Assessment and design implications of large ground deformations

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Large ground deformation effects

- Liquefaction & lateral spreading are major causes of foundation damage during earthquakes.
- Past 10 years …
Field studies

- Detailed studies of unique cases involving fine-grained soils from the 1999 Kocaeli and 1999 Chi-Chi earthquakes.
- Basis for re-examination of broader databases.

R. B. Seed
Field studies

Findings led to advances in design practices for:

- Liquefaction susceptibility for fine-grained soils
- Liquefaction triggering
- Lateral spreading assessments

Soils reported by Bray et al. (2004b) to have liquefied at Adapazari in 1999.

Criteria by Bray et al. (2004a):
1. $\text{PI} \leq 12$ & $w_c > 0.85 \text{LL}$: susceptible to liquefaction.
2. $12 < \text{PI} < 20$ & $w_c > 0.8 \text{LL}$: systematically more resistant to liquefaction but still susceptible to cyclic mobility.

Bray et al. Boulanger & Idriss

Seed et al.
Simulation

- Hierarchy of 2-D and 3-D modeling capabilities developed.
Simulation

- Enabled studies of deep foundation systems.
- Expanded practice through tools & design guidance.
- Opened new opportunities for future advances.

Elgamal et al.

Jeremic et al.
Validation

Dynamic centrifuge, shake table, and field tests addressed knowledge gaps for deep foundations.

Ashford et al.
Validation

- Mechanisms of interaction.
- Provided for validation/evaluation of analysis methods
  - Equivalent static design methods, and
  - Nonlinear dynamic analyses.

![Graph showing predicted pile cap displacement](image)

*Chang et al.*

![Diagram showing M, P, V, I](image)

*Brandenberg et al.*
Design

Benchmarking studies to demonstrate methodologies and facilitate early adoption in practice.

Arduino/Kramer/Shin
Partnerships

- Rapid advances through numerous strong collaborations across:
  - PEER and PEER Lifelines
  - Engineering practice – private and government
  - National and international researchers
PEER Achievements

- Diverse contributions on science & design practices for the effects of large ground deformations
  - Field studies
  - Simulation
  - Validation
  - Design
  - Partnerships
- Significant impacts on PBEE and decision making for risk mitigation.
- Strong "foundation" for continuing contributions.