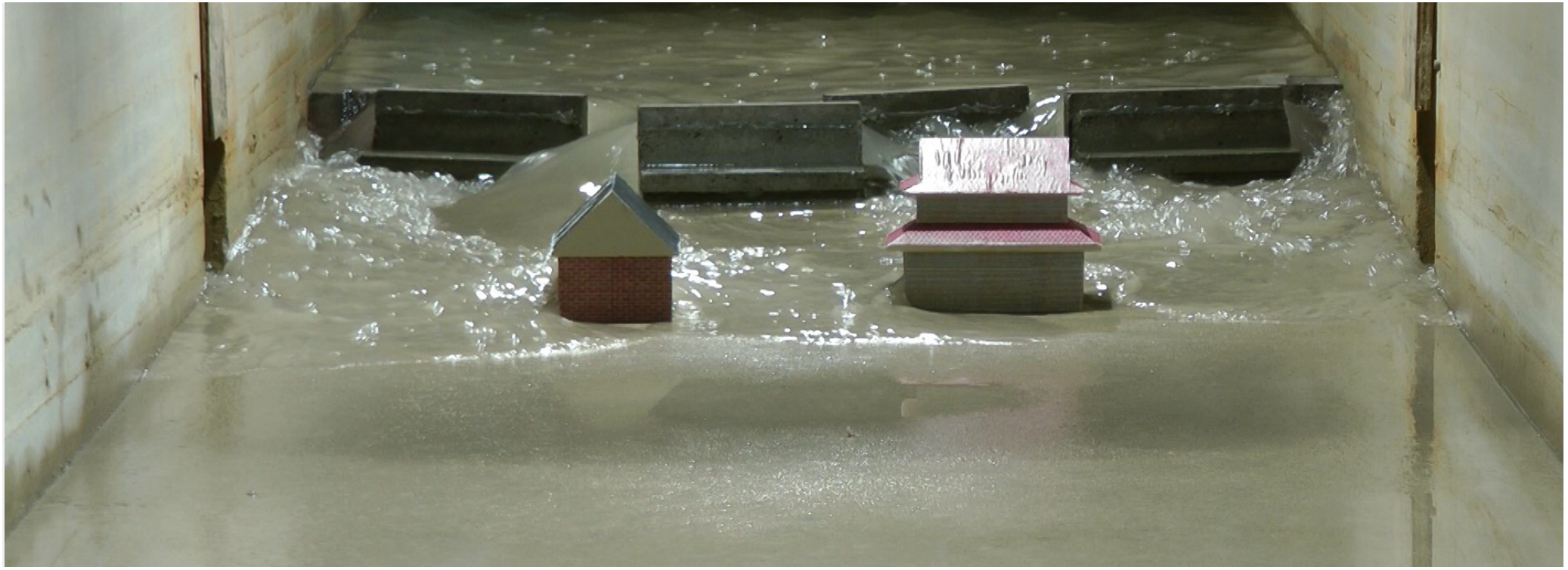
HR Wallingford
*Working with water*

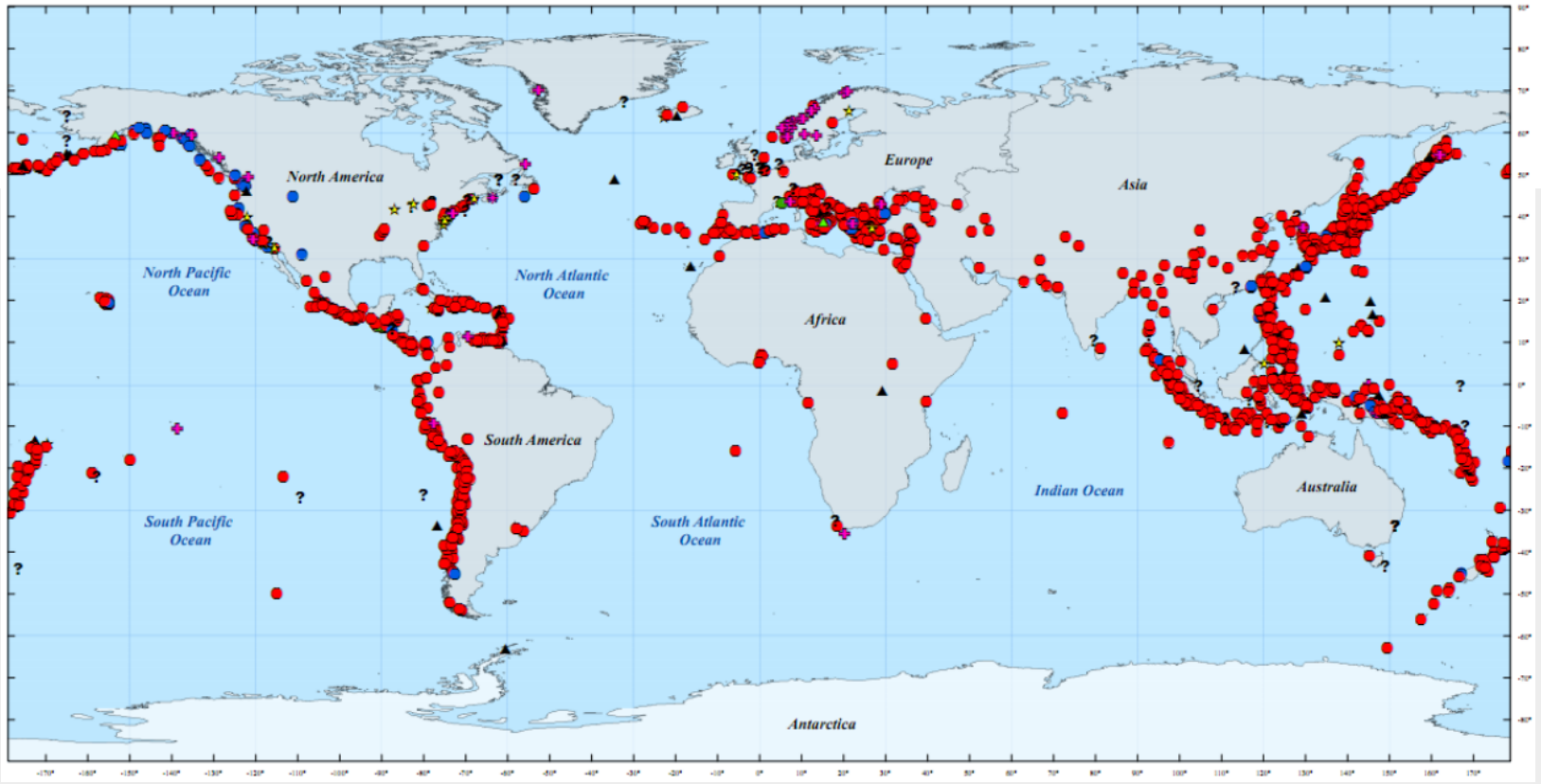


# Tsunami Simulators in Physical Modelling

## Concept to Practical Solutions

27 April 2017

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



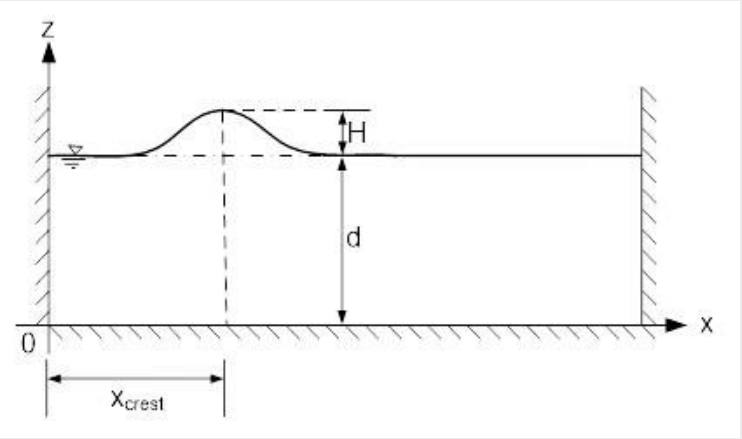

- 2240 recorded tsunami events from 6100 BC to 2016*
- 5 major tsunami since 2004 (~ 297,300 deaths)
- Economic loss from Japan 2011 tsunami estimated at $210 Billion**
