

# **Discussion of Ballot Items - Seismic Guide Specifications and Revised LRFD Seismic Provisions**

Presentation for AASHTO Annual Meeting  
T-3 Committee

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(Re-presented to WSDOT ACEC Structures Team - June 13, 2008)

# Background

- 2006 Draft Guide Specification
- Approx 700 Comments
- SGSIT (Seismic Guide Spec Improvement Team)
- 2007 Guide Spec and Revised LRFD Seismic
- Parking Lot – 75 Items
- SGSIT Reconvened
- January 2008 Draft T- 3 Ballot
- Comments from the States
- 2008 AASHTO T- 3 Ballot

# 2007 -2008 AASHTO SGSIT (Seismic Guide Specification Improvement Team)

Elmer Marx – AK

Dan Tobias – IL

Tony Allen – WA

Chyuan –Shen Lee – WA

Mark Mahan – CA

Fadel Alameddine – CA

Mohammed Islam – CA

Derrell Manceaux – FHWA

Lucero Mesa – SC

Stephanie Brandenberger – MT

Ian Buckle – Univ Nev Reno

Roy Imbsen – Imbsen  
Consulting

Don Anderson – CH2M Hill

Lee Marsh – BERGER/ABAM

# Summary of Parking Lot Items (2008 Ballot Effort)

- Categories and Number of Items (75 Total)
  - Ground Motion and Site-Related Items (14)
  - General Structural Items (28)
  - Foundation Items (16)
  - Liquefaction-Associated Items (17)
- Status – Addressed All 75 Items, Although Some Remain Parking Lot Items

# T- 3 Ballot Items

- Guide Specifications (Agenda Item 74)
  - General Structural
  - Ground Motion and Site-Related Items
  - Foundation
- Span Length – GS and LRFD (Agenda Item 75)
- Liquefaction – GS and LRFD (Agenda Item 76)

# Span Length Ballot Item

- Article 3.10.1 LRFD and Article 3.1 GS
  - Eliminates the current 500-ft span-length limitation for applicability of the seismic provisions
  - Reasoning:
    - Original length was arbitrary
    - Intent was to limit specifications to structure types of more common construction and not include specialized long-span structure types in specifications
  - Alternate language added to explicitly describe the types of structures to which the specs apply.
  - Benefit: Clearer guidance to designers

# Liquefaction Ballot Item

- Articles 10.5.4.2, A10.1, 2, and 3 in LRFD
  - Complete Replacement of Specs and Elimination of Outdated Commentary
- Article 6.8 in Guide Spec
  - Complete Replacement
- Key Improvements:
  - Areas Where Liquefaction Must Be Assessed Have Been Expanded
  - Significantly Improved Guidance to Designers Reflecting Current Best Practice

# Liquefaction Ballot Item Highlights

- LRFD and GS Are Consistent with Each Other
- Liquefaction Assessment Required in Zones 3 & 4 (SDCs C & D) and Suggested in Zone 2 and SDC B
  - Note That Basis is Still  $S_1$  Partitioning
  - Once Assessment Is Triggered, Site-Class Adjusted Ground Acceleration ( $A_s = PGA * F_{pga}$ ) Is Used For Evaluation
- Additional Soil and Site Criteria Provided in Trigger
  - Ground Water Within 50-ft of Surface
  - Soil Characteristics Favorable to Liquefaction
    - SPT < 25 bpf, CPT < 150, Vs < 660 fps, or soil unit has previously liquefied
    - For SDC B, Suggest Assess When: SPT < 10 bpf, CPT < 75 when  $A_s > 0.15$

# Liquefaction Highlights (cont)

- Effects of Liquefaction To Be Considered
  - Loss of Soil Strength, Ground Settlement, and Lateral Movement
- Analyze Two 'Structural' Configurations
  - No Liquefaction
  - Liquefied Condition (Using Non-Liquefied Spectra)
    - With Owner's Approval or Direction, Site-Specific Spectra May Be Used

# Liquefaction Highlights (cont)

- Adjustment of Spectra For Liquefied Conditions
  - No Site-Specific Response Study Performed
    - Use Non-Liquefied Spectrum If Bridge Period Is Less Than 1 Sec
    - Consider Site Class E Spectrum If Bridge Period Exceeds 1 Sec

