I-880 Bridge Testbed Simulations: Soil–Foundation–Structure Interaction Issues

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I–880 Bridge SFSI Issues

- Seismic response of I–880 viaduct using performance based engineering

- Hierarchical set of SFSI simulations models developed to represent engineering demand parameters (EDP)

- Local site conditions (inelastic SFSI interaction problem)

- Wave propagation over the bridge length (scale problem)

- Single point (spatial) far field input motions

- Stochastic distribution of materials (properties) over spatial scales

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I–880: Where in the World? 

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I–880: Local Site Conditions

- Adjacency of foundations in soft and stiff soil
- Spatial distribution of soil materials (?)
I–880: Foundation System

- Similar pile group beneath all piers
I–880: Hierarchy of Models
I–880: Systems Approach
Where are we Going

- Currently investigated SFSI issues
  - Wave propagation over the bridge length (scale problem)
  - Single point (spatial) far field input motions
  - Stochastic distribution of materials (properties) over spatial scales

- Application of the Domain Reduction Method to the bridge system simulations
Domain Reduction Method (DRM)

- Work by Bielak et al. (since 1986, current paper: 2003, Bulletin of the Seismological Society of America) at CMU.
- Modular, two step procedure for large 3D dynamics problems.
  - Background wave field on simplified domain
  - Local wave field (coupled through acc. and disp.)
- Green’s functions solutions, Quake system, SCEC database, SHAKE, 3D downhole arrays,
DRM: Dynamic (Seismic) Forces

\[
\begin{bmatrix}
P_{i}^{\text{eff}} \\
P_{b}^{\text{eff}} \\
P_{e}^{\text{eff}}
\end{bmatrix}
= 
\begin{bmatrix}
0 \\
-M_{be}^{\Omega+}\ddot{u}_{e}^{0} - K_{be}^{\Omega+}u_{e}^{0} \\
M_{eb}^{\Omega+}\ddot{u}_{b}^{0} + K_{eb}^{\Omega+}u_{b}^{0}
\end{bmatrix}
\]

- Seismic forces $P_{e}$ replaced by the effective nodal forces $P_{i}^{\text{eff}}$,
- $P_{i}^{\text{eff}}$ involve only submatrices, $M_{be}, K_{be}, M_{eb}, K_{eb}$
- They vanish everywhere except in the single layer of elements in $\Omega^{+}$ adjacent to $\Gamma$.
- The material inside $\Omega$ does not have to be linear elastic
SSI Model: Stiff Soil

Free field  SFSI

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SSI Model: Soft Soil

Free field

SFSI

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SSI Model: Seismic Amplification

Stiff soil

Soft soil

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Currently in Works

• Generation of background wave fields from point seismic motions data

• Development of full soil–foundation–structure bridge model to investigate influences of
  – Local site amplifications
  – Coherency loss (stochastic variations)
  – Time lag (wave passage effects)