

Experimental and computational characterization of a 12.5 m long wave flume installed at the research facilities of the University of the Basque Country

Ander Aristondo*, [Urko Izquierdo](#), Lander Galera, Jesús M. Blanco, Gustavo A. Esteban, Iñigo Albaina and Alberto Peña

Faculty of Engineering in Bilbao - Department of Nuclear Engineering and Fluid Mechanics - Plaza Ingeniero Torres Quevedo (Edificio I) - 48013 - Bilbao (Spain)

* Email: anderaris1@gmail.com

Keywords: wave flume, characterization, numerical wave flume validation, wavemaker

ABSTRACT

A wave flume of 12.5 x 0.6 x 0.7 m (length x width x height) able to reproduce the ocean conditions of the most representative research facilities in the Basque Country (BiMEP-Biscay Marine Energy Platform and Mutriku Wave Energy Plant) has been installed at the laboratory of Fluid Mechanics of the Faculty of Engineering in Bilbao. This facility is able to produce a large range of monochromatic and panchromatic waves by means of a piston-type wavemaker. The surface elevation is measured by using ultrasonic probes, and wave energy is dissipated at the end of the flume by means of a passive self-designed parabolic beach.

An experimental campaign has been carried out in order to fully characterize the type of waves that can be generated by the piston type wavemaker, in terms of wave height, period and wavelength. Together with the experimental campaign, a numerical model based on Reynolds Averaged Navier Stokes (RANS) equations has been developed to represent the turbulence and Eulerian Volume of Fluid (VOF) unsteady approach in STAR-CCM+ CFD code to track the evolution of the free surface. The numerical model has been successfully validated with the experimental results.

In the present work, a triple comparison between the experimental, computational and theoretical results has been carried out. The generation and propagation of waves has been studied in order to obtain expressions that relate the wavemaker displacement and the generated waves, defining the operation range of the flume. For a complete characterization, immediate work will focus on the analysis of the reflection taking place at the beach and the interaction between reflected and generated wave spectra. Future experimental campaign will focus on the analysis of the interaction between generated waves and floating structures, wave energy converters and mooring systems.

VI MARINE ENERGY CONFERENCE

EXPERIMENTAL AND COMPUTATIONAL CHARACTERIZATION OF A 12.5 m LONG WAVE FLUME INSTALLED AT THE RESEARCH FACILITIES OF THE UNIVERSITY OF THE BASQUE COUNTRY

Ander Aristondo*, Urko Izquierdo, Lander Galera, Jesús M. Blanco, Gustavo A. Esteban, Iñigo Albaina and Alberto Peña

Department of Nuclear Engineering and Fluid Mechanics, Faculty of Engineering in Bilbao

