Power & Scour: Laboratory simulations of tsunami-induced scour

HR Wallingford
Working with water

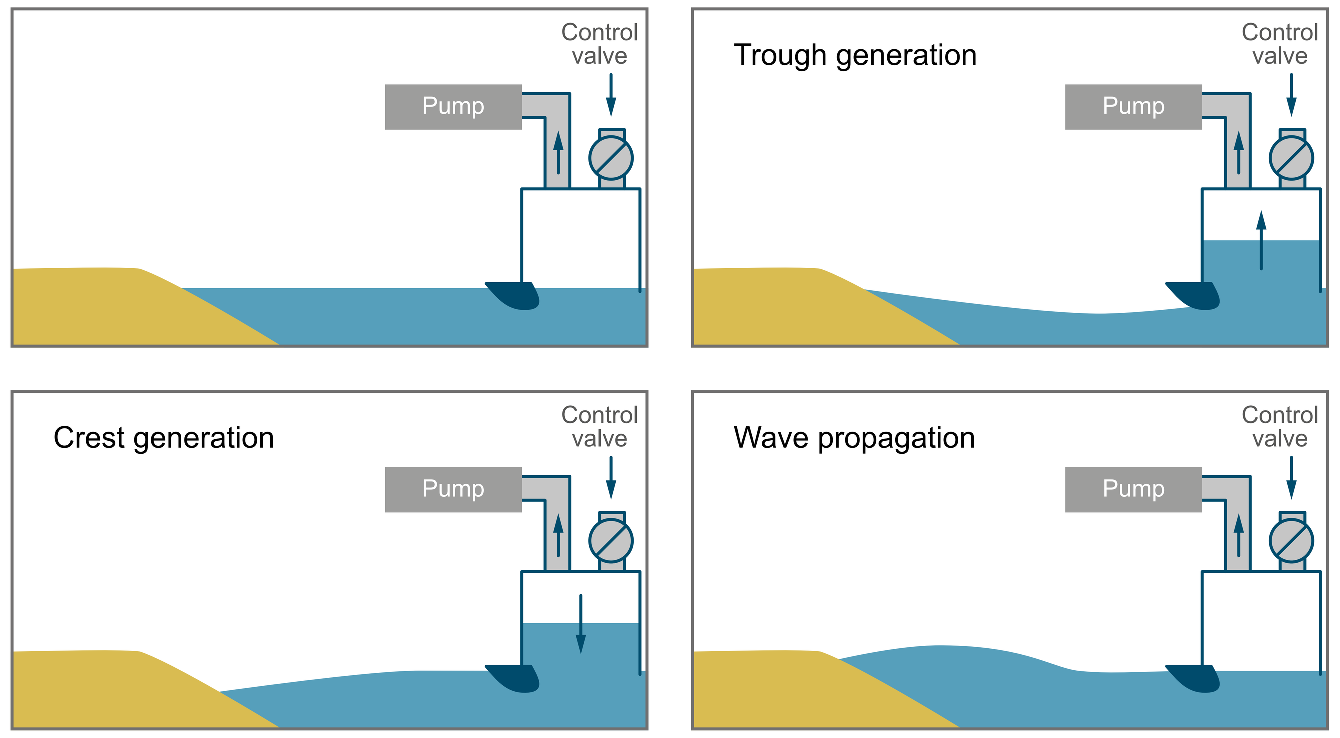
www.hrwallingford.com @hrwallingford

David Todd[1], David McGovern[2], Richard Whitehouse[1], John Harris[1], Tiziana Rossetto[2]

Simulating tsunami in the laboratory

The 3rd generation pneumatic tsunami simulator works through the use of a storage chamber, vacuum pumps, and a control valve.

When the control valve is closed, water is drawn into the storage chamber – simulating the leading trough often associated with an imminent tsunami event.



