LRFD Procedures for Geotechnical Seismic Design

Jointly sponsored by Caltrans & WSDOT

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Objective

To develop framework for computing load and resistance factors for geotechnical elements of bridge structures and transportation facilities. The framework is intended to be consistent with, and take advantage of, the PEER PBEE framework.

The framework will be applied to two problems:

1. Pile foundations (in non-liquefiable soil), and
2. TBD

Scope of Work

- Review current LRFD approaches for problems of interest
- Identify application problems
- Define performance levels and target reliabilities
- Identify appropriate response models
- Characterize parametric and model uncertainties for foundation response models
- Develop appropriate load and resistance factors for application problems of interest
- Determine load combination factors for application problems of interest
- Check results against typical design practice

Approach

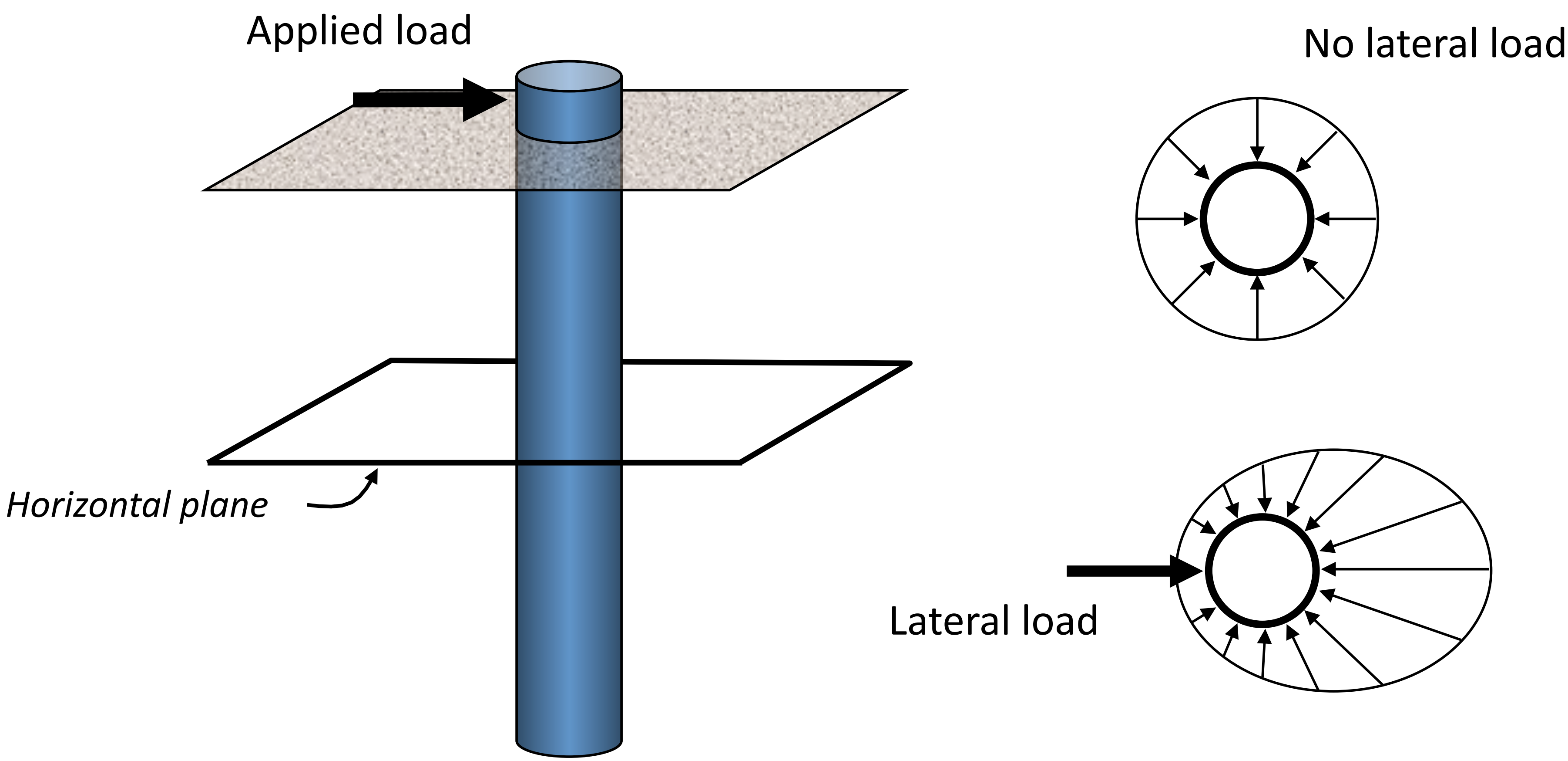
- LRFD is recognized as one method of implementation of reliability-based design (RBD); developed procedures should be as "fundamentally correct" as possible from RBD perspective. Uncertainties in earthquake ground motions, soil properties, and pile response should be quantified and properly accounted for.
- Developed approach should allow evaluation of actual reliabilities produced by current, and eventual proposed, LRFD procedures.
- For consistency, approach should converge to result given by current, non-seismic LRFD procedures for earthquake ground motions of zero amplitude.
- Approach should include improved limit state definitions, both for strength and serviceability limit states.