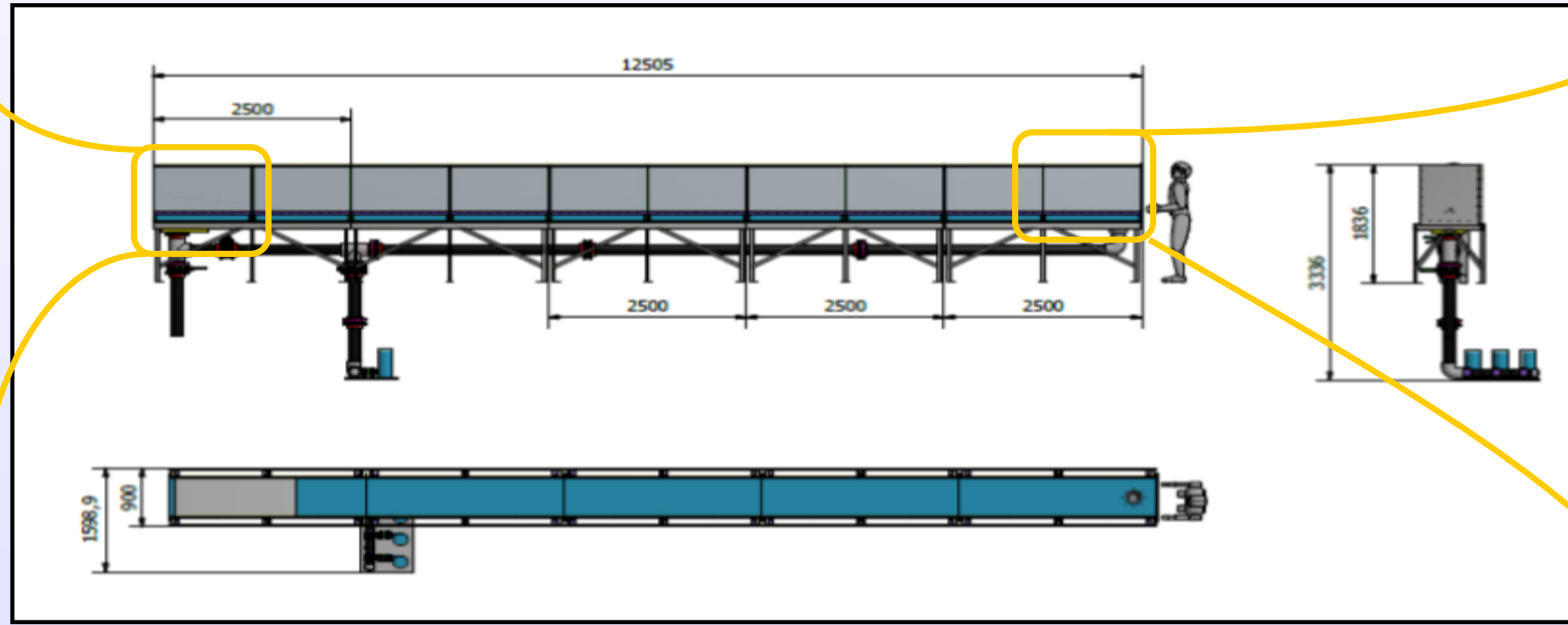
*anderaris1@gmail.com

CONSTRUCTIVE CHARACTERISTICS OF THE FLUME



EXTINCTION ZONE

The extinction zone consists of a self-designed passive parabolic absorber. The position and inclination of the beach can be adjusted by means of two screws.



MAIN CHARACTERISTICS AND DIMENSIONS

The main dimensions of the flume are: 12.5 m long, 0.6 m wide and 0.7 m high. The structure consists of 5 modules made of stainless steel and ten pieces of laminated tempered glass (2.5 x 0.7 m) define the available working space. Three pumps installed in a water tank under the flume are used to quickly fill up the flume.

