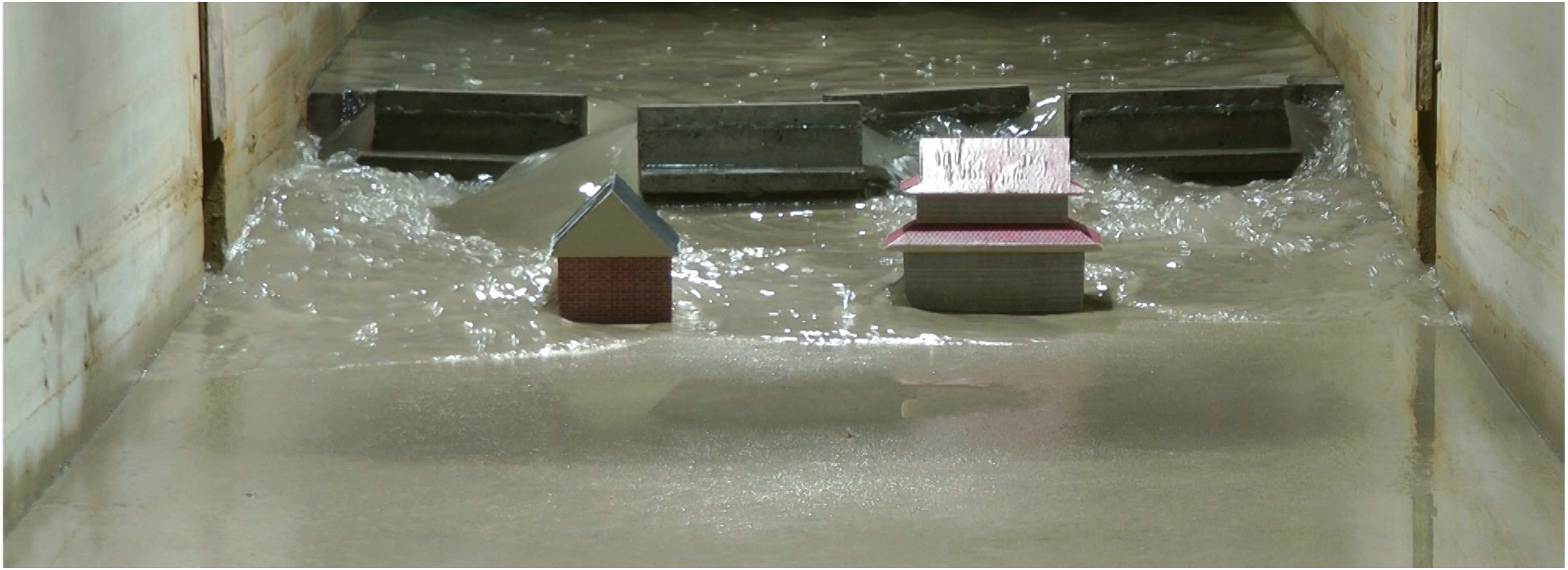
HR Wallingford
Working with water

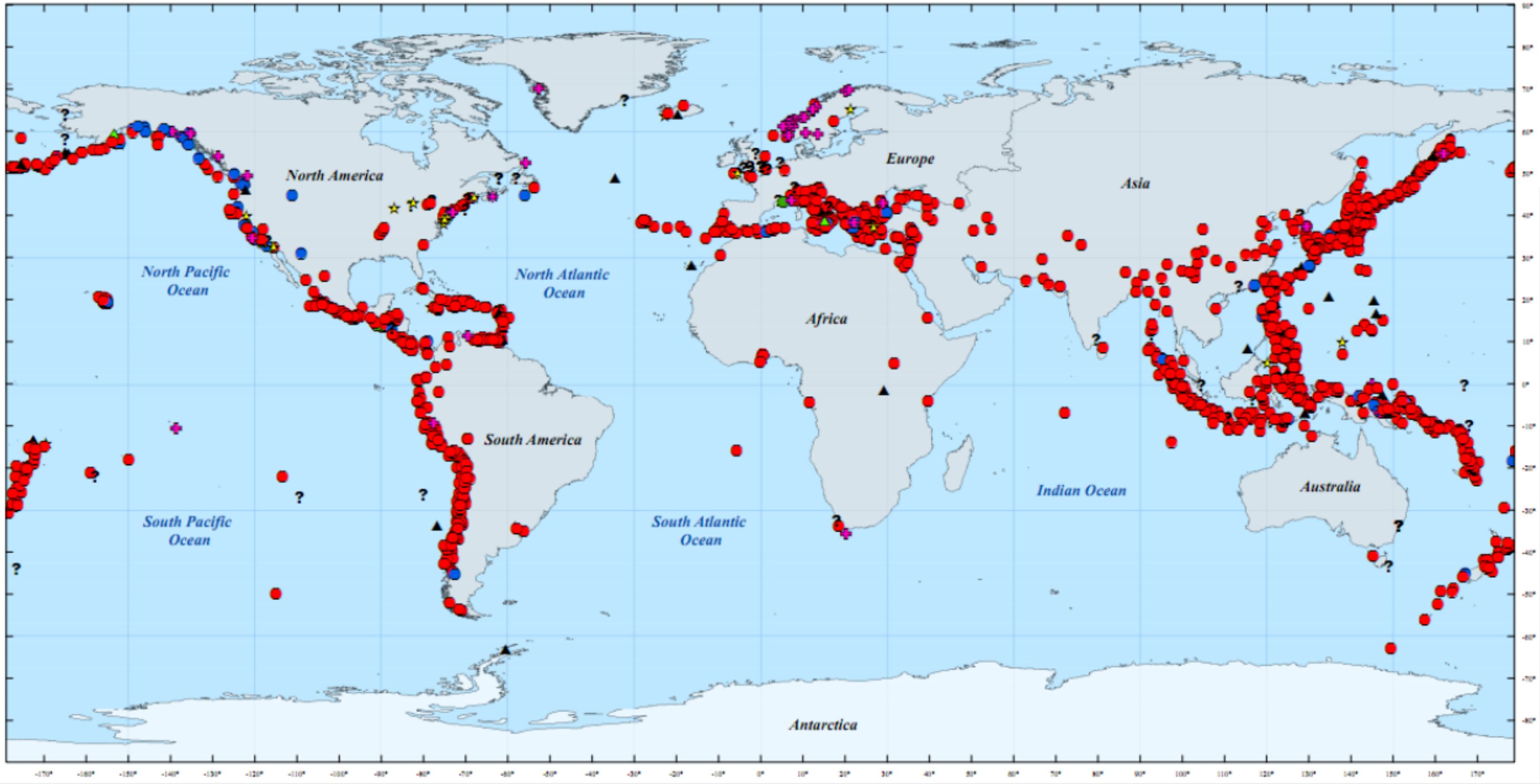


Tsunami Simulators in Physical Modelling

Concept to Practical Solutions

27 April 2017

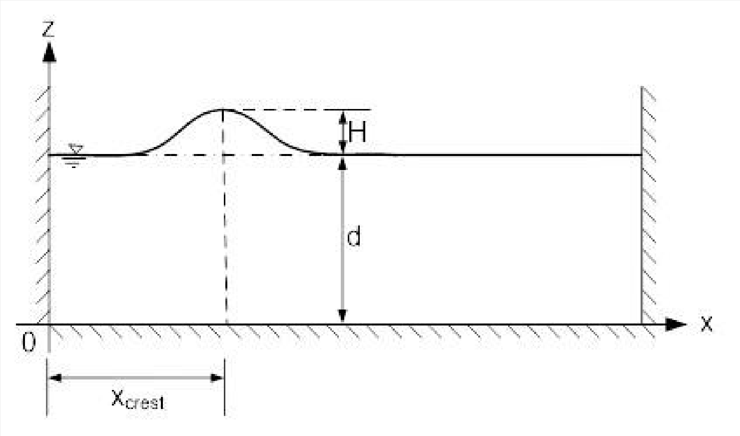
Dr Ian Chandler, W Allsop, D Robinson,
T Rossetto, D McGovern & D Todd



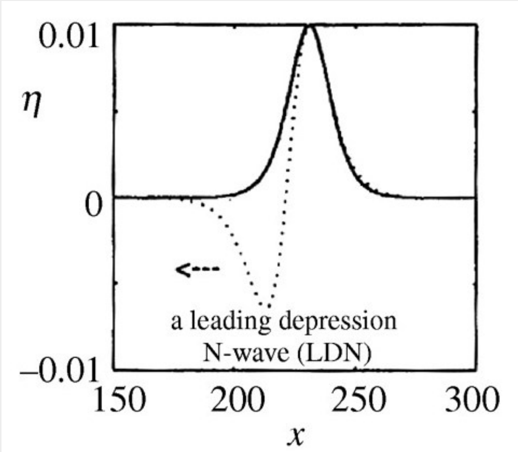
- 2240 recorded tsunami events from 6100 BC to 2016*
- 5 major tsunami since 2004 (~ 297,300 deaths)
- Economic loss from Japan 2011 tsunami estimated at $210 Billion**
