Tsunami Bridge Modeling Workshop

Michael H. Scott

PEER Annual Meeting

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Wave Loading on Structures

- Recent natural disasters
  - 2004 Indian Ocean tsunami
  - 2005 Hurricane Katrina
  - 2011 Tohoku earthquake and tsunami
  - 2012 Superstorm Sandy

- Simulating wave loads from tsunami and storm surge essential for refining design guidelines and assessing mitigation strategies for critical infrastructure
  - Coastal bridges
  - Evacuation shelters
  - Power plants and energy facilities

- Tsunami following earthquake

Challenges in Simulating FSI

- Simulation was a critical component to PEER's PBEE methodology
  - Led to the development and wide adoption of OpenSees
  - Experiments help validate simulation models and models guide experimental design
- Simulation of FSI for PBTE will face many of the same issues as encountered in simulating seismic response
  - How accurate do models need to be in order to be reliable?
  - Balance between accuracy and efficiency
  - Sensitivity to boundary conditions and model parameters
  - Characterization of hazard – flow height and velocity
  - Can refined analyses inform estimation of loads?

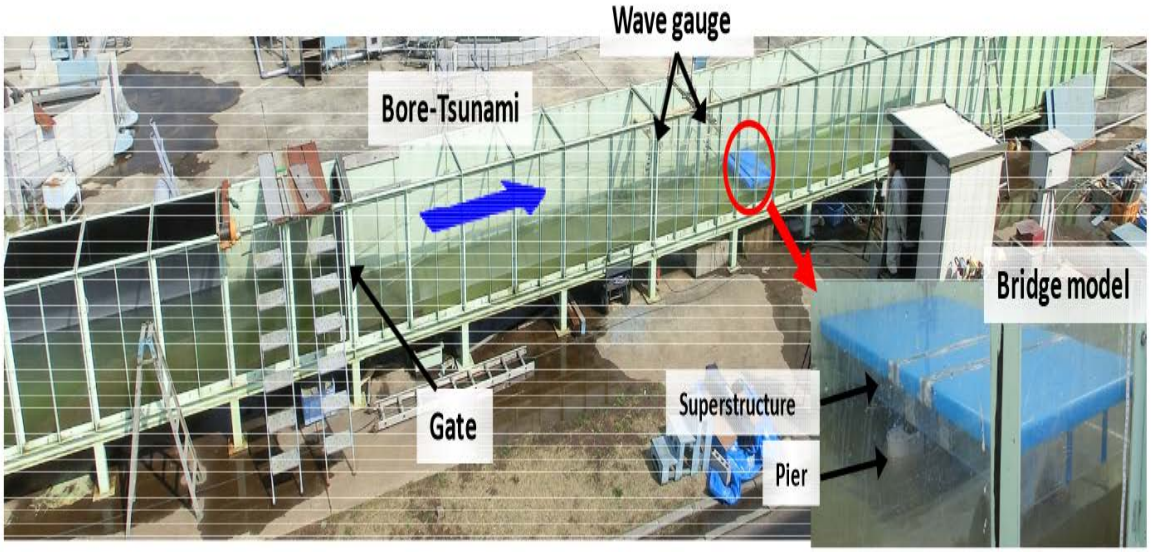
Tsunami Bridge Modeling Workshop

- Collaboration between PEER, PWRI, and UJNR
- 33 participants from US and Japan
- Compare simulation methods, discuss differences in results
- Identify knowledge gaps for PEER PBTE

