NEHRP Site Factors for CENA

Workshop #1

PEER Center, 325 Davis Hall

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Panel Members

- Gail M. Atkinson, Western University, Canada
- David M Boore, USGS Menlo Park, CA
- Robert W Darragh, Seismologist
- Christine A Goulet, PEER Center
- Youssef MA Hashash, University of Illinois
- Walter J Silva, Pacific Engineering and Analysis
- Jonathan P. Stewart, UCLA, Chair

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Agenda

- Introduction and end-user perspective. Stewart, Petersen
- Proponent models:
  - GWG-S: Hashash
  - GWG-E: Parker
  - Atkinson group: Atkinson
  - PEA: Darragh
  - Others: Parker
- Discussion

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Meeting Goals

- Understand project objectives
- Become familiar with available models
- Identify short-term work to guide deliberations

- Next meeting – review findings and provide recommendations on models/weights

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General Problem Statement

- NGA-East models apply for 3 km/s reference condition
- Applications require site factors for slower V_{S30}
- Present site factors considered inadequate
- Provide recommendations to USGS to support V_{S30} -based hazard analysis using ergodic models
- *Our goal is not to provide recommendations for site-specific analysis in CENA*

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Some background and context…

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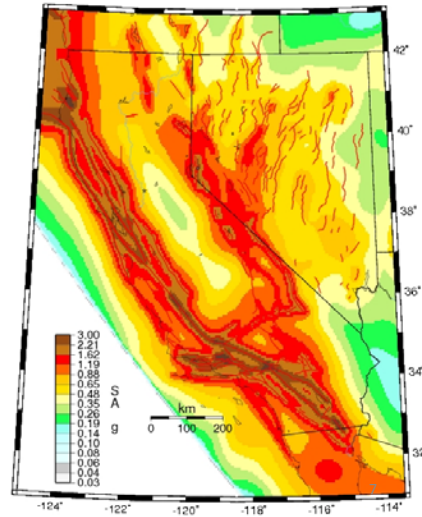## Traditional Role of NEHRP Site Factors

Reference site ground motion based on PSHA at three periods (PGA, 0.2 & 1.0 sec PSA) with adjustments for:

- Deterministic cap
- Max component
- Uniform risk

Establishes the level of risk for code-based design.

Parameters: PGA, S_S, S_1

Calif NV, 5-Hz SA w/2%PE50yr. 760 m/s Rock

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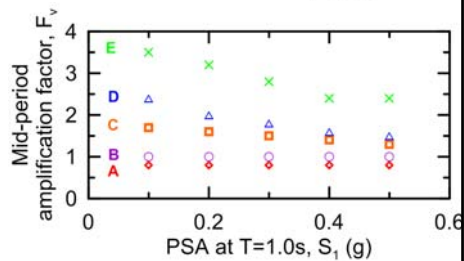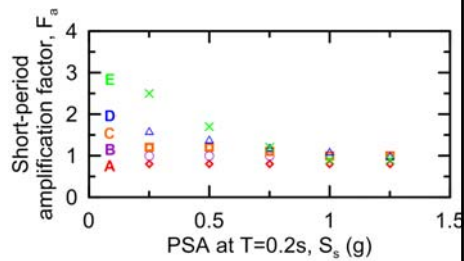- Max component
- Uniform risk

Establishes the level of risk for code-based design

Parameters: PGA, S_S, S_1

Rock motion deterministically modified for site condition

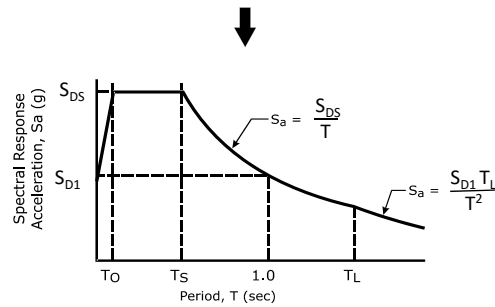Parameters: F_{PGA}, F_a, F_1

Nonlinearity depends on the rock ground motion level

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Traditional Role of NEHRP Site Factors

Standard (prescriptive) code spectrum constructed

$$S_{DS} = S_s \times F_a \qquad S_{D1} = S_1 \times F_v$$

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## *Traditional Role of NEHRP Site Factors*

Standard (prescriptive) code spectrum constructed

$$S_{DS} = S_s \times F_a \qquad S_{D1} = S_1 \times F_v$$

Approach is referred to as hybrid (term from Cramer, 2003) since it combines probabilistic rock motion with deterministic site amplification.

