Numerical Investigation of Boulder Movement on the Seabed

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Background on boulders

Nott's Equation (Nott 2003) for subaerial boulder

$$H \geq \frac{\frac{1}{\delta}\left(\frac{\rho_s - \rho_w}{\rho_w}\right) 2a - 4C_m\left(\frac{a}{b}\right)\left(\frac{\ddot{u}}{g}\right)}{C_D\left(\frac{ac}{b^2}\right) + C_L}$$

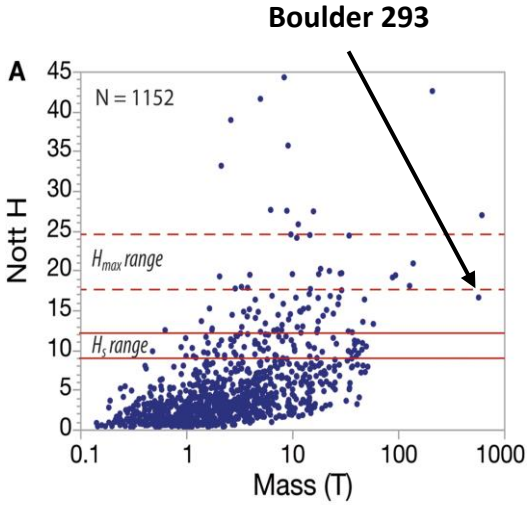
$a, b, c, g, \rho_s, \rho_w$ Known constants physical parameters

Suggested values for unknowns by Nott:

$\ddot{u} = 1\ m/s^2$	Instantaneous acceleration of the flow
$C_L = 0.178$	Coefficient of Lift
$C_D = 1.5$	Coefficient of Drag
$C_m = 2$	Coefficient of inertia

$$\delta = Fr^2 = \frac{U^2}{gH} = \begin{cases} 1 & \text{for storm waves} \\ 4 & \text{for tsunami flows} \end{cases}$$

Cox et al. 2018



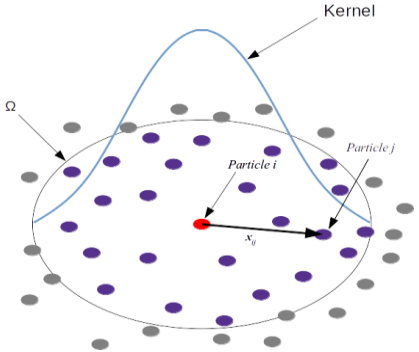
Cox et al. 2020

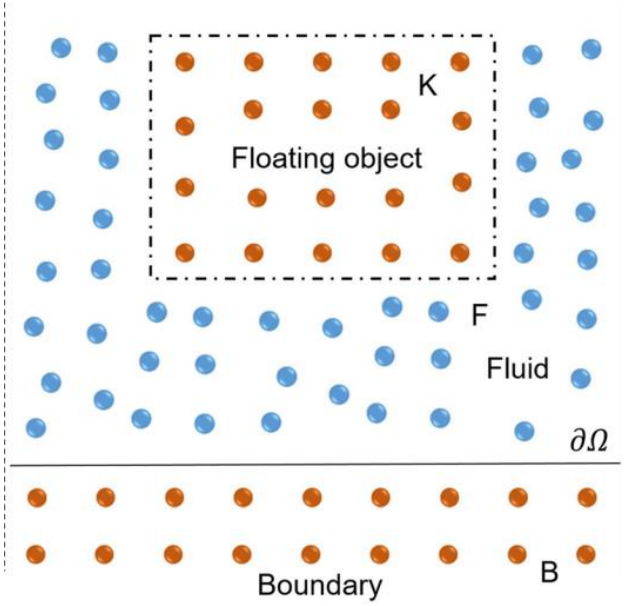
Smoothed Particles Hydrodynamics (SPH)

Advantages:

- Fully Lagrangian or meshless method
- Free surface arises naturally
- Moving boundaries easily implemented

$$\langle f(\boldsymbol{x})\rangle = \int_{\Omega} f(\boldsymbol{x}')W(\boldsymbol{x}-\boldsymbol{x}',h)d\boldsymbol{x}'$$
$$\approx \sum_{j} \frac{m_j}{\rho_j} f(\boldsymbol{x}_j)W(\boldsymbol{x}_i-\boldsymbol{x}_j,h)$$