OR

- Develop Site-Specific Response Spectrum
  - Can Not Reduce Spectrum Below  $2/3$  of 'Basic Spectrum'
  - Typically Will See Short Period Reductions and Longer Period Increases – Hence Conservative Guidance Given Above

# Liquefaction Highlights (cont)

- General Guidance Provided For:
  - Methods For Screening Liquefaction Susceptibility
  - Slope Failure, Flow Failure, and Lateral Spreading
    - When to assess and overall design process to use
    - Impact on Structure and Potential for In-Ground Damage – Recommends Use of SDC D Procedures
  - Effect of Liquefaction on Foundation Vertical and Lateral Resistance/Response
  - Timing of Liquefaction vs Peak Inertial Shaking of Structure
  - Methods For Mitigating Liquefaction

# Section 6.8 (Liquefaction) Ballot Item Recommendation

- A big improvement over what is currently available
- Up-to-date
- Broad based
- In general, previous parking lot items have been addressed in the proposed specification
- Recommend the parking lot items that follow be addressed in the coming years
- We are already gathering input on how to address the parking lot items

# Liquefaction Parking Lot Items

- Need guidelines on use of cyclic simple shear or cyclic triaxial tests to assess liquefaction potential, residual strength, and liquefaction settlement, including selection of test parameters, interpretation of results, and how to use them for various aspects of liquefaction design (guidelines in Section 6.2.2 are not adequate)
- Liquefaction screening based on WT depth (currently at 50 ft, should it be deeper, e.g., as deep as 75 ft?)
- Section 6.8, 5<sup>th</sup> paragraph: Specs currently say liquefied response spectrum “shall” not be reduced to less than 2/3 of general spectrum – would “should” be better here?
- Need guidance on the determination of liquefied lateral stiffness (P-Y) parameters

# Liquefaction Parking Lot Items

- Need guidance on acceptable methods to estimate liquefaction settlement
- Current guidance in LRFD Specifications, Article 3.11.8, regarding estimation of liquefaction DD loads is lacking and potentially unconservative – need to update
- Need better guidance on how to consider soil inertial forces and liquefied conditions when assessing flow failure, including timing, magnitude of  $A_s$ , and development of liquefied residual strength
- Need to clarify and augment guidance on when and how to consider flow failure versus lateral spreading

