Tsunami Simulators in Physical Modelling

Concept to Practical Solutions

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- 2240 recorded tsunami events from 6100 BC to 2016*
- 5 major tsunami since 2004 (~ 297,300 deaths)
- Economic loss from Japan 2011 tsunami estimated at $210 Billion**
- 150M people and £20Trillion in assets forecast to be exposed to coastal flooding by 2070 (Nicholls et al 2007)

*Adapted from A.Nassirpour (2014) MSc thesis UCL  **Swiss Re (2012)
Solitary waves
Miles (1980)

N-waves
Tadepalli & Synolakis (1994)
Superimposition of solitary waves on measurements for a) the Tohoku tsunami and b) the Indian Ocean tsunami, from Schimmels et al (2016)
The Question from UCL:
- Can we generate realistic tsunami in a practical physical model facility?

What are the engineering questions?
- What are the tsunami forces on buildings and coastal defences?
- Are existing guidelines adequate?
- Is engineering design the solutions?

Credit: Professor Tiziana Rossetto, UCL
Tsunami modelling facilities

Large Hydro-Geo Flume, PARI, Japan
- 184 m long, 3.5 m wide, 12 m deep

Large Wave Flume, Oregon State University
- 104 m long, 3.7 m wide, 4.6 m deep

West Tank, W. M. Keck Hydraulics Laboratory of the California Institute of Technology US
- 32 m long, 0.4 m wide, 0.6 m deep

Hammack (1972), Goring (1978), Synolakis (1986)
HRW Tsunami Simulator – concept

Diagram showing the components of the simulator:
- Pump
- Valve 1
- Valve 2
- Tank
- Water Level Gauge(s)
- Flume
- Bathymetry

Not to scale.
How it works

Trough generation

Crest generation

Wave propagation
HRW Tsunami Simulator – 1st Generation

Facility
- 1.2 m wide by 45 m long

TS dimensions
- 1.8 m tall, 1.2 m wide and 4.8 m long
- Variable height outlet

TS equipment
- Pressure transducer
- Computer controlled 45° butterfly valve
- x1 Zepher UK vacuum pumps
Outlet improvements for 1\textsuperscript{st} generation

Improving 1\textsuperscript{st} generation TS

Calibration of ‘Mercator’ wave at 1:50 scale
Facility
- 1.8 m wide by 100 m long

TS dimensions
- 3.5 m tall, 1.8 m wide and 4.0 m long
- 0.4 m outlet height

TS equipment
- x2 ultrasonic level sensors
- Pressure transducer
- Computer controlled 45° butterfly valve
- x2 ZepherUK vacuum pumps
Elevated waves

<table>
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<tr>
<th>Name</th>
<th>Period, T (s)</th>
<th>Crest amplitude, $a_+$ (m)</th>
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<tr>
<td>E160</td>
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<td>E20</td>
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N-waves
Research with 2nd generation – Phase 1

Run-up

Coastal defences

Single buildings

Initial building array tests
Facility
- 4.0 m wide by 70 m long

TS dimensions
- 4.0 m tall, 4.0 m wide and 4.4 m long
- 0.4m outlet height

TS equipment
- High resolution level sensors
- Pressure transducer
- Closed loop computer controlled 45° butterfly valve
- x2 Zepher UK vacuum pumps
Research with 3\textsuperscript{rd} generation – Phase 2

Coastal defences
Building arrays
‘Failing’ coastal defences
Scour around buildings
Research with 3\textsuperscript{rd} generation
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