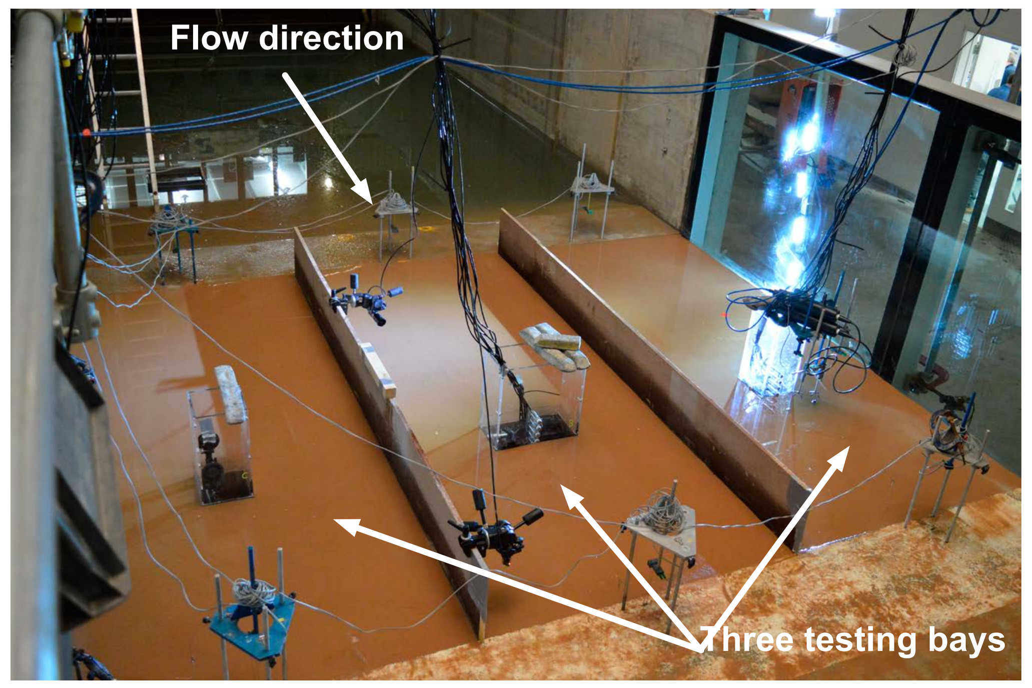
As the control valve is opened, the vacuum is released and water flows from the chamber under gravity, creating the tsunami crest. The valve is controllable, allowing the release of water to be calibrated to simulate both artificial and "real-world" tsunami traces. In addition, as waves of wave length longer than the length of the facility are being generated, the valve can be used to account for reflections and flume harmonics.

This method allows investigation into both the initial impact forces of the tsunami, as well as the ongoing overland flow. Using previous methodologies, research has often been restricted to one-or-other of these important mechanisms.

Test set-up

Tests were conducted in the 4 m wide, 70 m long main channel of the Fast Flow Facility at HR Wallingford. The facility is a recirculating combined wave-current-sediment flume capable of flows of up to 2 m/s and waves of up to 1 m (H_{max}).

Fast Flow Facility



Results

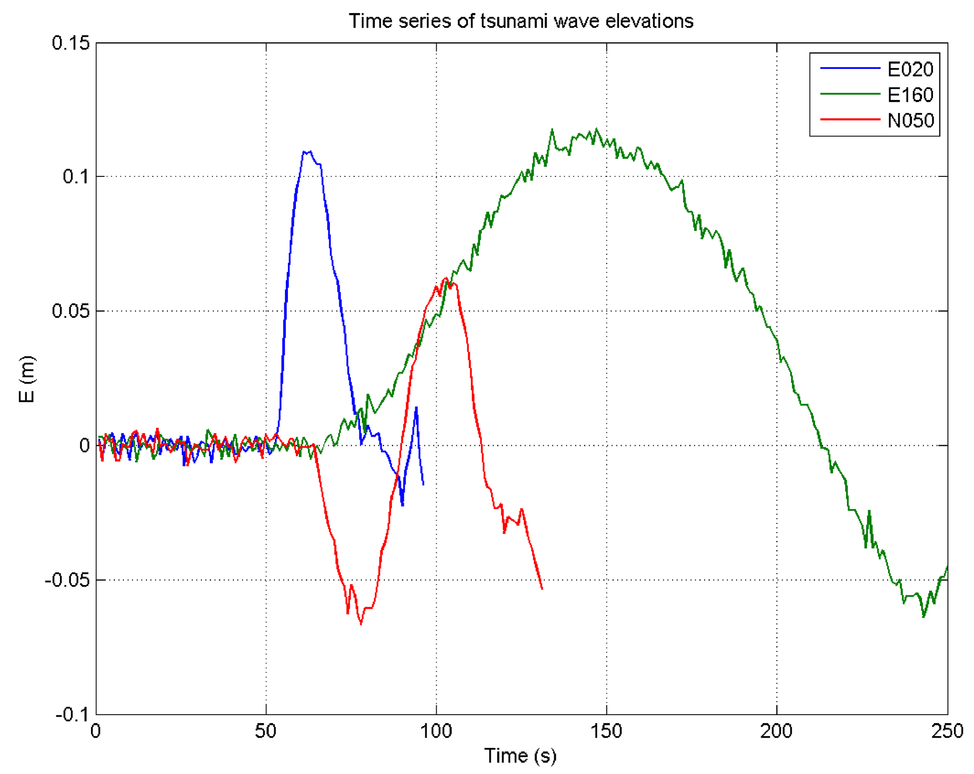
1 Types of waves

Three types of waves were simulated:

- 160s Elevated Wave
- 50s N-Wave
- 20s Elevated Wave

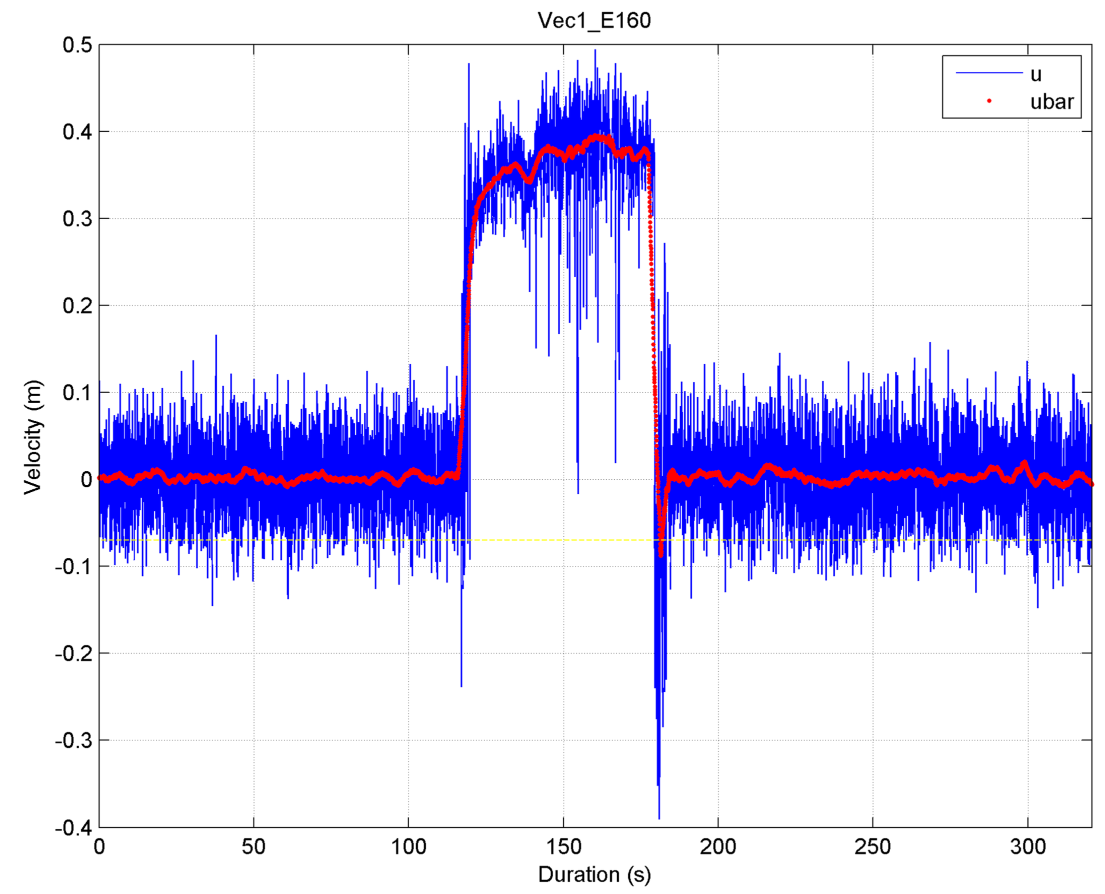
The effects of the waves upon round, square, and rectangular cylinders were measured using pressure sensors, Nortek Vectrino II Profilers, resistance wave gauges and high-speed cameras.

Offshore velocity and pressure data were recorded by a Nortek HR Aquadopp and are shown here.



2 Velocities

The velocity time series, shown below, was recorded using a Nortek Vectrino II ADV positioned 0.1 m from the upstream corner of a 400 x 200 mm surface piercing rectangular cylinder during an Elevated wave of 160 s period. The data shown are an average of the bottom 30 mm of the water column.



Velocity acceleration is rapid for the first few seconds, with the rate then slowing and peaking at approximately 0.4 m/s. Deceleration is similarly rapid.

Due to the wave in which the instrument measures, the Vectrino was deployed at a height of approximately 70 mm above the bed and began returning a signal once the transducer head was submerged after the water depth reached 70 mm. The first part of the wave is therefore missing from these data.