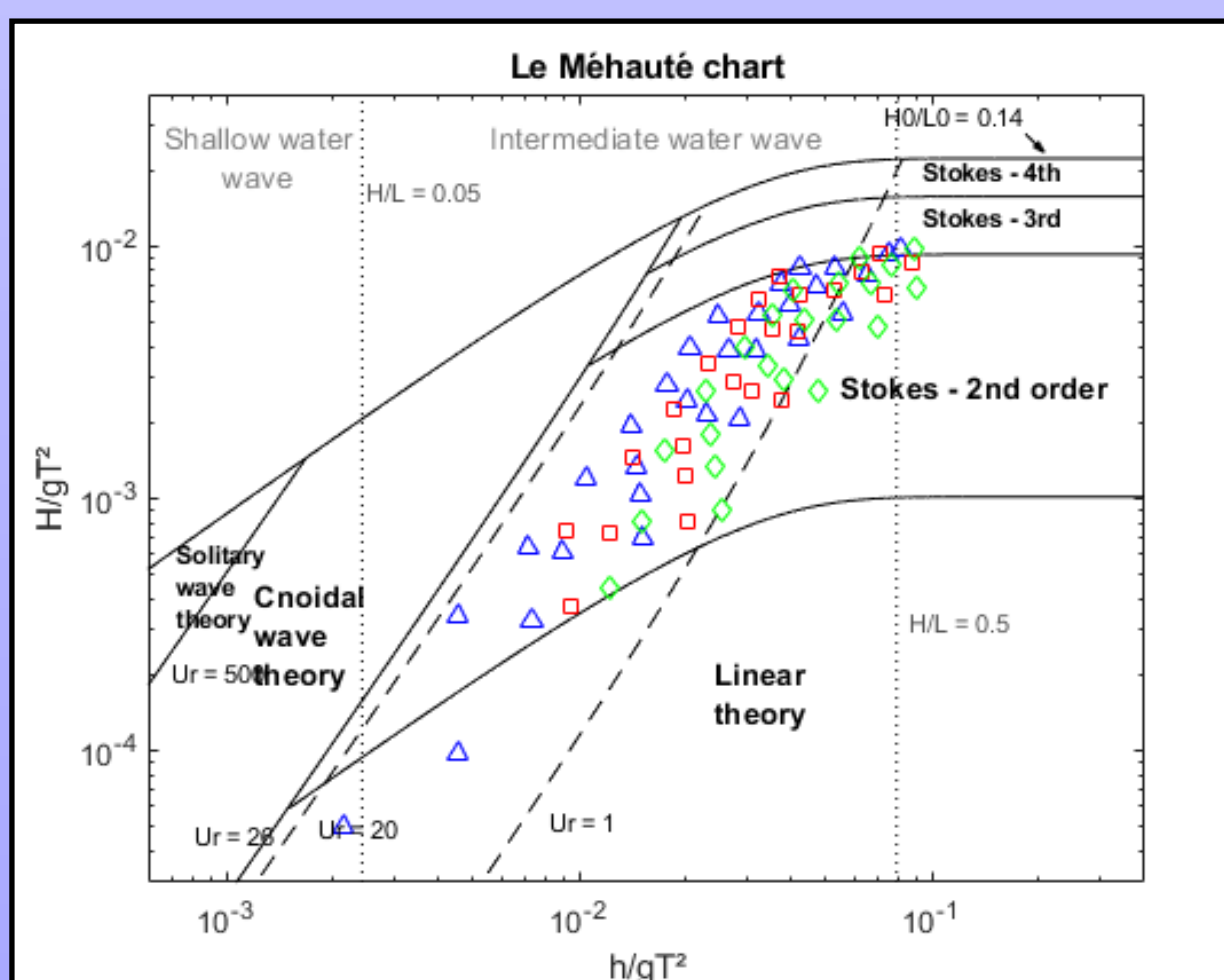
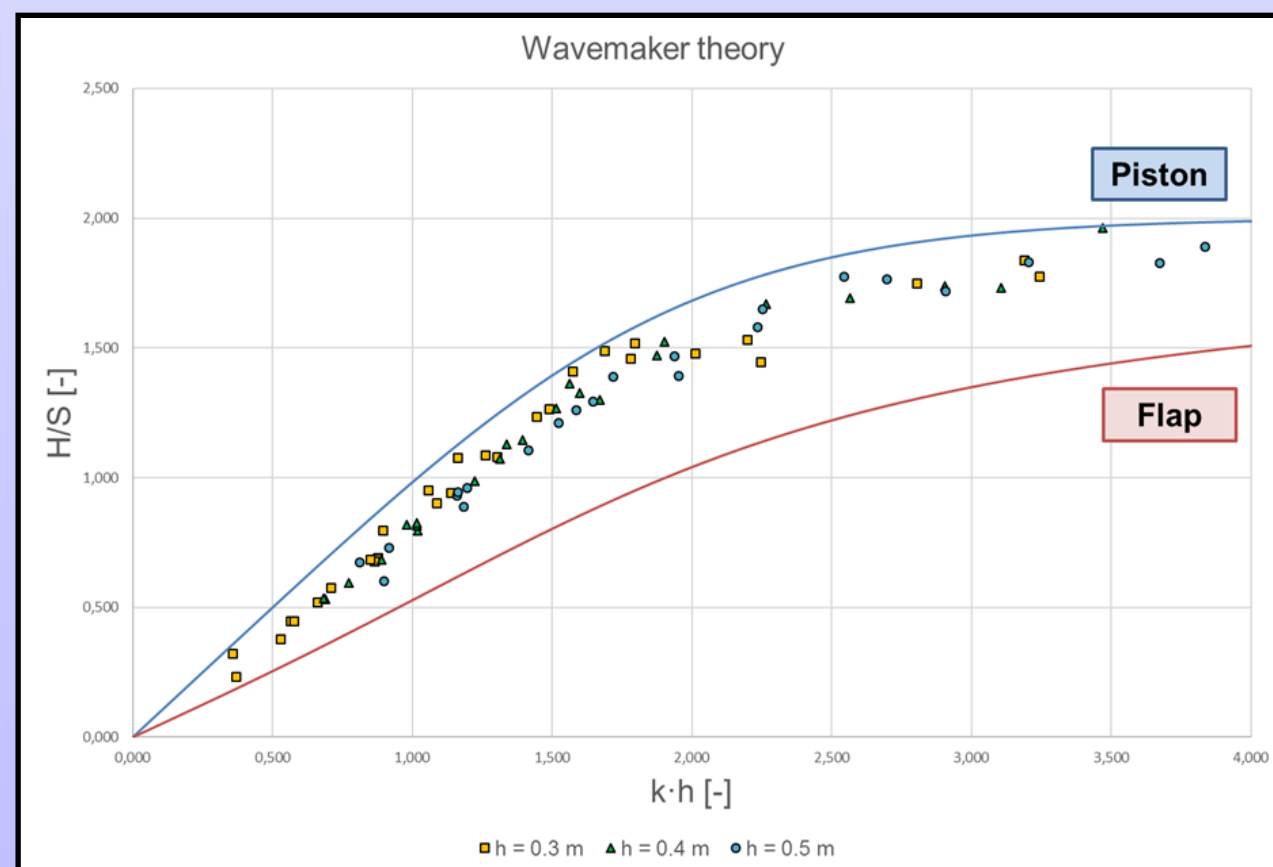


WAVE GENERATION

Waves are generated by means of a piston-type wavemaker, which is able to perform a pure sinusoidal oscillating movement. The sides of the moving paddle are sealed.