Current Procedures

- Current LRFD procedures use load factor of 1.0 for seismic.
- Loading expressed in terms of S_a at a single return period
- Resistance factors applied to total capacity, not to individual parameters that control uncertainty in capacity and potential for deformations
- Little data for calibration available
- Current resistance factors calibrated to be consistent with working stress design
- For bridges in non-liquefiable soils, inertial interaction effects are most important
- Vertical displacements (settlement) are particularly important due to demands placed on deck

Deep Foundations

Single pile/shaft behavior – lateral loading



Deep Foundations

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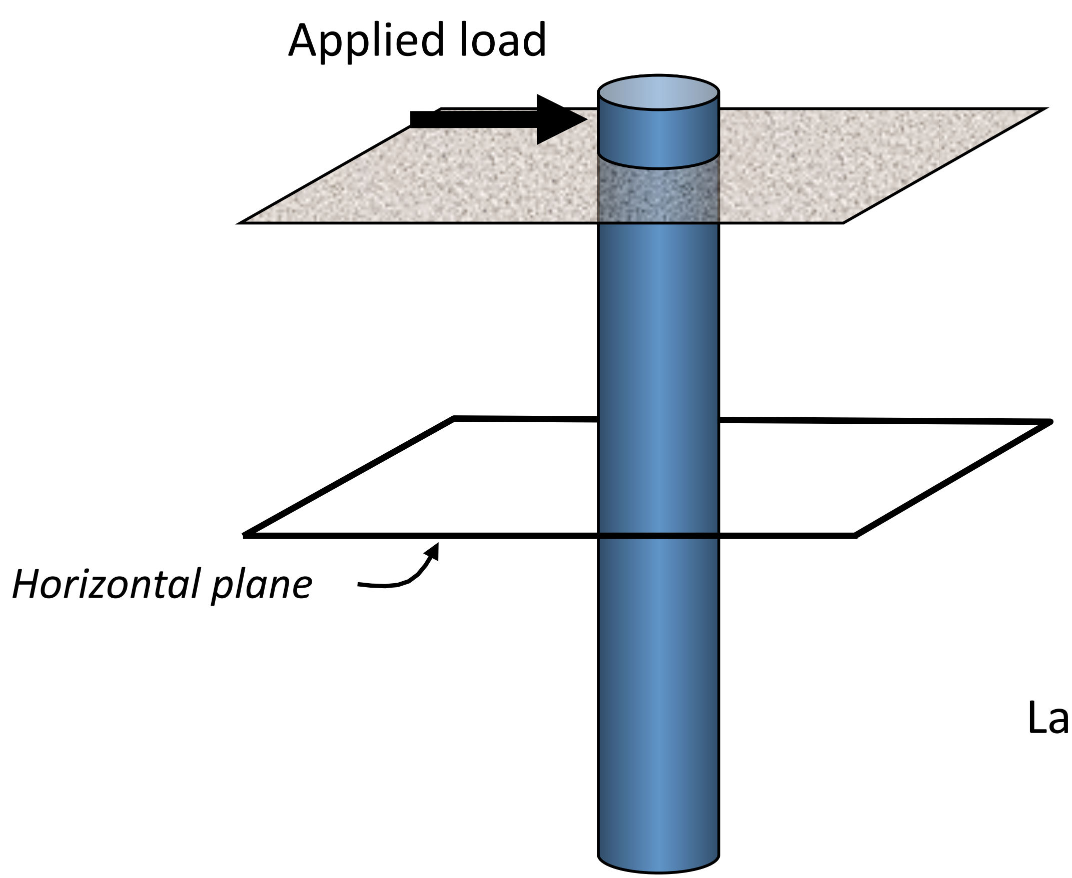