From Dominguez et.al. 2022

DualSPHysics

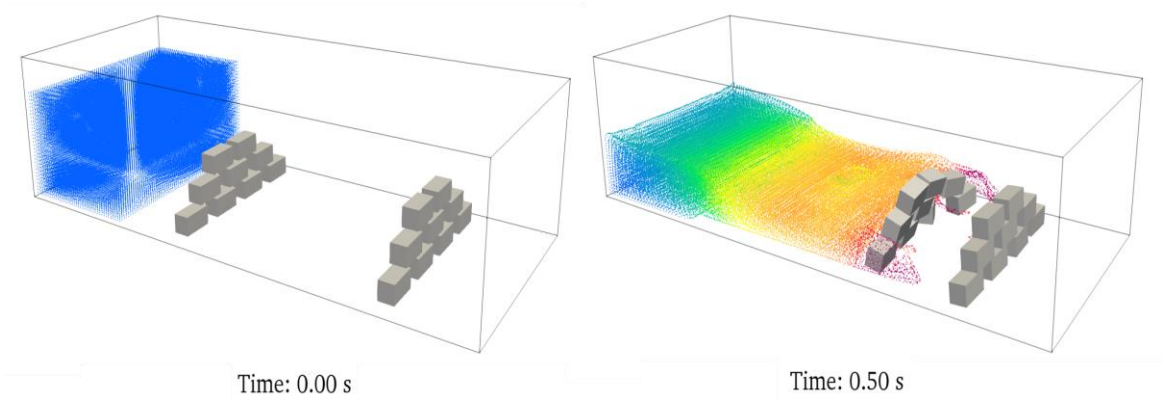
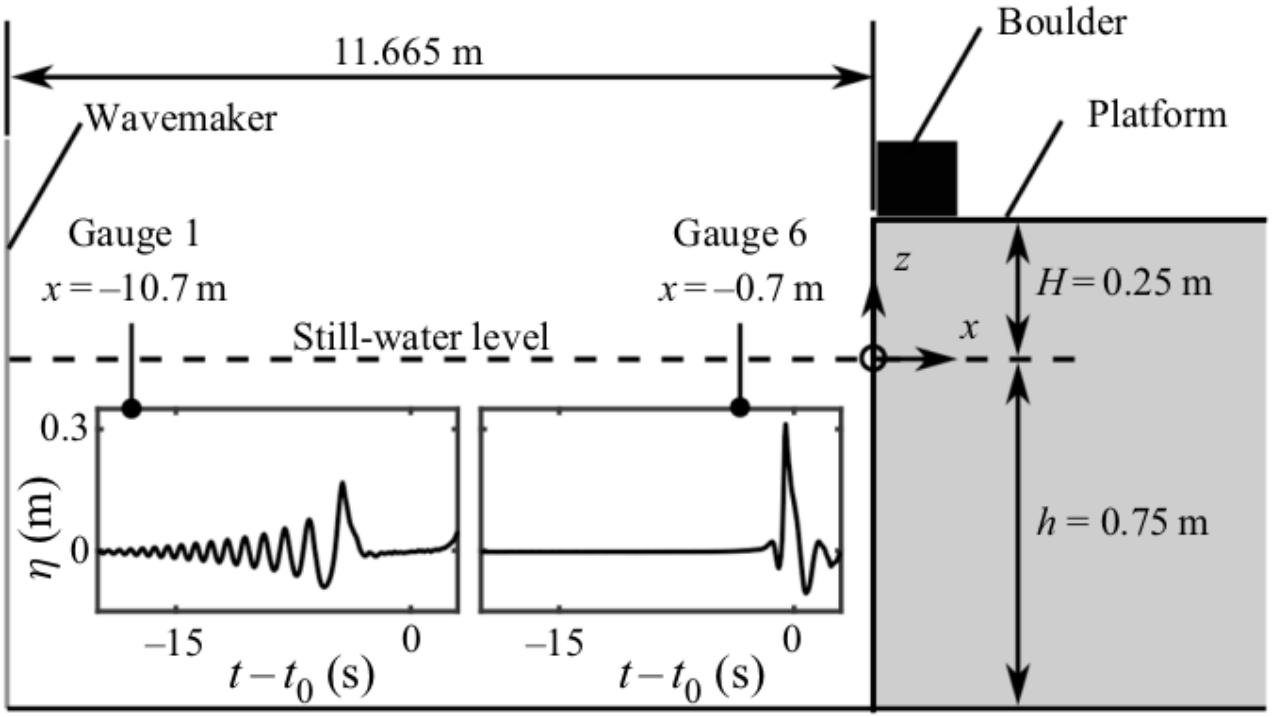


Image from https://github.com/DualSPHysics/DualSPHysics/wiki/7.-Testcases#73-chrono-examples

Laboratory setup

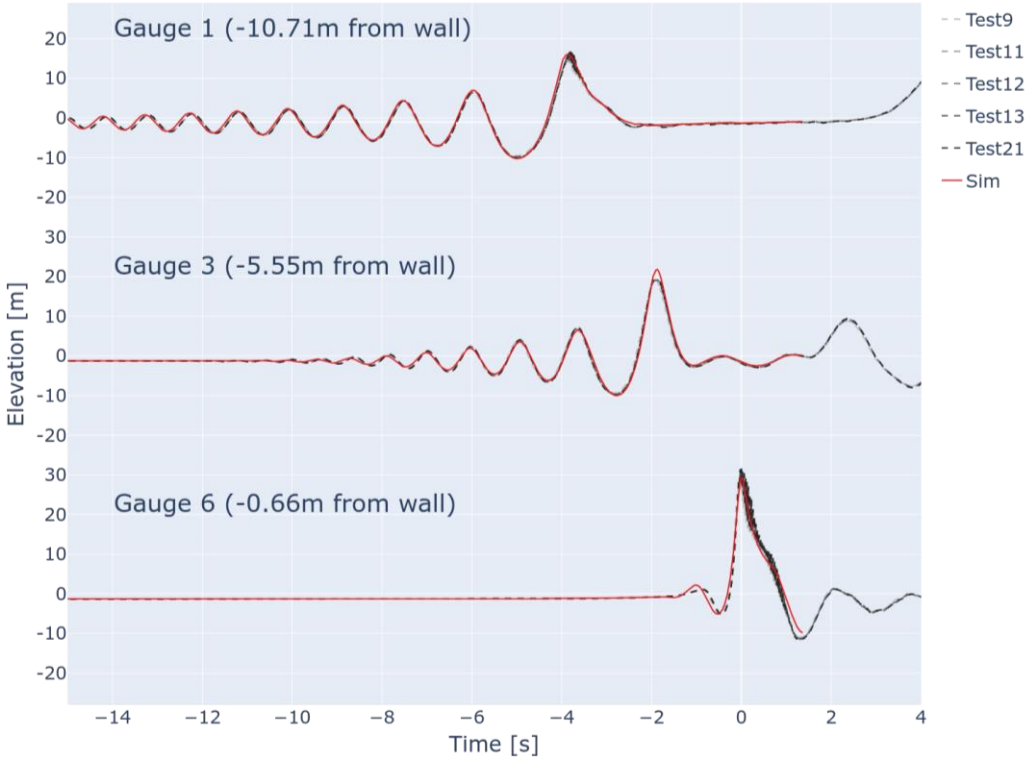


J. N. Steer, O. Kimmoun and F. Dias 2021

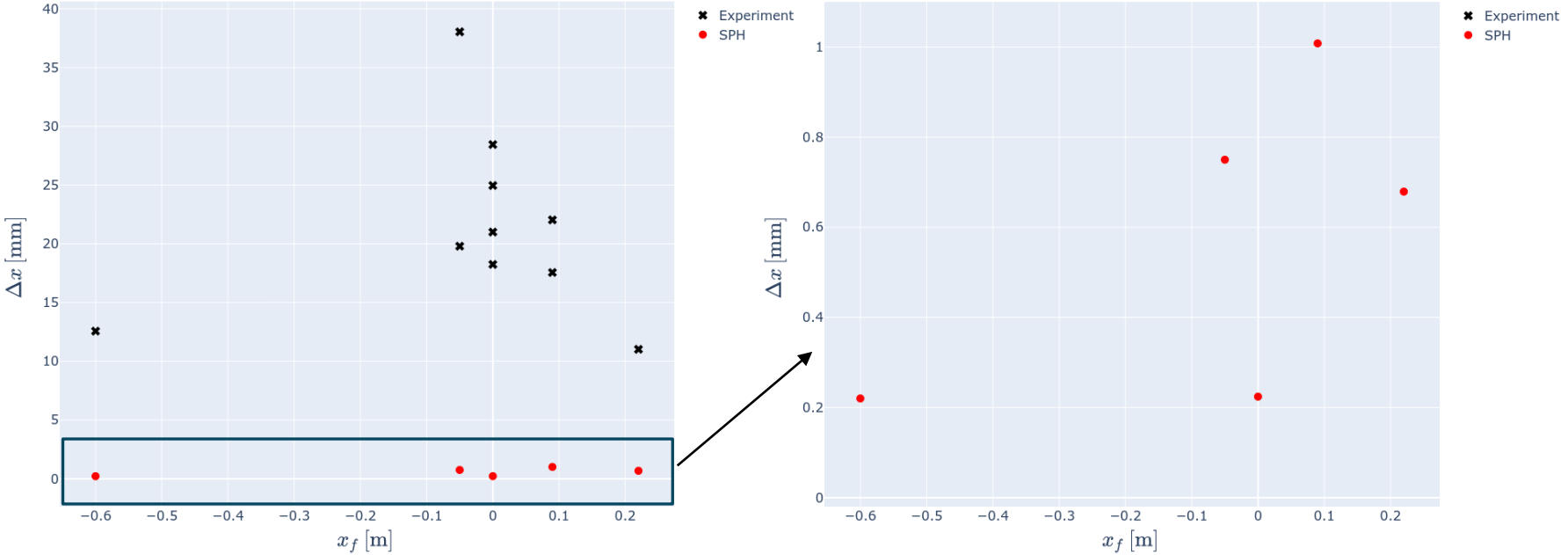
