSE-1E	BSE-2E
I & II *(Typical buildings)*	**Life Safety** Structural Performance **Life Safety** Nonstructural Performance	**Collapse Prevention** Structural Performance ***Hazards Reduced*** *Nonstructural Performance*
III *(Schools, Assembly)*	**Damage Control** Structural Performance **Position Retention** Nonstructural Performance	**Limited Safety** Structural Performance ***Hazards Reduced*** *Nonstructural Performance*
IV *(Essential facilities, i.e. hospitals & EOCs)*	**Immediate Occupancy** Structural Performance **Position Retention** Nonstructural Performance	**Life Safety** Structural Performance ***Hazards Reduced*** *Nonstructural Performance*

Overview – Chapters 4 and 17 Tier 1 Screening and Checklists

- Impacts of BPOE changes
- Checklist reorganization
- Checklist updates
- Quick Check acceptance criteria

Updates for BPOE

- ASCE 41-13: Checklists completed for LS in BSE-1E, then deemed to comply with CP in BSE-2E
- ASCE 41-17: Checklists completed for CP in BSE-2E, then deemed to comply with LS in BSE-1E
- Therefore, no fundamental change to structural checklists, just rename LS checklists to CP checklists

~~16~~17.1.2~~LS~~CP ~~Life Safety~~Collapse Prevention Basic Configuration Checklist This Basic Configuration Checklist shall be completed for all building types, except buildings in Very Low Seismicity, being evaluated to the ~~Life Safety~~Collapse Prevention Performance Level. Once this checklist has been completed, complete the appropriate building type checklist for the desired Performance Level as shown in Table ~~4-7~~4-6. Tier 1 screening shall include on-site investigation and condition assessment as required by Section 4.2.1.

- Hazards Reduced added to nonstructural checklists

Quick Check Acceptance Criteria

- Provide Ms factors for 3 performance levels: IO, LS, and CP
  - IO & LS for RC IV
  - CP for RC II
  - Interpolate between CP and LS for RC III
- ASCE 41-13 LS & IO Ms factors reduced by ~25% to account for the elimination of the "75% factor" from 31-03 to 41-13
- Add new Ms factors for CP, set at ~1.5xLS…..why?
  - Life Safety performance has traditionally be considered as a 25 percent margin against collapse (based on a detailed quantitative analysis)
  - The failure rate for buildings undergoing Tier 1 screening generally has been perceived to be too low
  - The ratio to BSE-2E to BSE-1E ground motions in the western US is typically 1.5 to 2.5
  - Consistency between Ms and m factors not a primary consideration (system vs element)

Nonstructural Checklist Updates

- Added Hazards Reduced (HR) criteria
  - No added statements, just classifying current statements as HR or not

Partitions

HR-LMH; LS-LMH; PR-LMH. UNREINFORCED MASONRY: Unreinforced masonry or hollow-clay tile partitions are braced at a spacing of at most 10 ft in Low or Moderate Seismicity, or at most 6 ft in High Seismicity. (Commentary: Sec. A.7.1.1. Tier 2: Sec. 13.6.2)

HR-LMH; LS-LMH; PR-LMH. HEAVY PARTITIONS SUPPORTED BY CEILINGS: The tops of masonry or hollow-clay tile partitions are not laterally supported by an integrated ceiling system. (Commentary: Sec. A.7.2.1. Tier 2: Sec. 13.6.2)

HR-not required; LS-MH; PR-MH. DRIFT: Rigid cementitious partitions are detailed to accommodate the following drift ratios: in steel moment frame, concrete moment frame, and wood frame buildings, 0.02; in other buildings, 0.005. (Commentary A.7.1.2. Tier 2: Sec. 13.6.2)

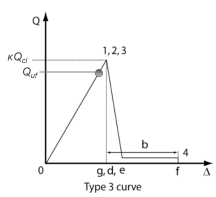
HR-not required; LS-not required; PR-MH. LIGHT PARTITIONS SUPPORTED BY CEILINGS: The tops of gypsum board partitions are not laterally supported by an integrated ceiling system. (Commentary: Sec. A.7.2.1. Tier 2: Sec. 13.6.2)