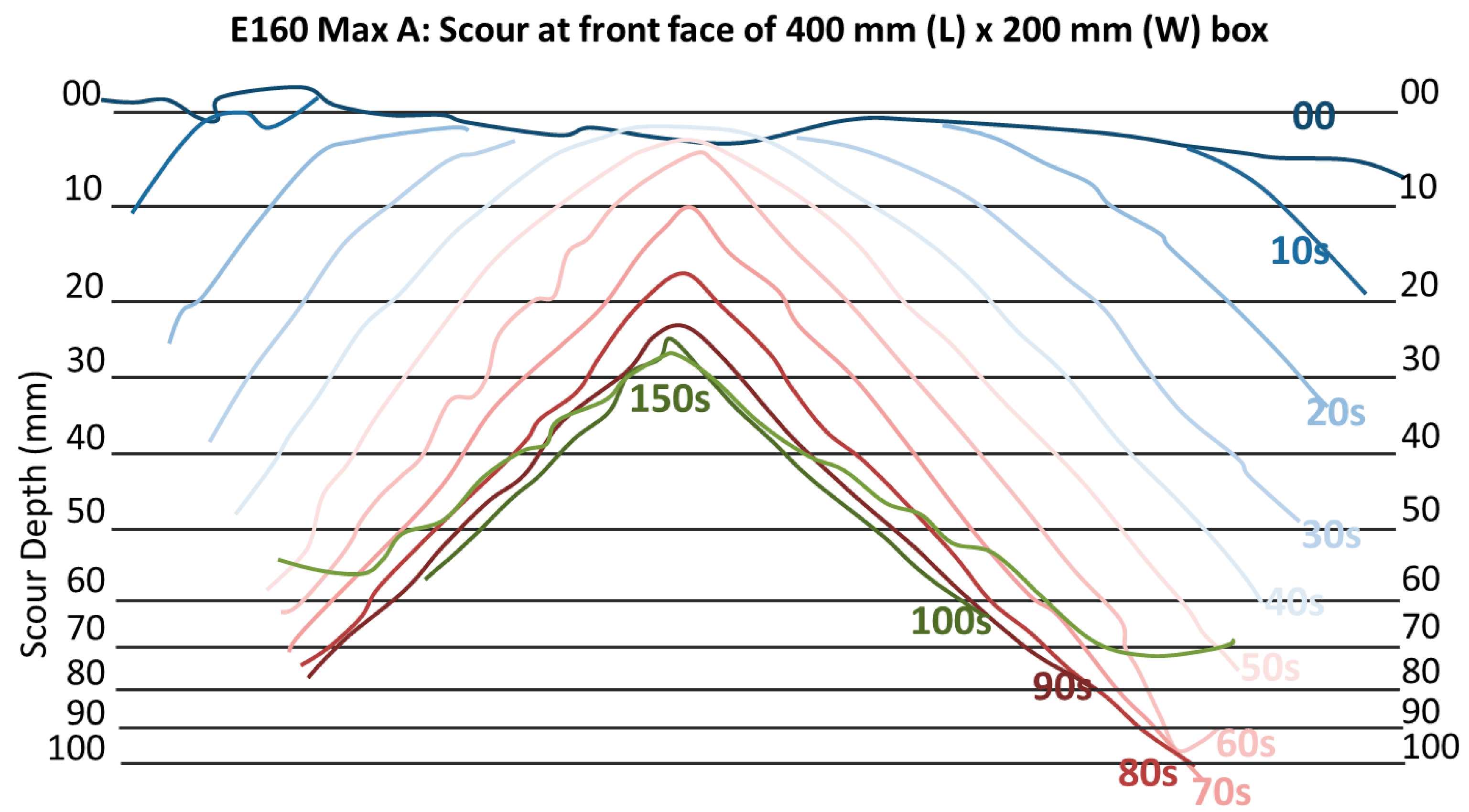
3 Time series of scour

A time-series of scour at the front face of a 400 x 200 mm surface piercing rectangular cylinder is shown below.

Scour begins initially at the corners of the cylinder, which deepen rapidly, reaching depths of 50 mm in just 30 seconds (3.5 minutes prototype). This is equivalent to 2.5 m scour occurring in 3.5 minutes at the nominal testing scale of 1:50. The scour at the cylinder corners gradually progressed inwards toward the centre of the cylinder.

In total, in excess of 70 mm of elevation change occurred at the cylinder edges during this single wave event, equivalent to 3.5 m of scour occurring over a time period of 12 minutes.

It is important to note that the deepest scour was not present at the end of the test. Once the energy of the wave began to lessen, the scour hole immediately began to backfill.



Note: This image is preliminary and has not yet been fully georectified. Apparent asymmetry may be the result of the angle of the camera

Contact

[1] HR Wallingford, Howbery Park, Wallingford, Oxfordshire OX10 8BA, United Kingdom d.todd@hrwallingford.com

[2] UCL, Gower Street, Bloomsbury, London, WC1E 6BT, United Kingdom d.mcgovern@ucl.ac.uk

EPICentre
EPSRC Engineering and Physical Sciences Research Council
erc European Research Council