- 150M people and £20Trillion in assets forecast to be exposed to coastal flooding by 2070 (Nicholls et al 2007)

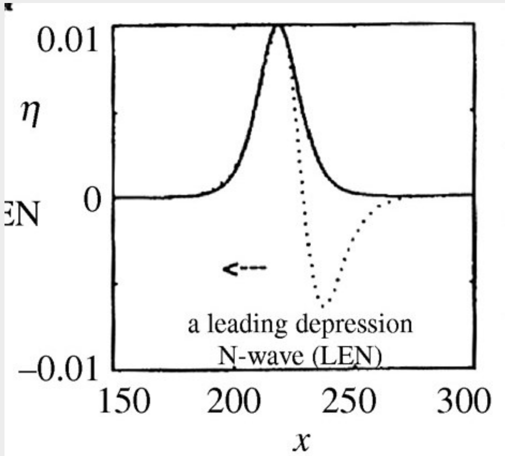
*Adapted from A.Nassirpour (2014) MSc thesis UCL **Swiss Re (2012)

Modelling tsunami waves



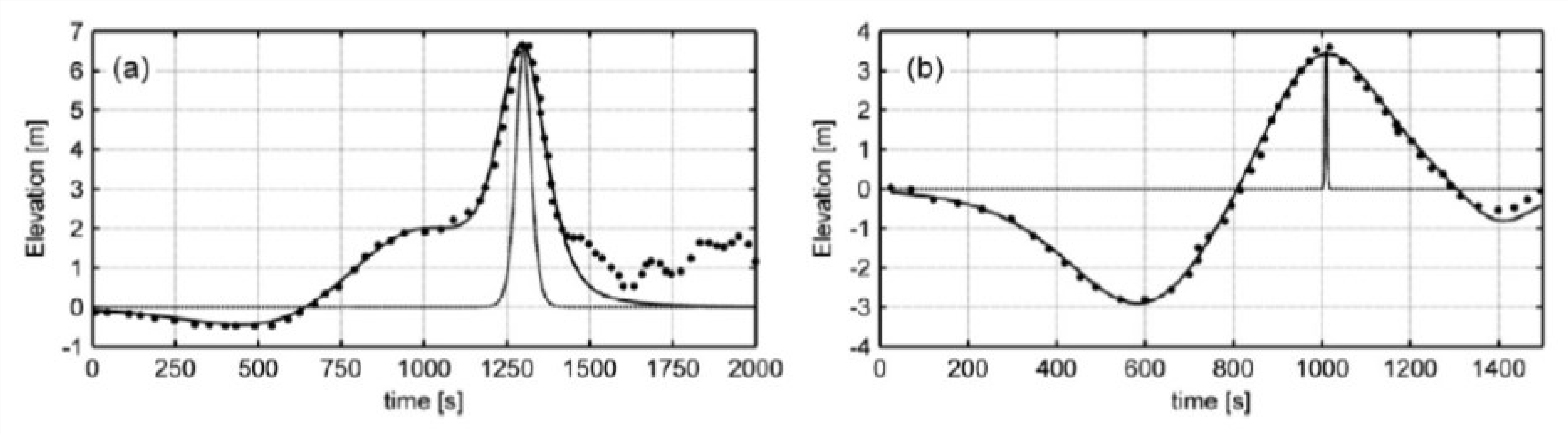
Solitary waves
Miles (1980)





N-waves
Tadepalli & Synolakis (1994)

Modelling tsunami waves



Superimposition of solitary waves on measurements for a) the Tohoku tsunami and b) the Indian Ocean tsunami, from Schimmels et al (2016)