- 150M people and £20Trillion in assets forecast to be exposed to coastal flooding by 2070 (Nicholls et al 2007)

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

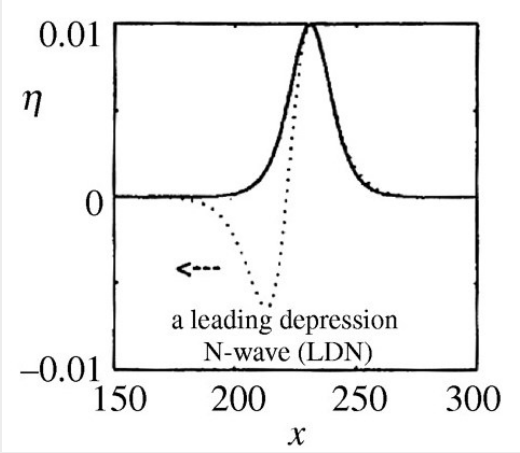
 

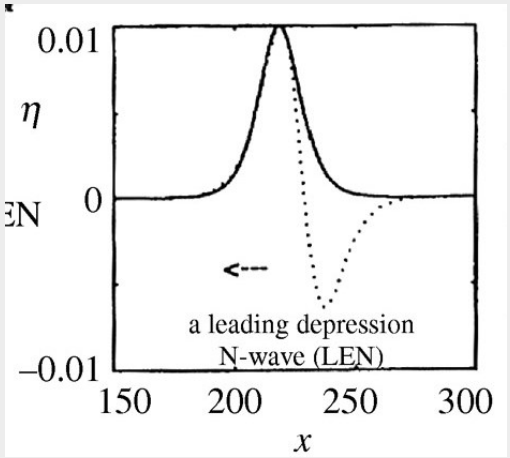
# Modelling tsunami waves

## Solitary waves
Miles (1980)



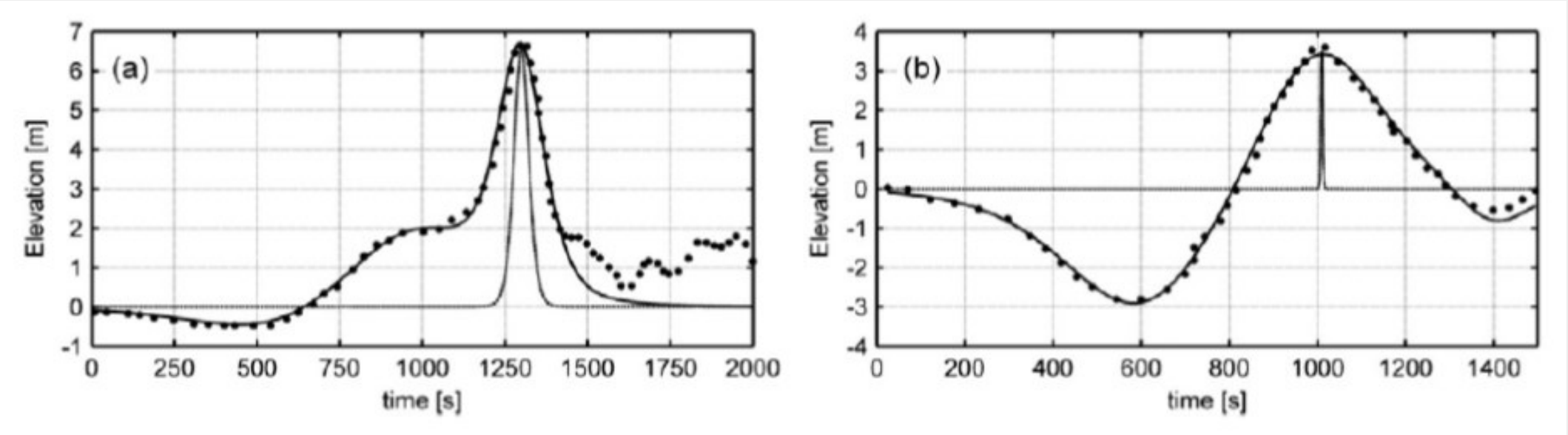

## N-waves
Tadepalli & Synolakis (1994)



# 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?

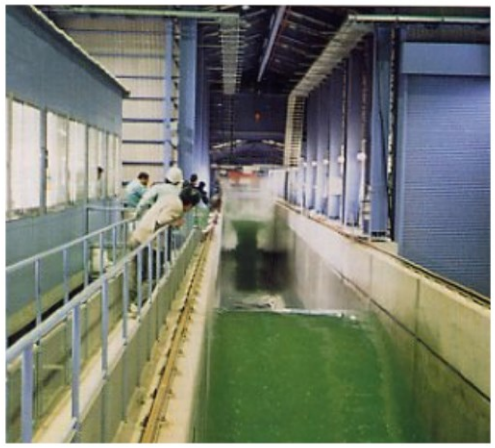
## What are the engineering questions?