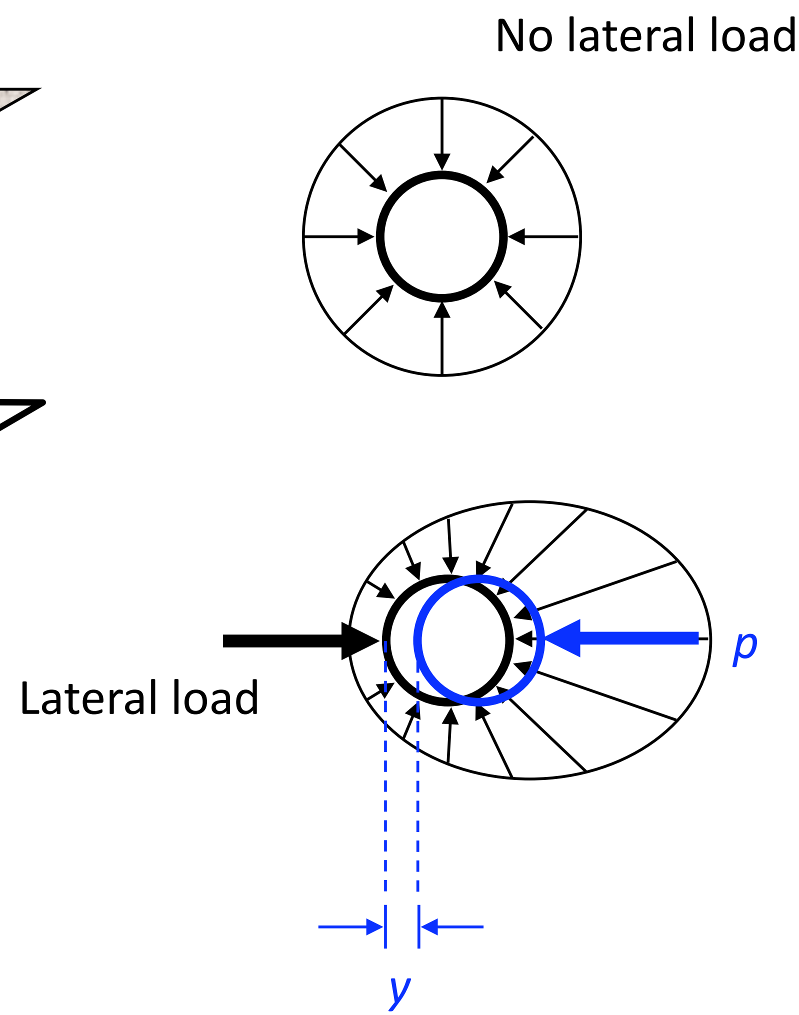

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