URBANWAVES – UCL and HR Wallingford

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

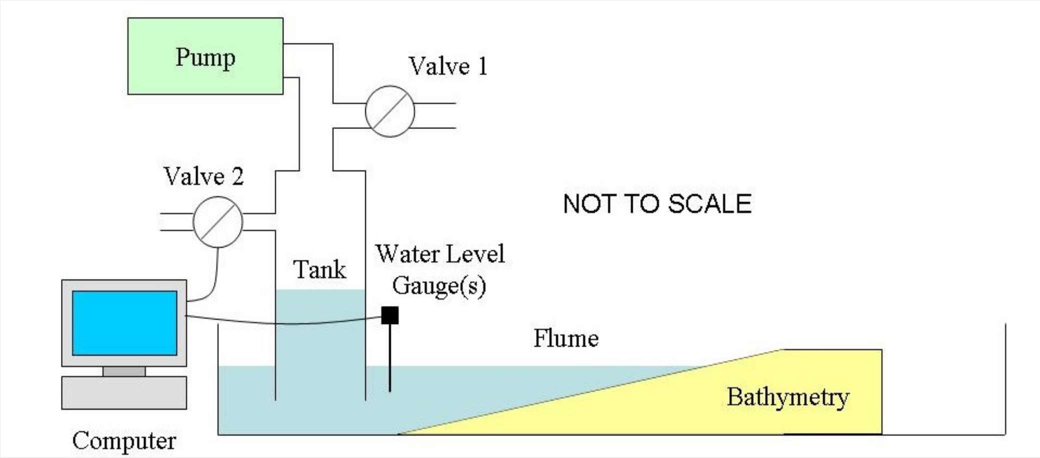
104 m long,
3.7 m wide,
4.6 m deep

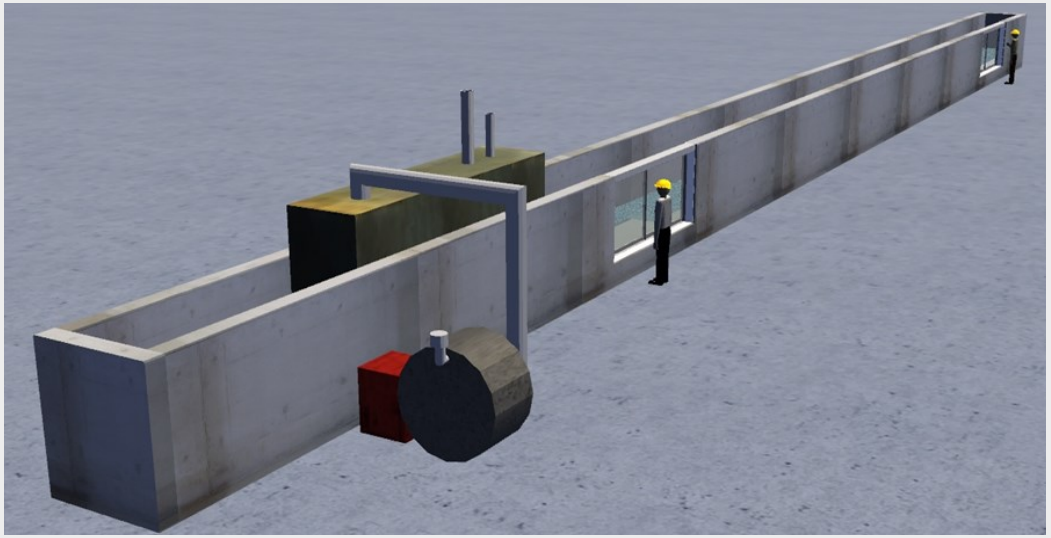
West Tank, W. M. Keck Hydraulics Laboratory of the California Institute of Technology US

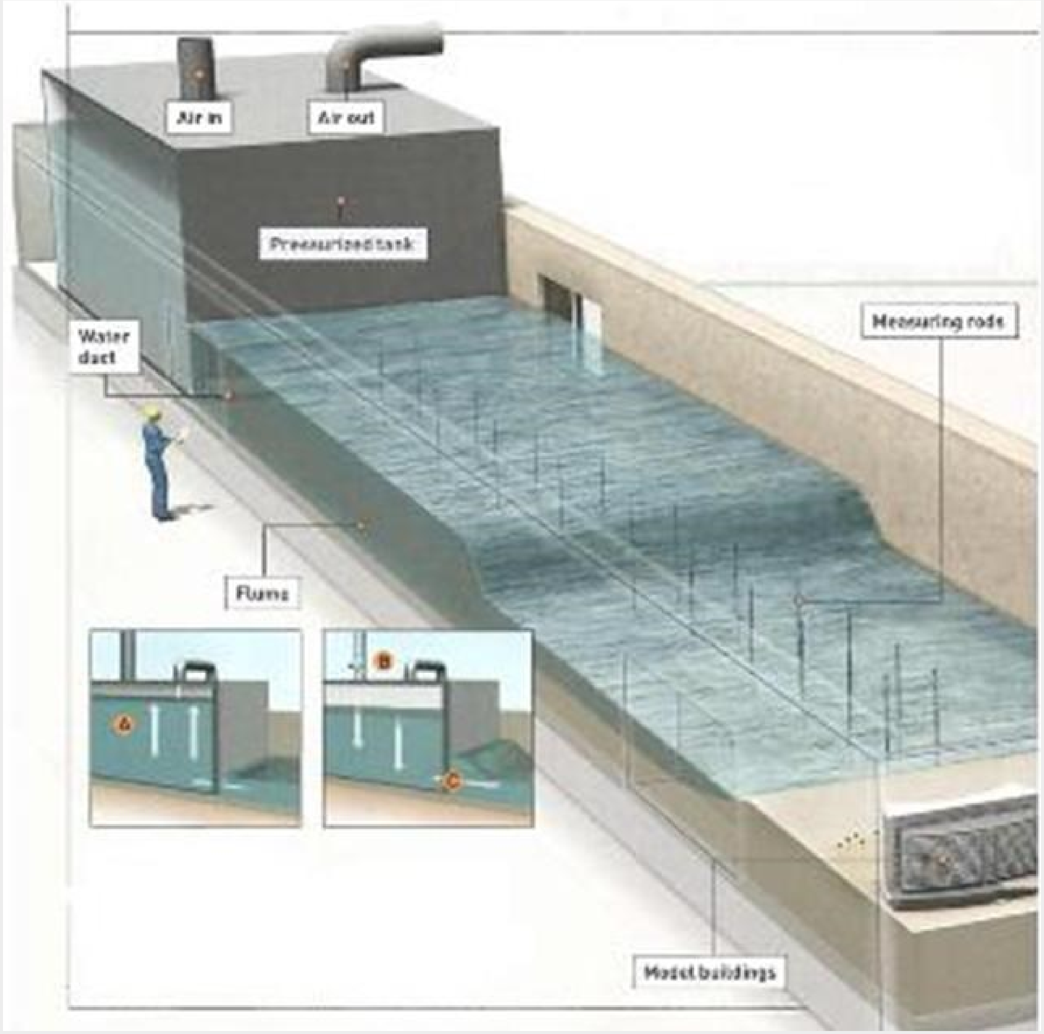
32 m long,
0.4m wide,
0.6 m deep

Hammack (1972), Goring (1978), Synolakis (1986)

