DEVELOPMENT AND FEATURES OF THE NEW COASTAL AND OCEAN BASIN IN OSTEND, AS SUPPORTING RESEARCH INFRASTRUCTURE TO TACKLE CLIMATE CHANGE ISSUES RELATED TO URBANIZED COASTAL ENVIRONMENTS

BY PETER TROCH, VICKY STRATIGAKI, JAAK MONBALIU & FRANK MOSTAERT

The new Coastal and Ocean Basin (COB, cob.ugent.be) in the Flanders Maritime Laboratory, Ostend (Belgium), is the latest tool that will support the scientific community in their effort to tackle climate change and come up with countermeasures to protect coastal communities and offshore investments. The COB will be able to reproduce wave, current, and wind conditions, offering an unprecedented opportunity for researchers and consultants to take a closer look at ocean hydrodynamics, and the structural response of coastal and offshore structures. Also, it enables them to advance marine renewable energy technologies, and to validate numerical models. Construction of the COB started in 2017, and the facility is expected to be operational by end of 2021.

Acceleration in sea level rise and increased intensity of storms [1] have put coastal populations at risk, and pushed the scientific community to come up with better solutions through: designing coastal protection structures, developing new ocean renewable energy technologies, or implementing nature-based solutions. In any case, designers have to go through the so-called integrated research methodology, which combines both numerical and physical scale modelling. Flanders is no stranger to this long-lasting quest and already has experimental infrastructures at Ghent University (UGent) and Flanders Hydraulics Research (FHR), with a limitation to relatively small-scale experiments. Therefore, and to cope with the emerging needs, a consortium led by the Civil Engineering department at UGent, and in partnership with KU Leuven and FHR secured funding for a new state-of-the-art test facility, the new Coastal and Ocean Basin (COB).

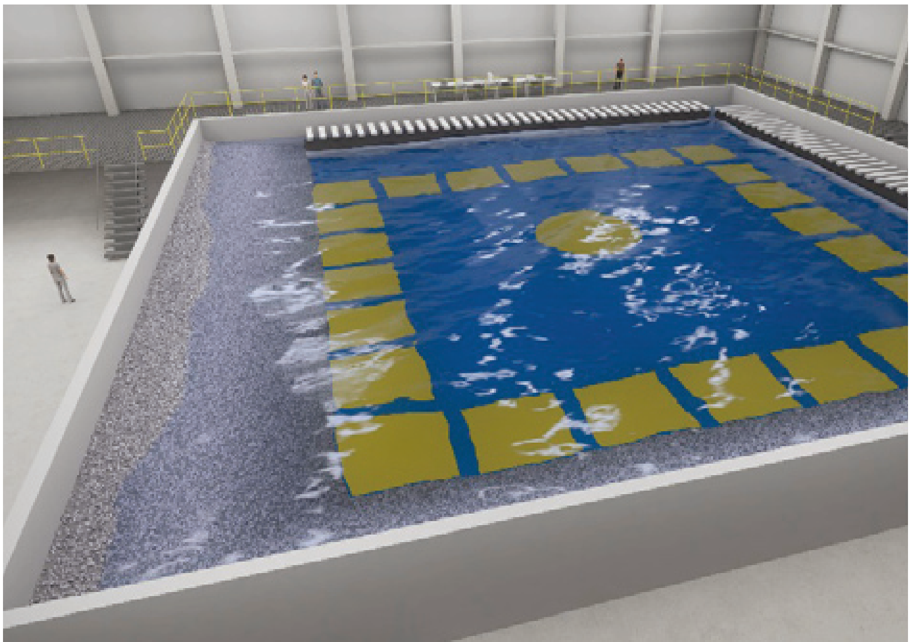


Figure 1. Artist impression of the Coastal and Ocean Basin

The COB, as depicted in Figure 1, is designed to cover a wide range of physical modelling needs while minimizing operating costs. This has resulted in a large range of opportunities for academic research, and for governmental and private sector projects. Users of the new test facility are expected to come from different backgrounds and fields. Starting with coastal engineering, scale experiments will offer valuable data on the wave impact loading of structures, the prediction of wave overtopping over dikes and breakwaters and damage to coastal structures. Emerging marine renewable energy technologies including offshore wind, floating photovoltaics and tidal and wave energy converters will be also tested in the COB.

Figure 2. Front view of the facility hosting the COB and a towing tank (Ostend, Belgium).