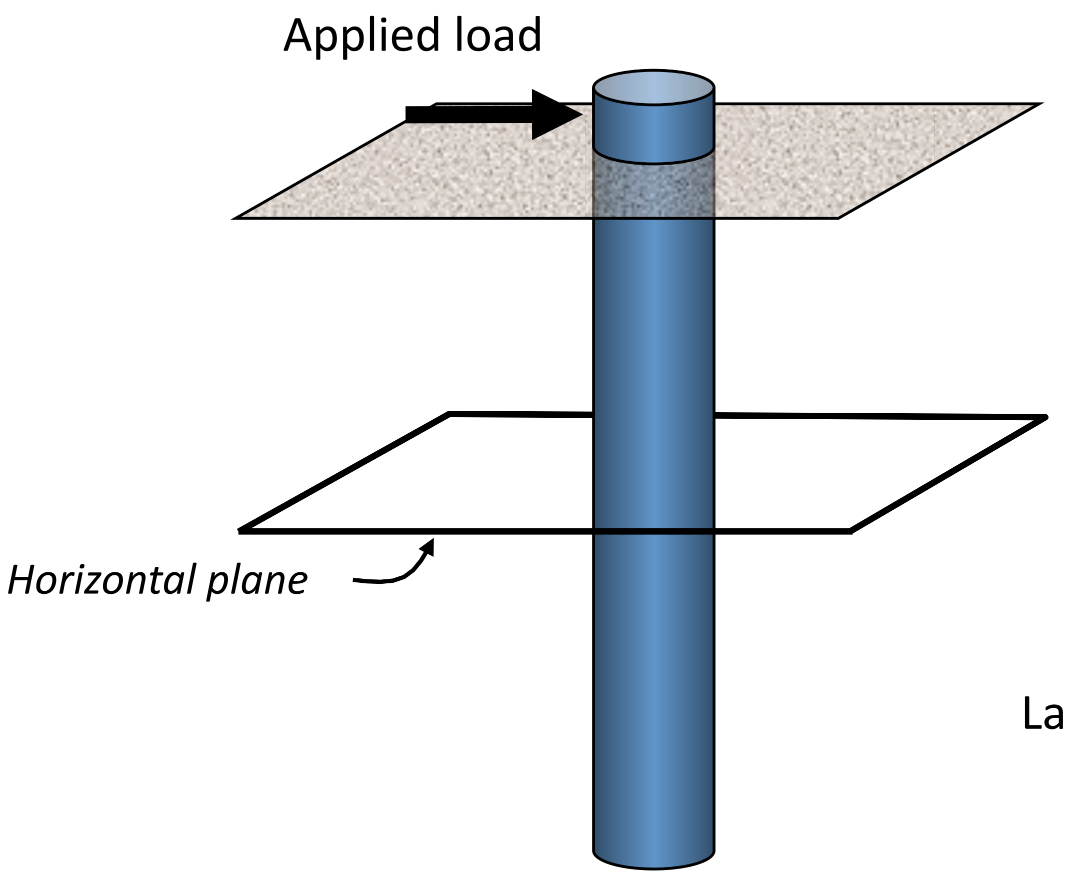
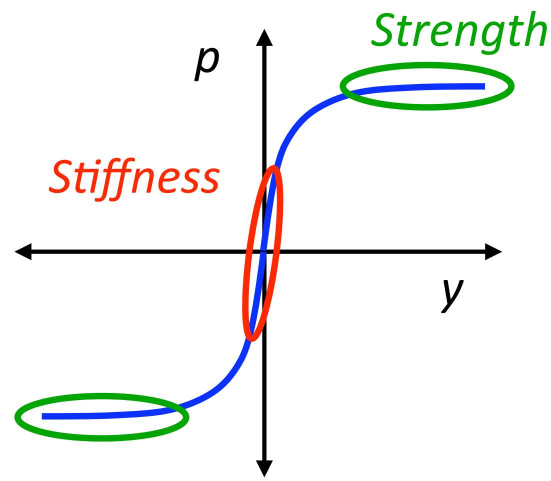