Approach is well established in seismic guidelines:

- All NEHRP provisions; see also Leyendecker et al (2000)

- US Nuclear Regulatory Commission (2001, 2002): Approach 1
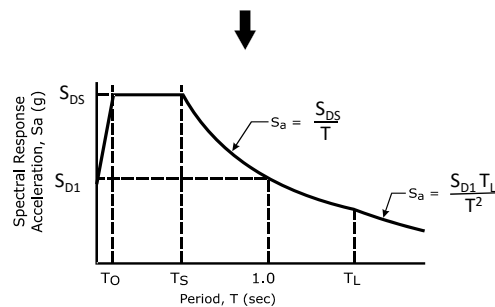
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2015 Update to NEHRP Site Factors

Based on PEER Task 8 committee associated with NGA-West2 project

Compiled and analyzed large data set for active crustal regions.

Ultimately developed a site amplification model with three terms:

- F_{lin}: describes V_{S30}-scaling of PSA and peak parameters
- F_{nl}: describes nonlinearity as function of strength of shaking and V_{S30}
- $F_{\delta z}$: describes effects of basin depth

Technical issues resolved, relative to previous site factors (circa 1992):

- Set amplification relative to 760 m/s (had been 1050 m/s)
- Updated scaling relationships for V_{S30} and nonlinearity
- Investigated regional effects
- Centered basin model on average for a given V_{S30}

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2015 Update to NEHRP Site Factors

Site factors (tables, equations) developed from this model in a deterministic sense.

- Intended for traditional hybrid application
- Approved with near consensus of Task 8 group (exception: R Borcherdt)
- Values centrally located relative to other NGA-West2 models.

These factors represent default values, even for CENA – they are included in the 2015 NEHRP Provisions and 2016 ASCE-7

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What's next?

Two ongoing projects will impact next set of USGS maps and NEHRP Provisions:

- Project 17: What should USGS map? (Hazard/risk levels, yo-yo effects, discovery of 'multi-period spectra')

- PUC for 2020 NEHRP: Will entertain proposal from P17 regarding ground motion definition

These projects aware of our committee – looking to us for guidance on CENA site amplification

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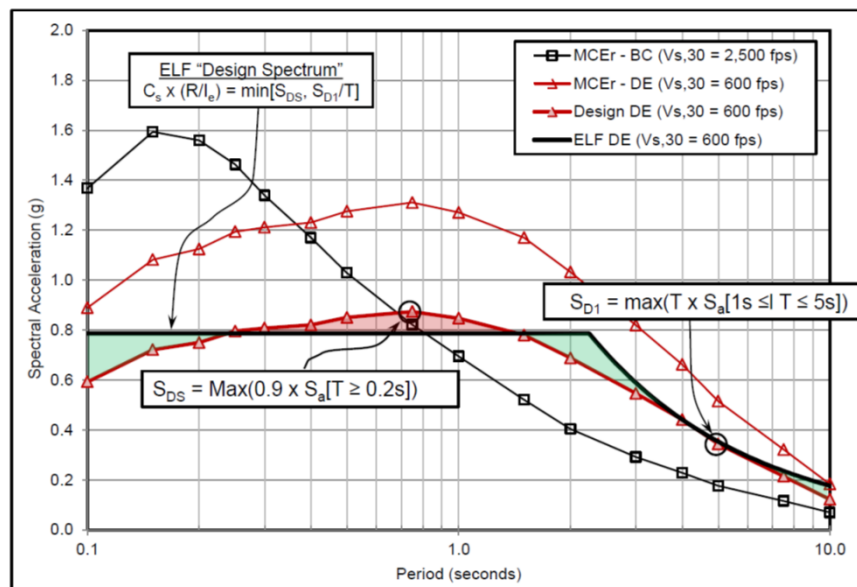
Courtesy CA Kircher, 4-12-2016