EXPERIMENTAL RESULTS

The wavemaker theory provides a theoretical relation between the piston movement and the waves generated in the flume. Experimental results have been compared to the ones predicted by this theory. In general, experimental values follow the theoretical trend, with slight differences in wave height, which can be solved by increasing the stroke.



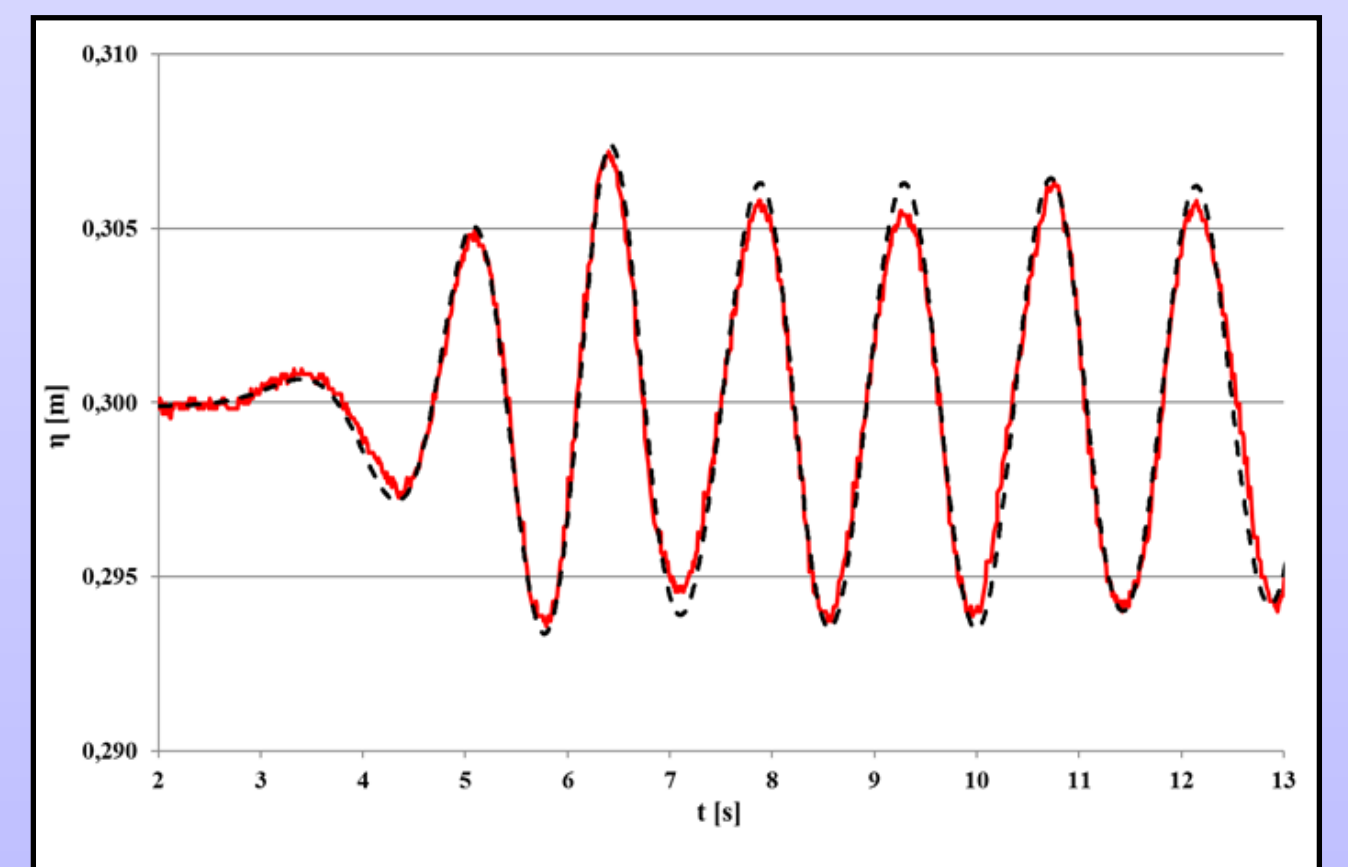
Le Méhauté's chart establish useful qualitative criteria to determine the most suitable theory that corresponds to each particular wave, according to three parameters: wave height, period and water depth. It is very useful to compare real sea waves and laboratory waves.

