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

Presentation for AASHTO Annual Meeting
T-3 Committee

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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  - Complete Replacement of Specs and Elimination of Outdated Commentary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 As > 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 2/3rds 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 next year
- 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, 5th 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

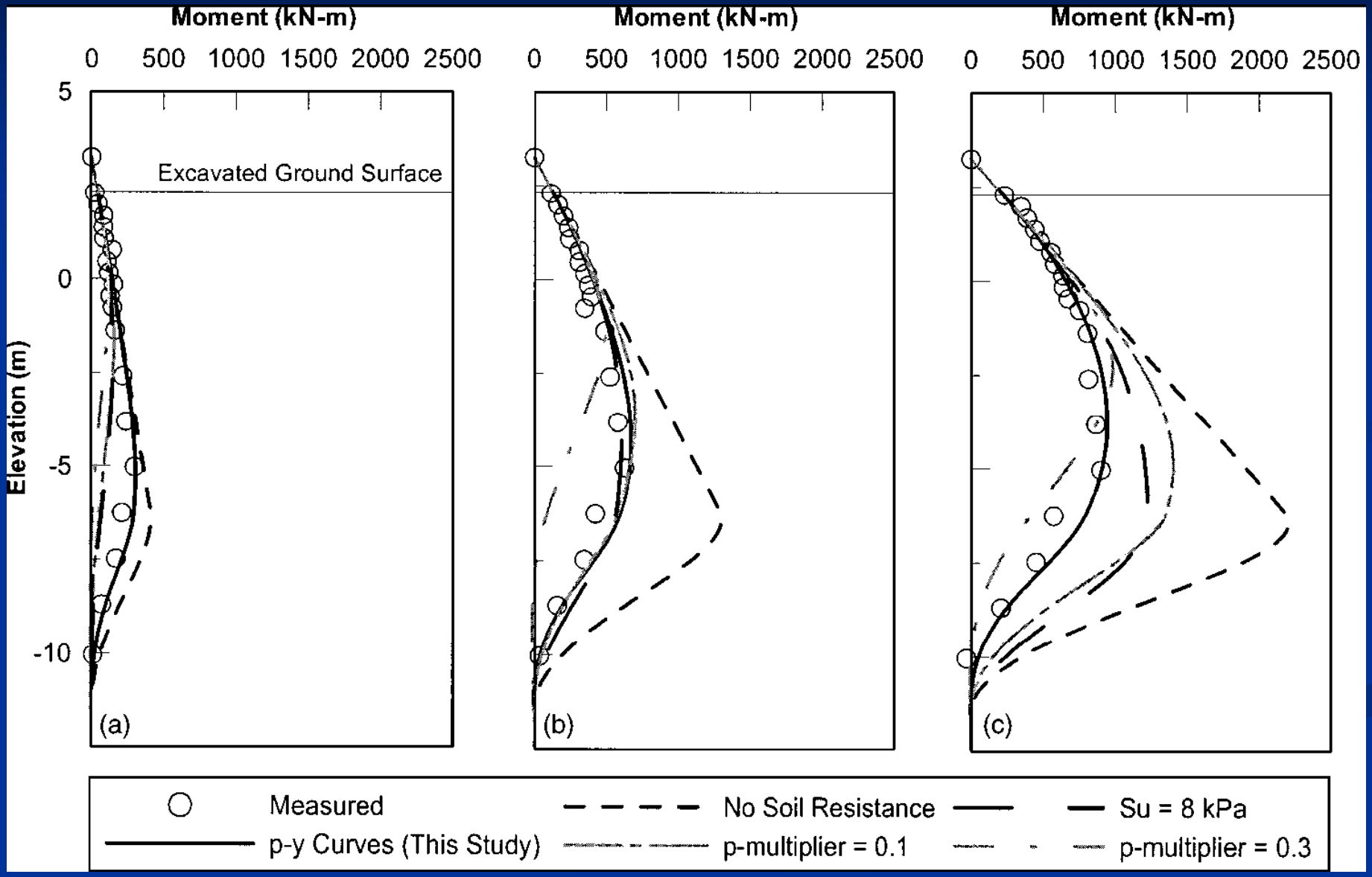
Liquefaction Parking Lot Items

- 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



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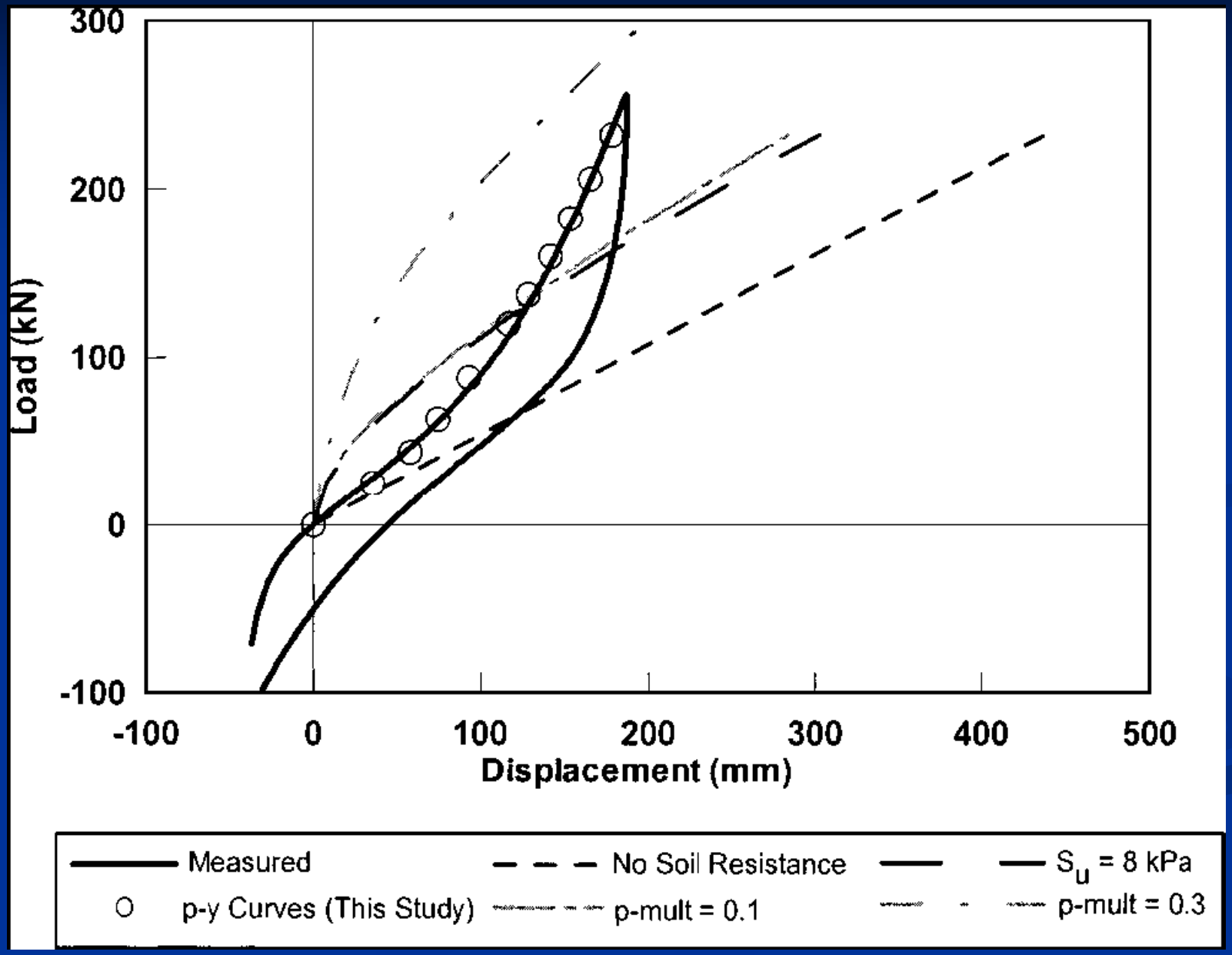