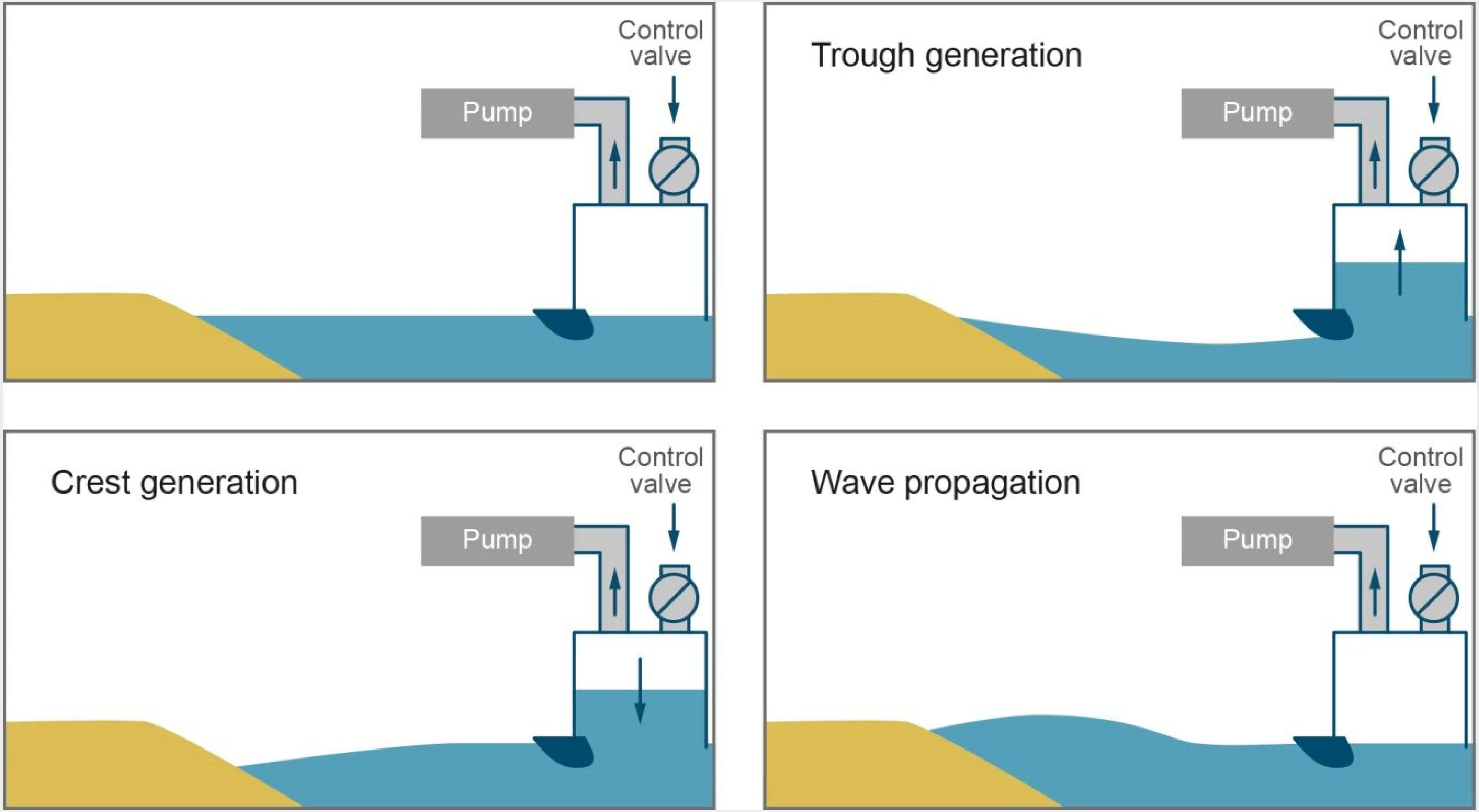
HRW Tsunami Simulator – concept







How it works


Control valve
Pump
Trough generation
Control valve
Pump
Crest generation
Control valve
Pump
Wave propagation
Control valve
Pump

HRW Tsunami Simulator – 1st Generation

Facility

- 1.2 m wide by 45 m long

TS dimensions

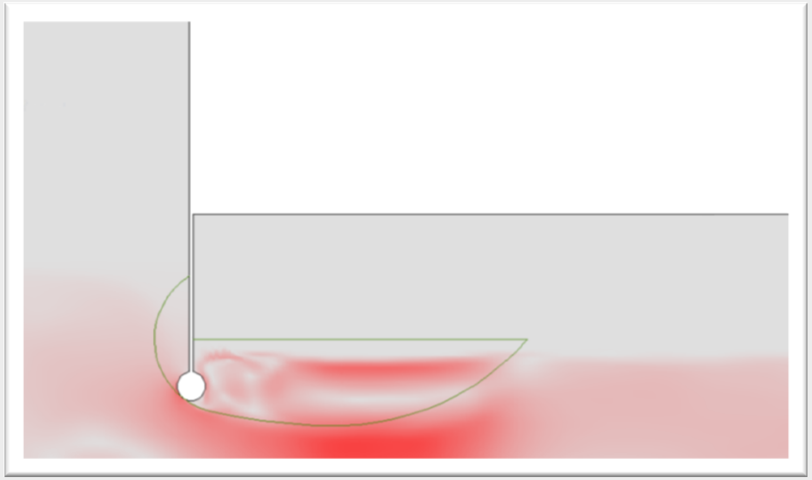
- 1.8 m tall, 1.2 m wide and 4.8 m long
- Variable height outlet

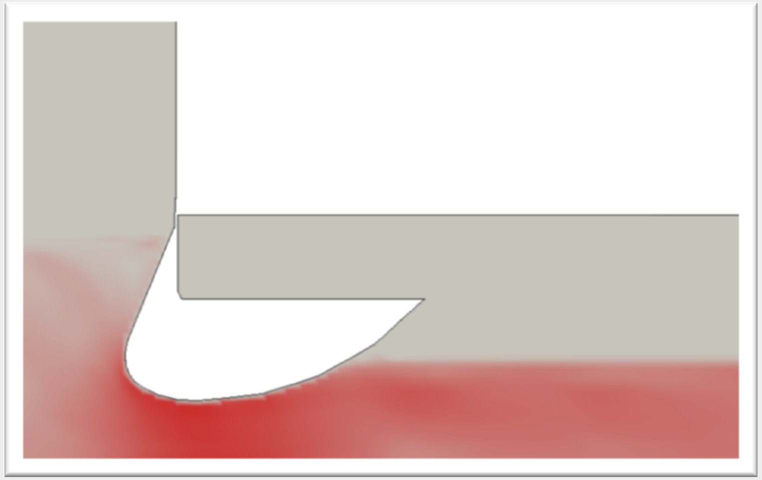
TS equipment

- Pressure transducer
- Computer controlled 45° butterfly valve
- x1 Zepher[UK] vacuum pumps