Moreover, interdisciplinary work that combines marine ecology with engineering will help shape the role of seagrass vegetation and natural reefs with their habitants. The Civil Engineering department from UGent focuses on these applications. Traditionally it has focused on wave overtopping [2], wave energy converters and scour protection [3], [4], and is a pioneer in coastal defenses and wave attenuation by vegetation [5].

Strategic hub connecting coastal and offshore research universities and governmental institutes with the private sector

The COB is hosted within the Flanders Maritime Laboratory, Ostend, Belgium (shown in Figure 2), a newly built research facility that houses alongside the COB a towing tank, which is also commissioned under a joint initiative between FHR and UGent [6]. This offers a unique opportunity to perform multipurpose tests within the same facility, which will create strong research synergies. Additionally, the laboratory provides a spacious workspace and modern offices to support operations.

What are the components of the COB and how does it work?

The COB laboratory will consist of a large technical facility housing the basin and the accompanying systems to operate it (see Figure 3). The main wave/current basin (see current view in Figure 4) will cover a total area of 900 m^2 (30 m x 30 m), and operate through four components: (i) wave generator, (ii) current generator, (iii) wind generator and (v) water transfer system. Additionally, a fully automated Data Acquisition System (DAQ) will ensure smooth and perfectly controlled set-up, start-up and management of all testing scenarios. Auxiliary systems that improve the efficiency of the experiments have been also installed; these include an access bridge, a crane, an operation control room, and a workshop.

The Wave generator

The wave generator is the most crucial mechanical system of the COB, and the design has been made bearing in mind the typical physical modelling scenarios that will be performed. To generate realistic waves, the wave generator ideally spatially covers two sides of the COB basin, forming an "L"-shaped corner (as presented in Figure 5.A). The wave generation system is composed of relatively narrow wave paddles capable of generating waves in any direction. This "L"-shaped configuration will

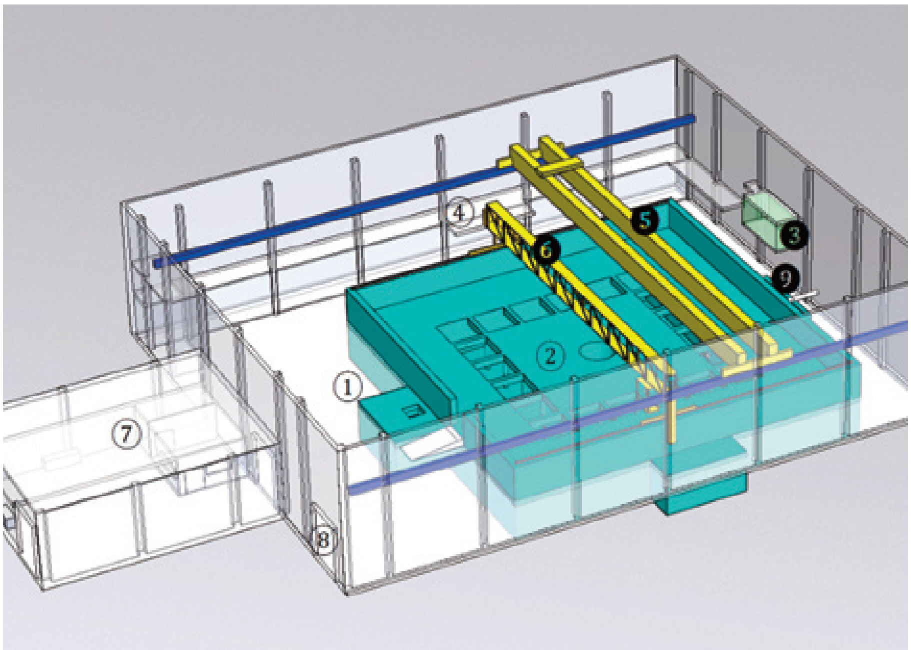


Figure 3. Overview of the layout of the components of the COB facility: 1) main hall, 2) COB basin, 3) main operation control location and office, 4) secondary operation and observation control location, 5) bridge crane, 6) carriage (access bridge), 7) workshop, 8) external access, and 9) water transfer system.

