DS-3
Response Analysis Tools

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Objectives of DS-3

Develop advanced response analysis tools for estimating peak structural response quantities

1. Simplified Demand Estimation
2. Detailed Analysis Environment
3. Soil Structure Interaction (SSI)
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- Develop simplified methods to account for SSI effects of various foundation types (embankments, pile foundations and shallow foundations etc.)
- Investigate the effects of SSI on the overall response of structures
What is SSI?

\[ \ddot{U}_g \]

\[ \ddot{U}_g \]
Why Is SSI Important?

Past Research Trends

- Analyze the force on a structure
- Piles dissipate energy into the soil
- SSI seen as beneficial and often ignored for simplicity.
Why Is SSI Important?

NEW Research Trends

- Analyze displacement of structure
- Consider structural & nonstructural damage
- SSI can cause more displacement at the surface, must be taken into consideration.
The Problem

- SSI is being assumed beneficial and ignored for simplification when it can actually have detrimental effects during an earthquake.

- SSI is a very complex phenomena, often exhibiting nonlinear and frequency-dependent behavior.
Response of Pile Group

- Kinematic response (motion amplification due to pile group)
- Nonlinearity of soil and pile shaft
- Pile-to-pile interaction (Group Behavior)
Modeling in ABAQUS

- Linear behavior of a single pile embedded in soil using Beam-on-Winkler-Foundation model
- Dynamic response of a single-degree-of-freedom system
Beam-on-Winkler-Foundation Model for Pile
ABAQUS Analysis

- Static Pushover Analysis
- Steady-State Dynamic Analysis
- Dynamic Time-history Analysis
Static Pushover Analysis

![Diagram of a structure with labeled forces and displacements.](image)
Steady-State Dynamic Analysis

\[ P(t) = P_0 \sin(\omega t) \]
**Time History Dynamic Analysis**

\[ M\ddot{u} + C\dot{u} + Ku = -M\ddot{U}g \]

\[ \ddot{U}g = \ddot{U}_0\sin(\omega t) \]

ABAQUS Solution

Analytical Solution

steady state
Future of the Project

- Pile Groups
- 3-D Finite Element Analysis

Outputs:
- DS-4 Vulnerability Functions
- DS-5 Response Simulation Across Regions
- CM-4 Structural Retrofit Strategies
Thank You

Questions?