- 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

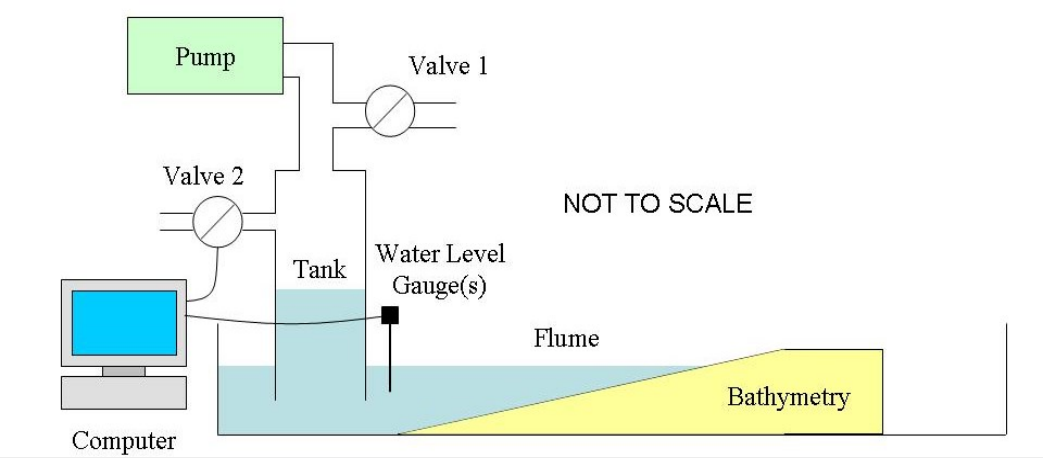
104 m long,
3.7 m wide,
4.6 m deep

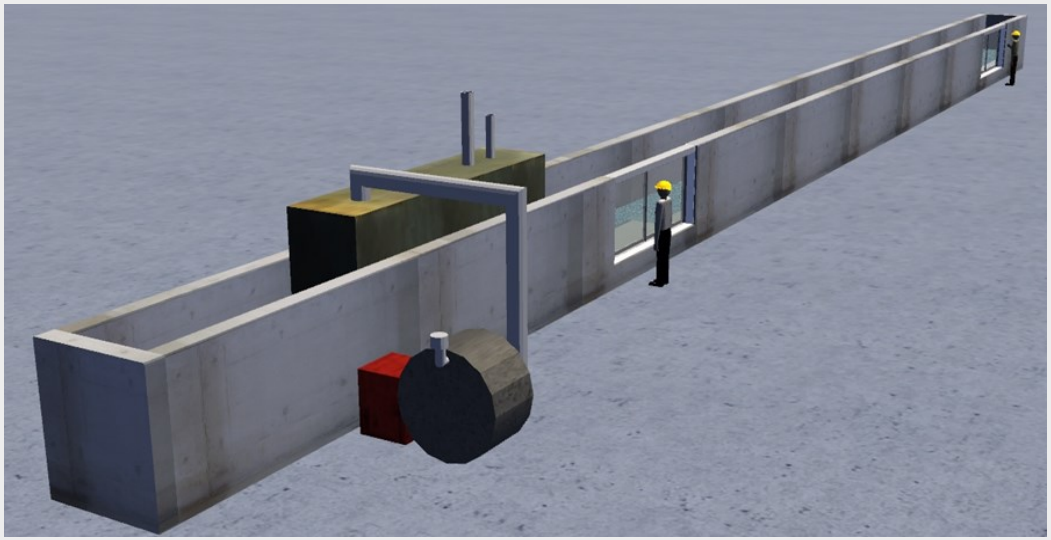
West Tank, W. M. Keck Hydraulics Laboratory of the California Institute of Technology US