Wave Propagation

Similar results for different focal points

Focusing location (x_f) = 0 m from wall



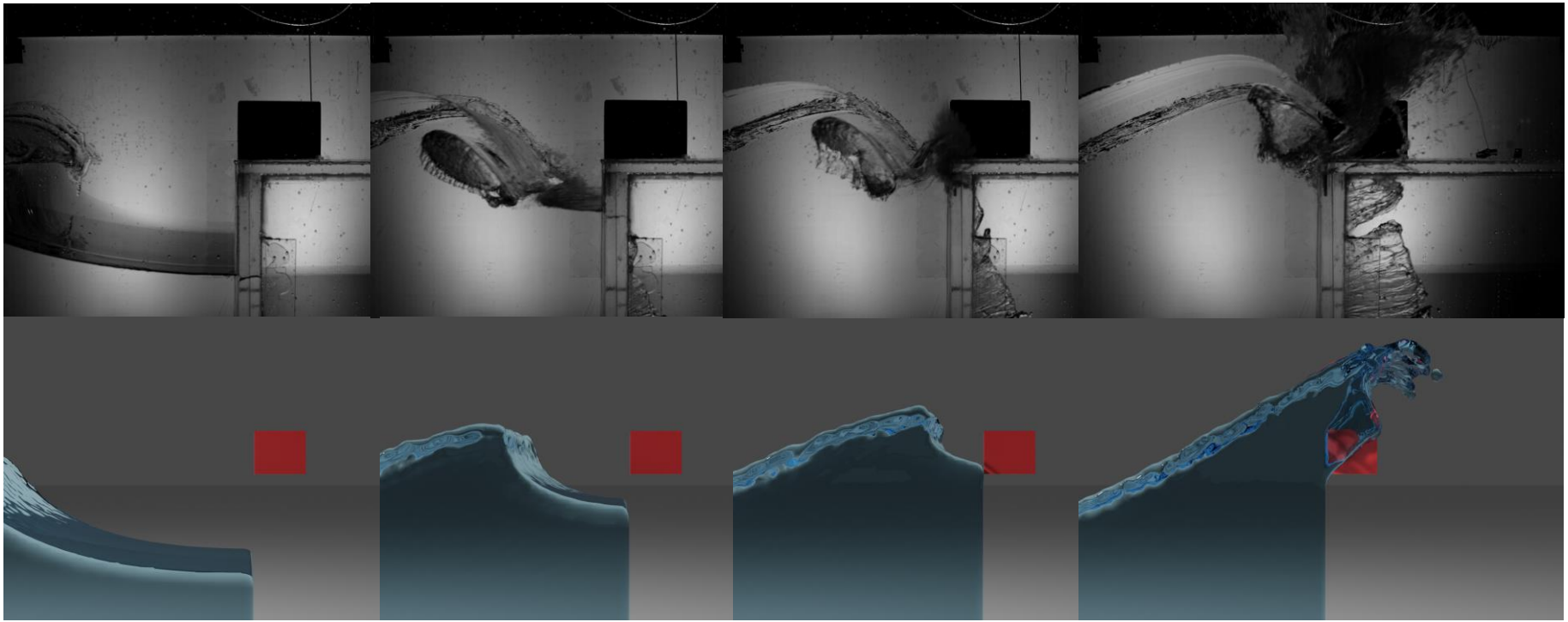
Boulder displacement



More than 1 order of magnitude difference between the experiment and the simulation