Figure 4. Work progress at the COB: the construction phase of the COB basin structural elements has been completed

Table 1. Selected examples of existing wave basins in relation to the COB

Name and location	Dimensions (length x width x water depth) (m)	Maximum Wave height (m)
COB (Belgium)	30.0 x 30.0 x 1.40 (with 4.0 m deep central pit)	0.55
Portaferry (Queen's U. Belfast, UK)	18.0 x 16.0 x 0.65	0.55
DHI shallow basin (DK)	25.0 x 35.0 x 0.80	est. 0.40
U. of Aalborg basin 1 (DK)	15.7 x 8.5 x 0.75	0.20
U. of Aalborg basin 2 (DK)	12.0 x 17.8 x 1.00	est. 0.50
Delta basin (Deltares, NL)	50.0 x 50.0 x 1.00	0.45
Pacific basin (Deltares, NL)	22.5 x 30.0 x 1.00	0.40
Atlantic basin (Deltares, NL)	75.0 x 8.7 x 1.00	0.45
Tsunami wave basin (Oregon State U., USA)	48.8 x 26.5 x 1.37	0.75
Coastal basin (U. of Plymouth, UK)	15.5 x 10.0 x 0.50	0.30
HR Wallingford (UK)	27.0 x 55.0 x 0.80	0.25

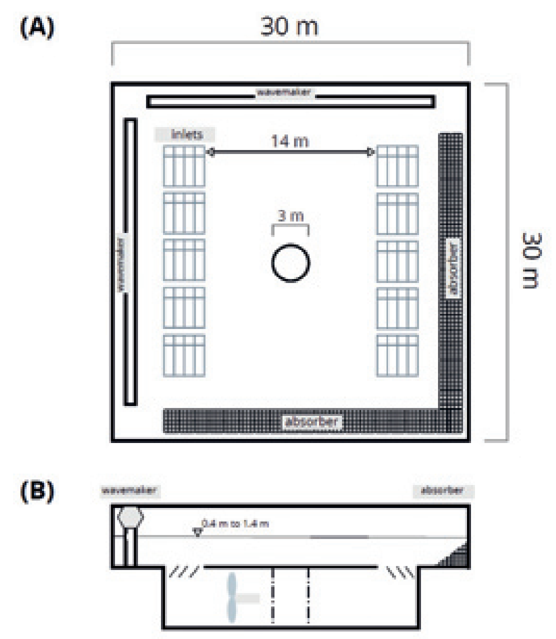


Figure 5. COB schematic (not to scale) including the wave generators at both sides (areas indicated as 'wavemaker') and the current generation system (A: plan view; B: cross section).

make it possible to test a large spectrum of oblique (short-crested) wave angles, and when coupled with the reversible current generation system, to achieve any desired relative angle between the generated current and waves. The dimensions of the COB basin combined with the wide range of hydrodynamic conditions to be reproduced, will place the COB in a leading position on the global scale in terms of both coastal and near offshore experimental setups. The COB offers a variable water depth ranging from 0.4 to 1.4 m, enhanced by a central pit with a maximum water depth of 4.0 m. Multi-directional wave generation with a maximum height of 0.55 m is targeted, together with a full spectrum of wave-current interaction, with currents of up to 0.4 m/s as described in the next section. Table 1 presents a list of operational wave basins at different hydraulic laboratories; the COB stands out clearly with regard to the relationship between maximum water depth and capability to generate large waves, emphasizing also on the practical aspects for easy, yet accurate, operation of the facility. Moreover, the COB offers the additional capability to test offshore scale models for applications in the fields of marine renewable energy and offshore engineering like monopile wind turbines, floating platforms and offshore devices, mooring applications, etc.

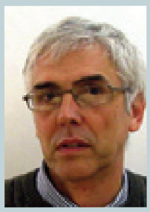
Current generator

One of the unique characteristics of the COB is its capacity to generate combined waves, currents and wind loads. To our knowledge, there are very few facilities reported in literature which offer combined wave and current generation at any relative angle of propagation. As a result, experiments regarding combined waves and currents are also scarce [7]. With no "off-the-shelf" solution available for the current generation system, a tailor-made solution that takes into account the basin layout and target flow rates has been developed and implemented. The target current flow velocity is based on the dominating flow conditions in the Belgian coastal waters, characterized by tidal currents with a typical depth-averaged flow velocity of about 1.0 m/s in full scale. Considering a maximum scaling factor of about 1:8, the flow velocity in the model is scaled down to 0.4 m/s, requiring a total discharge of approximately 11 m^3/s. These design parameters place the COB in a leading position with flow velocities that are almost as twice as the average of the maximum velocity at many other similar facilities of 0.25 m/s. Current and wave testing facilities mainly operate through three systems: jet induced flows, pump and pipe systems, and flow chambers. The first two systems are compact but lag in high power requirements due to the presence of high velocities in multiple sections of their components. To stay within reasonable operating costs, the use of a flow chamber below the level of the wave tank floor, namely a current tank, has been selected. Sketches of the current generation system are shown in Figure 5. The current is introduced in the basin through a set of guiding grids flush-mounted in the basin floor. Each grid can be replaced by a lid when the current system is not being operated.