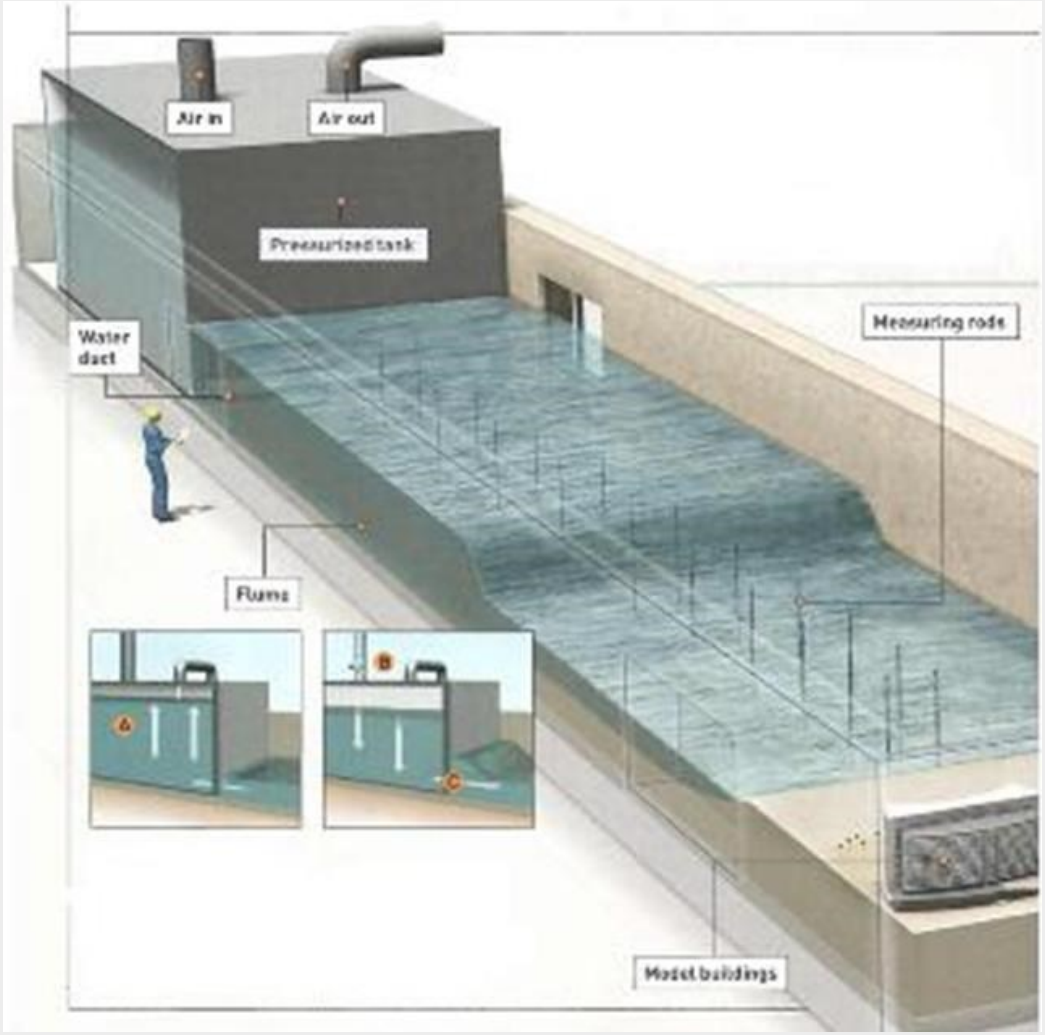
32 m long,
0.4m wide,
0.6 m deep

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

# HRW Tsunami Simulator – concept

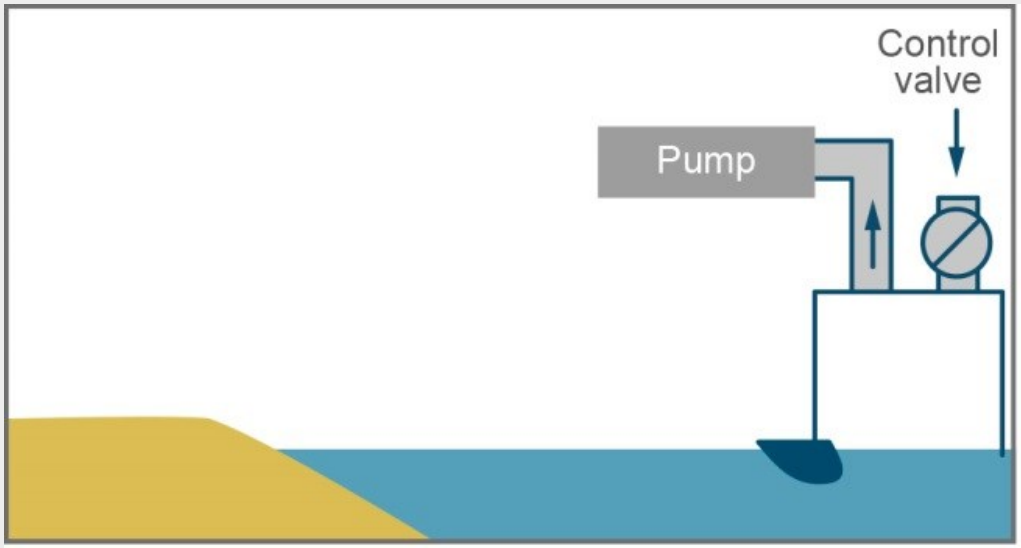


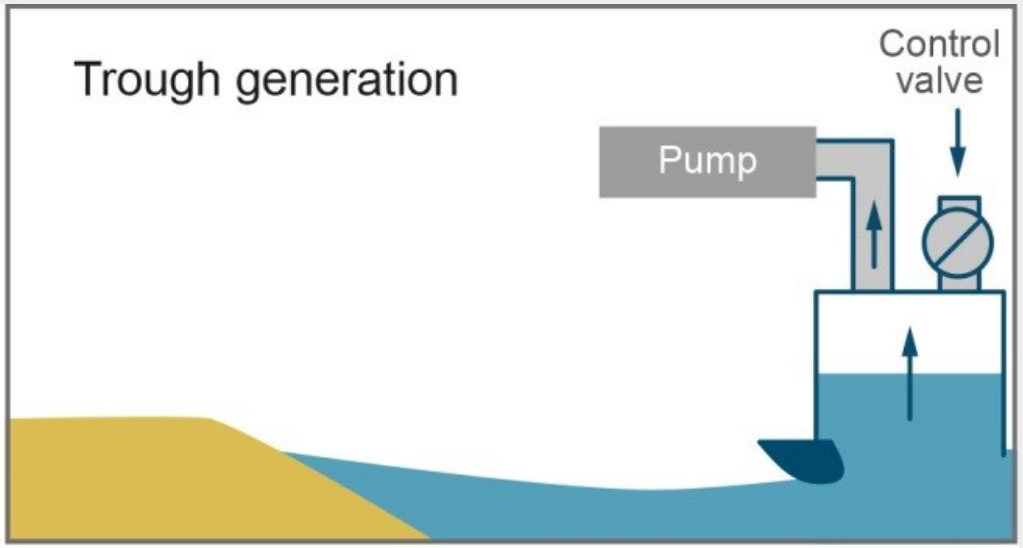



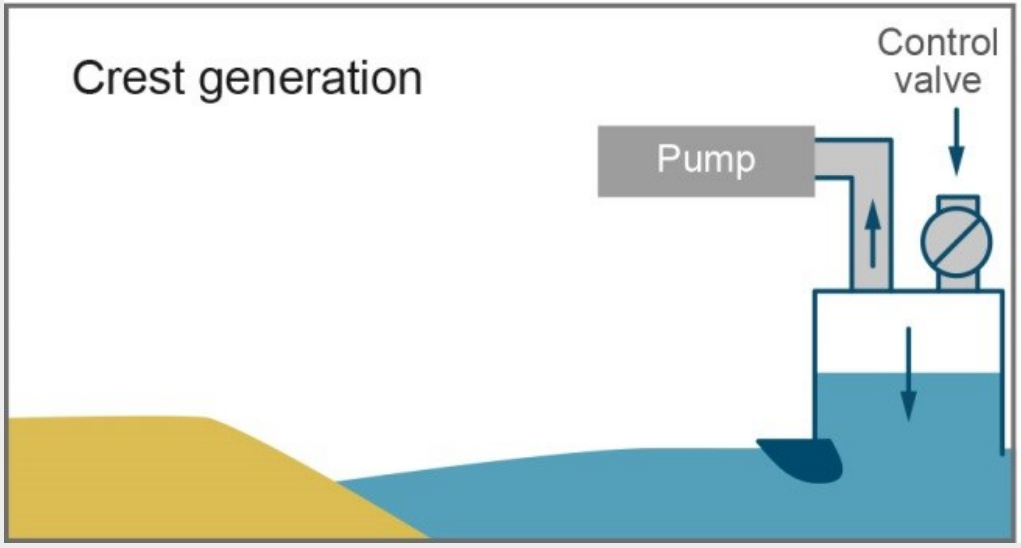


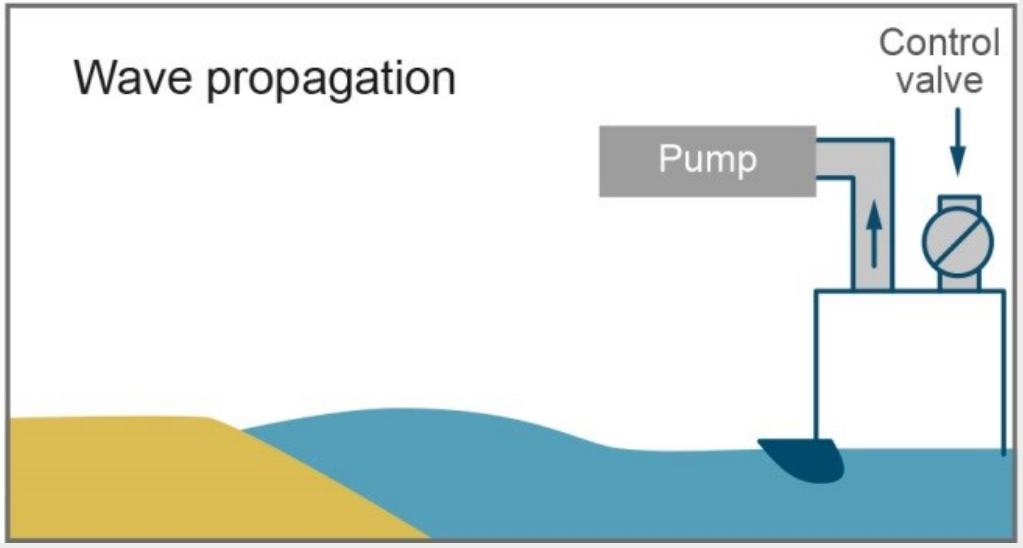

 