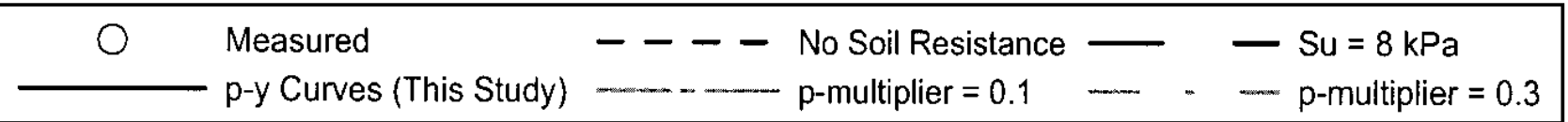
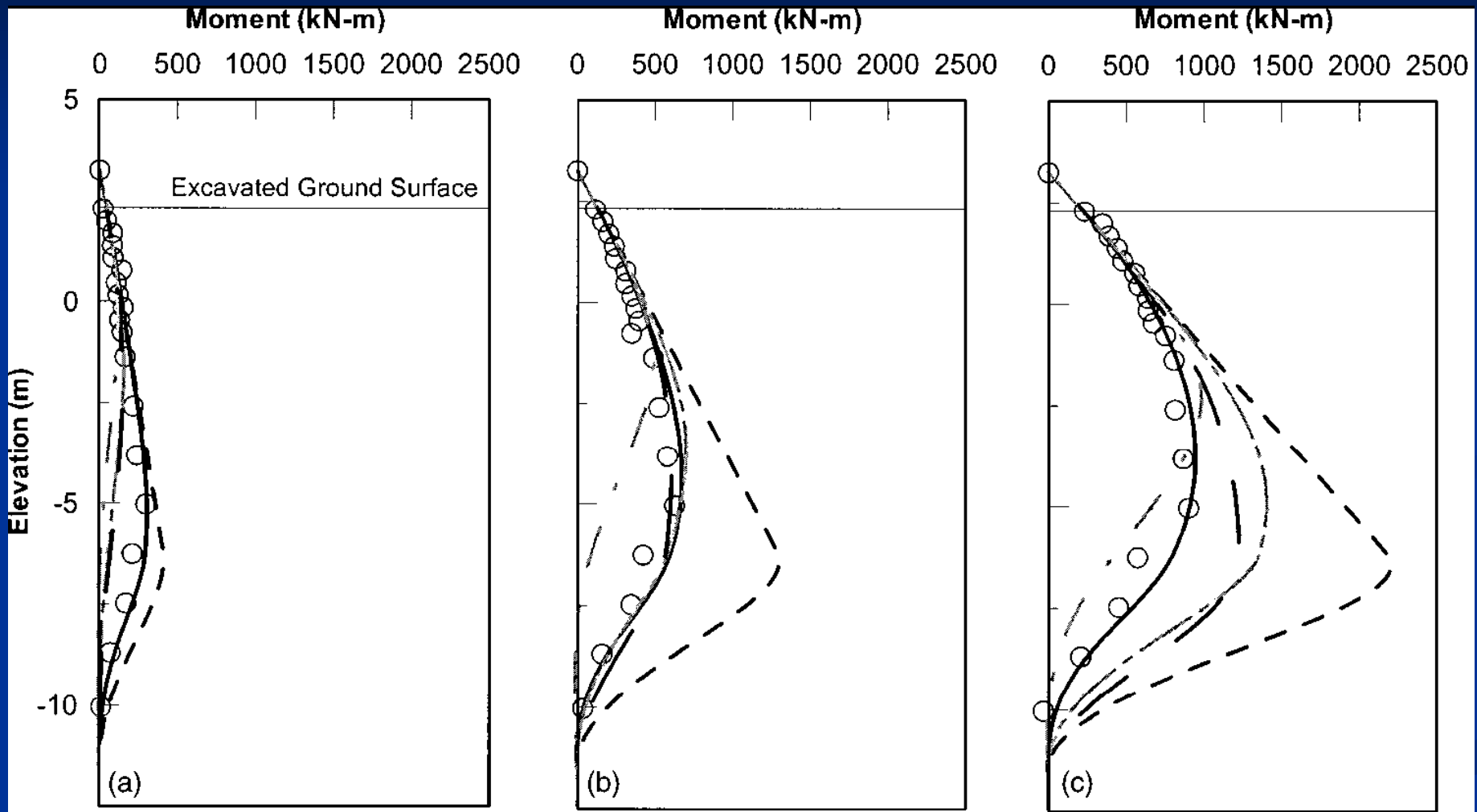
# Liquefaction Parking Lot Items

- Need guidance on flow failure and lateral spreading analysis approach
- Need guidance on how to estimate lateral forces applied to foundations due to lateral spreading or flow failure
- Min. requirements for the factor of safety against liquefaction ( $FS_{liq} = CRR/CSR$ ) to not have to consider liquefaction effects for a specific soil stratum
- Augment guidance on how to assess liquefaction potential using more theoretical methods, such as site specific total or effective stress methods