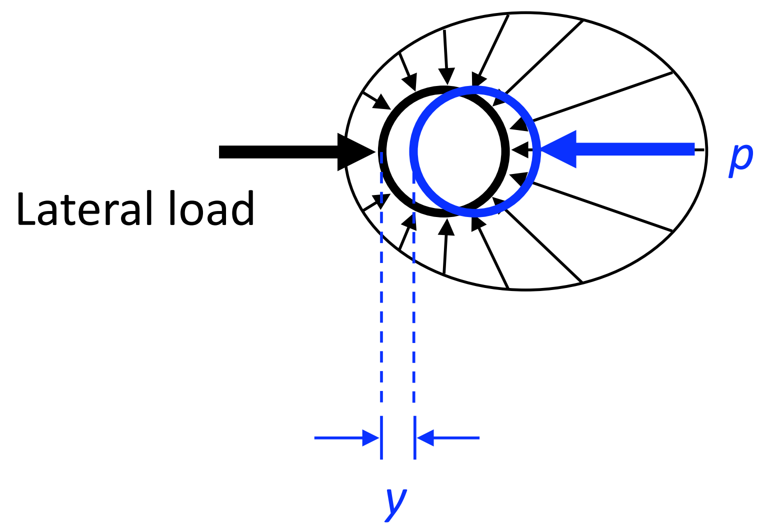
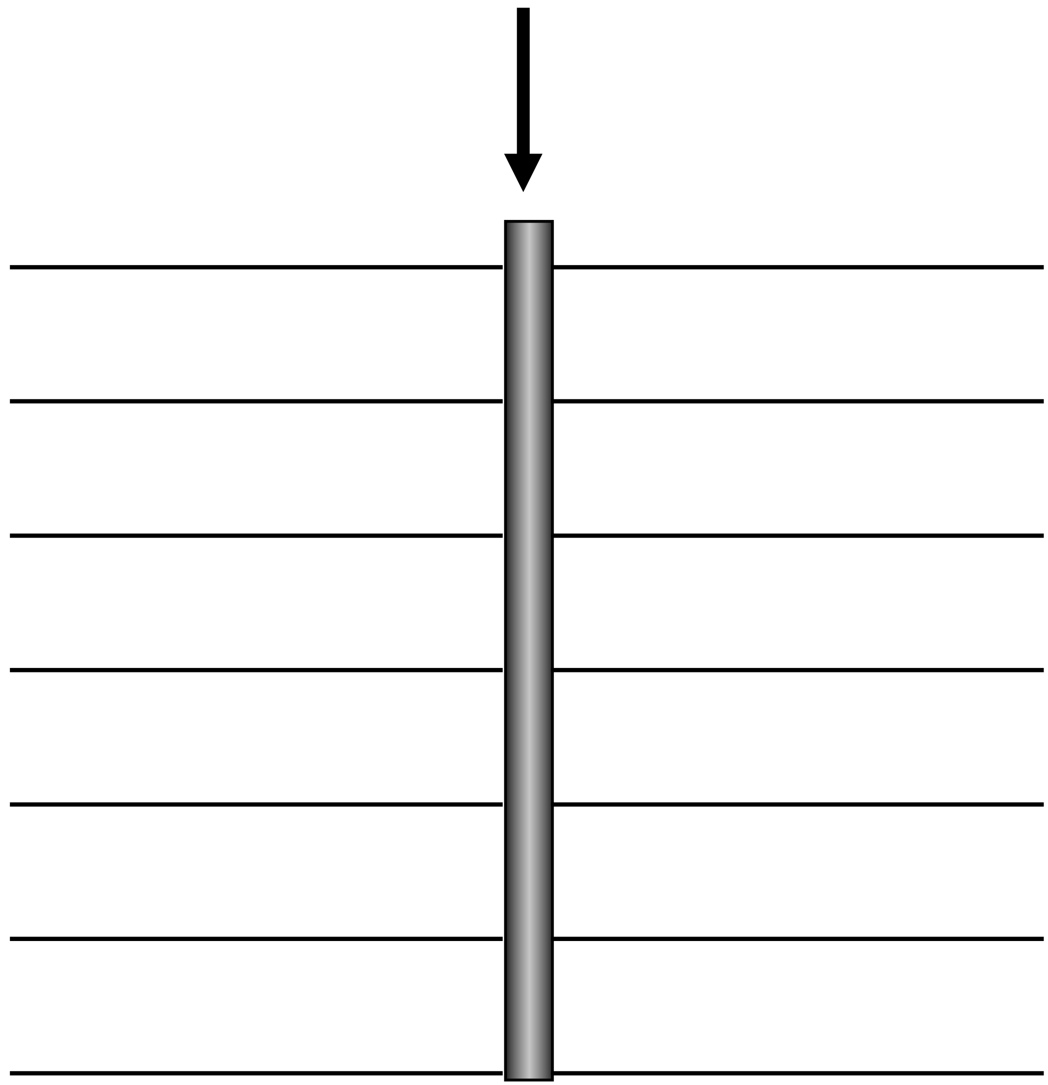