# How it works



# 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

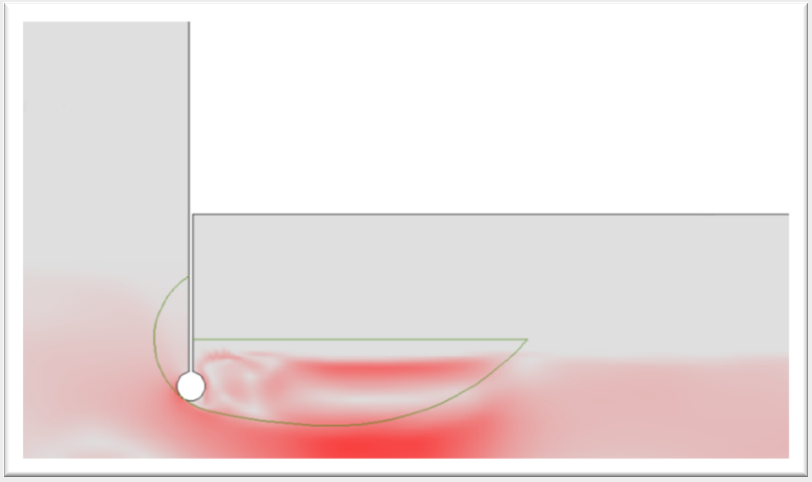
## TS equipment

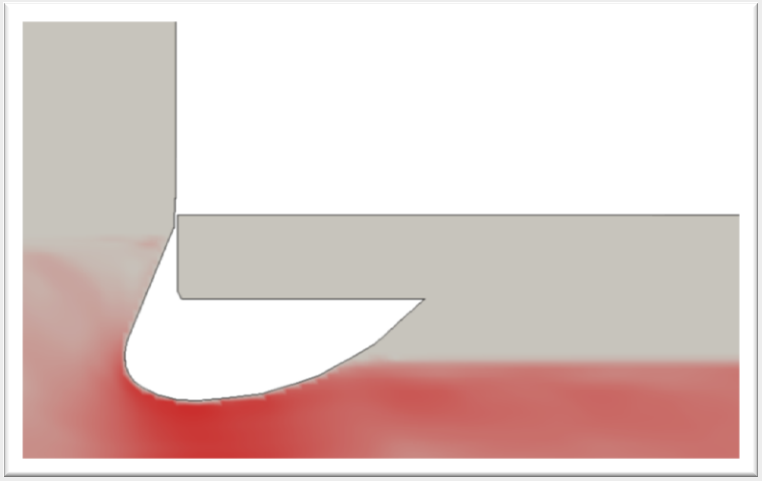
- Pressure transducer
- Computer controlled 45° butterfly valve
- x1 Zepher$^{UK}$ vacuum pumps

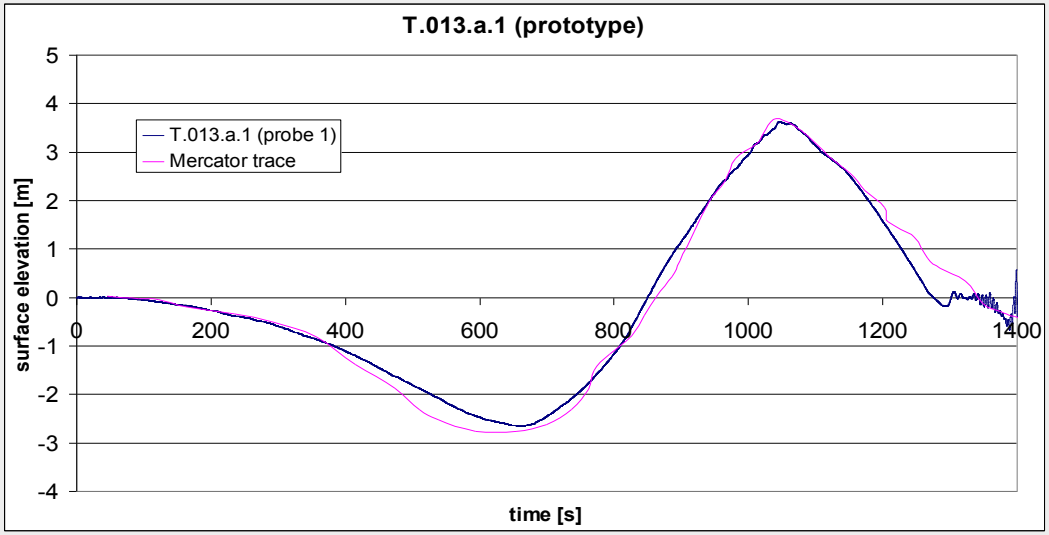
# Outlet improvements for 1st generation