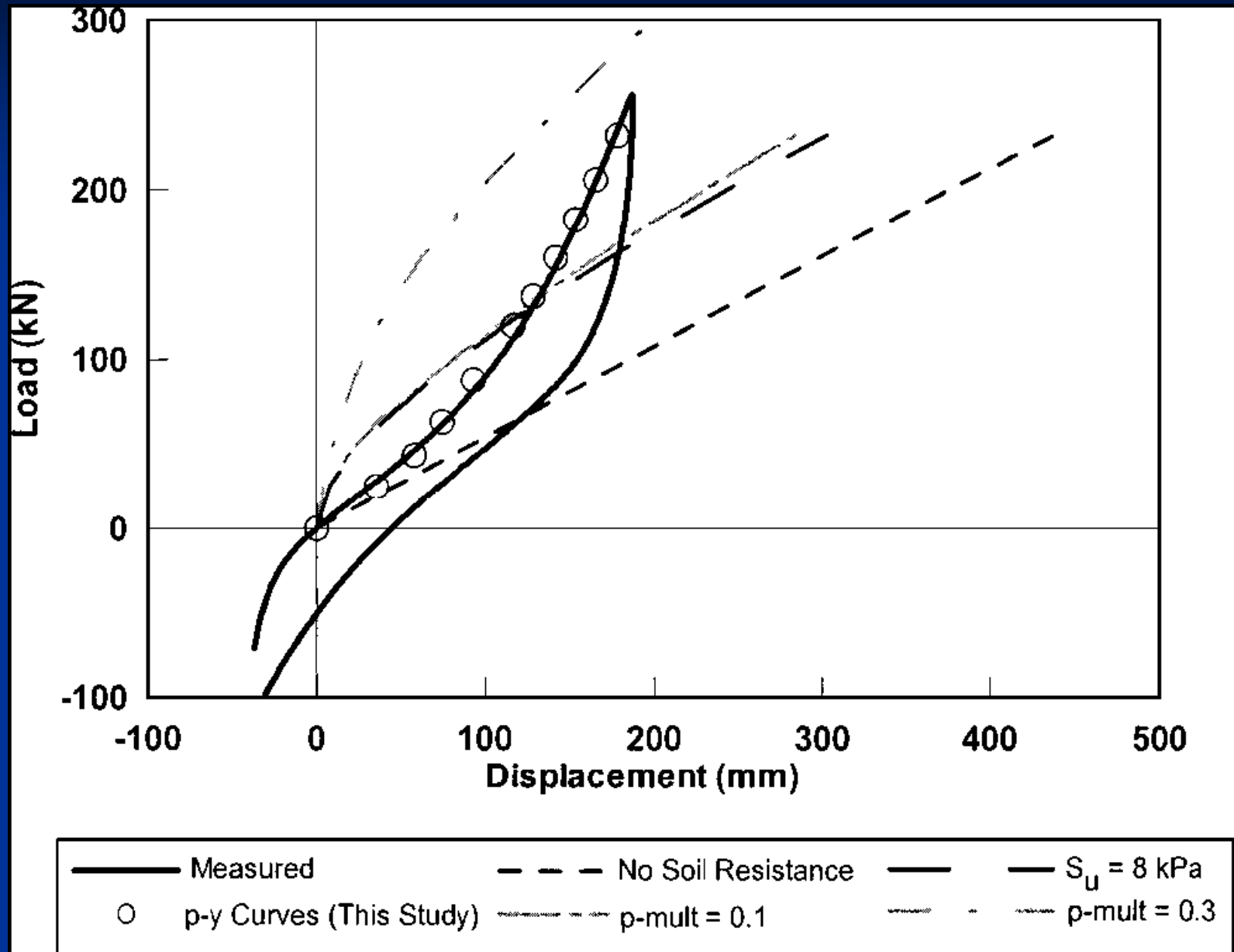
# Rewrite of Ch 6 of WSDOT GDM

- Make consistent with newly approved AASHTO seismic guide specifications
- Fill in gaps regarding use of site specific laboratory cyclic simple shear data to evaluate liquefied properties
- Coupled vs decoupled analyses regarding liquefied shear strength and seismic loading
- Clarify design for flow failure vs lateral spreading (definition, deformation prediction, lateral load potential)
- Clarify policy on liquefaction design for bridge widening
- Incorporate U of W (Steve Kramer) research on liquefaction
- Seismic springs for footings
- Estimating EQ magnitude
- Nonlinear time history analysis