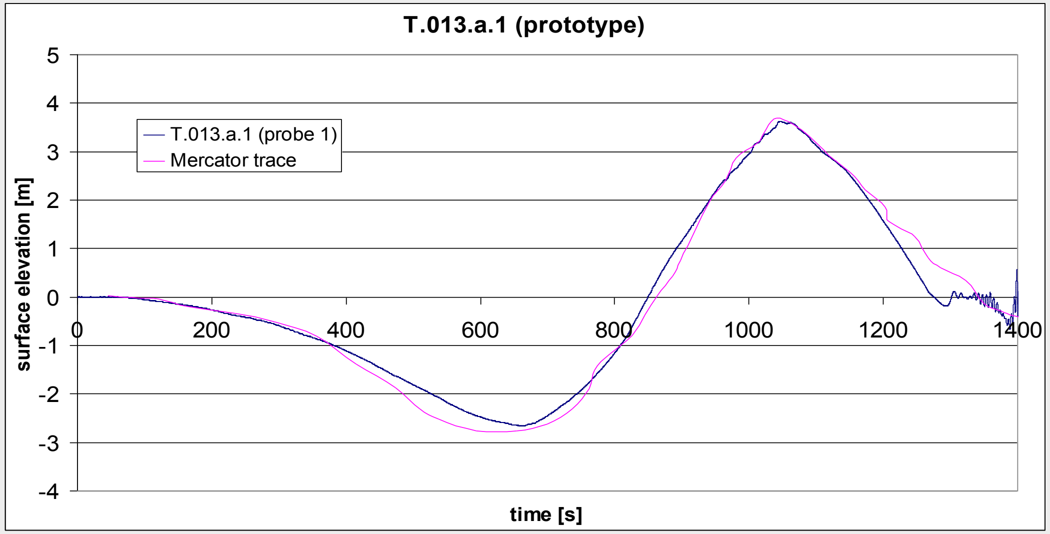
Outlet improvements for 1st generation

Improving 1st generation TS





Calibration of 'Mercator' wave at 1:50 scale



HRW Tsunami Simulator – 2nd Generation

Facility

- 1.8 m wide by 100 m long

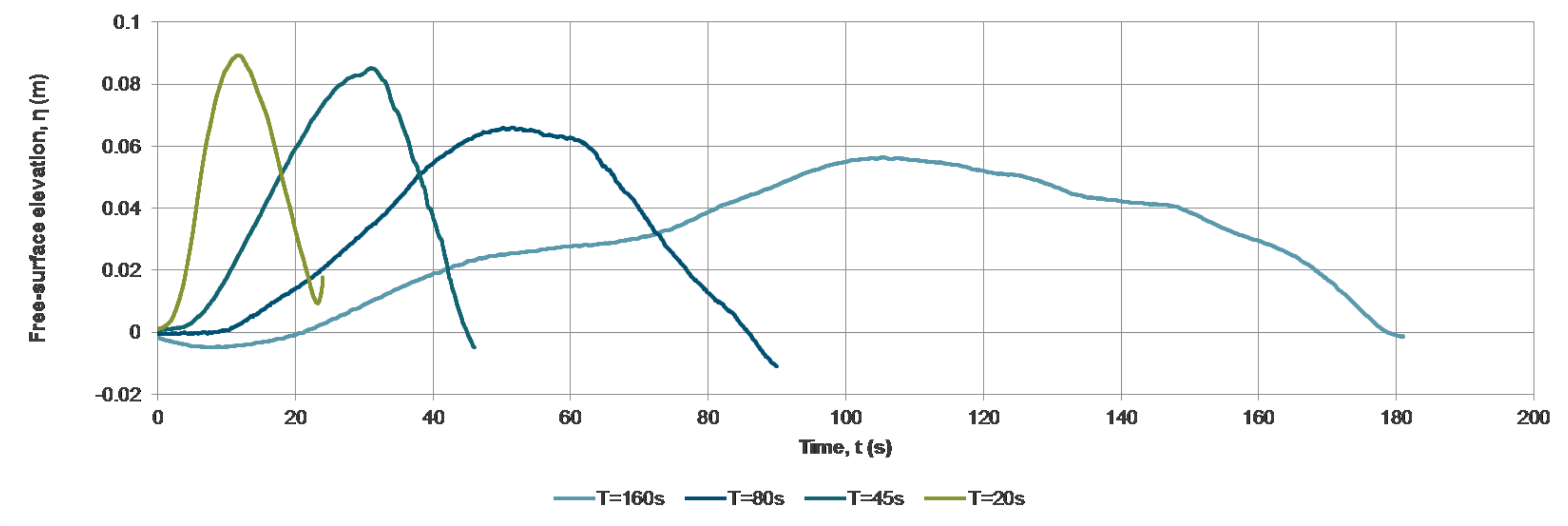
TS dimensions

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

TS equipment

- x2 ultrasonic level sensors
- Pressure transducer
- Computer controlled 45° butterfly valve
- x2 Zepher[UK] vacuum pumps