## 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

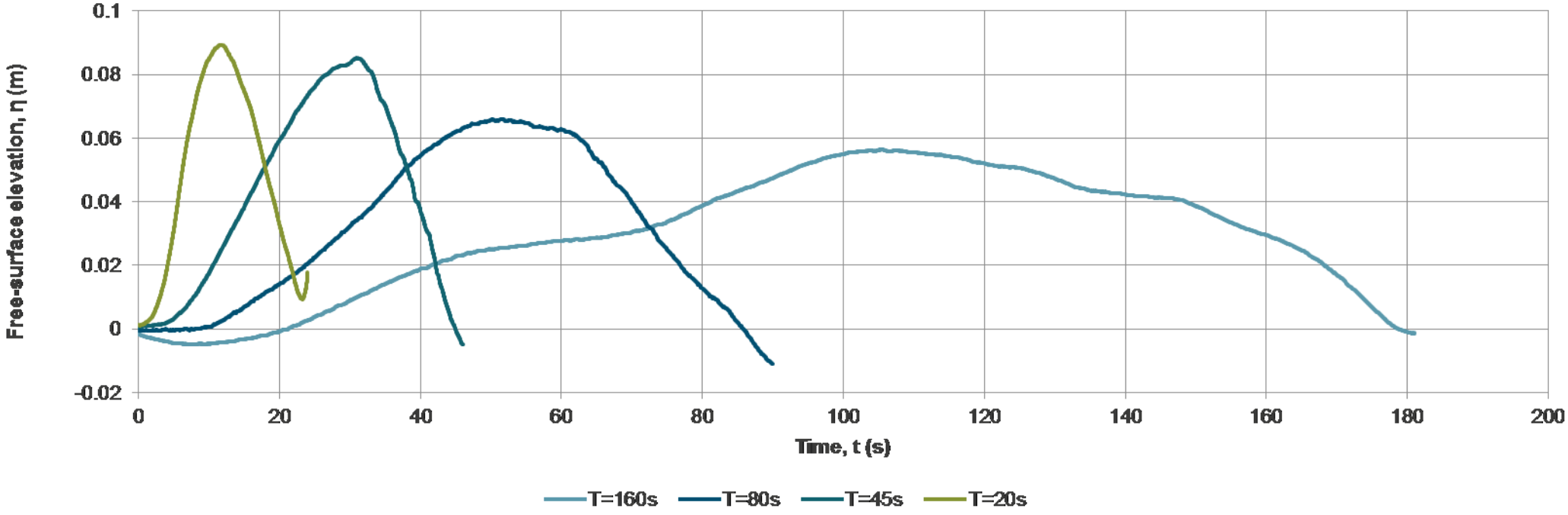
## TS dimensions

- 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

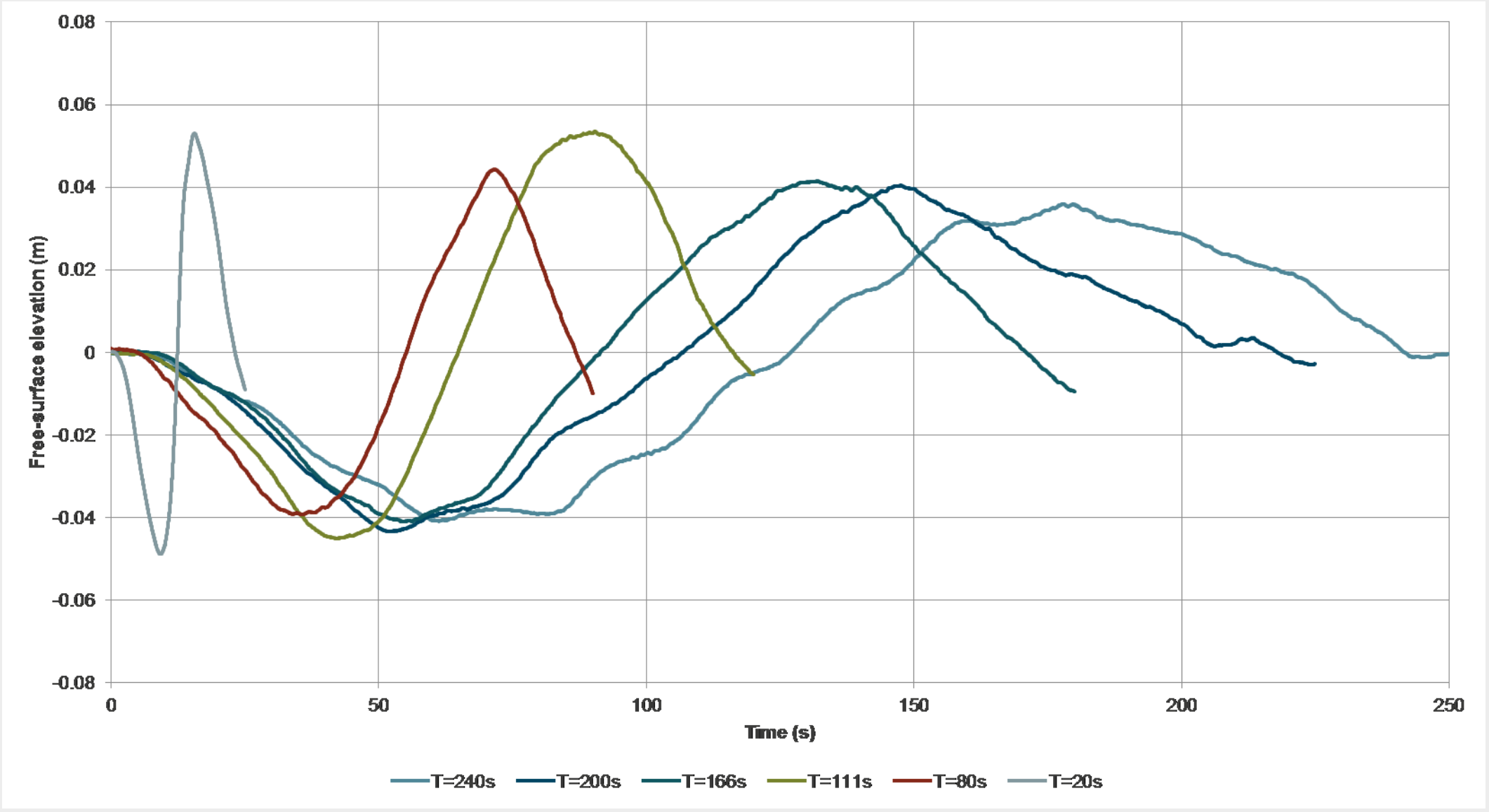
# Elevated waves




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

# N-waves



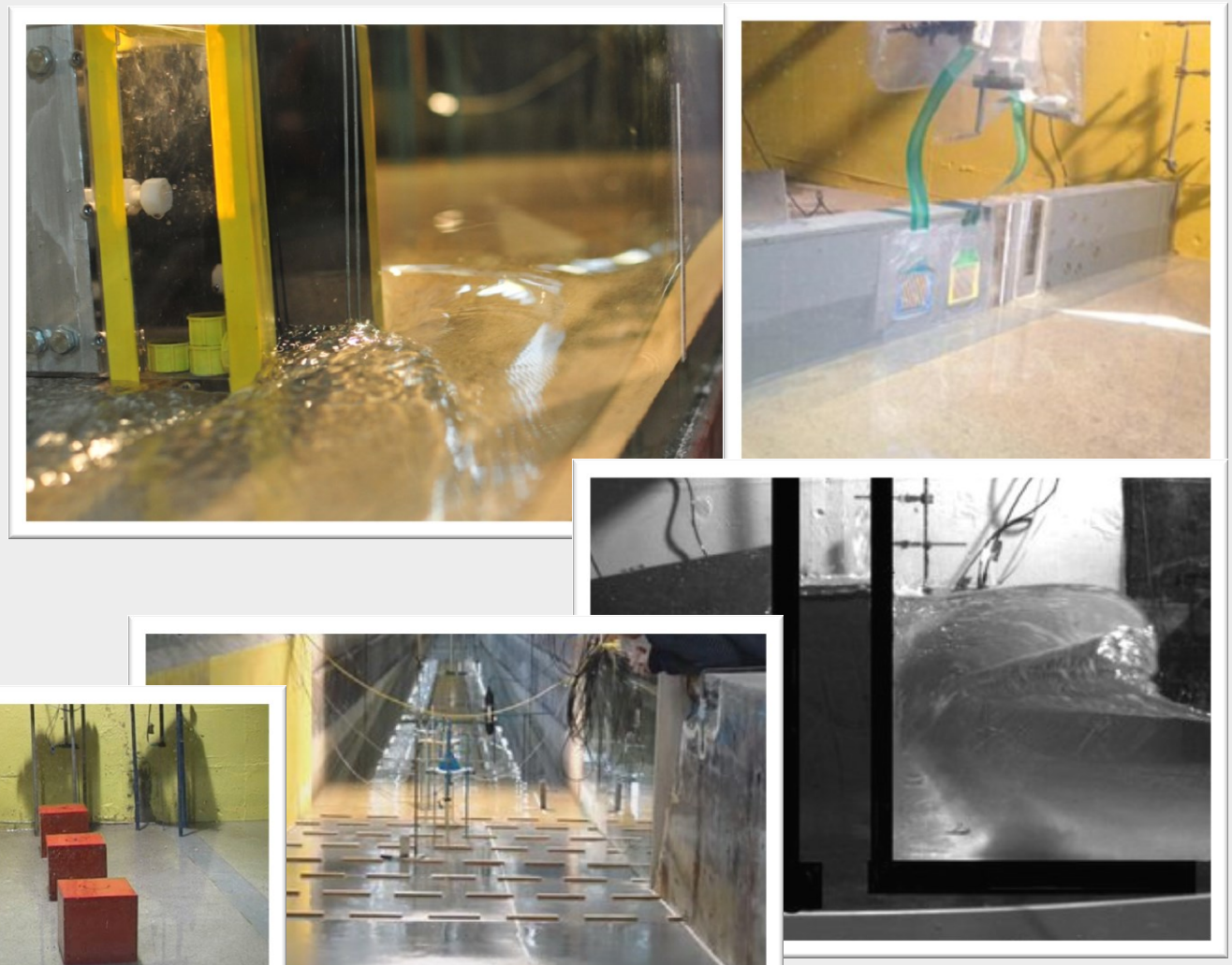
# Research with 2nd generation – Phase 1