# Deep Foundation Lateral Stiffness

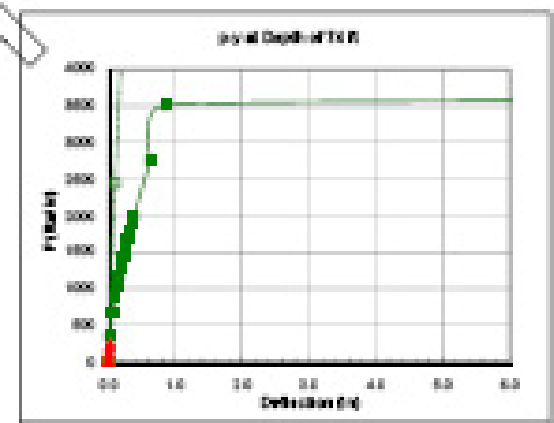
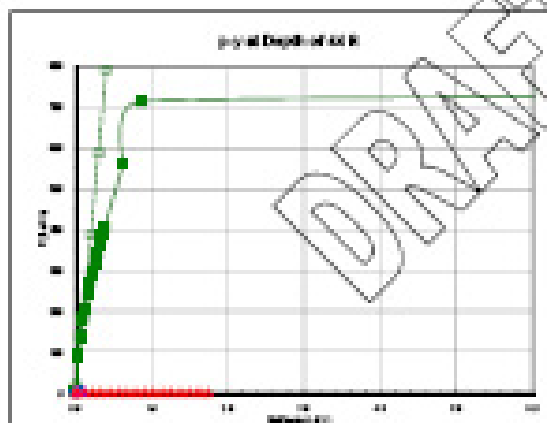
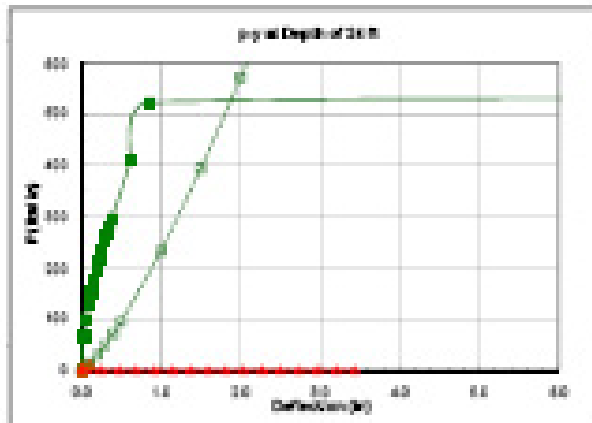
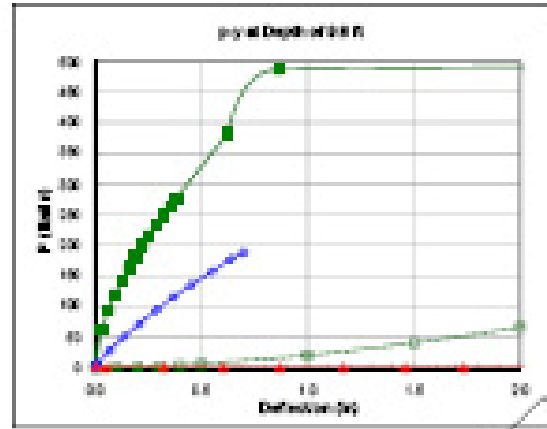
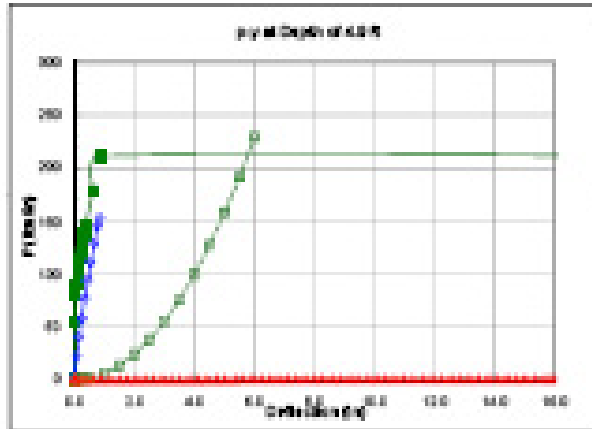


# Deep Foundation Lateral Stiffness



# Deep Foundation Lateral Stiffness

01-2-2008 by revised/initials/initials/initials



**LPILE - Liquefied** : uses internal liquefied p-y curves  
**OPBAP - Liquefied** : Designate Liquefied layers in OPBAP Program

■ LPILE - Revised    ■ OPBAP - Revised  
■ LPILE - Liquefied    ■ OPBAP - Liquefied

DRAFT

2-10-08

# Lateral Deep Foundation Soil Stiffness Issues

- DFSAP liquefaction pore pressure model (i.e., the liquefaction option) appears to not work well
- Adjusted p-y parameters or DFSAP input parameters reduced beforehand to simulate liquefied strength works better, but still leaves much to be desired
- Estimating liquefied soil properties for input into L-Pile or DFSAP needs to be better defined so we are at least handling this issue consistently

# Guide Specification Ballot Item

- Each of Nine Sections Has Some Revision
  - Many Are Editorial Or Add Definitions/Clarifications
  - Some Revise The Application of The Provisions And Are Therefore More Substantial
- Next Slides Are Organized By Section