HR-not required; LS-not required; PR-MH. STRUCTURAL SEPARATIONS: Partitions that cross structural separations have seismic or control joints. (Commentary: Sec. A.7.1.3. Tier 2. Sec. 13.6.2)

HR-not required; LS-not required; PR-MH. TOPS: The tops of ceiling-high framed or panelized partitions have lateral bracing to the structure at a spacing equal to or less than 6 ft. (Commentary: Sec. A.7.1.4. Tier 2. Sec. 13.6.2)

Linear Procedures – Force-Controlled Actions

$$Q_{UF} = Q_G \pm \frac{Q_E}{C_1 C_2 J}$$



No differentiation between force controlled demand for Performance Level.

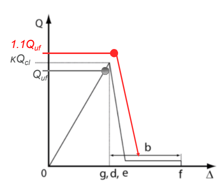
Force-controlled action that meets CP limit, also meets Immediate Occupancy

What happens if you get a slightly larger ground motion?

Linear Procedures – Force-Controlled Actions

"Structural Performance Level S-3, Life Safety, is defined as the postearthquake damage state in which a structure has damaged components but retains a **margin against the onset of partial or total collapse**. A structure in compliance with the acceptance criteria specified in this standard for this Structural Performance Level is expected to achieve this state.

$$Q_{UF} = Q_G \pm \frac{Q_E}{C_1 C_2 J}$$



Currently no margin of Safety against collapse for force-controlled actions.

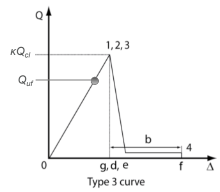
Linear Procedures – Force-Controlled Actions

$$Q_{UF} = Q_G \pm \frac{Q_E \chi}{C_1 C_2 J}$$

χ =1.0 for Collapse Prevention
1.3 for Life Safety and higher

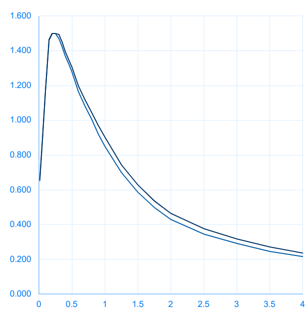
If Q_{uf} determined by mechanism assessment / capacity design, χ = 1.0

If J is taken as minimum DCR in the load path χ = 1.0



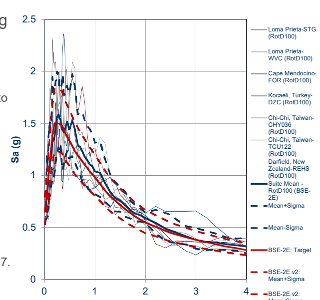
Site Specific Response Spectra

- Based on ASCE 7-16 Provisions.
- NGA-West 2 GMP increases long period region.
- Required for BSE-2N in Site Class D and E in regions of moderate and high seismicity.
- Not required for BSE-2E and BSE-1E.



Ground Motion Selection & Scaling

- Based on ASCE 7-16 Provisions.
- 11 records instead of 3 to 10.
- Scale maximum of two spectral ordinates to target spectrum.
- Random orientation unless near field.
- Near-field increased to 15km.
- Conditional Mean Spectra may be used
- Spectral matching permitted with a 10% penalty.
- Period range to scale different than ASCE 7. Upper bound of 1.5T instead of 2T.