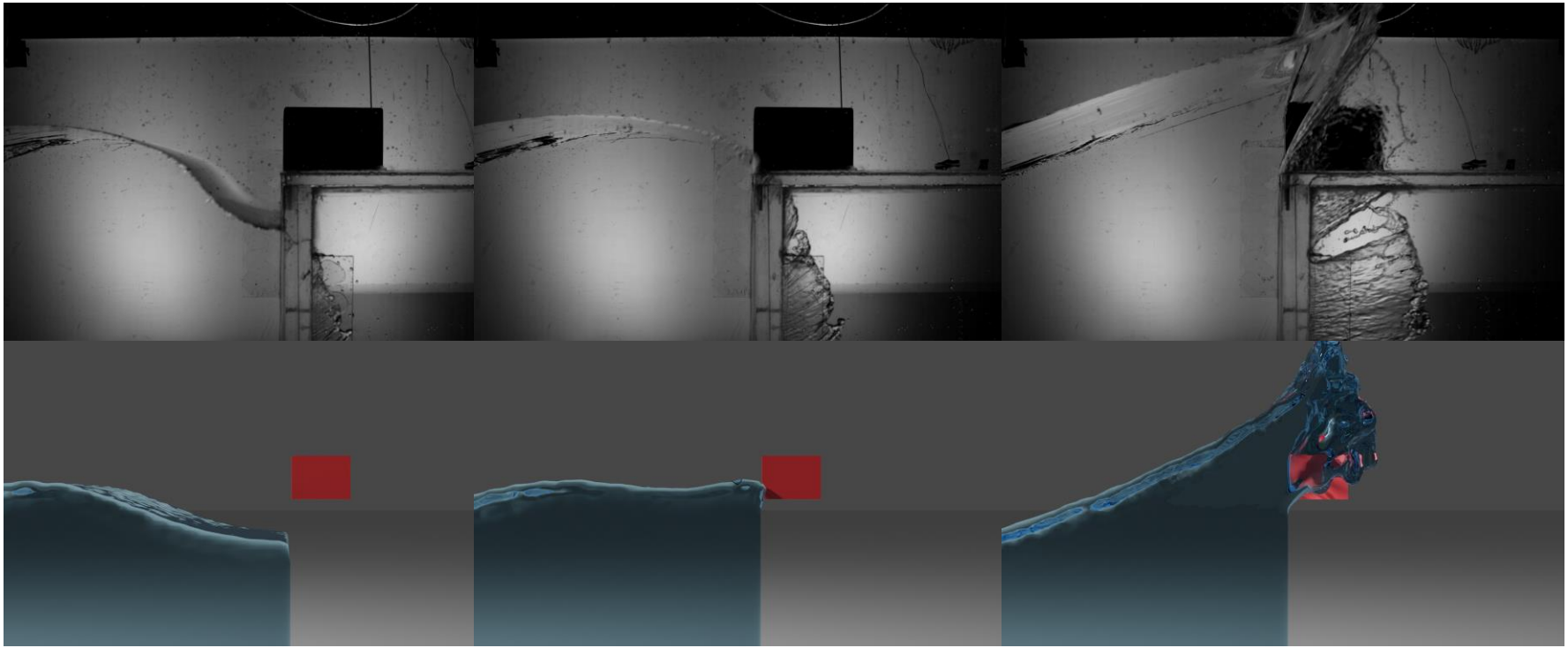
Snapshots of simulation vs experiment

x_f=-0.6 m from wall (Breaking case)