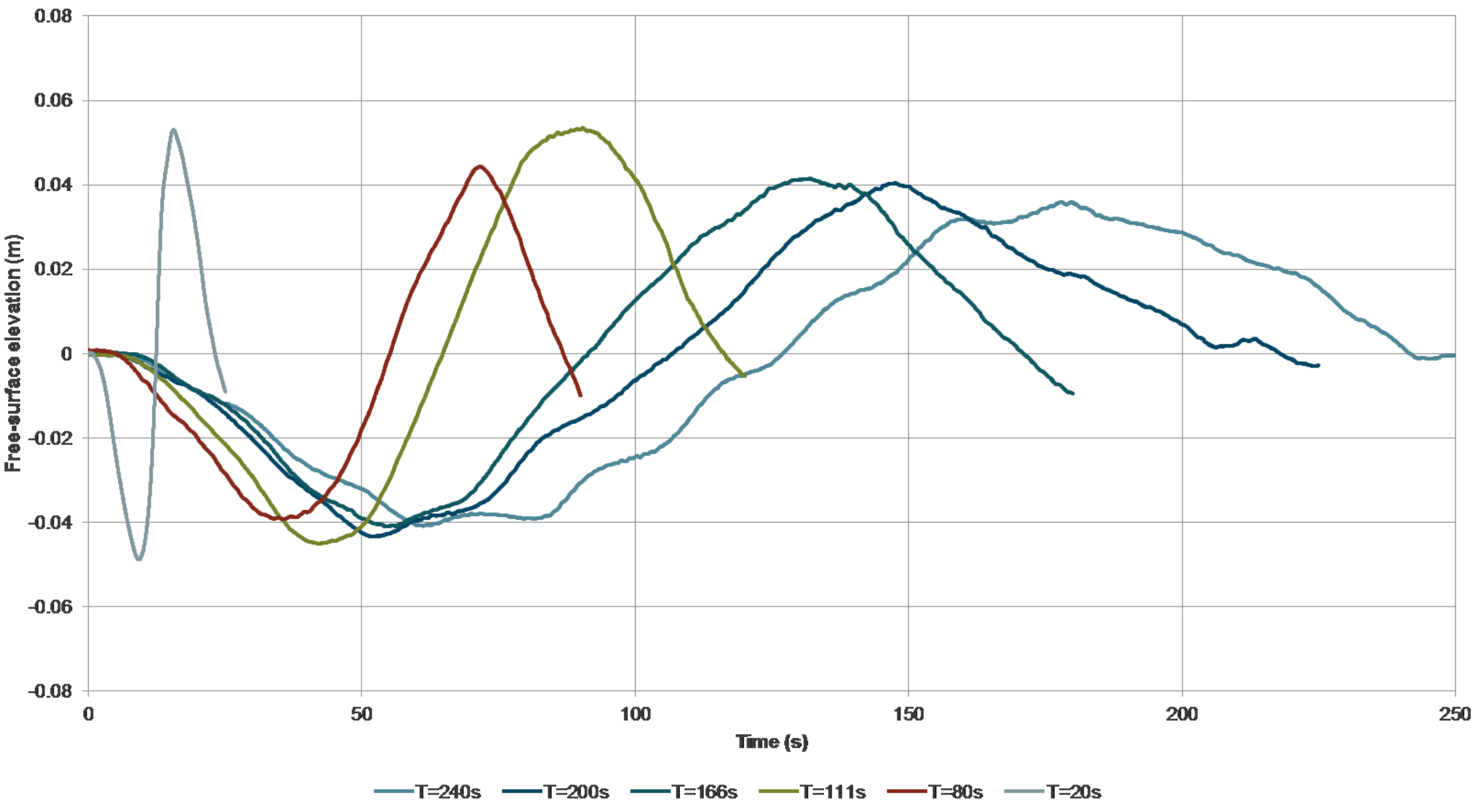
Elevated waves



Name	Period, T (s)	Crest amplitude, a_+ (m)
E160	160	0.056
E80	80	0.066
E45	45	0.085
E20	20	0.089