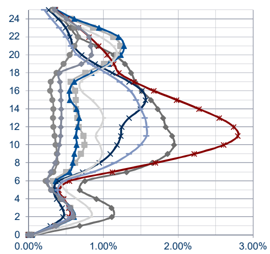


Nonlinear Response History Analysis – Unacceptable Response

In ASCE 41-13 all records must run to completion

In ASCE 41-17, 1 of 11 may be discarded *for Life Safety and lower performance* levels if:

- Record doesn't converge
- Collapse predicted
- Deformation controlled components exceed valid range of modeling (different than CP limit)
- Critical force-controlled actions do not exceed expected capacity



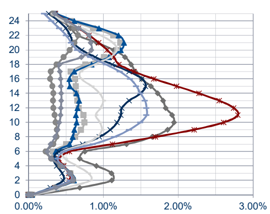
Force-controlled Actions Nonlinear Response History Analysis & Pushover

Amplify the demand to account for record-to-record variability and potential deformation-controlled element material overstrength.

$$Q_{uf} = \gamma\chi(Q_u - Q_g) + Q_g$$

γ = 1.3 for Critical
1.0 for Ordinary
1.0 for Noncritical
χ = 1.0 for Collapse Prevention
1.3 for Life Safety and higher
$\gamma\chi \le 1.5$

Q_{uf} may be determined by mechanism assessment instead.



Steel Columns Updates

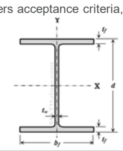
- Column linear criteria will be based on **Puf/Pye** instead of **Puf/Pcl**.
- Column nonlinear criteria will be based on Pg/Pye.
- Limit Pg/Pye for force-controlled behavior is 0.6 in nonlinear procedures.
- Additional parameters will affect nonlinear ductility, h/tw, b/2tf, and L/ry.
- Columns will have different nonlinear modeling parameters acceptance criteria, typically less conservative for higher axial forces.

For $\frac{P_G}{P_{ye}} \ge 0.2$ $\frac{h}{t_w} \ge 1.12\sqrt{\frac{E}{F_{ye}}}\left(2.33-\frac{P_G}{P_{ye}}\right) \ge 1.49\sqrt{\frac{E}{F_{ye}}}$

$$a = 1.2\left(1-\frac{P_G}{P_{ye}}\right)^{1.2}\left(1.4\frac{L}{r_y}+0.1\frac{h}{t_w}+0.9\frac{b}{2t_f}\right)^{-1}-0.0023 \ge 0$$

$$b = 2.5\left(1-\frac{P_G}{P_{ye}}\right)^{1.8}\left(0.1\frac{L}{r_y}+0.2\frac{h}{t_w}+2.7\frac{b}{2t_f}\right)^{-1}-0.0097 \ge 0$$

$$c = 0.5-0.5\frac{P_G}{P_{ye}}$$



Steel Panel Zone Updates

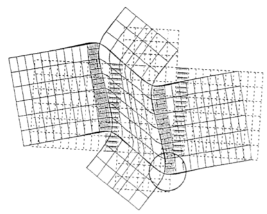


Figure 2-5 Deformed Finite Element Mesh of Connection with Panel Zone Yield

Source: FEMA 355D

Steel Panel Zone Updates

- In ASCE 41-17, panel zone m-factors and acceptance criteria can reduce due to axial force in column.
- Nonlinear criteria also has plastic deformation limit based on whether beam flange welds used notch-tough weldmetal.

$$\frac{0.092F_y}{G}\left(\alpha+\frac{3.45}{\alpha}\right)\left[1-\left(\frac{|P|}{2P_{ye,cf}}\right)^2\right] \leq 0.5\gamma_{p,pz}$$

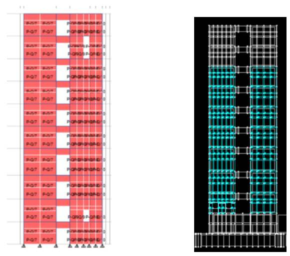
- Likely ASCE 41-23 issue: Are panel zone m-factors are too generous for pre-Northridge connections?