https://secure.engr.oregonstate.edu/wiki/tsunamiworkshop/index.php

December 10-12, 2014, Corvallis, OR

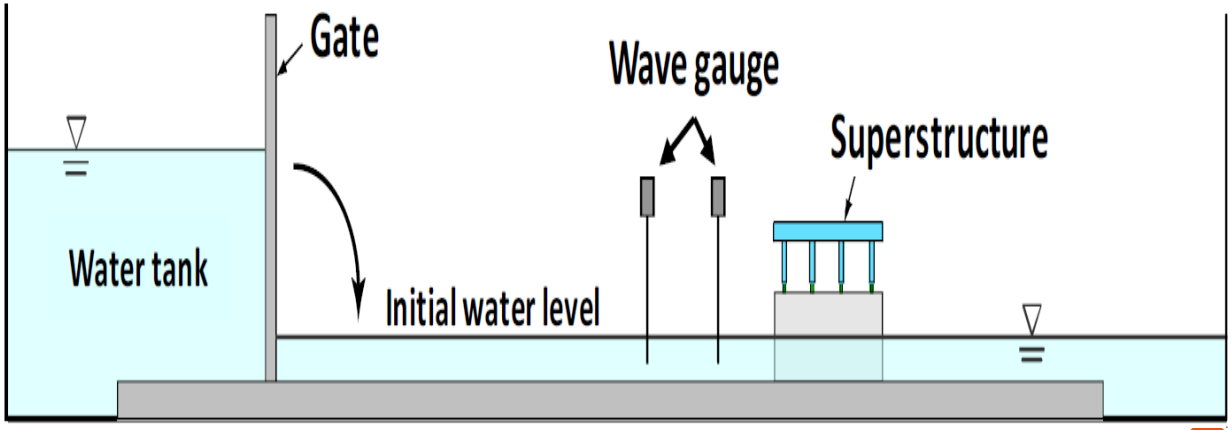
PWRI Experiments



1/20 scale bridge superstructures

30 m by 1 m flume

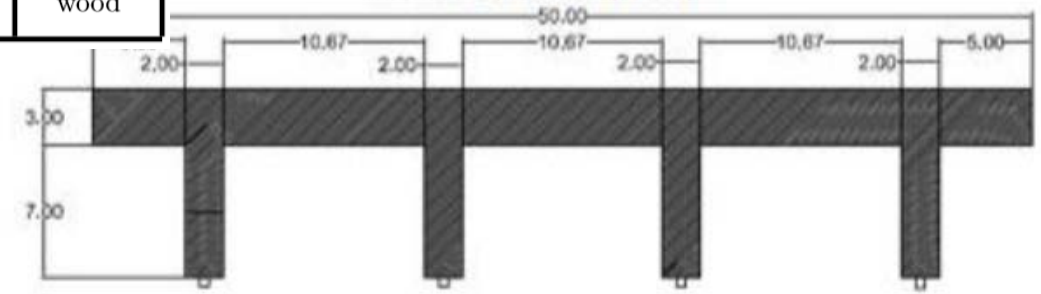
Gate release to initiate tsunami bore



Cases Simulated for Workshop

	Case 1	Case 2	Case 3	Case 4
Wave Height (cm)	15	20	15	20
Still Water Depth (cm)	20	10	15	10
Initial Tank Depth (cm)	51.8	61.7	51.8	61.7
Deck Type	A	B	B	C
Deck Material	acryl	wood	acryl	wood

Deck Type A (cm)



Deck Type B (cm)

Deck Type C (cm)