HR Wallingford
Working with water

N-waves



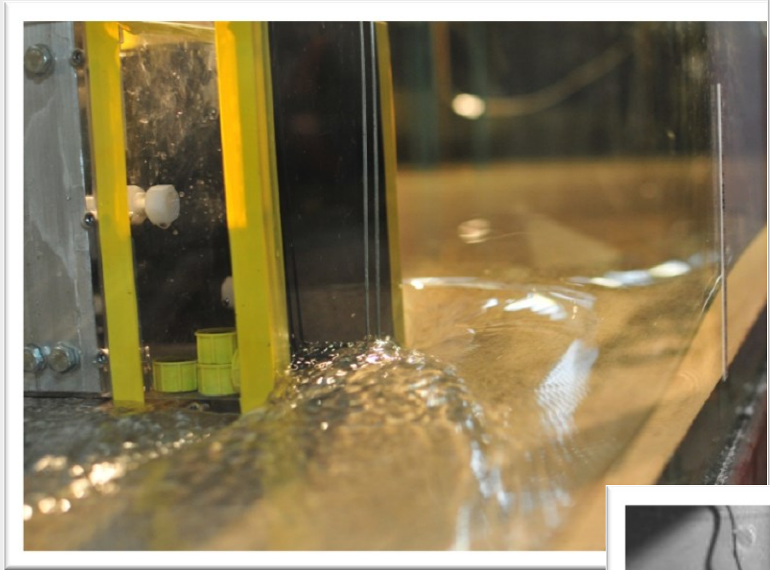
Research with 2nd generation – Phase 1

Run-up

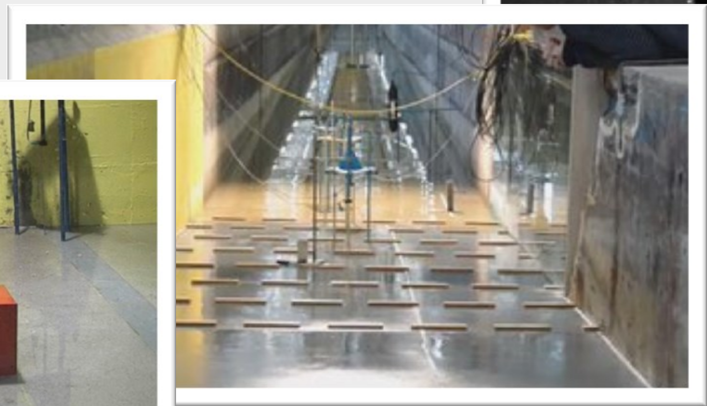
Coastal defences

Single buildings

Initial building array tests








HRW Tsunami Simulator – 3rd Generation

Facility

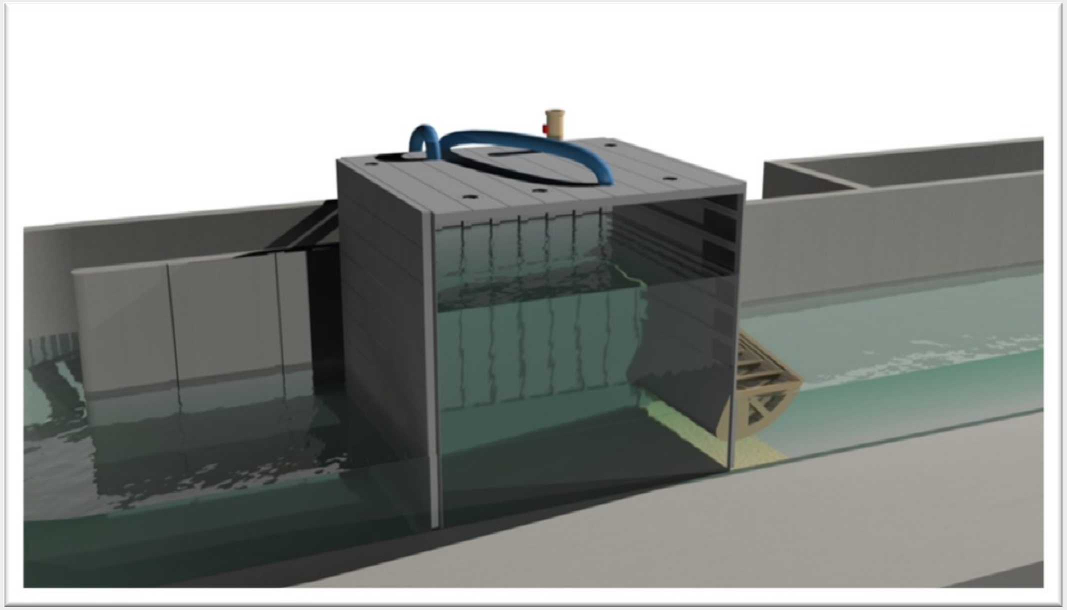
- 4.0 m wide by 70 m long

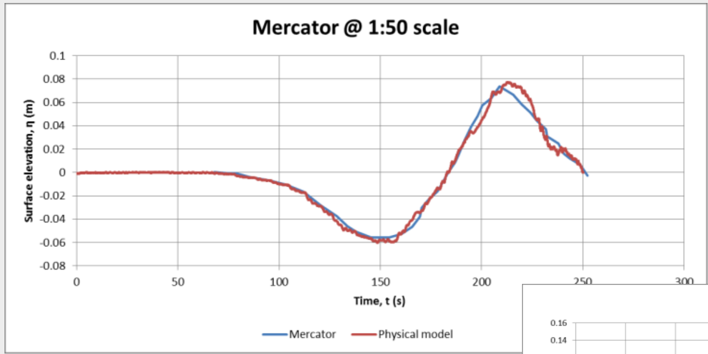
TS dimensions

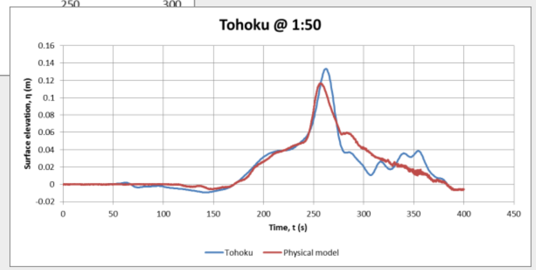
- 4.0 m tall, 4.0 m wide and 4.4 m long
- 0.4m outlet height

TS equipment

- High resolution level sensors
- Pressure transducer
- Closed loop computer controlled 45° butterfly valve
- x2 Zepher[UK] vacuum pumps







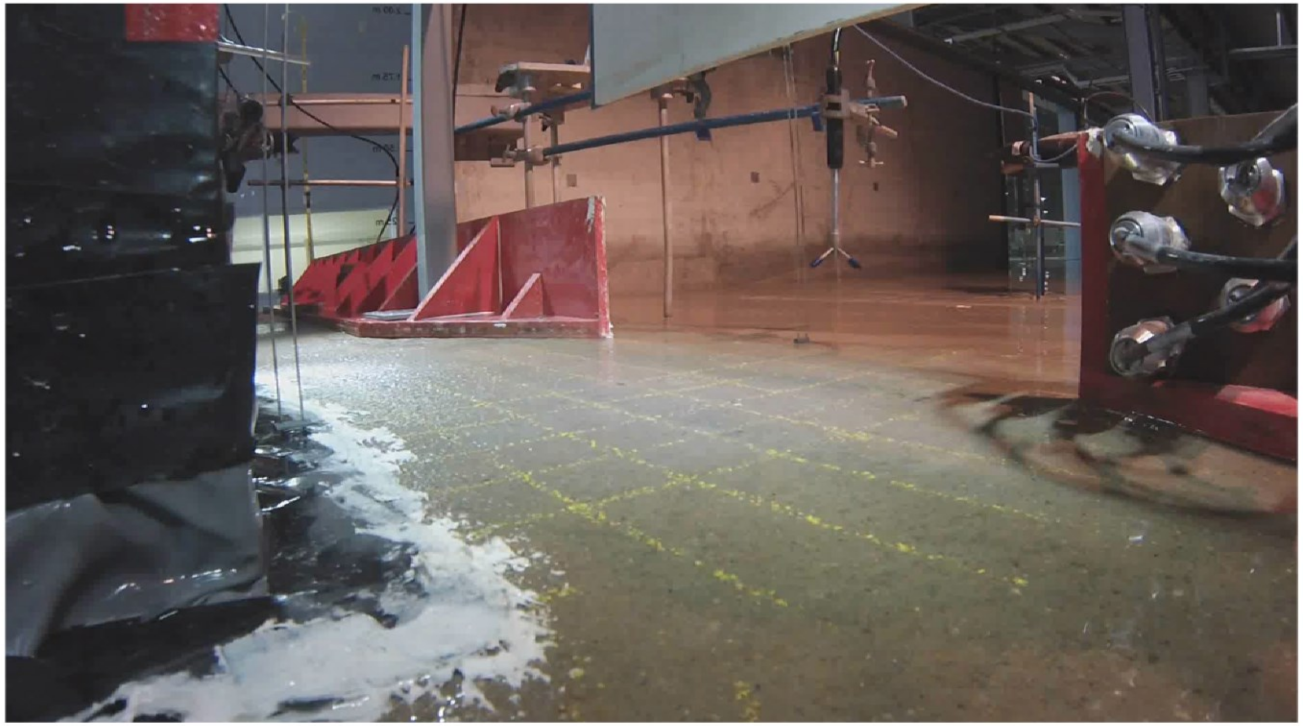
Research with 3rd generation – Phase 2

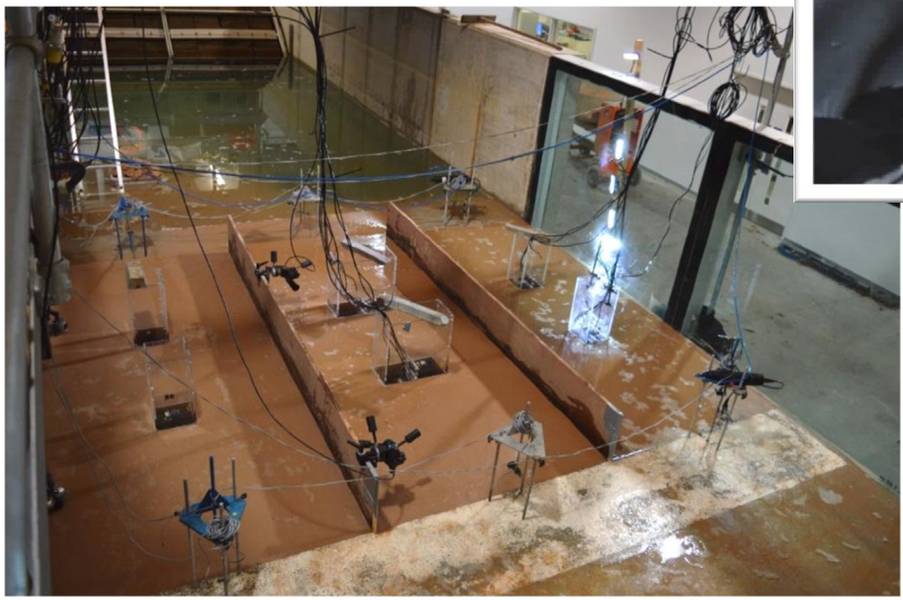
Coastal defences

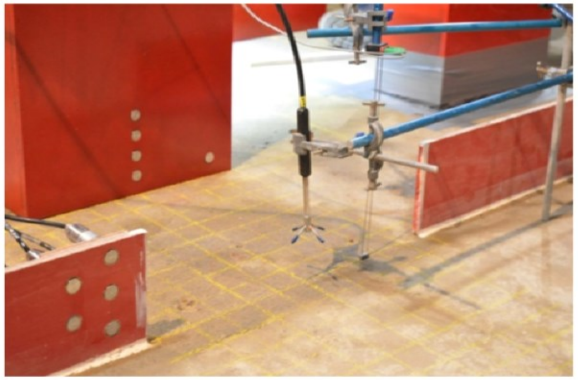
Building arrays

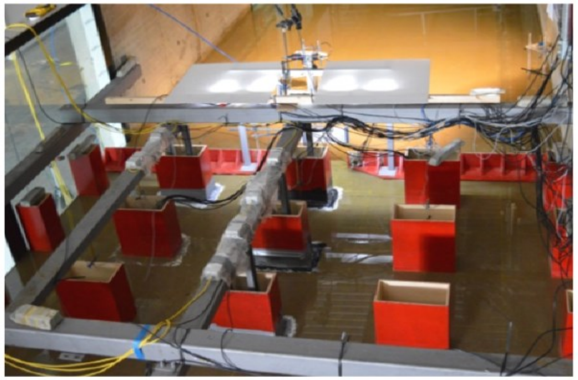
‘Failing’ coastal defences

Scour around buildings

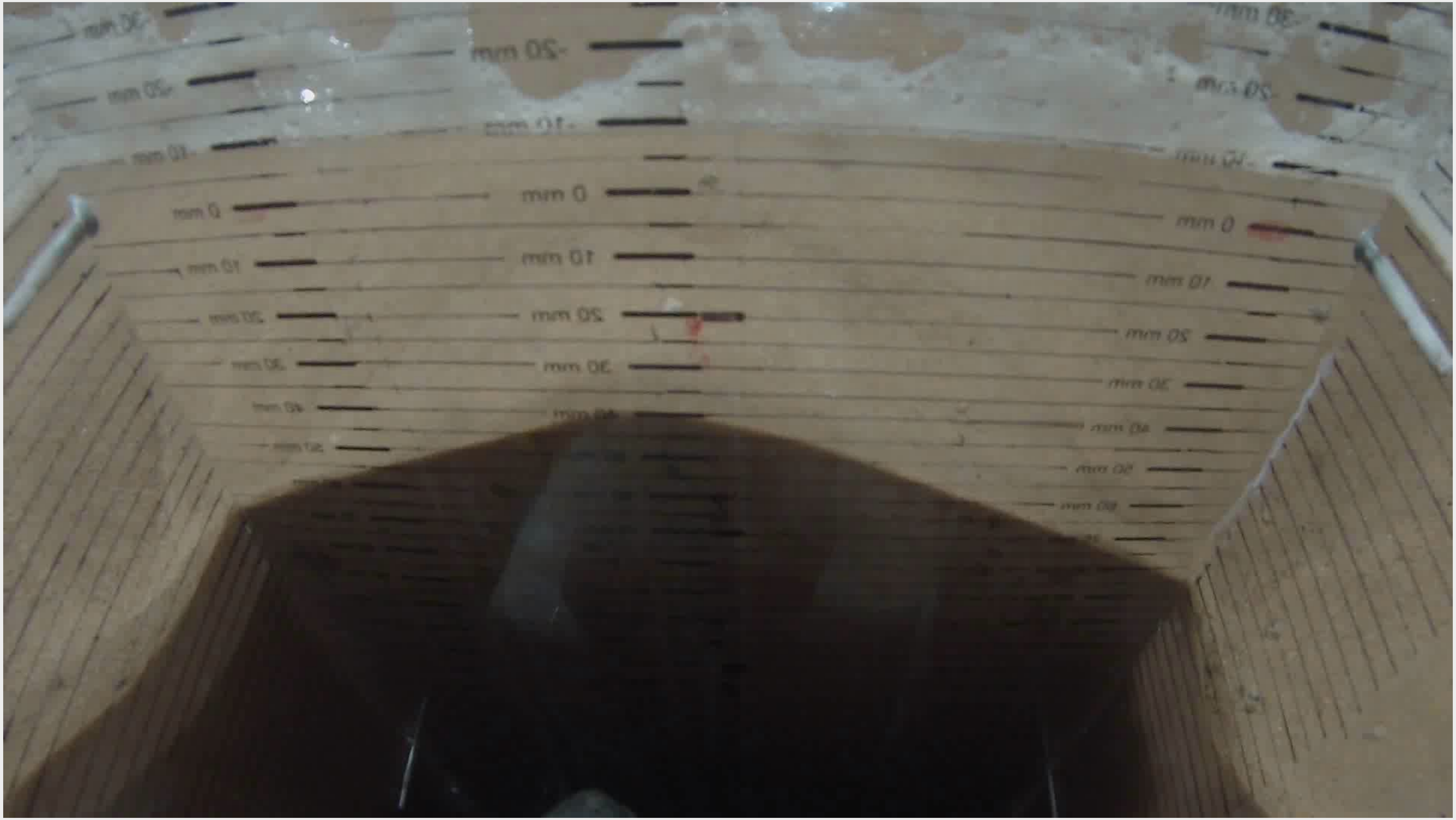








Research with 3rd generation



Acknowledgements

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Dr Ian Chandler, HR Wallingford