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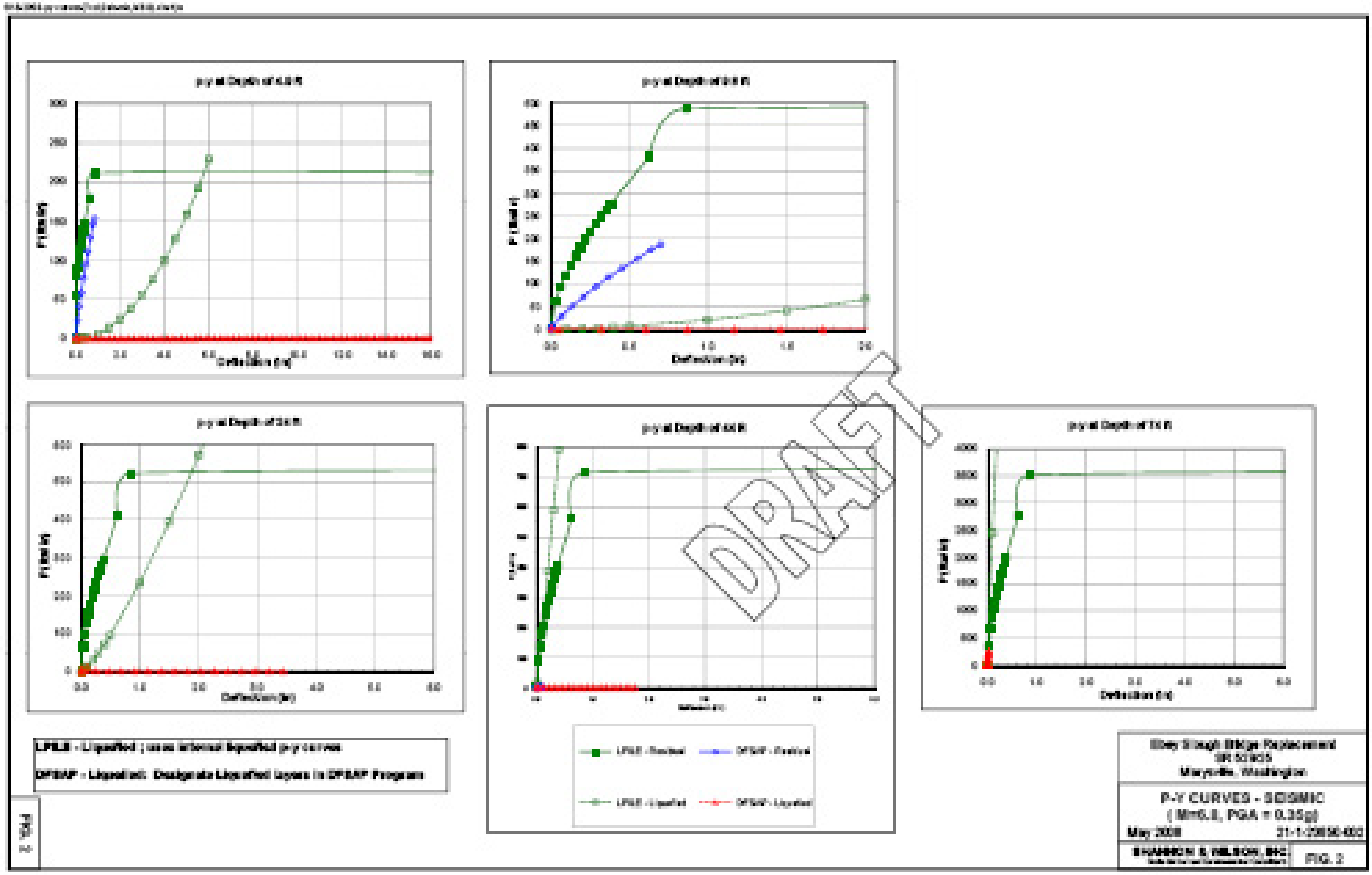

Lateral Deep Foundation Soil Stiffness Issues

- 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