Chapter 10 (Concrete) Background

- Chapter 10 maintained by ACI 369 committee
- ACI 369 report changed to mandatory language to be incorporated in ASCE 41
- ACI 369 committee votes on changes before going to ASCE 41 committee ballot

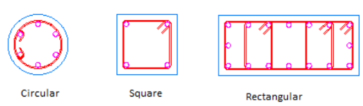
Chapter 10 Revisions

- Structural Wall Stiffness Provisions



Chapter 10 Revisions

- Modeling Parameters and Acceptance Criteria for Concrete Columns
  - No More Triple Interpolation!
- Column Tension Loads



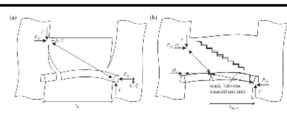
Chapter 10 Revisions

- Existing Anchorage Testing Requirements
  - Applies to roof to wall anchors
- Core Testing Requirements
  - Lower bound may be based on Section 6.4.3 of ACI 562-13 with a minimum of 4 tests

Anchor Testing (Usual Data Collection)

- **Cast-in-place or post-installed anchors** shall be classified in groups of similar type, size, geometry and structural use.
- In groups of anchors used for out-of-plane wall anchorage and in groups of anchors whose failure in tension or shear would cause the structure not to meet the selected Performance Objective, **5% of the anchors with a minimum of three anchors of each anchor group** shall be tested in-place in tension to establish an available strength, construction quality or both.
- The **test load shall** be specified by the licensed design professional and shall be based on the anticipated demand or strength in accordance with available construction information.
- Testing of the anchors **to failure is not required** and a test load lower than the expected failure load shall be permitted

Chapter 11 (Masonry) Revisions



- URM Behavior
  - Bed Joint Sliding – No change
  - Rocking – Changes to nonlinear criteria
  - New Spandrel Beam Provisions
    - Based on lintel type
    - Deformation controlled
  - Out-Of-Plane Action – Updates to add LS provisions
- URM Infill
  - In Plane Actions
  - Infill Out-Of-Plane Interaction
  - Infill In-Plane Acceptance Criteria
- Materials Condition Assessment and Enhancement Updates

For the Life Safety Structural Performance Level, a cracked wall shall be considered stable during dynamic excitation if $h/t \le 8$ or

$$S_{X1} \le C_a C_i C_d C_{pi} S_{aDXAPM}(1) \qquad (11\text{-}27a)$$

where

$S_{aDXAPM}(1) =$ [illegible] for stiff diaphragms; [illegible] for flexible diaphragms, and (11-27b)

and

C_a = Modification factor for axial loads acting on the wall

$$= \begin{cases} 1 + C_a'(P_W/685) & \text{for } \frac{h}{t} < 8 \\ 1 + C_a'(P_W/685)\left(1 - \frac{1}{12}\left(\frac{h}{t} - 8\right)\right) & \text{for } 8 \le \frac{h}{t} \le 20 \\ 1 & \text{for } \frac{h}{t} > 20 \end{cases} \qquad (11\text{-}27c)$$

where $C_a' = \begin{cases} 0.5 \text{ for stiff diaphragms} \\ 0.2 \text{ for flexible diaphragms} \end{cases}$

Chapter 12 (Wood) Revisions

- Diaphragm Strength Reduction for 2 inch Framing
- Shear Wall Strength Reduction for 2 inch Framing

12.4.4.6.2 Strength of Wood Structural Panel Sheathing or Siding Shear Walls….

- For existing wood structural panel shear walls framed with 2-in. nominal framing and 10d common or galvanized box nails at adjoining panel edges where 3-in. nominal framing is required per AWC SDPWS, the expected strength shall not be taken as greater than 0.90 times the expected strength associated with use of 3-in. nominal framing at adjoining panel edges.
- The 0.90 factor is based on the 10% strength reduction recognized in the 1979 UBC for such shear walls having sheathing nailed with 10d common (0.148" shank diameter) or galvanized box nails and is also applicable for longer 12d common nails of the same diameter.


ASCE 41-17
First Look
Garrett Hagen, SE
ghagen@Degenkolb.com
*The view expressed represent those of the author, not the standard's committee as a whole.