Four cases selected from PWRI suite of experiments

Three deck types

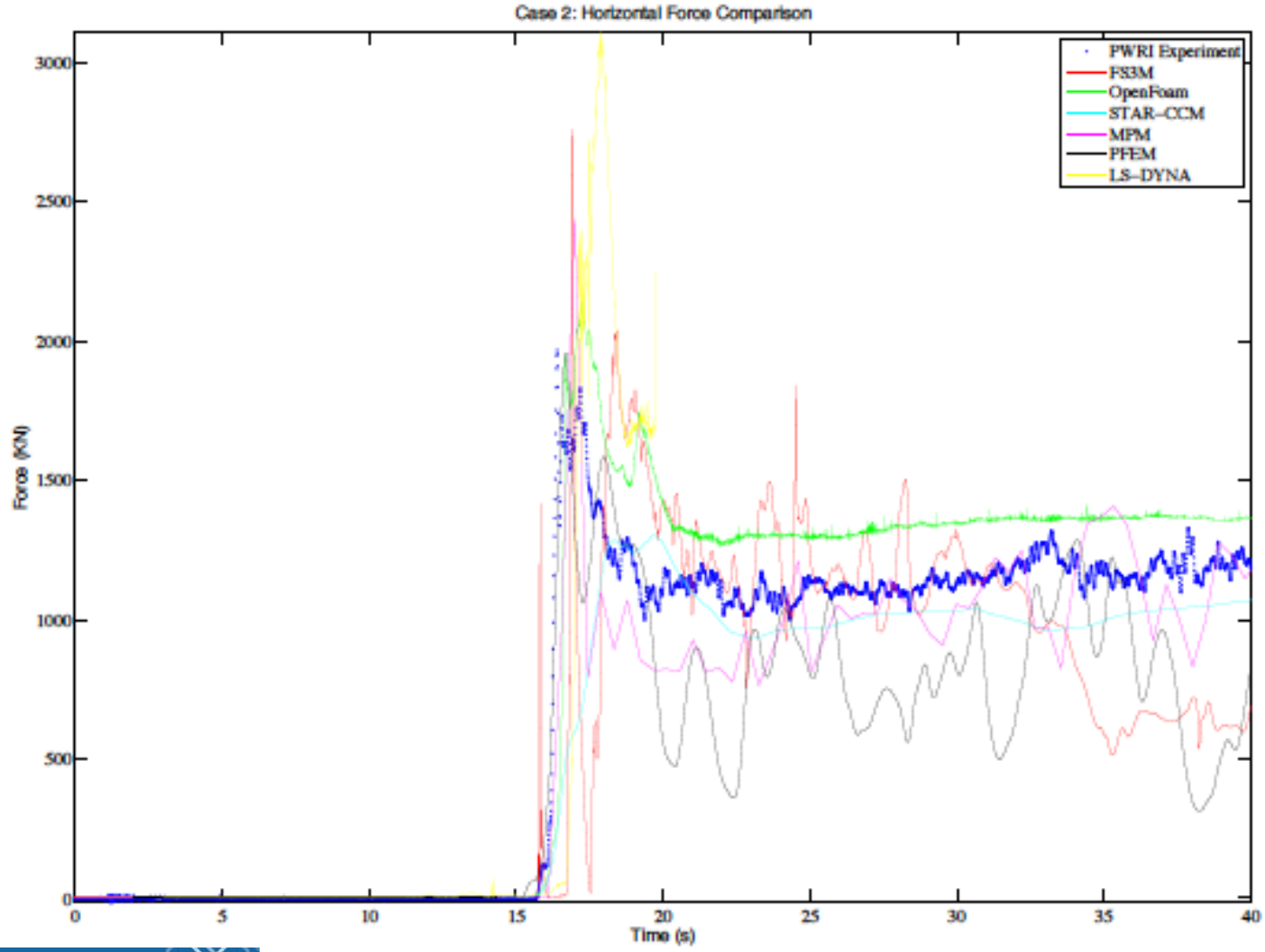
Differing wave heights and still water depths