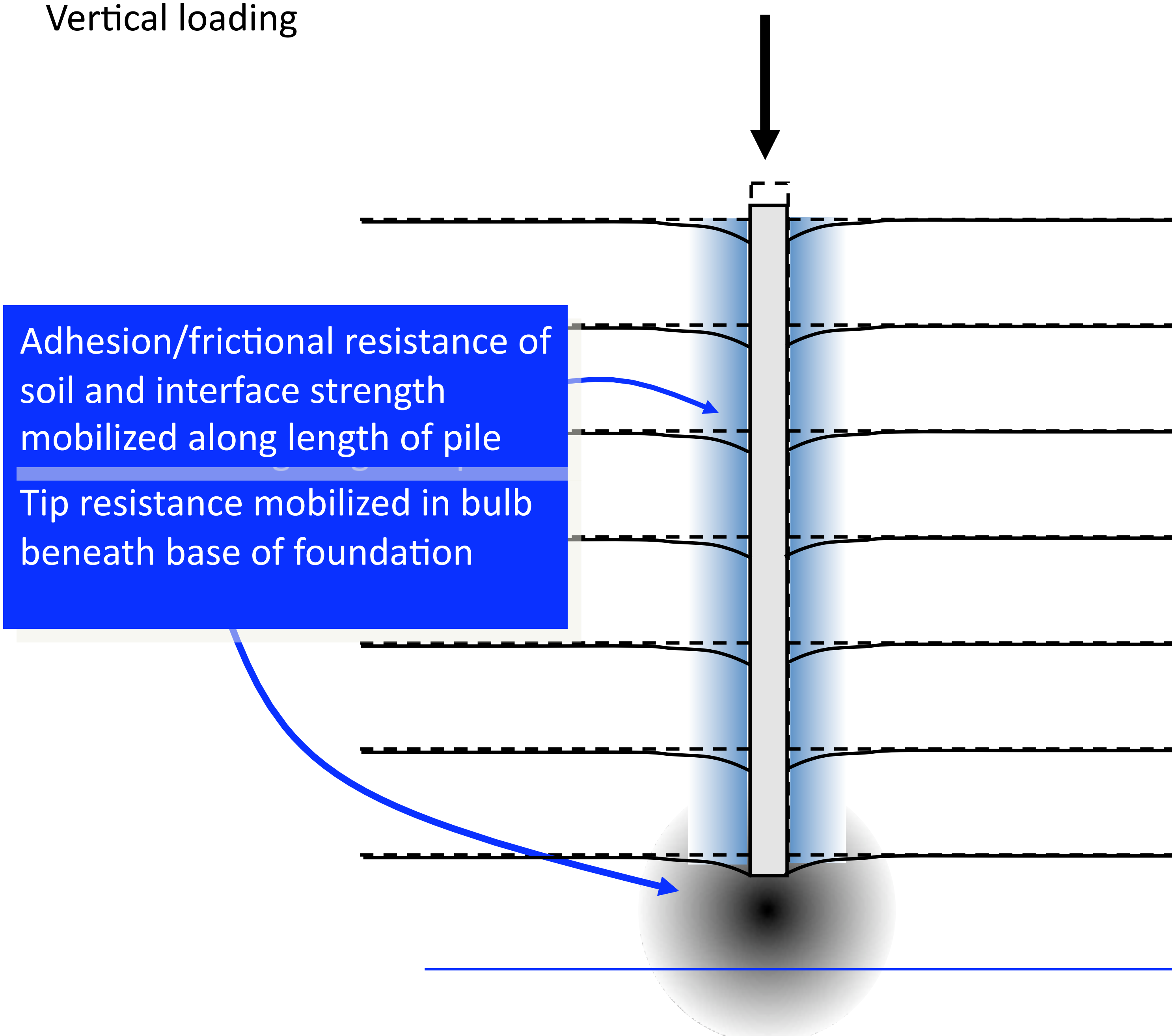
Deep Foundations

Vertical loading



Deep Foundations

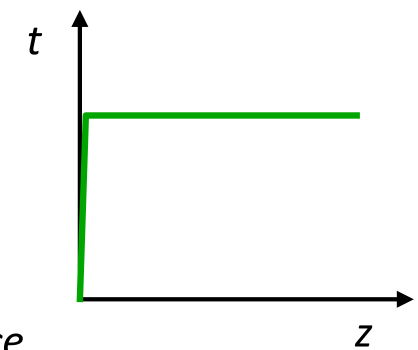
Vertical loading



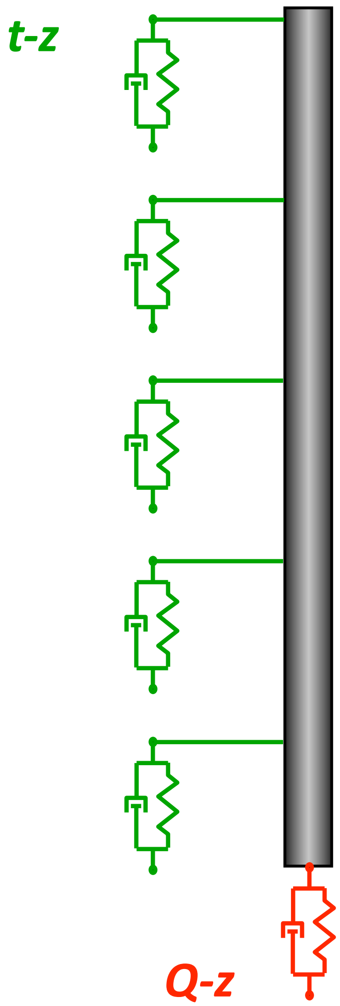
Deep Foundations

Analysis of deep foundation response – vertical loading, single foundation

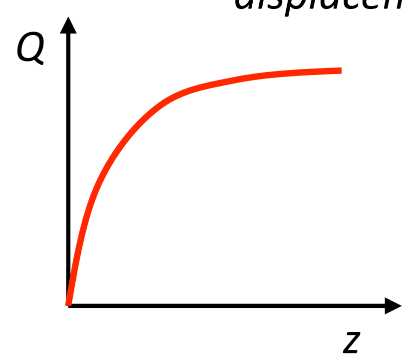
Discretize pile, represent nonlinear skin resistance using *t-z* curves