# Guide Specification – Section 1 (Introduction) and Section 2 (Definitions)

## ■ Section 1

- Rewritten To Eliminate The Narrative Of The Guide Specification Development
- Includes Updated General Requirements For The SDCs (Seismic Design Categories)
- Includes Updated Flowcharts

## ■ Section 2

- Includes Updated Definitions and Notation

# Guide Specification – Section 3 (General Requirements)

- Seismic Hazard Precisely Defined – Return Period of 975 Years (Useful For Site-Specific Work)
- Suggestion That ERS (Earthquake Resistance System) Be Identified in SDC B
- Seismic Ground Shaking Hazard Rewritten (3.4)
  - Emphasizes Difference Between Site-Specific Hazard and Site-Specific Ground Motion Response Analyses
  - Site-Specific Analyses Never Mandatory, But Guidance On When They Should Be Considered Provided
    - Essential or Critical Bridges
    - Hazard Not Included In USGS National Maps
    - Site Class F

# Guide Specification – Section 3 (General Requirements) Cont.

- Commentary Added Defining ‘Active’ Faults
- Clarification That Spectral Transition From  $A_s$  to  $S_{DS}$  Is To Be Used In Lieu Of  $S_{DS}$  Extending to Zero Period
- Long-Period Spectral Transition Addressed
- When Site-Specific Procedures Are Used:
  - Maximum Reduction Is To 2/3rds Of That From General Procedure
  - Guidance Is Provided For Liquefiable and Class F Sites
  - Owner’s Approval Required To Go Below 2/3rds Value

# Guide Specification – Section 3 (General Requirements) Cont.

- Site-Specific Hazard Analysis
  - Guidance Provided For Both Deterministic (DSHA) and Probabilistic Methods (PSHA)
  - NGA (Next Generation Attenuation) Relationships Addressed
  - Near-Fault Effects Addressed, though more work may be needed
- Site-Specific Ground Motion Response Analysis
  - Guidance For Determining When To Use And What To Include
  - Owner's Approval Required For Nonlinear, Effective Stress Modeling
- Guidance Provided For Acceleration Time Histories  
(However, more work may be needed to fill gaps)

# Guide Specification – Section 3 (General Requirements) Cont.

- Selection of Seismic Design Category (SDC) 3.5
  - Suggestion To Use SDC D When Liquefaction-Induced Lateral Spreading Or Slope Failure Could Affect Bridge
  - Summary of SDC Basic Requirements Updated
    - Liquefaction Assessment Requirements Included (Assuming Liquefaction Ballot Also Passes).
    - New Minimum Transverse Steel Requirements For ‘High’ SDC A
    - ERS Identification Encouraged For SDC B
    - Capacity Checks To Avoid Undesirable Weak Links Encouraged For SDC B
    - Capacity Design Encouraged, But Elastic Design Permitted, For SDC B

# Guide Specification – Section 4 (Analysis and Design Requirements)

- Vertical Ground Motion Effects Non-Mandatory For Essential or Critical Bridges
- Foundation Component Of Displacement Addressed For Local Displacement Capacity Assessment Of Columns
- Basis Of Implicit Displacement Method for SDC B and C Clarified
- In-Ground Hinging Ductility Limits Provided (Requires Owner Approval Though)
- Suggested Use of Capacity Checks In SDC B Added
- Commentary Added For Plastic Hinge Length Article

# Guide Specification – Section 5 (Analytical Models and Procedures)

- Commentary For Inclusion Of Soil Effects Behind Abutments Added
- Standard-Size Pile Reference Removed
- Spread Footing Modeling Article Revised
- Effective Flexural Stiffness For Prestressed Piling Added

# Guide Specification – Section 6 (Foundation and Abutment Design)

- Foundation Investigation Commentary Revised To Address Specific Seismic Issues
  - Depth Of Investigation (Characterize Site To 100-Ft Depth)
  - Groundwater Elevation
  - Cyclic Testing Requirements (Silts, Deep Samples, Sensitive Clays)
- Hazards To Evaluate And Include In Geotech Report Have Been Clarified
  - Liquefaction Potential, Seismic-Induced Settlement, and Lateral Spreading
  - Surface Rupture, Lurching, Cyclic Loading Effects

# Guide Specification – Section 6 (Foundation and Abutment Design)

- Spread Footings Not Permitted In Liquefiable Soils Unless Ground Improvement Used
- Limits On Spread Footing Uplift Included, If Uplift Is Greater, Then Use Appendix A – Rocking
- Pile Cap Foundation Requirements Clarified – Essentially Match Caltrans' Approach
- Guidance Provided For Pile Cap Passive Soil Resistance and Side Friction Contributions
- Abutment Longitudinal Soil Resistance Requirements Clarified (including use of 50% reduction factor)

# Guide Specification – Section 7 (Structural Steel Components)

- Added Reference To LRFD Force-Based Procedure
- Clarified Nominal Capacities ( $F_{ye}$  and  $\phi = 1.0$ )
- Added Requirements For Pipe Steel (A53 Gr B or API 5L X52)
- Rearranged A Number Of Requirements To More Logical Sections

# Guide Specification – Section 8 (Reinforced Concrete Components)

- SDC A: When  $S_{D1} > 0.10$ , Minimum Transverse Reinforcement As For SDC B Required
- SDC B:  $M_{ne}$  Can Be Taken As  $M_p$ ; No  $M-\phi$  Required
- SDC B: Elastic Shear Or Plastic Shear Of Column May Be Used To Design Transverse Reinforcement
- Definition Of Ultimate Curvature Condition (As Function Permissible Strains) Added
- Detailing Requirements For Transverse (Lateral) Reinforcement Added For Consistency With LRFD
- Detailing Requirements For Piles Added

# Guide Specification – Section 9 (References) and Appendix A (Rocking)

- Section 9 - References Updated
- Appendix A – Rocking
  - Limitations On Method Added (i.e. Method Derived Based On SDOF , Single-Column Bent Behavior)
  - Notation Updated To Match LRFD

# Comments

- CA (Liquefaction Ballot Item)
  - Clearly state liquefied soil cannot be considered for bearing resistance
    - Concur, Addressed
  - Suggest using same elevation for ground water table (50') and depth of potentially liquefiable soils (75') for liquefaction assessment threshold
    - Parking Lot
  - Provided 22 optional suggestions for consideration
    - 14 suggestions implemented, all considered

# Comments

- CA (Guide Spec) (cont)
  - Suggest modifying site-specific terminology:
    - Site-Specific Hazard Analysis > Site-Specific Ground Motion Hazard Analysis
    - Site-Specific Ground Motion Response Analysis > Site-Specific Dynamic Ground Response Analysis
    - Suggest Leaving As-Is For Now
      - Terms currently used are common
      - Too many places to change = risk at this time

# Comments (cont)

- TX (Span Length and Guide Spec)
  - Suggest Definition of “Small to Moderate Earthquakes”, etc
    - This language has been in spec since ATC-6, recommend leaving it alone.
  - Suggest adding trestle bents and drilled shafts to conventional construction list and R-factor table
    - Pile-bents are in substructure list, and ‘shafts’ are included, as well. Recommend leaving as is.

# Comments (cont)

- MO (Liquefaction Ballot Item)
  - Suggest Non-Mandatory Liquefaction Assessment
    - Recommend Retain Mandatory Language, As Written
- Others
  - Suggest Short-Period Partitioning
    - Parking Lot

# Potential Future Parking Lot Items, Other Than Liquefaction

- Handling near fault effects
- Acceleration time histories
  - Scaling and spectral matching
  - Clarifications on the uses of time histories and how that affects their development
- Vertical effects
- Short-Period Partitioning for SDCs:  $S_{DS}$  with  $S_{D1}$
- Abutment design for seismic lateral earth pressure (active and passive) – need to incorporate NCHRP 12-70 recommendations

# Potential Future Parking Lot Items, Other Than Liquefaction (cont)

- Pile group effects - group lateral resistance reduction factors for P-Y curves for seismic loading
- Use of FEMA 273 vs FEMA 356 to adjust the soil shear modulus for spread footing springs
- Abutment modeling and design procedures – improve shear key fusing procedures
- Eventual conversion of steel substructure design from force-based to displacement-based approach
- Improvement to concrete piling provisions – update as current research is completed

# Proposed Changes to 2008 Ballots

- See Handout