Simulation Software and Formulations

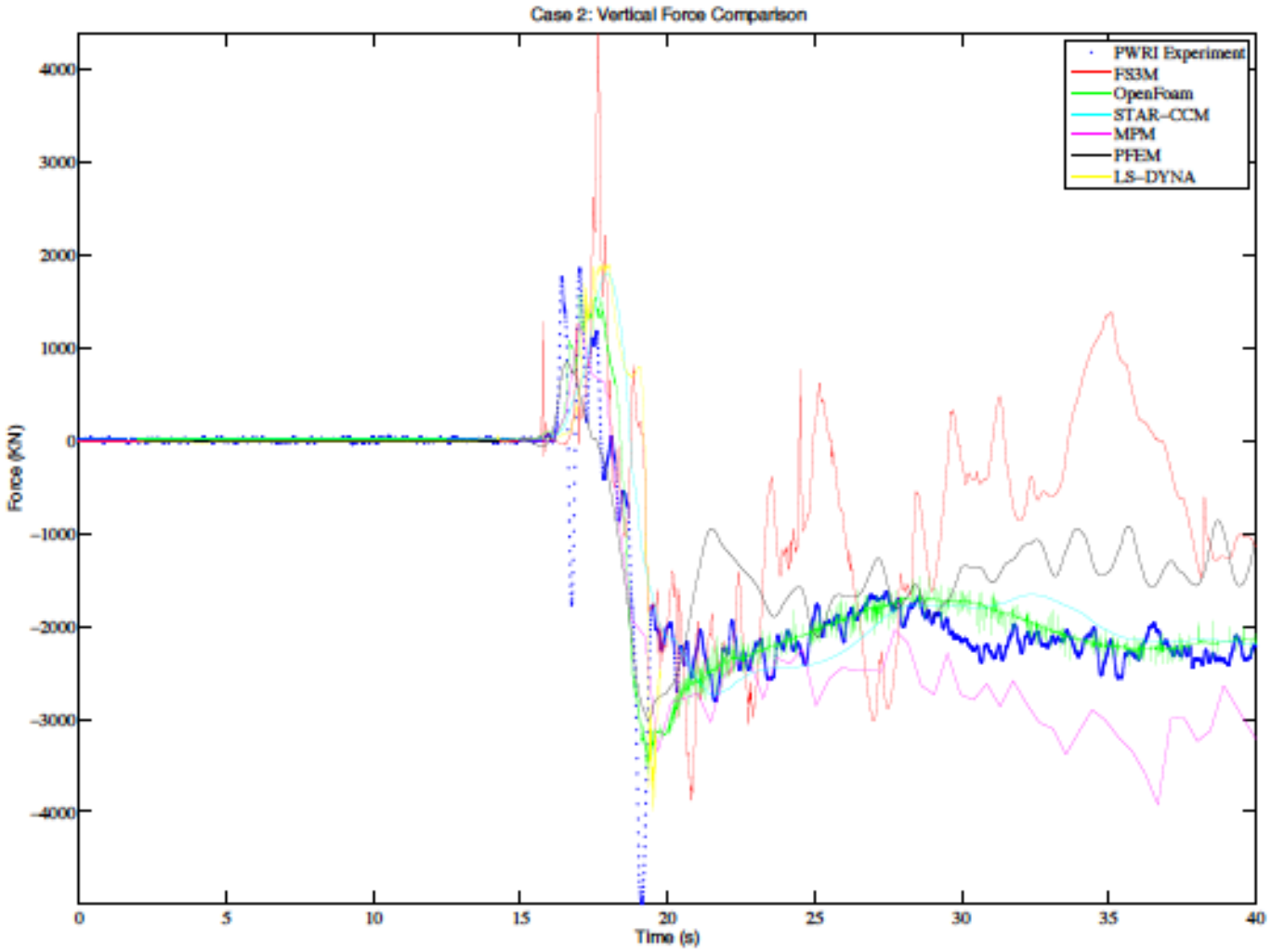
- Volume of Fluid (VOF) and Finite Element (FEM) approaches
- 2D and 3D models
- Single and Two-phase model
- Various turbulence models

Name	Numerical Formulation	Turbulence Model	Number of Dimensions	Type of Phase Model
CADMAS-SURF	VOF	$k-\epsilon$	2D	Two-Phase
FS3M	Multiple (coupled)	LES	3D	Two-Phase
OpenFOAM	VOF	$k-\epsilon$	Both 2D & 3D	Two-Phase
OpenSees PFEM	FEM	N/A	2D	Single Phase
Material Point Method (MPM)	FEM	N/A	2D	Single Phase
Stabilized FEM	FEM	Implicit LES	2D	Two-Phase
GPUSPH	SPH	Sub-Particle Scale (SPS)	3D	Single Phase
LS-DYNA	FEM	LES	3D	Two-Phase
STAR-CCM+CFD	VOF	$k-\epsilon$	3D	Two-Phase

Case 2 – Total Horizontal Force



Case 2 – Total Vertical Force



Key Observations from Workshop

- 3D models generally the worth additional computational effort compared to 2D models
  - Capture localized air pockets and vortex shedding
  - Easily adapted for skewed bridge decks
  - Open source software OpenFoam (next talk)
- Use of turbulence models better captures response to high speed steady flows
- Initial/boundary conditions important, particularly with respect to gate release of water reservoir
- Additional details on workshop webpage and final report