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Key Points

Site factor tables will no longer be included in NEHRP Provisions or ASCE 7

We are providing guidance for site terms to be used in GMPEs by USGS

These are ergodic models

As of now (July 2016), P17 does not want site parameters beyond V_{S30} to be used in ergodic models
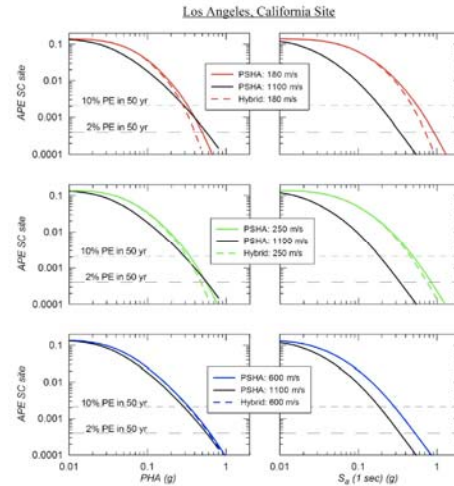
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Three additional considerations…

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#1 Hazard no longer hybrid

Nonlinear site amplification model to be included in hazard integral

- Affects the median ground motion for a given M, R, and V_{S30}
- Affects standard deviation terms
- Nonlinearity for a given M and R is set at a median rock intensity

Hybrid approach produces more nonlinearity, lower ground motions

Goulet and Stewart, 2009

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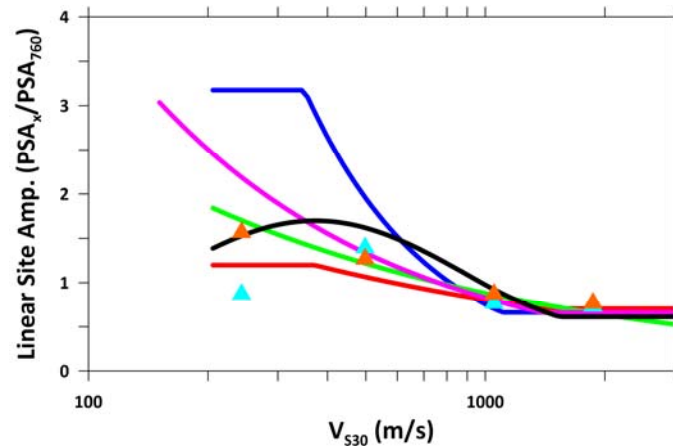### #2 New Site Categories vs V_{S30} & Related Issues

Do we support new site categories?

Should users be able to enter V_{S30} values; avoid steps at category boundaries?

S_u and N values for new categories

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#3 Large Variability Among CENA Site Models…

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Meeting Notes

- Push for V_{S30} as direct metric (in addition to categories)
- NCM - current GWG models not considering depth parameters from this model. Can we get depth parameters at selected lat/long?
- V_{S30}-scaling:
  - Use of empirical observations vs simulations
  - Do we allow reverse scaling for $V_{S30} < 400$ m/s
  - Are short period Amp- V_{S30} plots peaked if f_{peak} unknown?
  - Allow for glacial effect? Can we understand physical reason for this effect?

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Meeting Notes

- F (760/3000) factor. Options:
  - Yenier and Atkinson 2015
  - Boore-Campbell 2016 (in review)
  - GWG-S, depth-dependent
  - Others?
  - Have not been able to constrain empirically
- Should epistemic in F (760/3000) be taken as independent of the F (x/760) models?

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Meeting Notes

- What to do with depth/f_{peak} effects?
  - f_{peak} model: Empirical (Gail), Simulation (GWG-S)
  - Depth: Empirical (Grace, but not yet considered), Simulation (GWG-S)
  - Can this be included in site terms for USGS? Maybe the depth part if mappable.
  - Factors not in ergodic model can be recommended for site-specific analysis (Chap 21).
- Nonlinear:
  - Must be simulation based.
  - Only available CENA model is GWG-S (has been checked against NGA-W2 models)
  - Should we also use NL as implied from PEA simulations (CA profiles, nuclear study)
  - MRD curves are different (more nonlinear) than those used in sims for past NGA-West project

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Meeting Notes

- What models should we carry forward? V_{S30}-scaling
  - GWG-S
  - GWG-E
  - Atkinson
  - ANC 15
  - Graizer
  - ACR-based: SS14, PEA
- Nonlinearity
  - GWG-S
  - PEA

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