The flume is able to cover a wide range in the chart. Waves corresponding to linear theory, Stokes' 2nd and 3rd order and Cnoidal waves have been generated. The figure on the left hand side shows the resulting 2nd order Stokes' waves.

COMPUTATIONAL ANALYSIS

MODEL

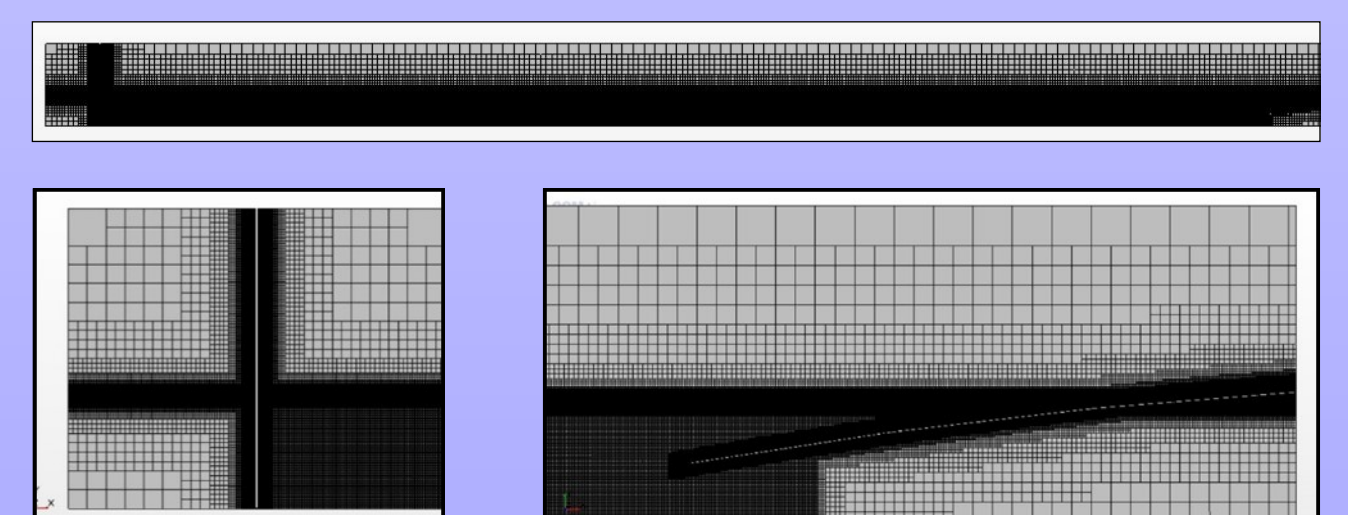
- Oscillating rigid paddle. Control parameters: stroke and period.
- Reynolds Averaged Navier-Stokes (RANS)
- Eulerian Volume of Fluid (VOF)
- Turbulence k-ε model
- Courant no. C = 1-2
- Δt = 0.001 - 0.002 s
- Wall y+ < 20



The computational model (black-dotted) has been validated with the corresponding experiments (red).

MESH		
Depth [mm]	no. of cells	Min. cell [mm]
300	328297	2.7
400	389292	3.3
500	788005	1.5

The no. of cells and the minimum cell size vary depending on the depth of study.



The geometry of the numerical wave flume (NWF) exactly corresponds to the geometry of the experimental wave flume (EWF). Cell size decreases around the moving paddle, the absorbing beach and the water-air interface.

ONGOING + FUTURE WORK

ONGOING WORK

A reflection study is being carried out in the flume. The aim of the study is to determine the reflection coefficient of the beach and its energy dissipation capacity.

FUTURE WORK

Future work in the flume will focus on the analysis of the interaction between generated waves and floating structures, wave energy converters and mooring systems.

CONCLUSIONS

A new wave flume was installed at the Fluid Mechanics Laboratory of the Faculty of Engineering in Bilbao at the beginning of this year.

A characterization work has been successfully carried out in order to determine the type of waves that can be generated and how to relate the wavemaker movement and the generated waves.

Once the reflection study is concluded, the flume will be ready and fully equipped to carry out any laboratory-scale hydrodynamic analysis concerning floating bodies, wave energy converters and moorings.

Parallel to the experimental campaign, a computational model able to reproduce the laboratory flume has been developed and validated.