Run-up

Coastal defences

Single buildings

Initial building array tests



# HRW Tsunami Simulator – 3rd Generation

## Facility

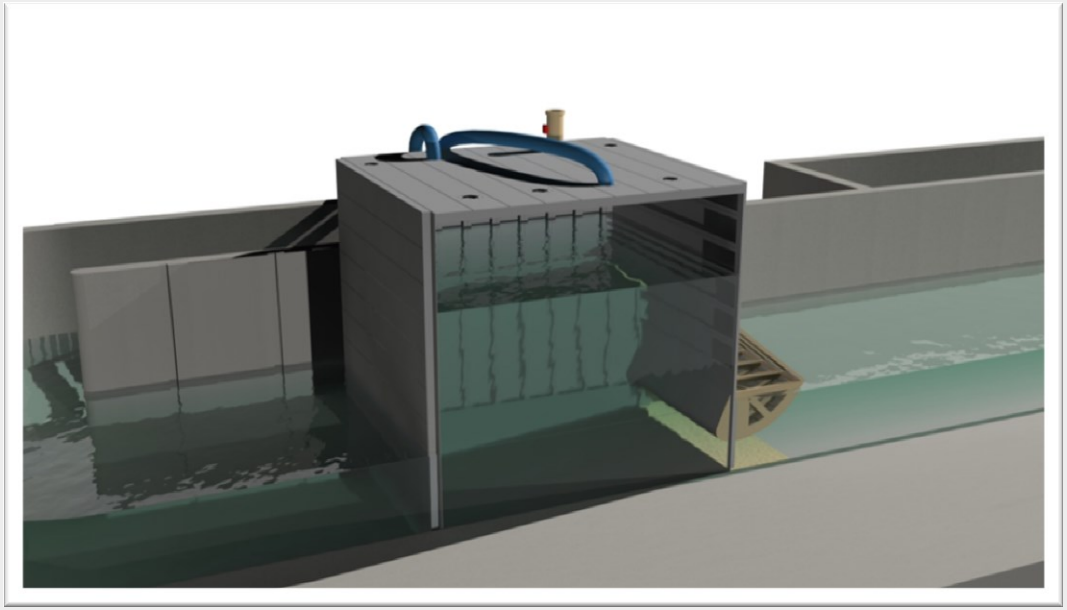
- 4.0 m wide by 70 m long

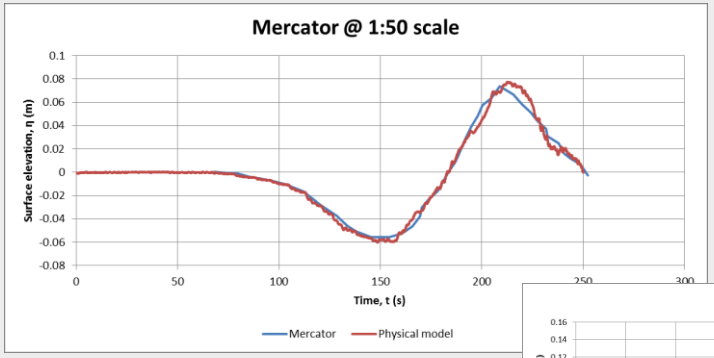
## TS dimensions

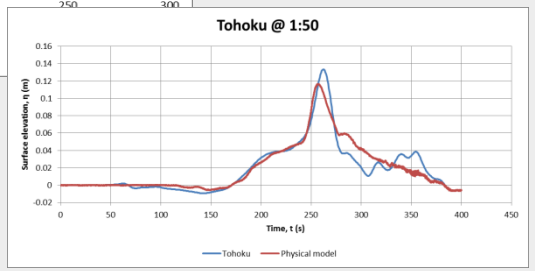
- 4.0 m tall, 4.0 m wide and 4.4 m long
- 0.4m outlet height

## TS equipment

- High resolution level sensors
- Pressure transducer
- Closed loop computer controlled 45° butterfly valve
- x2 Zepher$^{UK}$ vacuum pumps





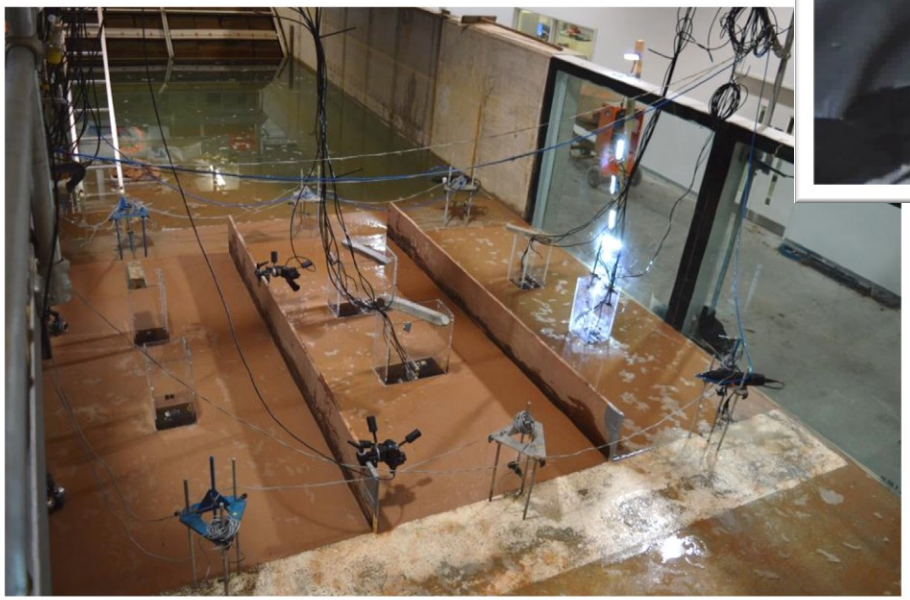
# Research with 3rd generation – Phase 2

