Using a Bore-Soliton-Splash to understand Rogue Waves, Tsunamis & Wave Energy

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1 Introduction

- Definition of rogue waves: abnormality index $AI = H_{\text{peak}}/H_{\text{rms}} > 2$ in rogue wave and significant wave heights.
- Causes: Linear interference, nonlinear modulation, wave caustics, episodic waves, ..., crossing & pyramidal seas.
- Turn problem around: Create highest rogue wave splash possible in water channel using bores & solitons; & explore it.
- Explore: relation w. tsunamis, wave pumps & wave energy?

2 Set-up Water Wave Channel

- Two sluice gates, one removable by excavator.
- Uniform channel section.
- Linearly converging channel at one end, see Fig. 1.

3 Splashing Results

<table>
<thead>
<tr>
<th>Case</th>
<th>$h_0$ (m)</th>
<th>$l_0$ (m)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.32</td>
<td>0.67</td>
<td>bore</td>
</tr>
<tr>
<td>2</td>
<td>0.38</td>
<td>0.74</td>
<td>good splash</td>
</tr>
<tr>
<td>3</td>
<td>0.41</td>
<td>0.9</td>
<td>BSS-Soliton-Splash, like cases 6 &amp; 8</td>
</tr>
<tr>
<td>4</td>
<td>0.47</td>
<td>1.0</td>
<td>bore</td>
</tr>
<tr>
<td>5</td>
<td>0.41</td>
<td>1.02</td>
<td>low BSS</td>
</tr>
<tr>
<td>6</td>
<td>0.41</td>
<td>0.9</td>
<td>BSS like cases 3 &amp; 8</td>
</tr>
<tr>
<td>7</td>
<td>0.45</td>
<td>0.8</td>
<td>good splash</td>
</tr>
<tr>
<td>8</td>
<td>0.41</td>
<td>0.9</td>
<td>BSS &amp; (highest?) splash</td>
</tr>
<tr>
<td>9</td>
<td>0.43</td>
<td>0.9</td>
<td>2 solitons &amp; low splash</td>
</tr>
</tbody>
</table>

Table 1: Cases 1 to 7: 27-09-2010. Sluice gates levels $h_0$. Movies. [7] Cases 8 & 9: 30-09-2010: extreme sensitivity to sluice gate levels. Why?

4 Tests for Numerical Model

- Wave propagation in channel with breaking waves.
- Wave reflection from walls.
- Convergence in channel & splash formation.
- Smoothed Particle Hydrodynamics pretty inaccurate!

5 Mathematical Challenges

- Exact solutions of KP equation approximately fit to the channel: optimum abnormality index $AI = 5$.
- Validate for new coastal water wave model with bores & vertical vorticity.
- Optimize abnormality index for BSS.

6 Rogue Waves and Tsunamis

- Nonlinear rogue waves are highest where bottom topography and waves of different directions locally focus.
- Tsunamis run-up is highest vertically in converging bays/valleys.

7 New Wave Energy Device?

- The tapered Channel (wave pump with hydropower) & Oscillating Water Column (wind turbine through (de)compression) use wave focussing in a convergence.
- IPS wave buoy has a linear dynamo below sea level.
- Designed & built new RogueWavEnergy device: it works, a LED is blinking & we measured the power output.

8 Conclusion & Discussion

- The tapered Channel for wave energy should be validated.
- Explore & employ (numerical) dispersive water wave model & KP, with bores.
- Clarify connection Bore-Soliton-Splash with rogue waves & tsunamis.
- New wave energy device, to do:
  - investigate efficiency;
  - ensure mechanical robustness in extreme events;
  - optimize output & wave climate & direction & statistics.

References