Navigating the Ground-Motion Requirements in Ch 11 & 21 in ASCE 7-16

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AECOM
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Presentation

- **Chapter 11**
  - Site Coefficient Tables, $F_a$ & $F_v$ (11.4.4)
  - Site-Specific Procedures & Exceptions (11.4.8)

- **Chapter 21**
  - Deterministic ($\text{MCE}_R$) Ground Motion (21.2.2)
  - Site-Specific $\text{MCE}_R$ (21.2.3)
Presentation (cont.)

- Background
- Problems with Ch 11 & 21 in 1st edition of ASCE 7-16
- Corrections in Supplement 1
- Problem in Ch 20 remains
### $F_a$: Pre ASCE 7-16 vs. ASCE 7-10

<table>
<thead>
<tr>
<th>Site Class</th>
<th>$S_s = 1.0$</th>
<th>$S_s = 1.25$</th>
<th>$S_s \geq 1.5$</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>pre 7-16</td>
<td>7-10</td>
<td>pre 7-16</td>
</tr>
<tr>
<td>A</td>
<td>0.8</td>
<td>0.8</td>
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</tr>
<tr>
<td>B</td>
<td>0.9</td>
<td>1.0</td>
<td>0.9</td>
</tr>
<tr>
<td>C</td>
<td>1.2</td>
<td>1.0</td>
<td>1.2</td>
</tr>
<tr>
<td>D</td>
<td>1.1</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>E</td>
<td>1.1</td>
<td>0.9</td>
<td>1.0</td>
</tr>
</tbody>
</table>

- **Green**: $\geq 10\%$ ↓
- **Orange**: $\geq 10\%$ ↑
- **Yellow**: New

2019 COSMOS Seminar
### $F_v$: Pre ASCE 7-16 vs. ASCE 7-10

<table>
<thead>
<tr>
<th>Site Class</th>
<th>$S_1 = 0.4$</th>
<th>$S_1 = 0.5$</th>
<th>$S_1 \geq 0.6$</th>
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</tr>
<tr>
<td>E</td>
<td>2.4</td>
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- **Green**: $\geq 10\% \downarrow$
- **Orange**: $\geq 10\% \uparrow$
- **Yellow**: New
Observation: Spectral shape for softer site classes in mostly high seismic regions was different than standard $S_a$ shape from $F_a$ & $F_v$ and $S_S$ & $S_1$

Problem: Standard $S_a$ shape for softer soils underestimated actual $S_a(T)$ at long $T$

Fix: Based on Kircher (2015) report
Example Design Spectra - Deterministic $MCE_R$ Ground Motions (ASCE 7-16) PEER NGA West2 GMPEs (M7.0 at $R_x = 6$ km, Site Class boundaries)

From Kircher
Example ELF “Design Spectrum” based on ASCE 7-16 (proposed) Site Factors
M8.0 earthquake ground motions at $R_X = 8.5$ km, Site Class D/E

$$C_s \times \left( \frac{R}{I_e} \right) = \min[SDS, S_{D1}/T]$$

**Ground Motion Values**
- $SDS = \frac{2}{3}F_aS_s = \frac{2}{3} \times 0.9 \times 1.56g = 0.94g$
- $S_{D1} = \frac{2}{3}F_vS_1 = \frac{2}{3} \times 1.85 \times 0.70g = 0.86g$

**ASCE 7-16 (Revised)**
- $F_a = 0.9 = \frac{1.0 + 0.8}{2}$
- $F_v = 1.85 = \frac{1.7 + 2.0}{2}$
- $T_s = 0.85s$

**Conservative**
- $SDS = 0.94g$
- $S_{D1} = 0.86g$

**Non-Conservative**
- $SDS = 0.94g$
- $S_{D1} = 0.86g$

From C. Kircher
\[ F_a \]: Fix in 1\textsuperscript{st} Edition of ASCE 7-16

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<thead>
<tr>
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### $F_v$: Fix in 1st Edition of ASCE 7-16

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<tr>
<td>D</td>
<td>1.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.7&lt;sup&gt;a&lt;/sup&gt;</td>
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<sup>a</sup> Also, see Section 11.4.8
Section 11.4.8

- **Requirement:** Site-Specific Study (Ch 21) unless an Exception is taken

- **Exception 3:** Structures on Site Class E with \( S_1 \geq 0.2 \), provided \( T \leq T_S \), and ELF is used

- **Problem:** Need \( F_V \) to compute \( T_S \)

- **Solution:** Insert \( F_V \) values for Site Class E in \( F_V \) Table
### F_v in Supplement 1 of ASCE 7-16

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<sup>a</sup> Also, see Section 11.4.8. These F_v values used only for calculation of Ts.
Ch. 21: Site-Specific Procedure in 7-16

- 1st Edition retained Deterministic Lower Limit (DLL) Spectrum

![Graph showing 1.5 Fa, 0.08* (Fv/Fa), 0.4* (Fv/Fa), and TL.]
Supplement 1 deleted DLL & replaced it with revised deterministic procedure

Reason: Revision better accounts for spectral shape differences for softer site classes

Best illustrated with figures
Sect. 21.2.2 – Exception to Deterministic $\text{MCE}_R$ (Low to Moderate Seismic Area)

$\text{Probabilistic } \text{MCE}_R = \text{Site-Specific } \text{MCE}_R$ if $\max S_a < 1.2 F_a$

Eliminates Need for Deterministic Analysis
Sect. 21.2: Deterministic MCE<sub>R</sub> (Very High Seismic Areas)

1.5 $F_a$

Max Direction $S_a$ = Site-Specific Deterministic MCE<sub>R</sub> if max $S_a \geq 1.5 F_a$
Sect. 21.2.2: Deterministic MCE$_R$ (High Seismic Area)

Scale up so max $S_a = 1.5 F_a$

= Site-Specific Deterministic MCE$_R$

84th %’ile
Max Direction $S_a$

$S_a$ vs $T$

1.5 $F_a$
Supplement 1 provided values of $F_a$

- Single value for each site class
- Covers all $S_S$ values
### Ch. 21.2: $F_a$ for Deterministic Procedure in Supplement 1

<table>
<thead>
<tr>
<th>Site Class</th>
<th>$F_a$ for $S_s = 1.5$</th>
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Sect. 21.2.3: Final Site-Specific $MCE_R$

Take smaller $S_a$ from Prob. & Det. $MCE_R$ at each $T$

No Change in this Criterion
Sect. 20.3.1: Problem with Site Class F

- Site response analysis required unless exception can be taken

- **Exception for Cat. 1 Soils** – Soils vulnerable to failure or collapse (e.g., liquefiable soils, quick & highly sensitive clays, collapsible weakly cemented soils)

- Exception says site response analysis not required if $T_{1x} \ & \ T_{1y} \leq 0.5$ sec

- Determine site class (C, D, or E), $F_a \ & \ F_v$ from Tables 11.4-1 & 11.4-2, and $S_{DS} \ & \ S_{D1}$
Prob.: No $F_a$ for Site Class E in Table 11.4-1

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Sect. 20.3.1: Problem with Site Class F

- **Fix:** none in Supplement 2 of ASCE 7-16
- **Solution 1:** Do site response analysis
- **Solution 2:** Request code exception from AHJ and select appropriate values of $F_a$ & $F_v$
Conclusions

- Need Supplement 1 to navigate the road though Chapters 11 & 21
- Road & ride are not smooth & dead ends in Exception in Sect. 20.3.1 (1) for Site Class E
- ASCE 7-22 should be smoother ride