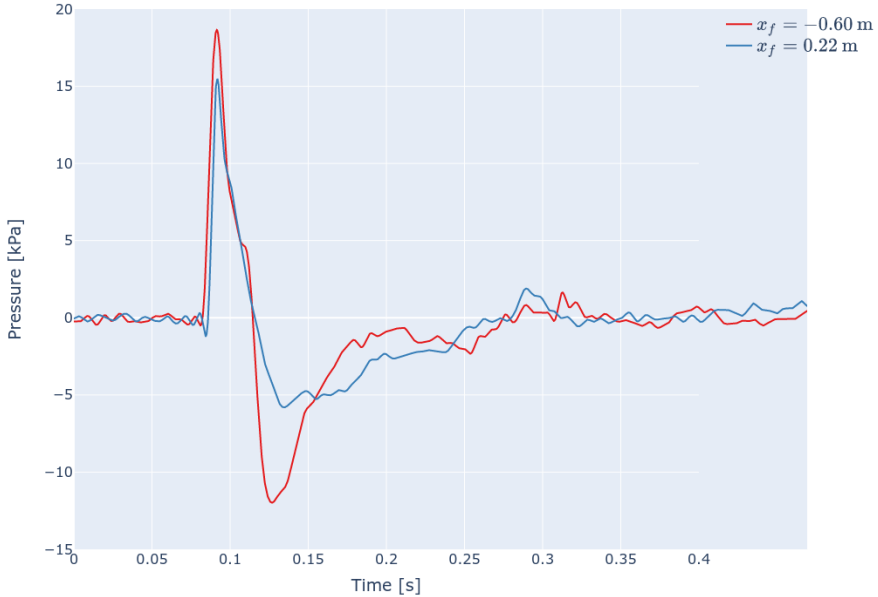
Snapshots of simulation vs experiment

x_f=0.22 m from wall (Non-breaking case)



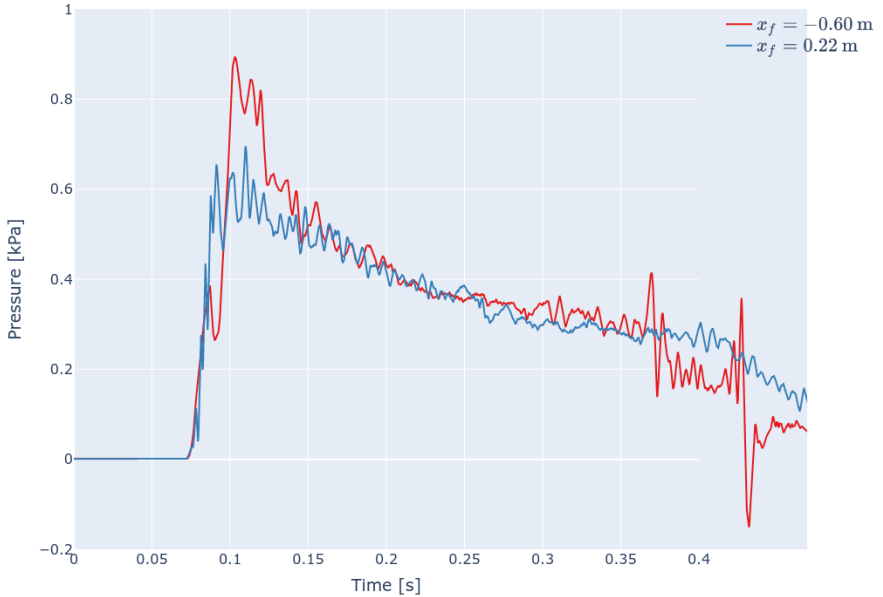
Pressure signal at impact

Experiment



Low sustained but impact pressure

SPH



Low impact but high sustained pressure

Conclusions

- SPH can accurately capture the wave propagation
- There is a shift between the breaking location of focused waves between SPH and experiments
- Reproducing impact pressure from focused waves with SPH is challenging
- Multiphase model might improve results

Future Research

- Simulate cases boulders on seabed below cliffs at Inis Meáin.
- Couple simulations with more accurate propagation models (i.e. SWASH).
- Simulate and compare results with field experiments at Inis Meáin.

References

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3. Domínguez, J. M., Fourtakas, G., Altomare, C., Canelas, R. B., Tafuni, A., García-Feal, O., Martínez-Estívez, I., Mokos, A., Vacondio, R., Crespo, A. J., Rogers, B. D., Stansby, P. K., and Gómez-Gesteira, M. *Dualsphysics: from fluid dynamics to multiphysics problems*. Computational Particle Mechanics 9 (9 -2022), 867–895.

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Thank you.

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