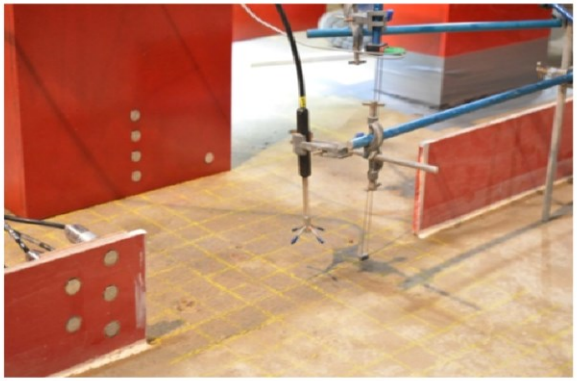
Coastal defences

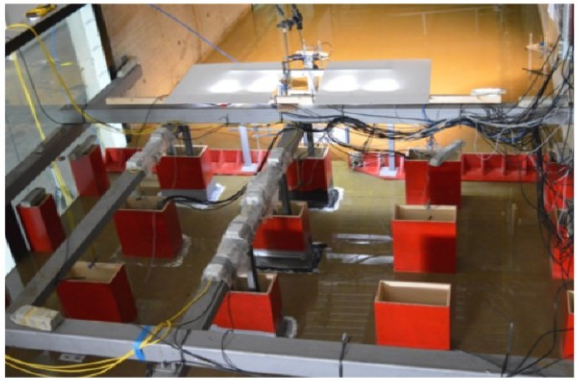
Building arrays

‘Failing’ coastal defences

Scour around buildings

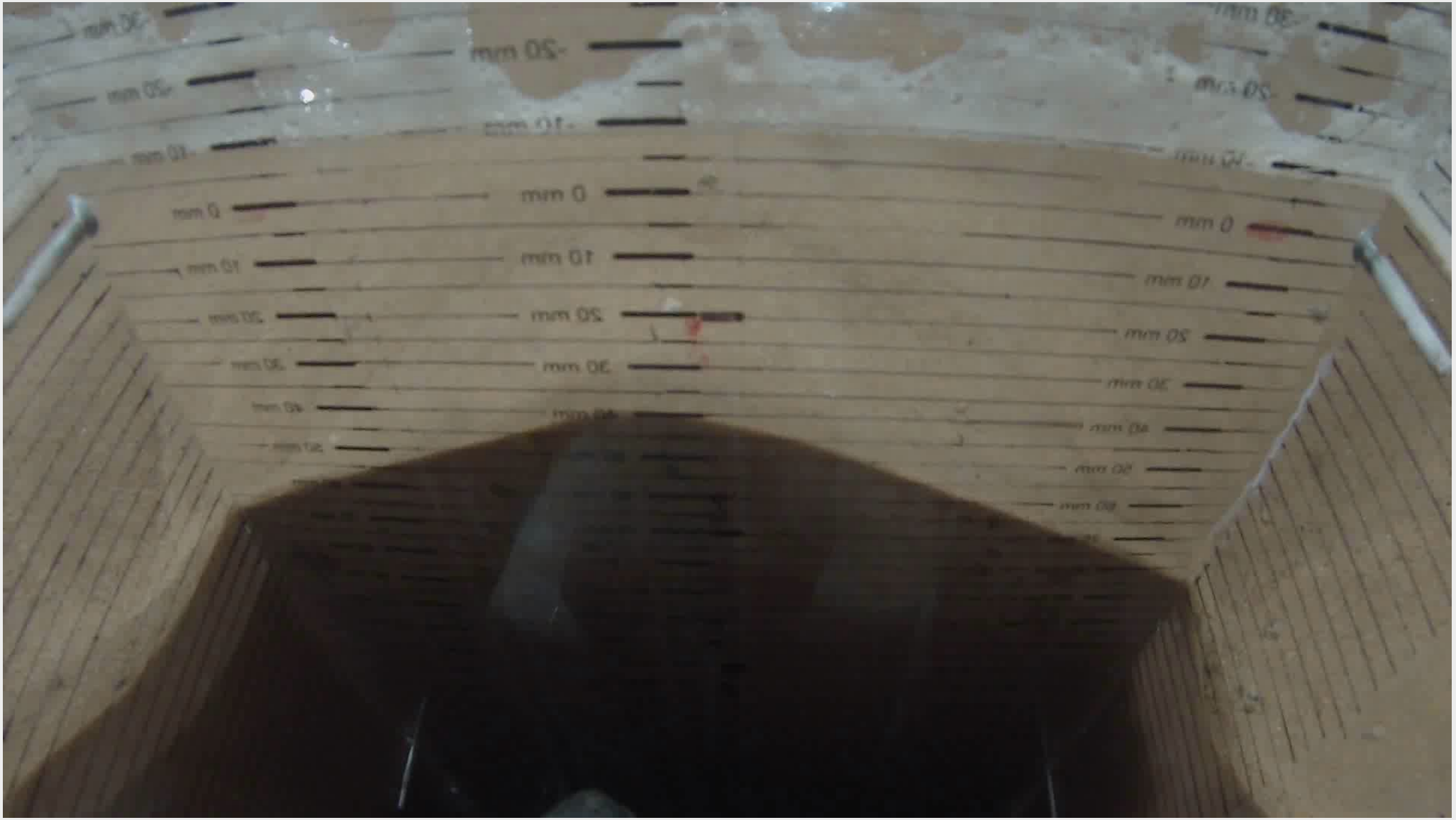






# Research with 3rd generation



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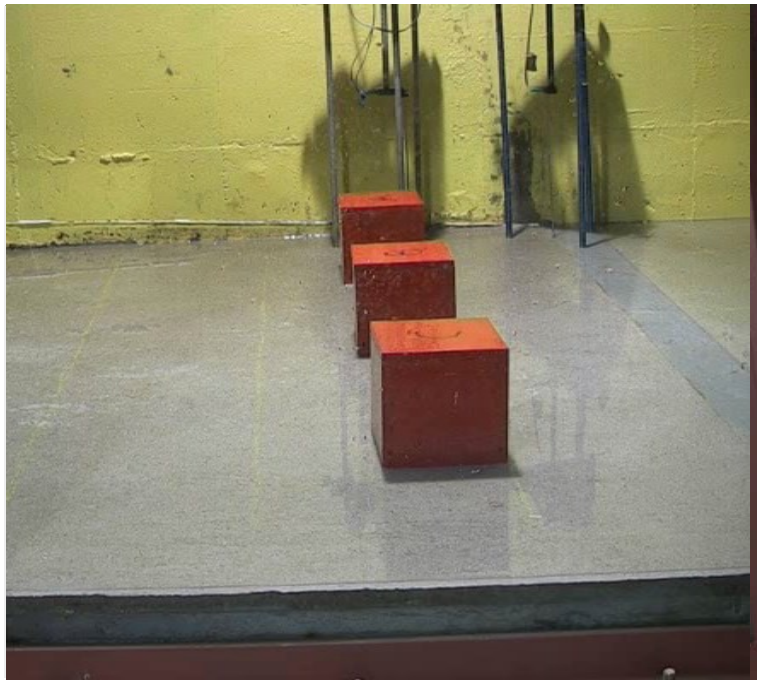
The European Research Council (ERC) funding for the URBANWAVES project (Grant No. 336084) and the Engineering and Physics Research Council (EPSRC) funding for the CRUST project (Grant No. EP/M001067/1) and previously EPICentre. We acknowledge support of numerous staff at HR Wallingford, particularly Dr S Richardson, Mr O Harris and Mr I Payne: visiting researchers, particularly Ingrid Charvet, Pierre-Henri Bazin, Alice Barthel, Mario Zaccaria, Ignacio Barranco-Granged, and Roberta Riva;  and of UCL (senior partners on the URBANWAVES grant), especially Dr T Robinson, Dr A Foster and Dr C Petrone.

HR Wallingford
*Working with water*



# Thank you

Dr Ian Chandler, HR Wallingford