Skin resistance generally mobilized quickly

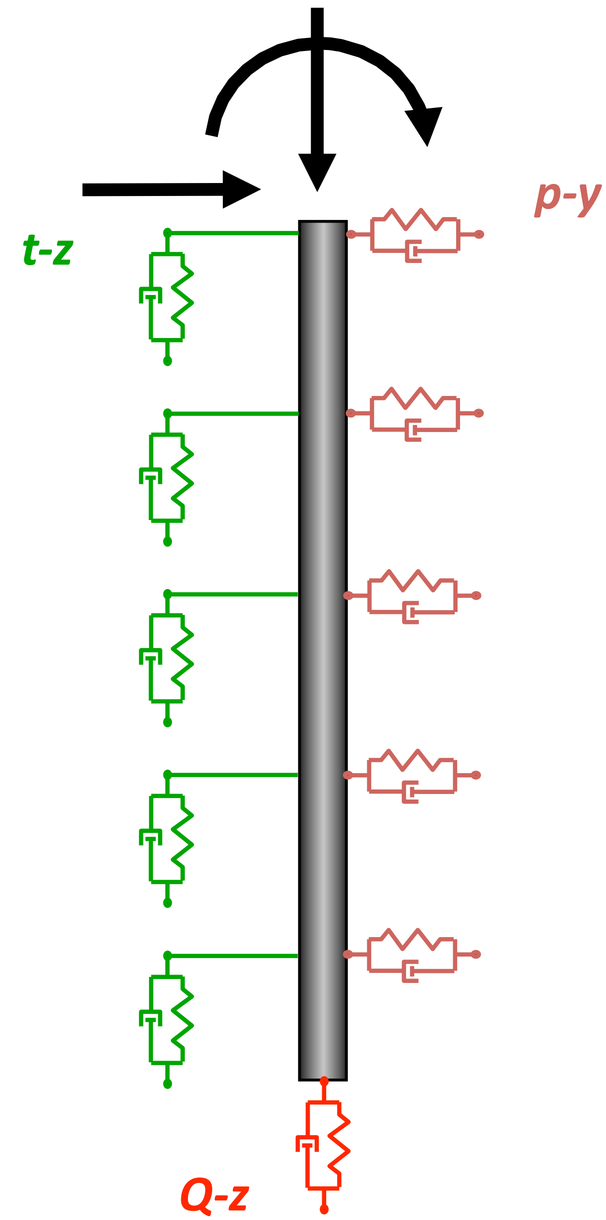


Tip resistance mobilized at larger displacements



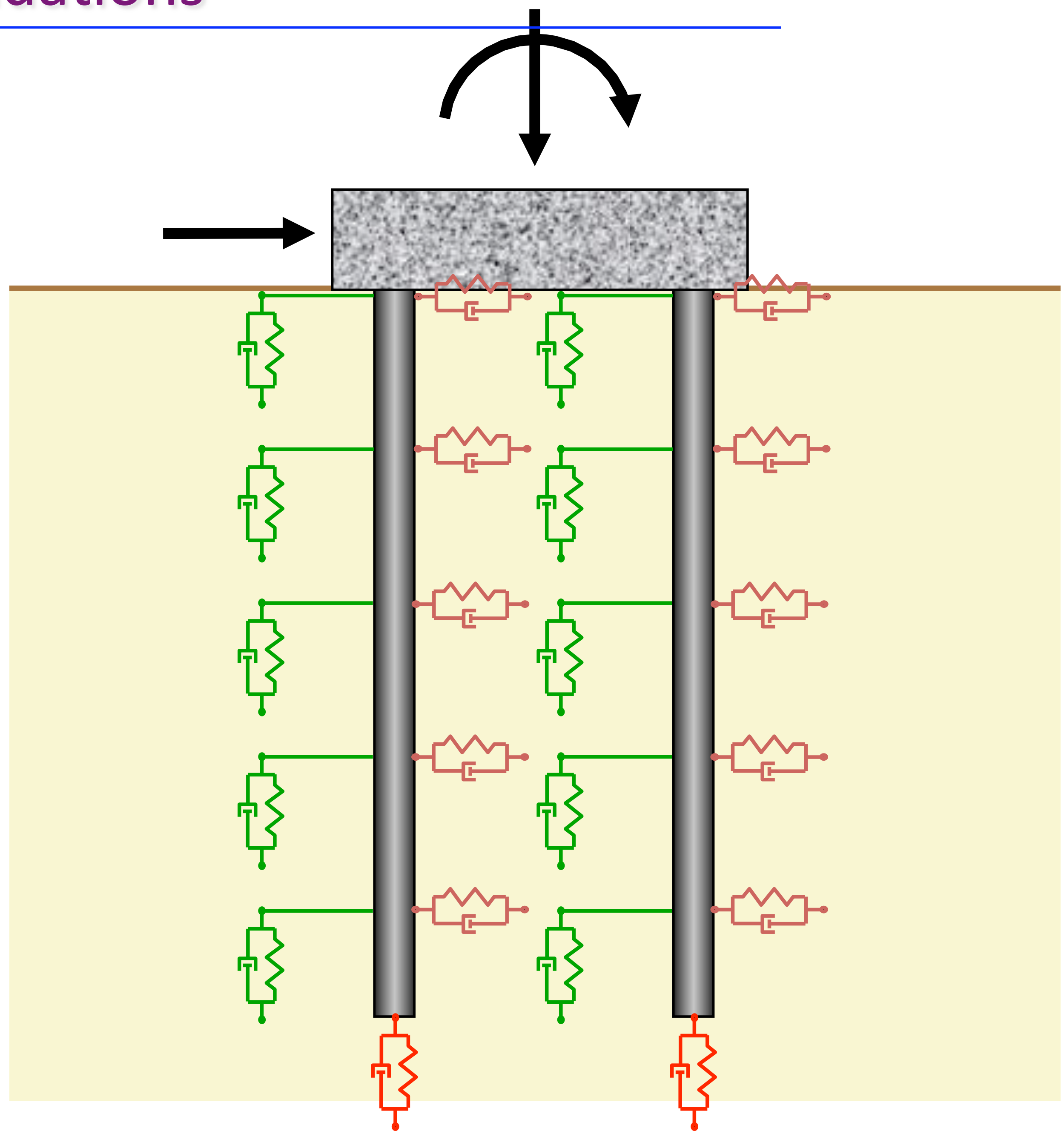
Deep Foundations

All forms of loading



Deep Foundations

Pile Groups



Current and Near Future Work

- Building OpenSees models of typical pile foundations
- Interaction to be handled by *p-y, t-z*, and *Q-z* curves
- Simulate static load tests - identify important variables
- Perform simulations of static load tests – using model uncertainty upon which current resistance factors are based, identify implied uncertainty in controlling variables
- With parametric uncertainty established, perform dynamic simulations using suites of binned ground motions
- Identify optimal *IM*s
- Evaluate distributions of response parameters (*EDP*|*IM*)