Prof. Peter Troch is the department chair and director of the Coastal Engineering Laboratory at UGent and coordinator of the Coastal and Ocean Basin, Ostend. He has 25 years of academic experience and focuses on wave induced response of coastal structures, on wave propagation and harbor penetration modelling, and on eco-hydraulics of vegetated lowland rivers. Prof. Troch coordinates a large team of researchers focusing on wave energy converters and coastal engineering. He has published in various international peer reviewed journals and conference proceedings, and he is member of the Editorial Board of Coastal Engineering. He is chair of the management committee of the COB.

Dr. Vicky Stratigaki is a Senior Research Engineer at the Civil Engineering Department of Ghent University (Belgium) with PhD in Civil Engineering, MSc in Civil Engineering, and an additional MSc in Environmental Sciences. Her numerical work with wave models focuses on wave transformation and penetration into harbors, diffraction around breakwaters/coastal structures, marine renewable energy devices and resources. Her current research topics focus on Coastal & Offshore Engineering, Nature-based techniques for coastal protection, and interdisciplinary ocean research topics including Aquaculture, Maritime Engineering and Marine Renewable Energy with a focus on Blue Growth and Blue Economy. Dr. Stratigaki has published her research on experimental testing and validation of numerical models in numerous international peer reviewed journal and conferences. Dr. Stratigaki is a team-leader in national and international research consortia and is Chair of the pan-European COST Action WECANet CA17105 of 31 countries. She is member of the design team of the COB.

Prof. Jaak Monbaliu is the chair of the Department of Civil Engineering and also teaches several courses including Coastal Engineering and Advanced Mathematics for Water Engineering. His sphere of research lies in (but is not limited to) wind waves, sediment transport under waves and currents, and remote sensing coastal zone and estuaries, with several publications in international peer reviewed journals. He is management committee member of the COB.



Prof. Frank Mostaert currently works at the Flanders Hydraulics Research as division head and is a part time lecturer at Hasselt University and Ghent University. His interdisciplinary experience bridges the academic sector of Belgium with the public and private sectors in Flanders. In his work he focuses on research in water management and water science and environmental science, holding publications in international peer reviewed journals. He is management committee member of the COB.

Data Acquisition System

Since the quality of acquired measurements and data is the most vital outcome of any experiment, special attention to detail has been put in the selection of the measurement instrumentation and the design of the Data Acquisition System (DAQ). The COB laboratory will have a large inventory of traditional and state-of-the-art instrumentation for measuring e.g. the water free surface (i.e. capacitive, resistive, ultrasonic wave gauges), the wave orbital and current velocities (Acoustic Doppler Velocimeter, Acoustic Doppler Profiler, micro-propeller velocimeter), loading pressures, loading stresses (axial load cells), wind parameters and loads (ultrasonic anemometer, cup anemometer, barometer, air temperature sensor), and water depth. In addition, 3D motion capture systems and a 3D laser scanner for topographic mapping are foreseen. The collected measurements information will be transferred to a local processing unit, which will be in turn connected to a server that provides real-time remote access.

Conclusions

Emerging challenges in the coastal sector due to sea level rise and higher storm waves, alongside the transition towards clean energy through wind, wave and current energy illustrate the importance of the COB in providing a test ground for prospective solutions and emerging technologies.

In the field of offshore renewable energy, there is a significant potential for exploitation of wave, wind and tidal energy worldwide which results in ample research opportunities focusing on all relevant technologies at various stages of development. Yet there is a clear need for new infrastructure to move from concept to open sea as recognized in various Research and Development and Innovation (R&D&I) roadmaps at European level. At the same time, and to tackle climate change impacts, there is also a clear need for physical modelling infrastructure within the fields of coastal engineering and marine ecology, where updated knowledge on coastal resilience and ecosystem protection methods, especially under 3D conditions and wave-current interaction, is still needed. The Coastal and Ocean Basin (COB) is serving these critical present-day and future needs by providing a versatile facility that will lead to the technologies and methods of the future.

Acknowledgements

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