FRAGILITY OF FLOATING DOCKS FOR SMALL CRAFT MARINAS

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OUTLINE

› What is a Tele-Tsunami?
› Fragility Curves Methodology
› Post-Tsunami Damage Assessment
› Conclusions
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CALIFORNIA TELE-Tsunamis

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› Sources:
  » 2010 Magnitude 8.8 Chile Event (Historical)
  » Magnitude 9.0 Cascadia Scenario
  » 2011 Magnitude 9.0 Japan Event (Historical)
  » Magnitude 9.4 Chile North Scenario
  » Magnitude 9.2 Eastern Aleutian-Alaska Scenario
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Is this what a tsunami looks like in California? Ummm…nope.
Many ports, harbors, and maritime facilities along the U.S. West Coast were adversely affected by surges and currents induced by the tsunami (Wilson et al. 2013; Wilson et al. 2012).

In Santa Cruz, all docks sustained some level of damage.

30 boats broke free from the docks, several of them sinking and a number sustaining serious damage.

There are two components in a floating dock system primarily believed to cause damage within the harbor: cleat and pile guide failure.
Tsunamis **ARE** a natural hazard.

Tsunamis **DO** cause damage.

Tsunamis **ARE NOT** what Hollywood makes of them.

For California, damage from tsunamis **IS** caused by high flow speed, **NOT** massive waves.
MOTIVATION

› The Problem: Existing methodologies to expose tsunami based vulnerability to small craft harbors are limited.

› The Need: Develop a robust method to quantitatively estimate the impact of tele-tsunamis to small craft harbors.
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Propose: A physics and Monte-Carlo based approach to fragility curves.
**METHODOLOGY: GOVERNING EQUATIONS**

**Demand to Capacity Equations for Cleats**

\[ F_{yc} = \frac{1}{2} \rho_w V_c^2 L_{wl} T C_{yc} \sin \theta \]

\[ F_{xc} = F_{x\text{FORM}} + F_{x\text{FRICITION}} \]

\[ F_{x\text{FORM}} = \frac{1}{2} \rho_w V_c^2 B T C_{xcb} \cos \theta \]

\[ F_{x\text{FRICITION}} = \frac{1}{2} \rho_w V_c^2 B S C_{xca} \cos \theta \]

**Demand to Capacity Equations for Pile Guides**

The equations to estimate pile guide demand are the same as cleats except they are 90 degrees out of phase.
**Methodology: Input Variables**

From the **aerial images** we get:

- Vessel length, draft
- Finger and walkway length/width, num. of slip/piles
**Methodology: Input Variables**

From the *numerical model* we get:
- Current speed/direction/water depth
METHODOLOGY: FRAGILITY CURVE
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POST-TSUNAMI DAMAGE ASSESSMENT: SANTA CRUZ

• Every floating dock within Santa Cruz sustained damage

• Mesiti-Miller Engineering Inc. conducted a damage evaluation

• Transformed Post Tsunami Damage Assessment: Santa Cruz ratings from A-F to Low-High damage ratings
POST-TSUNAMI DAMAGE ASSESSMENT: PILE GUIDES

• Results w.r.t. required capacity, can be interpreted as capacity needed to resist the tsunami demand.

• Fragility curves correspond to low (green), medium (yellow), and high (red) levels of damage from damage report.

• Damaged components have a relatively large capacity; components that weren’t damaged small capacity.
POST-Tsunami Damage Assessment: Cleats

• Results w.r.t. required capacity, can be interpreted as capacity needed to resist the tsunami demand.

• Difference between the north (solid) and south (dashed) harbor basins indicate age has an influence on capacity

• Cleat fragility curves order of magnitude lower than pile guide curves
**PRE-TSUNAMI DAMAGE ASSESSMENT**

<table>
<thead>
<tr>
<th>Tsunami Event</th>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
<th>Zone 4</th>
<th>Zone 5</th>
<th>Zone 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010 Magnitude 8.8 Chile Event (Historical)</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Magnitude 9.0 Cascadia Scenario</td>
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<td>Low</td>
<td>High</td>
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<td>High</td>
</tr>
</tbody>
</table>

Developed a robust method to quantitatively estimate the impact of tele-tsunamis to small craft harbors.

Method was able to capture variably in structural capacity for both cleats and pile guides.

Can be used as a predictive tool to estimate future tsunami risk for small craft harbors.
REFERENCES:


